DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

Appendix A:
Botanical Resources Report

January 2000

Integrated
Storage
Investigations

CALFED
BAY-DELTA
PROGRAM

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SUMMARY

This report summarizes a botanical resource assessment of the Sites, Colusa cell, Newville, and Red Bank reservoir sites in 1998 and 1999. The assessment included rare plant field surveys, mapping and analysis of vegetation communities, and an inventory of vascular plants in the reservoir inundation zone.

There were no State or federally threatened or endangered plants found in the reservoir areas during the course of the study. Populations of federal Species of Concern were identified in the Newville and Red Bank alternatives. Several rare and limited distribution species were also found in all of the alternatives. The Newville and Red Bank sites yielded the greatest number of populations of sensitive plant species.

Vegetation communities which may be affected by the proposed reservoirs include California annual grassland, valley and blue oak woodland, willow riparian scrub, cottonwood riparian woodland, foothill pine woodland, chaparral, vegetated wetlands, and vernal pools. More than 80 percent of the Sites, Colusa cell, and Newville reservoir areas support annual grassland, in contrast with Red Bank which is more than 80 percent oak and foothill pine woodland. Among the reservoir alternatives, the maximum oak woodland loss may be 1,800 acres. Vernal pool impacts vary between the sites from 0 to 23 acres.

A vascular plant inventory was prepared for each site, showing that species diversity is highest at the Newville site and lowest in the Colusa cell. Non-native species representation was also greatest at Newville. The annual grassland is dominated by non-native species such as yellow star thistle (*Centaurea solstitialis),* brome grasses (*Bromus* sp.), and medusa head (*Taeniatherum caput-medusae).* Non-native species density or cover was not quantified.

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INTRODUCTION

This report is a summary of a two year botanical resource assessment for four proposed Offstream Storage Reservoir alternatives: Sites, Colusa cell, Newville, and Red Bank. Colusa cell is defined for this study as the northern half of the Colusa Reservoir. Studies included a comprehensive literature background search, rare plant surveys and inventory of the inundation zones, and analysis of the vegetative communities in the proposed project areas. These studies were conducted in compliance with statutes and guidelines set forth in the California Environmental Quality Act, the California Endangered Species Act, and the Federal Endangered Species Act to determine the extent to which sensitive botanical resources would be affected by the proposed project.

1 METHODOLOGY

1.1. General Vegetation

The California Native Plant Society and the California Department of Fish and Game have classified natural plant communities in California for broad scale resource inventory and assessment. This classification system provides parameter definition for general vegetation types and of rare communities, as set forth in the CNPS Manual of California Vegetation (Sawyer and Keeler-Wolf 1995). The manuals classifications were used to define the natural communities which may be affected by the Offstream Storage Reservoirs. Plant communities were delineated on aerial photos (1:6,000; 1:12,000). The photos were field verified and digitized, with computer mapping software, to obtain acreage estimates of the existing vegetation communities. These data were used to prepare a plant community profile illustrating the percent cover of dominant vegetation types within each reservoir.

1.2. Sensitive Plants

The CNPS, CDFG, and U.S. Fish and Wildlife Service have all developed standard classification systems for sensitive plants. To simplify these standards for the purpose of this report, sensitive plant species are defined by DWR as high priority, priority, and low priority. High priority species are either State or federally threatened, endangered, proposed threatened, or candidate species (State). Priority species are either federal Species of Concern, or CNPS List 1A, 1B, 2, or 3 species. The CNPS categories include species that are either believed to be extinct, may become listed, or are rare throughout their California range. Low priority species are defined as plants of limited distribution: CNPS List 4 (CDFG 1997, 1998, 1999; Harlow 1998; Skinner and Pavlik 1994; White 1997; USFWS 1996, 1997).

High priority plant species either are, or will soon be designated “threatened” or “endangered” under the CESA of 1985, or “rare” or “endangered” under the National Plant Protection Act of 1977 (CDFG code 1904, 2074.2, 2075.5). High priority species may also be protected under Section 7(c) of the FESA of 1973 (50 CFR). Since 1985, “threatened” plants are protected pursuant to CESA; “endangered” plants may be protected by CESA and NPPA. However, consideration of plants listed as “rare” are directed primarily by NPPA (CDFG code 1900, 1913(c).) and by guidelines set forth in the CEQA (1970,Cal. Pub. Res. Code 21000(a), 21151(a).) (Skinner and Pavlik 1994). Protection under State and federal law requires that a full environmental impact assessment will identify means to avoid impacts to the greatest extent possible and, where a significant impact would occur, acceptable measures will be identified to minimize or mitigate the impacts to below the level of significance.

References and regional specialists were consulted to identify documented occurrences of prioritized species and rare communities within the project area and adjacent USGS 7.5 minute quadrangles (Abrams 1923,1944,1951; Abrams and Ferris 1960; Griggs 1997; Isle 1998, 1999; Hickman 1993; Horenstein 1998, 1999; Lis 1998, 1999; Munz and Keck 1973; USDA Forest Service 1994):

CDFG, California Natural Diversity Data Base, 1998, 1999
A Manual of California Vegetation
CDFG List of Endangered and Threatened Species, April 1999
CNPS Electronic Inventory, 1999
United States Fish and Wildlife Service list of federally endangered, threatened, proposed and candidate species, December 1998
CDFG Region I, Redding, California
CDFG, Region 2, Sacramento, California

1.2.1. High Priority Species Background

Ten high priority plant species were identified from the literature search as previously documented within 30 miles of the proposed reservoirs (Table I.2.1). The probability for finding these species in the project was predicted by using known habitat parameters and proximity of the nearest occurrence (Table 1.2.2.).

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Table 1.2.1. High Priority Plant Species with Potential to Occur in the Vicinity of the Offstream Storage Reservoir Projects, Tehama, Glenn, and Colusa Counties, California.

Species Common Name[1]	State Status[2]	USFWS listing [3]	CNPS status[4]	Distribution by County	Habitat Type (typical elevation)
Brodiaea coronaria ssp. *rosea* Indian Valley broadiaea	CE	SC	List 1B	COL GLE LAK TEH	chaparral, cismontane woodland, valley & foothill grassland/ serpentinite (0-100 m)
Chamaesyce hooveri Hoover's spurge	none	FT	List 1B	BUT GLE MER STA TEH TUL	vernal pools (25-250 m)
Cordylanthus palmatus palmate-bracted bird's-beak	CE	FE	List 1B	ALA COL FRE GLE MAD SJQ YOL	chenopod scrub, valley & foothill grassland/alkaline (5-155 m)
Gratiola heterosepala Bogg's Lake hedge-hyssop	CE	none	List 1B	FRE LAK LAS MAD MOD PLA SAC SHA SJQ SOL TEH OR	marshes, swamps (lake margins), vernal pools (0-1,200 m)
Lupinus milo-bakeri Milo Baker's lupine	CT	SC	List 1B	COL MEN	cismontane woodland, valley & foothill grassland (395-430 m)
Neostaphia Colusana Colusa grass	CE	FT	List 1B	COL GLE MER SOL STA YOL	vernal pools/adobe (5-200 m)
Orcuttia pilosa hairy Orcutt grass	CE	FE	List 1B	BUT GLE MAD MER STA TEH	vernal pools (55-200 m)
Orcuttia tenuis slender Orcutt grass	CE	FT	List 1B	LAK LAS PLU SAC SHA SIS TEH	vernal pools (200-1,100 m)
Silene campanulata ssp. *campanulata* Red Mtn. catchfly	CE	FC	List 1B	COL MEN	chaparral, lower montane coniferous forest/serpentinite rocky (425-1,230 m)
Tuctoria greenei Greene's tuctoria	CR	FE	List 1B	BUT FRE MAD MER SHA SJQ STA THE TUL	vernal pools (<200 m)

Notes:[1] Nomenclature corresponds to Skinner and Pavlik 1994;[2] CE State Listed as endangered; CR State Listed as rare (Section 1904, DFG code,1994);[3] SC federal Species of Concern; FC federal candidate; FE Listed as endangered by federal government; FP federally proposed threatened; FT Listed as threatened by federal government (USFWS, December 1998); [4] Listed 1B plants rare, threatened, or endangered in California and elsewhere (California Native Plant Society).

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The following information includes the most current literature and resource knowledge of known populations, ecological requirements, range and distribution, and potential or existing threats to high priority species.

Indian valley brodiaea (*Brodiaea coronaria* ssp. *rosea*) is listed as California Endangered and a Federal Species of Special Concern. This perennial herb in the Liliaceae family flowers from May to June. Its habitat includes closed-cone coniferous forest, chaparral, cismontane woodland, and valley and foothill grasslands with serpentinite soils at elevations ranging from 0 to 100 meters.

Range CNDDB information indicates that 14 occurrences of this species have been reported in Colusa, Glenn, Lake, and Tehama counties (one of which is possibly extirpated). These sites are on Bureau of Land Management, U.S. Forest Service, private, and unknown ownership properties. Potential habitat exists at all the reservoir sites and known populations occur within 6 miles of Sites, within about 8 miles of Colusa cell, within about 10 miles of Red Bank, and within 2 miles of Newville.

Threats Various threats to these populations have been identified, including inundation by reservoir construction, mining, off-road recreational vehicle activity, road or trail construction, horticultural collecting, vandalism, and dumping. Populations are protected in part at a BLM Area of Critical Environmental Concern in Lake County.

Hoover's spurge (*Chamaesyce hooveri*) is listed as Federally Threatened with no State status. This annual herb in the Euphorbiaceae family flowers in July and August. Its habitat is vernal pools at elevations ranging from 25 to 250 meters.

Range According to CNDDB records Hoover's spurge has been reported from 30 occurrences in Butte, Glenn, Stanislaus, Merced, Tehama, and Tulare counties. These plants are on CDFG, The Nature Conservancy, USFWS, private, and unknown ownership properties. Potential habitat exists at Sites and Colusa cell and known populations occur within 7 miles of these reservoirs.

Threats Threats include agriculture, altered hydrology, competition from non-native plants, erosion or runoff, trampling, and grazing. Populations are protected in part at the CDFG Stone Corral Ecological Reserve, USFWS Sacramento National Wildlife Refuge, and TNC Vina Plains Preserve.

Palmate-bracted bird's beak (*Cordylanthus palmatus*) is listed as California Endangered and Federally Endangered. This annual herb in the Scrophulariaceae family flowers from May through October. Its habitat is chenopod scrub and alkaline areas in valley and foothill grassland at elevations ranging from 5 to 155 meters.

Range CNDDB information indicates that 21 occurrences of this plant are known from Alameda, Colusa, Fresno, San Joaquin, and Yolo counties. This species is thought to be extirpated from Madera and Glenn counties. These populations occur on land owned by the City of Woodland, CDFG, City of Livermore, USFWS, and private entities. Known sites occur within 5 miles of Colusa cell and 7 miles of Sites reservoirs.

Threats Threats include agriculture, altered hydrology, competition from exotic plants, biocides, grazing, off road vehicle use, vandalism/dumping, and road and trail construction. Populations are protected at the CDFG Alkali Sink Ecological Reserve and Mendota Wildlife Area and at the Sacramento National Wildlife Refuge.

Bogg's Lake hedge-hyssop (*Gratiola heterosepala*) is listed as California Endangered with no Federal status. This annual herb in the Scrophulariaceae family flowers from

April to June. Its habitat includes shallow water in marshes, swamps (lake margins), and vernal pools at elevations ranging from 0 to 1,200 meters.

Range CNDDB information indicates that 77 occurrences of this species (one of which is possibly extirpated) have been reported in Fresno, Lake, Lassen, Madera, Modoc, Placer, Sacramento, San Joaquin, Shasta, Solano, and Tehama counties. These sites are on land owned by the BLM, CDFG, TNC, Sacramento County, Solano County Farmlands and Open Space, The Trust for Wildland Communities, US Forest Service, private, and unknown entities. Potential habitat exists at all the reservoir sites. However, the closest known location is 12 miles northeast of the Newville Reservoir alternative.

Threats Threats include agriculture, altered flood regime, development, herbicide use, feral pigs, grazing, foot traffic, recreational use, road and trail construction, and landfill construction. Populations are protected in private preserves, BLM Research Areas, a USFWS Botanical Special Interest Area, and CDFG Ecological Reserves.

Milo Baker's lupine (*Lupinus milo-bakeri*) is listed as California Threatened and Federal Species of Special Concern. This annual herb in the Fabaceae family flowers from June through September. Its habitat includes cismontane woodland (often along roads) and foothill and valley grasslands at elevations from 395 to 430 meters.

Range According to CNDDB records Milo Baker's lupine has been reported from 17 occurrences in Colusa and Mendocino counties. Four Mendocino County sites may have been extirpated. These sites are on land under Bureau of Indian Affairs, CALTRANS, and private ownership.

Threats This species is threatened by biocides, grazing, and road and trail construction.

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Colusa grass (*Neostapfia Colusana*) is listed as California Endangered and Federally Threatened. This annual grass flowers from May to August. Its habitat is vernal pools, alkali playas, or adobe soils at elevations ranging from 5 to 200 meters.

Range According to CNDDB records, this species is reported from 56 occurrences in Merced, Solano, Stanislaus, and Yolo counties. It has been extirpated from Colusa County and from some sites in Stanislaus, Merced, and Glenn counties. Colusa grass occurs on land owned by TNC, Solano County Farmlands and Open Space, Stanislaus County, the US Department of Defense, and private and unknown entities. Potential habitat occurs at Sites and Colusa cell reservoirs and known populations occur approximately 10 miles to the east.

Threats Various threats to these populations include agricultural practices and grazing, altered flood regime and surface water diversion, biocides, competition from exotics, inundation, foot traffic, off-road vehicle activity, and road construction. Some populations are protected by TNC and Solano County Farmlands and Open Space.

Hairy Orcutt grass (*Orcuttia pilosa*) is listed as California Endangered and Federally Endangered. This annual grass flowers from May to September. Its habitat is vernal pools ranging in elevation from 55 to 200 meters.

Range CNDDB information indicates that 39 occurrences of this species have been reported in Butte, Glenn, Madera, Merced, Stanislaus, and Tehama counties (11 of these occurrences have been extirpated). These populations occur on land owned by the USBR, CALTRANS, TNC, USFWS, and private parties. Potential habitat exists at Sites and Colusa cell reservoirs and known populations occur within 9 miles.

Threats Threats include agriculture, competition from exotic plants, development, grazing, off-road vehicle use, and road and trail construction. Some populations are protected at Vina Plains Nature Conservancy Preserve and at the Sacramento National Wildlife Refuge.

Slender Orcutt grass (*Orcuttia tenuis*) is listed as California Endangered and Federally Threatened. This annual grass flowers from May to July. Its habitat is vernal pools ranging in elevation from 200 to 1,100 meters.

Range CNDDB information indicates that 76 occurrences of this species have been found in Lake, Lassen, Plumas, Sacramento, Shasta, Siskiyou, and Tehama counties. Four of the sites in Shasta County have been extirpated. These plants occur on land under BLM, City of Redding, CDFG, USFS, TNC, Trust for Wildland Communities, and private and unknown ownership. Potential habitat occurs at all the reservoirs, but no known populations occur within 20 miles.

Threats Threats include altered hydrology and surface water, competition from exotics, development, trampling, grazing, landfills, logging, off-road vehicle activity, vandalism, and dumping. Populations are protected in part at TNC Vina Plains Preserve, CDFG's Dales Lake Ecological Reserve, BLM Alturas RA, and Redding RA.

Red Mountain catchfly (*Silene campanulata* ssp. *campanulata*) is listed as California Endangered and a federal candidate. This perennial herb in the Caryophyllaceae family flowers from May to June. Its habitat includes chaparral and lower montane coniferous forest with serpentinite or rocky soils at elevations ranging from 425 to 1,230 meters.

Range CNDDB information indicates that seven occurrences of this plant have been found in Colusa and Mendocino counties. These populations occur on land under BLM and private ownership. A known population of this species grows within 5 miles of Sites reservoir. However, the proposed reservoir maximum pool is well below the observed elevation range of the species.

Threats Threats include erosion or runoff and mining. One population may have been extirpated by logging activities.

Greene's tuctoria (*Tuctoria greenei*) is listed as California Rare and Federally Endangered. This annual grass flowers from May to July. Its habitat is vernal pools at elevations less than 200 meters.

Range CNDDB information indicates that 38 occurrences of this species have been found. Nineteen of those populations occur in Butte, Merced, Shasta, and Tehama counties. Other occurrences are thought to be extirpated from Fresno, Madera, Stanislaus, Tulare, and San Joaquin counties. These plants occur on private land, TNC, and unknown ownership properties. Potential habitat occurs at all of the north of the Delta offstream storage reservoir alternatives. However, the nearest known population is more than 20 miles from any of the reservoir sites.

Threats Threats include agriculture, altered hydrology and surface water diversions, and competition from exotic plants, grazing, and exotics. Populations are protected in part at TNC Vina Plains Preserve.

Table 1.2.2. Probability Estimates for Occurrence of High Priority Plant Species in the Four Offstream Storage Reservoirs (Probabilities are based on existing habitat and known occurrences).

Species Common Name[1]	**Probability for occurrence** [2]			
	Sites	**Colusa cell**	**Newville**	**Red Bank**
Brodiaea coronaria ssp. *rosea* Indian Valley broadiaea	low	low	low	low
Chamaesyce hooveri Hoover's spurge	low	low	low	none
Cordylanthus palmatus palmate-bracted bird's-beak	low	low	low	none
Gratiola heterosepala Bogg's Lake hedge-hyssop	med	med	med	med
Lupinus milo-bakeri Milo Baker's lupine	low	low	low	low
Neostaphia Colusalna Colusa grass	low	low	low	none
Orcuttia pilosa hairy Orcutt grass	low	low	low	none
Orcuttia tenuis slender Orcutt grass	low	low	low	none
Silene campanulata ssp. *campanulata* Red Mtn. catchfly	none	none	low	low
Tuctoria greenei Greene's tuctoria	low	low	low	none

Notes: [1] Nomenclature corresponds to Skinner and Pavlik 1994. [2] Probability based on closest known occurrence records and potential habitat within the reservoirs in 1998-99.

1.2.2. Priority and Low Priority Species

The literature and regional references identified 42 priority and 30 low priority species within 30 miles of the proposed reservoirs (Table 1.2.3; Table 1.2.4).

Table 1.2.3. Priority Plant Species with Potential to Occur in the Vicinity of the Offstream Storage Reservoir Projects, Tehama, Glenn and Colusa Counties, California.

Species Common Name[1]	State Status	USFWS listing[2]	CNPS status[3]	Distribution by County	Habitat type
Antirrhinum subcordatum dimorphic snapdragon	none	none	List 1B	COL GLE LAK THE	chaparral/sometimes serpentinite (85-800m)
Astragalus rattanii var. *jepsonianus* Jepson's milk-vetch	none	none	List 1B	COL GLE LAK NAP TEH YOL	woodland, grassland/often serpentiinte (320-700m)
Astragalus tener var. *ferrisiae* Ferris's milk-vetch	none	SC	List 1B	BUT COL GLE SOL SUT YOL	meadows, grassland, subalkaline flats (5-75m)
Atriplex cordulata heartscale	none	SC	List 1B	ALA BUT CCA FRE GLE KNG KRN MAD MER SJQ SOL STA TUL YOL	meadows, grassland, saline/alkaline (1-275m)
Atriplex depressa brittlescale	none	none	List 1B	ALA BUT CCA COL FRE GLE KRN MAD MER SOL STA TUL YOL	Chenopod scrub, meadows, playas, grassland, vernal pools/alkaline, clay (1-320m)
Atriplex joaquiniana San Joaquin spearscale	none	SC	List 1B	ALA CCA COL GLE MER NAP SAC SBT SCL SJQ SOL TUL YOL	Chenopod scrub, meadows, playas, grassland, vernal pools/alkaline (1-320m)
Atriplex persistens vernal pool saltbush	none	none	List 1B	GLE MER STA TUL	vernal pools/alkaline (10-115m)
Balsamorhiza macrolepis ssp *macrolepis* big-scale balsamroot	none	none	List 1B	ALA BUT MPA NAP PLA SCL TEH	woodland, grassland/sometimes serpentinite (< 1,400m)
Chlorogalum pomeridianum var. *minus* dwarf soaproot	none	none	List 1B	COL LAK SLO SON THE	chaparral/serpentinite (305-750m)
Cryptantha crinita silky cryptantha	none	SC	List 1B	SHA THE	woodland, riparian, grasslands/gravelly streambeds (150-300m)

(continued)

Species *(Table* 1.2.3. *page 2 of 4)* Common Name[1]	State Status	USFWS listing[2]	CNPS status[3]	Distribution by County	Habitat type
Delphinium recurvatum recurved larkspur	none	SC	List 1B	ALA CCA COL FRE KNG KRN MER SLO SOL TUL	chenopod scrub, woodland, grassland, vernal pools/alkaline (3-750m)
Downingia pusilla dwarf downingia	none	none	List 1B	MER MPA NAP PLA SAC SOL SON STA TEH SA	mesic grassland, vernal pools (± 150m)
Eleocharis quadrangulata four-angled spikerush	none	none	List 2	BUT MER THE	freshwater marsh (<500m)
Eriastrum brandegeae Brandegee's eriastrum	none	SC	List 1B	COL GLE LAK SCL TEH TRI	chaparral, woodland/volcanic (315-1,030m)
Eriogonum luteolum var. *caninum* Tiburon buckwheat	none	none	List 3	ALA CCA COL LAK MRN NAP SCL SMT	chaparral, grassland, serpentinite (< 500m)
Eriogonum nervulosum Snow Mtn. Buckwheat	none	SC	List 1B	COL GLE LAK NAP SON YOL	chaparral, serpentinite (300-2,105m)
Eschscholzia rhombipetala diamond-petaled California poppy	none	SC	List 1A	ALA CCA COL SLO STA	grassland/alkaline (0-975m)
Fritillaria pluriflora adobe lily	none	SC	List 1B	BUT COL GLE LAK NAP PLU SOL TEH YOL	chaparral, woodland, grassland/often adobe (60-705m)
Hesperevax acaulis var. *acaulis* *dwarf evax*	none	none	List 1B	AMA BUT COL ELD FRE MAD MNT SAC SCL SLO STA TEH TUL	woodland, grassland, vernal pools (30-1,000m)
Hesperolinon drymarioides drymaria-like western flax	none	SC	List 1B	COL GLE LAK NAP YOL	chaparral, woodland, grassland/often serpentinite (100-1,130m)
Hesperolinon tehamense Tehama Co. western flax	none	SC	List 1B	GLE THE	chaparral, woodland/often serpentinite (100-1,000m)

(continued)

Species (*Table* 1.2.3. *page 3 of 4*) Common Name[1]	State Status	USFWS listing[2]	CNPS status[3]	Distribution by County	Habitat type
Hibiscus lasiocarpus California hibiscus	none	none	List 2	COL GLE THE	freshwater marsh ((0-120m)
Juglans californica var *hindsii* Northern California black walnut	none	SC	List 1B	CCA NAP SAC SOL YOL	riparian forest and woodland (50-200 m)
Juncus leiospermus var. *leiospermus* Red Bluff dwarf rush	none	none	List 1B	BUT SHA THE	chaparral, woodland, grassland, vernal pools (35-1,020m)
Layia septentrionalis Colusayia	none	none	List 1B	COL GLE LAK MEN NPA SON SUT TEH YOL	chaparral, woodland grassland/sandy, serpentinite (100-1,095m)
Legenere limosa Legenere	none	SC	List 1B	LAK NAP PLA SAC SMT SOL SON STA TEH	vernal pools (<150)
Lepidium latipes var. *heckardii* Heckard's pepper-grass	none	none	List 1B	GLE SOL YOL	grassland/alkaline falts (10-200m)
Limnanthes floccosa ssp. *floccosa* woolly meadowfoam	none	none	List 2	BUT LAK SHA SIS THE TRI OR	vernally mesic woodland, grassland (<400m)
Lotus rubriflorus Red-flowered lotus	none	SC	List 1B	COL STA THE	woodland, grassland (+/-200m)
Lupinus sericatus Cobb Mtn. Lupine	none	none	List 1B	COL LAK NAP SON	chaparral, woodland (500-1,500m)
Madia hallii Hall's madia	none	SC	List 1B	COL LAK NAP YOL	chaparral/serpentinite (50-670m)
Madia stebbinsii Stebbin's madia	none	none	List 1B	SHA TEH TRI	chaparral,/serpentinite (400-1,580m)

(continued)

Species (*Table* 1.2.3. *page 4 of 4*) Common Name[1]	State Status	USFWS listing[2]	CNPS status[3]	Distribution by County	Habitat type
Microseris sylvatica woodland microseris	none	none	List 3	BUT GLE LAX SBT	chaparral, woodland, grassland (60-1,500m)
Myosurus minimus ssp. *apus* little mousetail	none	SC	List 3	BUT COL KRN SOL STA OR	vernal pools/alkaline (>1,500m)
Myosurus sessilis sessile mousetail	none	none	List 3	CCA COL FRE GLE MER SBT DJQ SOL STA YOL OR	grassland, vernal pools (<150m)
Navarretia leucocephala ssp. *bakeri* Baker's navarretia	none	none	List 1B	COL LAK MEN MRN NAP SOL SON TEH	woodland, meadows (mesic), grassland, vernal pools (<1,700m)
Paronychia ahartii Ahart's paronychia	none	SC	List 1B	BUT SHA THE	woodland, grassland, vernal pools (<500m)
Sagittaria sanfordii Sandford's arrowhead	none	SC	List 1B	BUT DNT FRE KRN MER MRN ORA SAC SHA SJQ TEH VEN	marsh & swamp (assorted shallow freshwater) (<300m)
Sanicula tracyi Tracy's sanicle	none	SC	List 1B	BUT DNT HUM TEH TRI	woodland (100-1,000m)
Trichocoronis wrightii var. *wrightii* Wright's trichocoronis	none	none	List 2	COL MER RIV SJQ SUT TX	meadows, freshwater marsh, riparian, vernal pools/alkaline
Tropidocarpum capparideum caper-fruited tropidocarpum	none	SC	List 1A	ALA CCA GLE MNT SCL SJQ	grassland/alkaline hills (1-455m)
Viburnum ellipticum Western viburnum	none	none	List 3	CCA FRE ELD GLE HUM MEN NAP SHA SON	chaparral, woodland (300-1,400m)

Notes: 1. Nomenclature corresponds to Skinner and Pavlik 1994. 2. SC-federal Species of Concern 3. California Native Plant Society; List 1A-plants presumed to be extinct in California List 1B-plants rare, Threatened, or endangered in California and elsewhere; List 2-plants rare, threatened, or endangered in California but more common elsewhere; List 3-plants about which more information is needed.

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Table 1.2.4. Low Priority Plant Species with Potential to Occur in the Vicinity of the Offstream Storage Reservoir Project, Tehama, Glenn and Colusa Counties, California (all are CNPS "Limited distribution" List 4).

Scientific Name	**Common Name**
Allium fimbriatum var. *purdyi*	Purdy's onion
Allium sanbornii var. *sanbornii*	Sanborn's onion
Androsace elongata ssp. *acuta*	rock jasmine
Antirrhinum cornutum	spurred snapdragon
Asclepias solanoana	serpentine milkweed
Astragalus breweri	Brewer's milk-vetch
Astragalus clevelandii	Cleveland's milk-vetch
Astragalus pauperculus	depauperate milk-vetch
Astragalus rattanii var. *rattanii*	Rattan's milk-vetch
Ceanothus jepsonii var. *albiflorus*	musk brush
Chamaesyce ocellata ssp. *rattanii*	Stony Creek spurge
Collinsia sparsiflora var. *arvensis*	few-flowered collinsia
Collomia diversifolia	serpentine collomia
Cryptantha excavata	deep-scarred cryptantha
Eriogonum luteolum var. *caninum*	Tiberon buckwheat
Eriogonum tripodum	tripod eriogonum
Erodium macrophyllum	large-leaved filaree
Helianthus exilis	serpentine sunflower
Hesperevax caulescens	hogwallow evax
Juncus articulatus	jointed rush
Linanthus latisectus	linanthus
Lomatium ciliolatum var. *hooveri*	ciliate biscuitroot
Mimulus glaucescens	shield-bracted monkeyflower
Navarretia eriocephala	hoary navarrettia
Navarretia heterandra	Tehama navarretia
Navarretia jepsonii	Jepson's navarretia
Navarretia subuligera	awl-leaved navarretia
Orobanche valida ssp. *howellii*	Howell's broom-rape
Polygonum bidwelliae	Bidwell's knotweed
Streptanthus drepanoides	sickle-fruited jewel-flower

Nomenclature corresponds to Skinner and Pavlik 1994.

Field personnel examined preserved specimens of prioritized species at the California Academy of Sciences, University of California Berkeley, U.C. Davis, and California State University Chico herbaria. The Jepson Manual (Hickman 1993) and A California Flora and Supplement (Munz and Keck 1973) were checked for species habitat descriptions and flowering periods. Regional botanists were consulted about local occurrences of sensitive species. For species with known soil associations, United States Department of Agriculture Natural Resource Conservation Service data were used to generate maps of Lodo shale and clay soils to assist in narrowing the focus of the surveys (Table 1.2.5.; Attachment I.a-d.) (Harradine 1948; USDA 1965).

Table 1.2.5. Acreage estimates of Lodo shale and clay soil which are associated with several prioritized plant species in the Offstream Storage Reservoirs.

Soils	Number Of Acres Of Mapped Soil Units			
	Sites	Colusa Cell	Newville	Red Bank
Lodo Shales	0	0	7,182	3,101
Clay	8,916	4,950	2,074	305

1.3. Field Survey Methods

Within the reservoir inundation elevations, field surveys were conducted for prioritized species according to established guidelines and protocols (CDFG 1984; USFWS 1996; Nelson 1985, 1987). Under these guidelines, focused habitat-specific surveys were conducted, using wandering transect methodology, between February and October 1998 and 1999. These months coincided with the appropriate phenological stages (flowering and fruiting) necessary for the identification of most plant species occurring in the area, including all prioritized species (Table 1.2.1 through 1.2.4). Transects were spaced 5 to 10 meters apart except in microhabitats, such as riparian areas, where they were 1 meter apart. Dense valley stands of star thistle (*Centaurea solstitialis*), ridge tops, vertical shale slopes, and impenetrable chaparral and woodland stands were perimeter surveyed only due to the lack of potential habitat. Where access and topography allowed, potential habitat was surveyed completely. Relatively minor areas at each reservoir could not be surveyed due to lack of authorized private property access.

Field survey coverage areas were estimated for each reservoir based on the level of coverage accomplished. Survey coverage was divided into three effort classes: 0 percent, less than 50 percent, and 50-100 percent coverage. Land that was not surveyed (0 percent) included: areas that do not support suitable habitat for the prioritized species, unauthorized access properties, private residences and yards, cemeteries, bedrock stream channels, vertical slopes, ridge tops above reservoir elevation, 100 percent vegetated chaparral or scrub areas, and large solid stands of yellow star thistle (*Centaurea solstitialis*). Areas which were surveyed less than 50 percent included two types of effort. These areas were surveyed during less than half of the phenological time period for the prioritized species, or half of the area was actually surveyed. These areas consisted of marginal habitat, land lacking sensitive species habitat, or land in a degraded condition which would not warrant further surveys. In areas which were surveyed greater than 50 percent and up to 100 percent, both phenological and transect surveys were done.

Areas with high quality potential habitat were prioritized and surveyed throughout the phenological time period with more complete transect coverage. Habitat parameters, including mapped soils, aspect, and plant associates, defined the number of return visits and the level of coverage. One hundred percent coverage was accomplished only in potential habitat known to support the prioritized plant species.

Plant species were identified and recorded in the field whenever possible, or preserved in a voucher collection for identification at a later date. The voucher collection consists of plant specimens which were collected and preserved as proof for species on the plant inventory lists. A plant voucher database was prepared for collections. Previously undocumented populations of prioritized species were recorded in a DWR botanical inventory database. Data were collected about each sensitive plant population including habitat parameters, approximate number of individuals, phenological state, full location description, plant community associates, existing site conditions, and present or possible threats to the population. Population definitions in this report follow the CNDDB occurrence reporting standard of at least one-quarter of a mile separation between stands or colonies of a prioritized species. Surveys, inventories, and plant identification were conducted by DWR staff botanists (Attachment 2). Field survey activities were documented throughout the two year study, including dates, location, authorized property access, and assigned personnel (Attachment 3).

Annual precipitation totals, which significantly influence annual plant species germination, were noted for the 1998 and 1999 water years (Table I.2.6.).

Table 1.2.6. Total Precipitation and Percent of Average for Water Year 1998 and 1999 in Red Bluff, Orland, and East Park Reservoir, California.

	WATER YEAR[1] Total Precipitation (inches) / Percent of Annual Average	
STATION	**October 1997-September 1998**	**October 1998-May 1999**
Red Bluff (Red Bank)	21.51 / 213	17.02 / 83
Orland (Newville)	20.36 / 232	15.93 / 82
East Park Reservoir (Sites/Colusa cell)	18.98 / 232	16.46 / 90

Notes:1 California Department of Water Resources, Division of Flood Management, 1999.

2. RESULTS

2.1. General Vegetation: Summary of Findings

The following natural communities and vegetation types occur within the reservoir sites. These classifications or series are based on the dominant vegetation of a given area. These series are recognized in the literature as occurring in portions of the inner North Coast Range and Central Valley of California including Glenn, Colusa, and Tehama counties (Keeler-Wolf 1995).

Grassland *California annual (includes vernal pools and swales)*

This upland plant community of herbaceous annual grasses and herbs is characteristically composed of many non-native and native species. Species composition is highly variable among stands and throughout the growing season. Vernal pools and swales, within the annual grassland, support unique assemblages of native annuals. Annual grassland occurs at all the reservoir alternatives. Red Bank reservoir is the only site that did not have vernal pools.

nodding needlegrass (*Nassella cernua*)

This upland series is dominated by herbaceous plants with nodding needlegrass the sole or dominant grass in the ground layer. Other native and non-native perennial grasses and emergent shrubs and trees are present but the grass layer is less than 1 meter tall. Numerous small stands (less than 5 square meters) were observed on clay soil in blue oak woodland in all reservoirs although these were not large enough to be mapped from the aerial photographs.

purple needlegrass (*Nassella pulchra)*

Purple needlegrass, a perennial bunchgrass, is the sole or dominant grass in this upland series which may include other native or non-native perennial and annual grasses less than 1 meter tall. It was observed in all of the reservoir sites on clay soils, generally in openings in blue oak woodland, in small unmapped units.

Chaparral

chamise (*Adenostoma fasciculatum*)

Chamise is the sole or dominant shrub (greater than 60 percent) in continuous upland canopy in this series. Emergent trees may be present but native shrubs such as poison oak and manzanita form a mosaic with the chamise and the ground layer is sparse. Chamise chaparral was found on the western edges of the Red Bank and Newville sites.

wedgeleaf ceanothus (*Ceanothus cuneatus*)

Wedgeleaf ceanothus is the dominant canopy in this upland woody series. Other native shrub species form a mosaic with *Ceanothus* which can form a continuous or intermittent canopy with a very sparsely vegetated ground layer. This series occurs sporadically in the Red Bank, Newville, and Sites reservoirs.

Riparian

Riparian vegetation is associated with intermittently or seasonally flooded or saturated intermittent drainages, stream corridors or floodplain terraces. Dominant stands of Fremont's cottonwood (*Populus fremontii*), mixed willow (*Salix spp.*), and narrowleaf willow (*Salix exigua*) series were observed in the reservoir sites. Mexican elderberry (*Sambucus mexicanus*) series occurs in stands which were not large enough to be mapped as distinct vegetation units.

Woodland

Valley oak (*Quercus lobata*)

Valley oak woodland is the sole or dominant tree in a continuous, intermittent, or open canopy which may include other native tree and shrub species. Associated with intermittently flooded or seasonally saturated wetlands and uplands, openings are characteristically grassy. This series occurs along the major tributaries in the reservoir sites.

Blue oak (*Quercus douglasii*)

Blue oak is the sole or dominant tree in this woody upland series. Canopy density may be variable and the understory may include shrubs and a grassy ground layer. This series occurs in the reservoir sites in the valleys, on slopes, and in moderately rocky to well-drained areas.

Mixed oak (*Quercus* spp.)

Several species of oak may be present in this upland woody series, including blue oak (*Q. douglasii)*, interior live oak *(Q. wislizenii)*, and/or valley oak (*Q. lobata)*. Other native tree species including foothill pine (*Pinus sabiniana*) may be present in addition to native shrubs and a grassy ground layer. This series occurs in the Red Bank and Newville reservoir sites.

Foothill Pine (*Pinus sabiniana*)

Foothill pine is the sole or dominant canopy species, or may be an emergent tree over a continuous to intermittent shrub canopy.Other native tree and shrub species may also form a mosaic with a grassy to sparse ground layer. This series may occur in intermittent freshwater wetlands and rocky to well-drained uplands. This is the dominant vegetation community at the Red Bank site. Foothill pine community does not occur in the Sites, Colusa cell, or Newville reservoir areas.

Ruderal

This category refers to weedy or disturbed conditions including areas surrounding residences, out-buildings, and stockyards. These areas may also include non-native, ornamental varieties of plants.

Cultivated grains/crop

Orchards, grain crops, and vineyards were observed in all the reservoirs. These include cultivar varieties of non-native plants.

Wetlands — Spikerush (*Eleocharis* sp.), and vernal pools are discussed here as mapped vegetated wetland series. Spikerush wetland was observed in the Sites, Colusa cell, and Newville sites. Vernal pools occur in all the reservoirs except Red Bank. Other wetlands and water, which occur in the reservoirs, but are not discussed here, include intermittent drainages, streams, and ponds.

Acreage estimates of mapped vegetation types were calculated in each reservoir (Table 2.1.; Figure 2.2).

Table 2.1. Acreage Estimates for the Dominant Vegetation Communities Mapped Within the Offstream Storage Reservoir Alternatives, 1999.

Vegetation[1]	**Acreage By Reservoir**				
	Sites	**Colusa Cell**	**Colusa Reservoir**[2]	**Thomes/ Newville**	**Red Bank**
Grassland	12,602	13,540	26,142	14,492	565
Woodland (oak)	923	20	943	1,839	899
Woodland (foothill pine)	0	0	0	0	2826
Chaparral	5	0	5	363	98
Riparian	52	37	89	64	73
Vegetated wetland	23	15	38	0	1
Cultivated grain	277	0	277	0	0
Vegetation Subtotal	13,882	13,612	27,494	16,758	4,462
Other	280	51	331	315	142
Total reservoir acreage	14,162	13,663	27,825	17,073	4,604

January 4, 2000

Notes: [1] Other classification refers to disturbed/developed acreage within the inundation elevations.
[2].Colusa Reservoir is a northward extention of the Sites reservoir which expands to include the Colusa cell acreage.

2.2. Sensitive Plants: Summary of Findings

There were no high priority plant species found in the Offstream Storage Reservoir alternatives during 1998-1999 field surveys. Six priority and 8 low priority species were found within the project inundation areas, with a collective total of 143 populations (Table 2.2.1).

2.2.1. Sites and Colusa Cell Reservoirs There were no high priority or priority species found in the Sites or Colusa cell alternatives. Ten total occurrences of four low priority plant species were identified at Sites reservoir compared with six total occurrences of the same four species in Colusa cell (Table 2.2.1.). Thirty percent of the species identified from Sites are non-native, compared to 27 percent in Colusa cell (Table 2.2.2). Although only approximately one-third of all the species identified for these sites are non-native, qualitatively these non-natives make up the dominant vegetative cover in the annual grassland.

2.2.2. Newville Reservoir Thirty-one total occurrences of 4 low priority species and 23 total occurrences of 5 priority species were identified in the Newville reservoir (Table 2.2.1.). North and south-facing shale slopes and heavy clay deposits are associated with several prioritized species in this reservoir. In comparison with Sites and the Colusa cell reservoir sites, only 24 percent of the Newville species are non-native, however; they constitute the dominant cover at this site also. Newville has the greatest vascular plant diversity and the greatest number of plant families (85), genera (259), and species (522) represented (Table 2.2.2.).

Red Bank Reservoir Ten prioritized plant species and 73 total populations were found in this location; 39 priority species populations and 34 populations of low priority species (Table 2.2.1.). Although 21 percent of all species identified in Red Bank are non-native, at this site non-natives are not the dominant vegetation relative to cover. Native woodland species constitute the dominant vegetative cover (78 percent) at this site (Table 2.1.).

Table 2.2.1. Summary of Prioritized Plant Species found in the Offstream Storage Reservoir project, 1998-1999.

Reservoir	Common Name (scientific name)[1]	Number of Occurrences[2]	Status[3] State/USFWS/ CNPS
RED BANK	fairy candelabra (*Androsace elongata* ssp.acuta)	1	– / – / List 4
	dimorphic snapdragon (*Antirrhinum subcordatum)*	23*	– / -- / 1B
	Jepson's milkvetch (*Astragalus rattanii* var. *jepsonianus*)	*8**	– / -- / 1B
	Stony Creek spurge (*Chamaesyce ocellata* ssp *rattanii)*	9	– / -- / List 4
	Brandegee's eriastrum (*Eriastrum brandegeae)*	3*	– / SC / 1B
	adobe lily (*Fritillaria pluriflora)*	5*	– / SC / 1B
	woolly meadowfoam *(Limnanthes floccosa* ssp. *floccosa*)	1	– / --/ List 4
	Jepson's navarretia (*Navarretia jepsonii)*	8	– / – / List 4
	Tehama navarretia (*Navarretia heterandra)*	11	– / -- / List 4
	sickle-fruit jewel-flower *(Streptanthus drepanoides*)	4	--/ – / List 4
THOMES-NEWVILLE	fairy candelabra (*Androsace elongata* ssp. acuta)	13	– / – / List 4
	dimorphic snapdragon *(Antirrhinum subcordatum*)	7*	– / -- / 1B
	Jepson's milk-vetch *(Astragalus rattanii* var. *jepsonianus)*	1*	– / -- / 1B
	Stony Creek spurge (*Chamaesyce ocellata* ssp *rattanii)*	7	– / -- / List 4
	adobe lily (*Fritillaria pluriflora)*	12*	– / SC / 1B
	hogwallow evax (*Hesperevax caulescens*)	4	– / -- / List 4
	Tehama dwarf flax (*Hesperolinon tehamense)*	2*	– / SC / 1B
	N.California black walnut (Juglans californica var. hindsii)	1*	– / SC / 1B
	Tehama navarretia (Navarretia heterandra)	7	– / -- / List 4
SITES	fairy candelabra (*Androsace elongata* ssp. acuta)	3	– / – / List 4
	hogwallow evax (*Hesperevax caulescens*)	3	– / -- / List 4
	hoary navarretia (*Navarretia eriocephala*)	1	– / -- / List 4
	Tehama navarretia (*Navarretia heterandra)*	3	– / -- / List 4
COLUSA CELL	fairy candelabra (*Androsace elongata* ssp. acuta)	2	– / – / List 4
	hogwallow evax (*Hesperevax caulescens*)	2	– / -- / List 4
	hoary navarretia (*Navarretia eriocephala*)	1	– / -- / List 4
	Tehama navarretia (*Navarretia heterandra)*	1	– / -- / List 4

Notes: [1] Nomenclature corresponds to Skinner and Pavlik 1994. [2] Occurrences are defined under CNPS 1999 guidelines as population findings separated by at least 0.25 miles;* = DWR Priority species. [3] USFWS 1998:SC (Species of Concern); Skinner and Pavlik 1994; CNPS IB; (Plants rare, threatened, or endangered in California and elsewhere); CNPS List 4 (Plants of limited distribution).

Table 2.2.2. Diversity of Vascular Plant Families, Genera, and Species by Reservoir, and Native and Non-native Species.

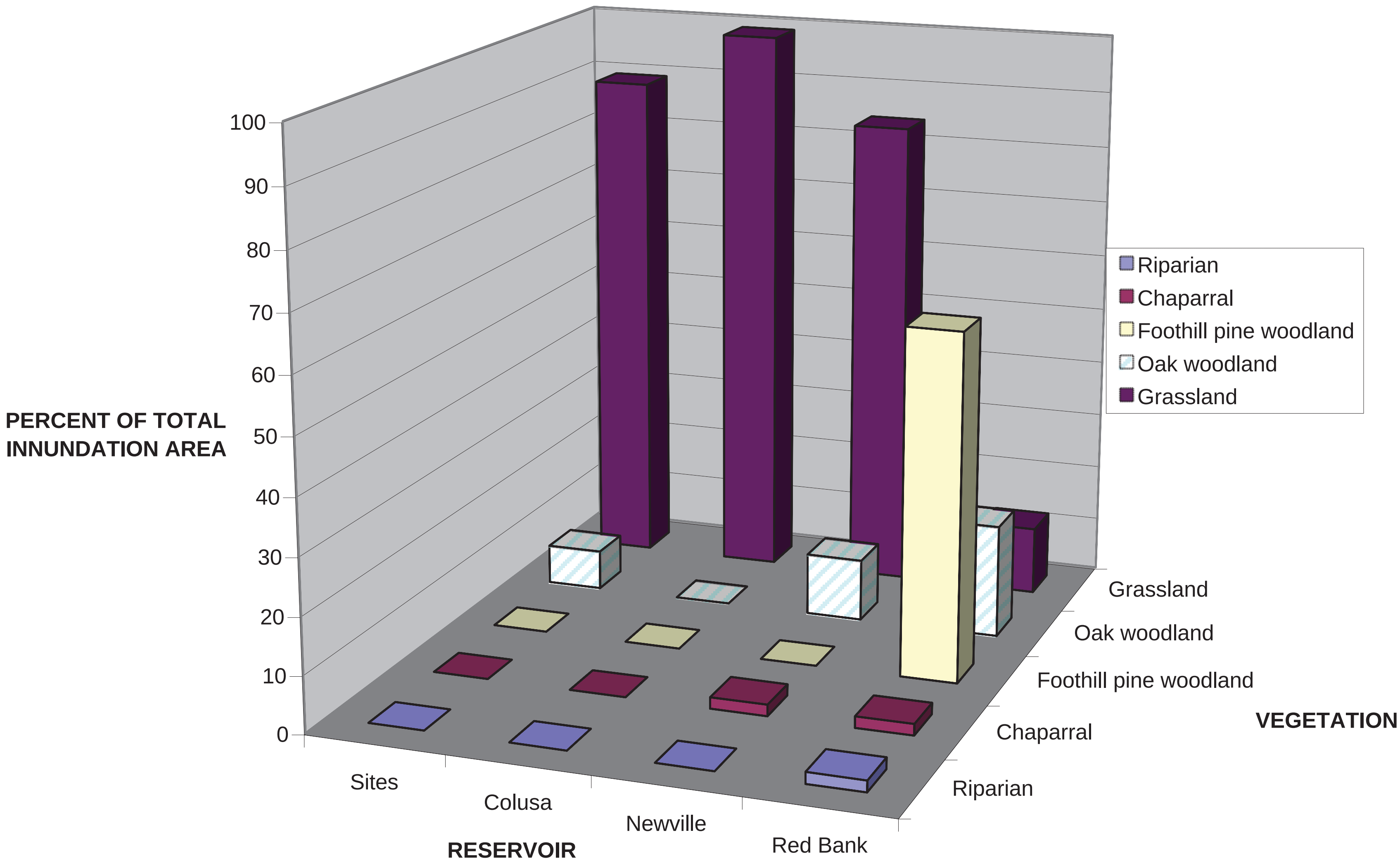
VASCULAR PLANT DIVERSITY	Sites	Colusa Cell	Thomes/ Newville	Red Bank
Number of families	62	58	85	76
Number of genera	219	193	259	229
Number of species	363	287	522	456
Native species	254	210	398	358
Nonnative species	109	77	124	98

2.2.4. Documentation Maps were prepared of the estimated survey coverage area and the level of survey effort (Figure 2.2.a-d). An inventory of identified vascular plants, including prioritized species, was compiled (Attachment 5). In addition, a plant voucher collection list was compiled for plants which were identified from preserved specimens (Attachment 6). Vouchers were placed in a preserved DWR collection. One hundred and fourty-three prioritized species population records were documented in the project areas (Attachment 7). Color photographs were taken of prioritized species, their habitat, and plant communities in the reservoir sites (Attachment 8).

2.3. DISCUSSION

Percent cover calculations from the aerial photographs and the plant community profile show that annual grassland is the dominant plant community in the Sites, Colusa cell, and Newville reservoir areas (Figure 2.1; attachment 4.a-e). Grassland vegetation at these sites is 89, 99, and 84 percent of the total cover, respectively. Microhabitats within these annual grasslands support unique native annual plant species; these are northern clay hardpan vernal pools, swales, and seasonal wetlands. While the annual grasslands are highly variable with respect to species composition, the dominant species are European forage grasses,

Figure II.1 OFFSTREAM STORAGE RESERVOIR INVESTIGATION:
Percent Dominant Vegetation by Reservoir Site



OFFSTREAM STORAGE RESERVOIR INVESTIGATION

SITES RESERVOIR

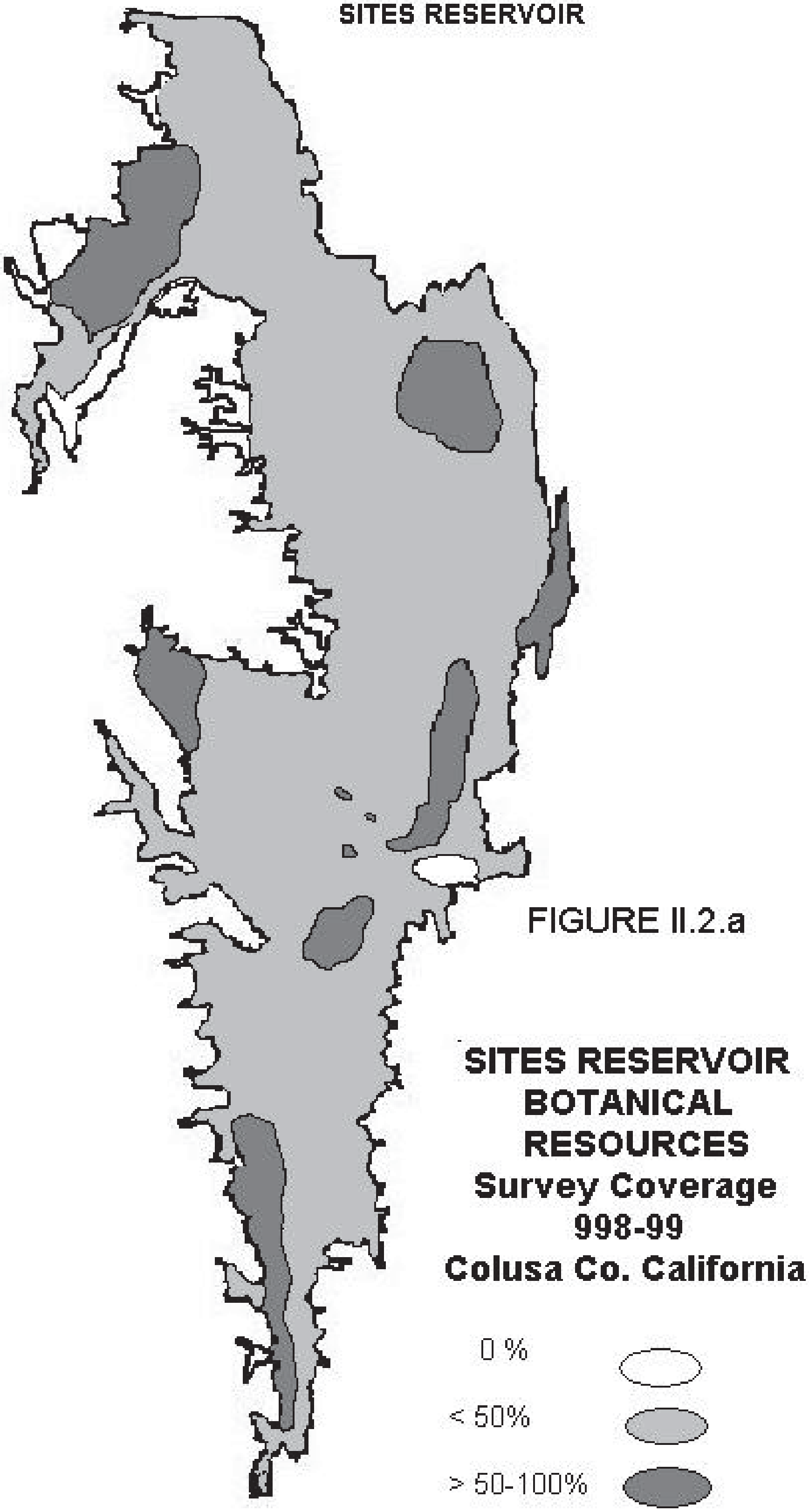


FIGURE II.2.a

OFFSTREAM STORAGE RESERVOIR INVESTIGATION
COLUSA CELL RESERVOIR

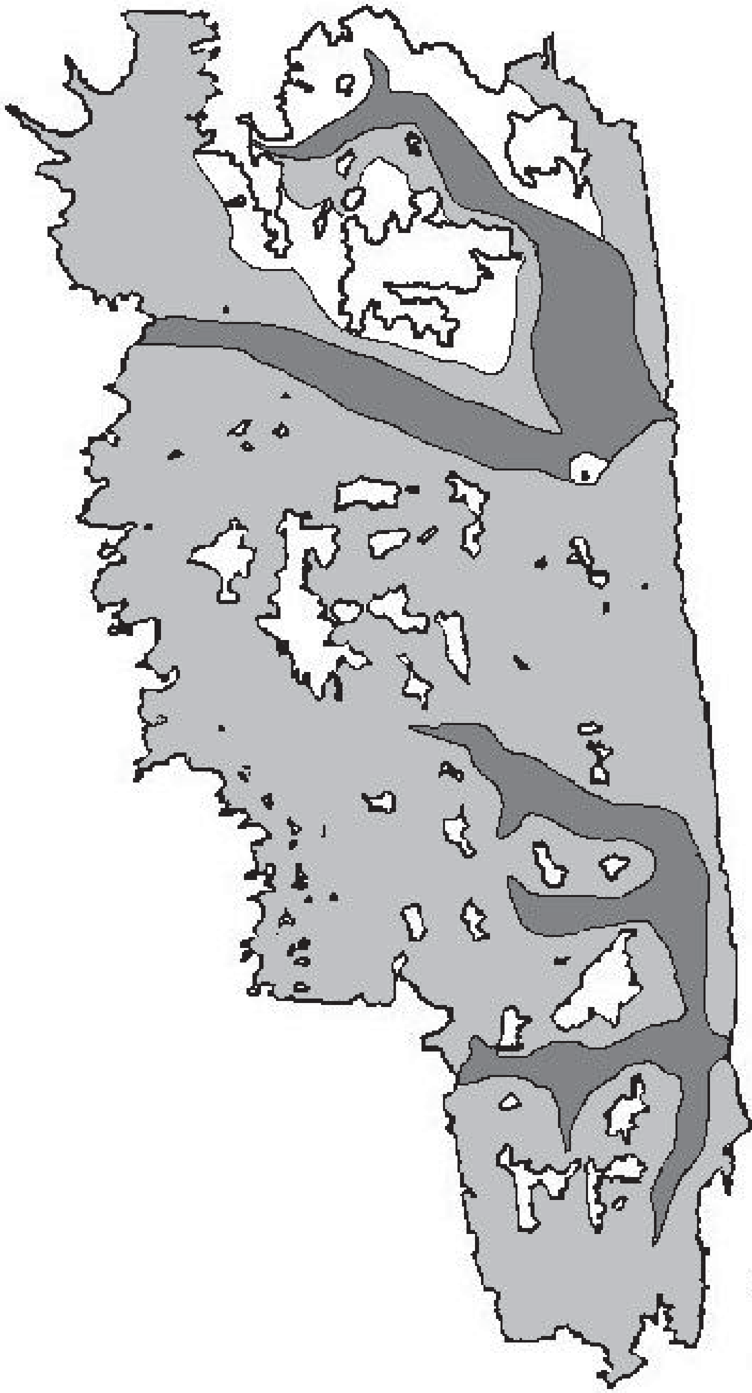


FIGURE II.2.b

BOTANICAL RESOURCES
SURVEY COVERAGE
1998-99
Colusa & Glenn Co. California

0%

<50%

50-100%

OFFSTREAM STORAGE RESERVOIR INVESTIGATION

NEWVILLE RESERVOIR

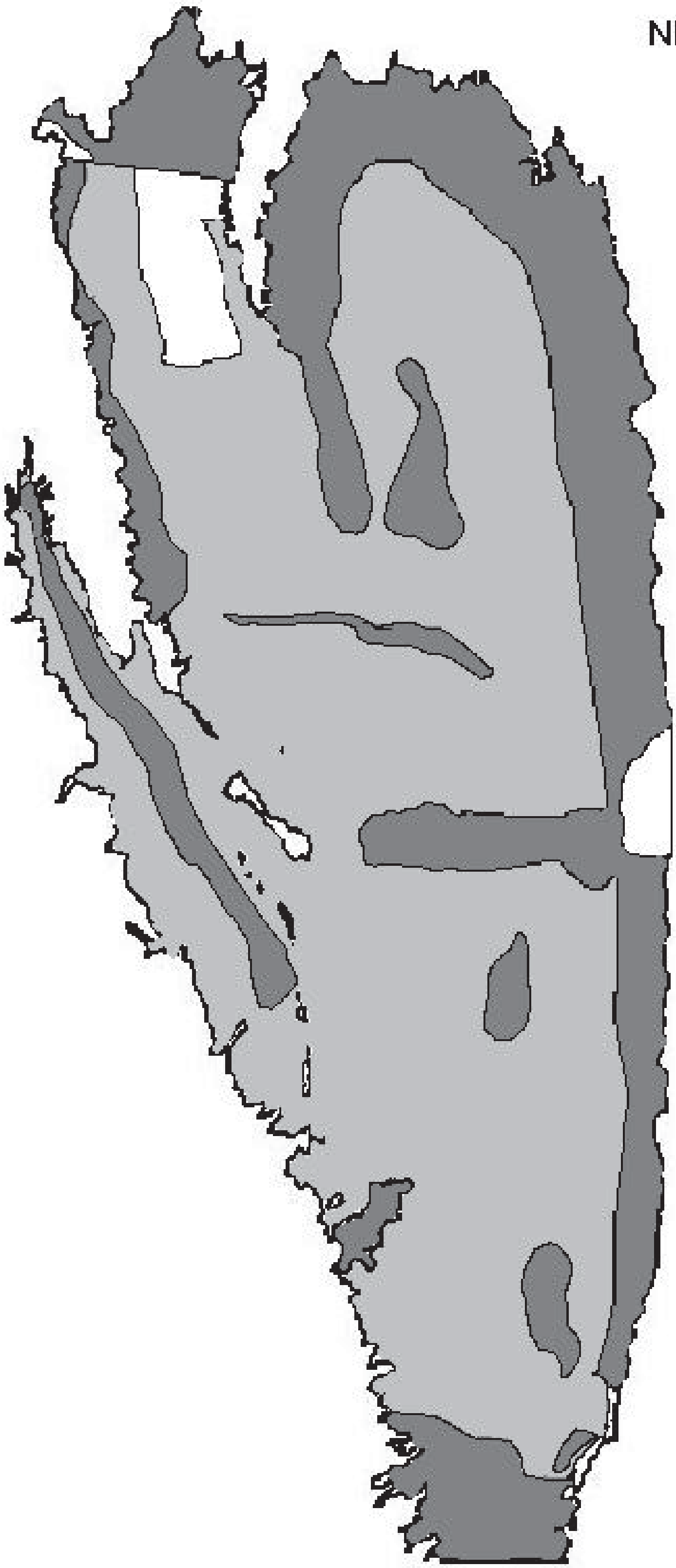


FIGURE II.2.c

BOTANICAL RESOURCES SURVEY COVERAGE 1998-99 Glenn & Tehama Co.

0 %

<50%

50-100%

OFFSTREAM STORAGE RESERVOIR INVESTIGATION
RED BANK RESERVOIR

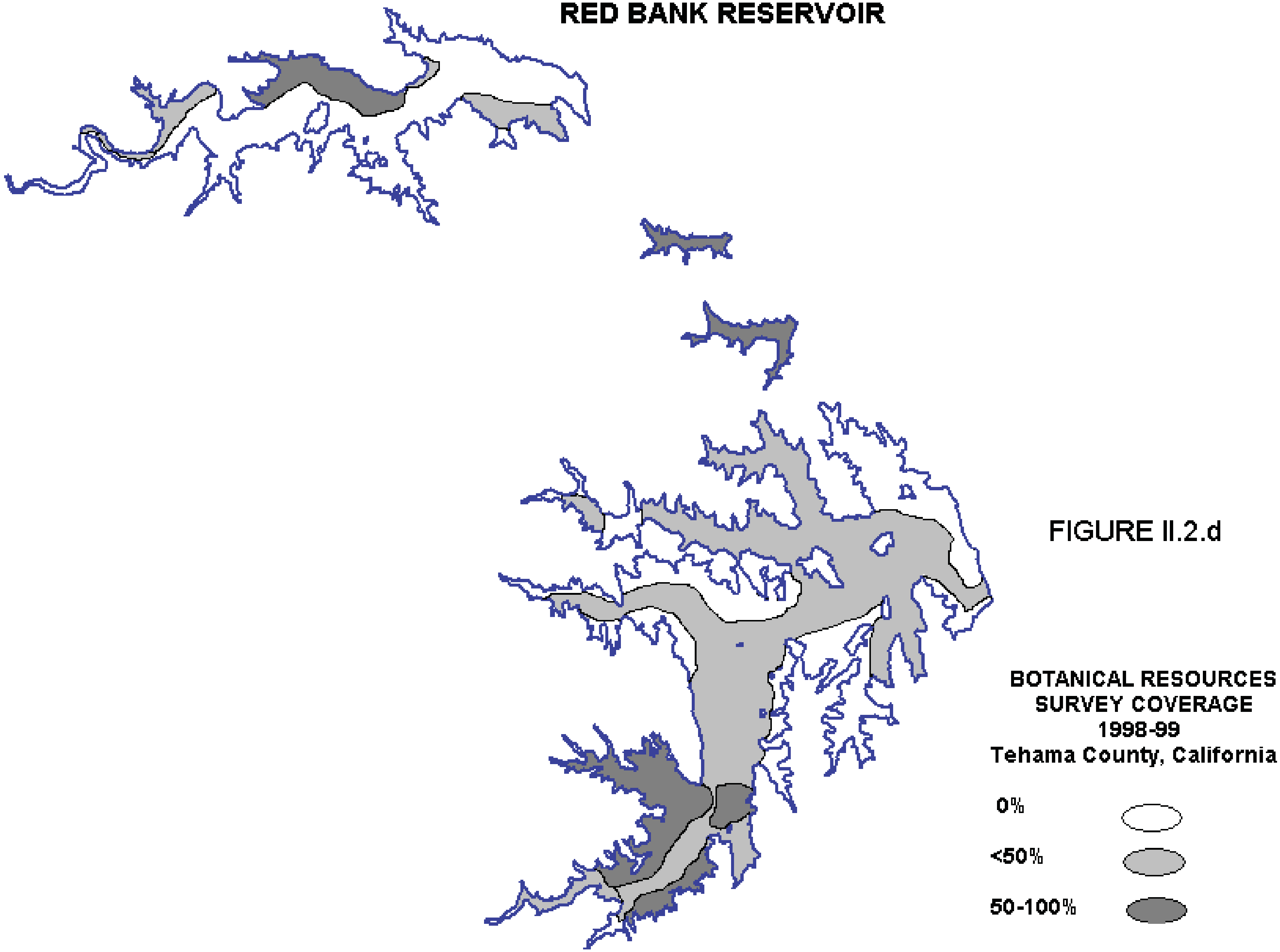


FIGURE II.2.d

such as Italian ryegrass (*Lolium* sp.), wild oats (*Avena* sp.), and the forb, yellow star thistle (*Centaurea solstitialis*).

2.3.1. Sites and Colusa Cell Reservoirs Sites and the Colusa cell receive less average annual rainfall than Newville and Red Bank, and have a predominance of annual grassland vegetation that is managed for high intensity cattle grazing. Less than 10 percent of the vegetation in these reservoirs is woodland (*Quercus* sp. or *Pinus sabiniana*), chaparral, riparian, or vegetated wetland (*Eleocharis* sp.). Only six percent (923 acres) of the total inundation area of the Sites Reservoir supports oak woodland. Some of the oak woodland includes scattered low density stands of valley oak (*Quercus lobata)* on high terrace floodplains adjacent to Funks, Grapevine, and Antelope Creeks. There are few seedlings and saplings in the existing valley oak stands, which consist of large mature and senescent trees. The blue oak stands, however, have a diverse age class representation. Oak age classes were not measured. Nine-hundred twenty-three acres of oak woodland would be lost at Sites, and 20 acres would be lost at the Colusa cell reservoir.

The Sites reservoir area and Colusa cell do not have shale soil or potential habitat for the plants associated with this soil type. However, approximately 65 percent (8,916 acres) of Sites inundation area is clay soils, and the Colusa cell is approximately 36 percent (4,950 acres) clay substrate. Three of the four prioritized plants species found in the reservoirs were on clay soil.

Approximately 5 acres of vernal pools occur in the Sites reservoir. Three acres of vernal pools occur in the Colusa cell. Although six of the potential high priority species are vernal pool endemics, the probability of finding them is low because of the existing land use conditions. Clay hardpan vernal pools and alkaline wetlands were variable in quality and species composition. Although several pools in the Sites reservoir support common vernal pool species, all of the vernal pools were grazed and no prioritized species were observed. The majority of the mapped clay substrates support non-native annual vegetation.

Potential habitat for high priority and priority species exists in Sites and Colusa cell reservoirs, however, current management practices may not be compatible with supporting the prioritized species. Potential habitat includes vernal pools, swales and alkali wetlands, and valley and foothill grassland.

2.3.2. Newville Reservoir This site receives more average annual rainfall than the Sites and Colusa cell alternatives and has greater inherent topographic variability and soil conditions compatible with suitable habitat for priority and low priority species. The diversity of the vegetation communities, as well as clay and shale substrates at Newville, resulted in an increase in the total number of species and occurrences of prioritized species. Annual grassland, blue oak woodland (*Quercus douglasii*), valley oak woodland (*Quercus lobata*), mixed willow riparian (*Salix* spp.), and chaparral communities occur in the site.

Newville reservoir site supports valley and blue oak woodland vegetation over 11 percent (1,839 acres) of the inundation area. The valley oak stands are primarily along Upper Stony Creek at this site. The existing oak woodlands do not appear to be as heavily grazed as the Sites and Colusa cell woodlands. There are oak seedling and juvenile age classes in some areas, although this parameter was not quantified.

This reservoir supports more populations of priority and low priority species than Sites, Colusa cell, or Red Bank alternatives. It should be noted that the current land use practices are compatible with and sustain these prioritized plant populations. Roughly 7,000 acres of Lodo shale soil was mapped in this reservoir, but not all of this was potential habitat for the associated species. North and south-facing slopes, chaparral vegetation, and slopes with less than 50 percent vegetative cover were some of the other necessary parameters to support the shale-associated species. Although over 2,000 acres of clay soil were mapped, the observed prioritized species populations tended to occur only on the moderate north-facing slopes or flats. All clay and Lodo shale soils were adequately surveyed.

Vernal pools and alkaline wetlands in the Newville reservoir area were variable in quality, ranging from 0 to 100 percent cover and moderate to extreme grazing effect. Twenty-three acres of vernal pools were mapped in the inundation zone. There were good quality vernal pools with representation of common vernal pool flora; however, all the pools were grazed. No high priority species were found in any of the vernal pool habitat.

2.3.3. Red Bank Reservoir The 4,600 acre Red Bank project area is dominated by native blue oak (*Quercus douglasii*), mixed oak (*Quercus* spp.), and foothill pine (*Pinus sabiniana*). Although oak woodlands represent approximately 20 percent (899 acres) of the project area, the total amount of woodland habitat including foothill pine woodland comprises 83 percent of vegetative cover. At this site, only 2 percent of the cover is chaparral scrub, and 12 percent (565 acres) is annual grassland. The grassland vegetation occurs on the high terrace floodplain of Red Bank Creek, and on several low hills (Attachment 4). Occasional native bunch grass (*Nassella* spp.) stands occur on moderate slopes under blue oak woodland.

The Red Bank alternative receives the most annual rainfall of the reservoir sites, has the most variable topography and vegetation, and moderate to light cattle grazing influence.

Several prioritized species were found on clay and Lodo shale soil. The 3,101 acres of mapped Lodo shale soil (67 percent) was not all potential habitat for the associated sensitive plant species. Prioritized species were found with additional microsite parameters, such as north- or south-facing aspect, moderate slope, less than 50 percent vegetative cover, or chaparral plant associates. Much of the Lodo shale soil was not suitable habitat for the prioritized species because these other microsite conditions were lacking.

Approximately 305 acres of clay soil was mapped but only three populations of a clay-associated priority species were found. The Lodo shale and clay soil areas were adequately surveyed except where no access was allowed or where terrain or vegetation made it infeasible.

Potential habitat exists at this site for the chaparral, valley and foothill woodland, and valley and foothill grassland prioritized species. There was no vernal pool or alkaline wetland habitat observed in the Red Bank reservoir site.

2.3.4. Future Needs

Surveys will be needed in each reservoir alternative where property access was not allowed in 1998 and 1999. Secondary effect areas, or areas just around the reservoirs, which may experience environmental impacts related to the reservoir projects include power lines, road realignments, conveyance facilities, recreation areas, or mitigation lands. These areas will require rare plant and inventory surveys and vegetation community mapping. Continued surveys of vernal pools, swales, and alkaline wetlands in the reservoir inundation zones are recommended by CDFG if property access allows (Lis 1999; Horenstein 1999).

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USFWS. 1997. Letter to Naser Bateni; Species lists for Redbanks reservoir sites Tehama Counties, California. USDI USFWS Sacramento, CA.

______. 1997. Letter to Naser Bateni; Species lists for Newville reservoir sites, Glenn and Tehama counties, California. USDI USFWS Sacramento, CA.

January 4, 2000

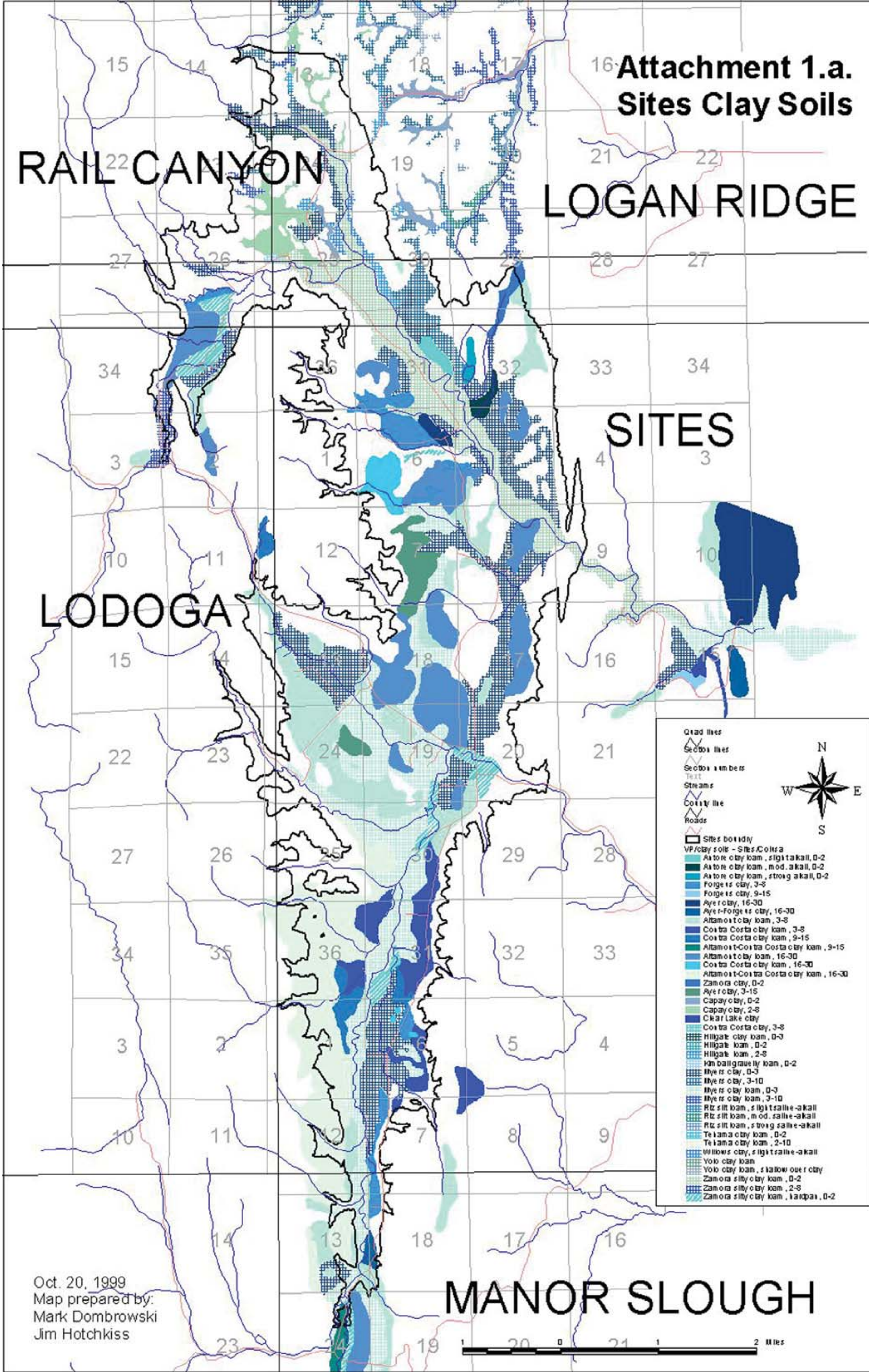
ATTACHMENT 1.
OFFSTREAM STORAGE RESERVOIR INVESTIGATION:
Mapped Lodo shale and clay soils

a. Sites clay soil

b. Colusa cell clay soil

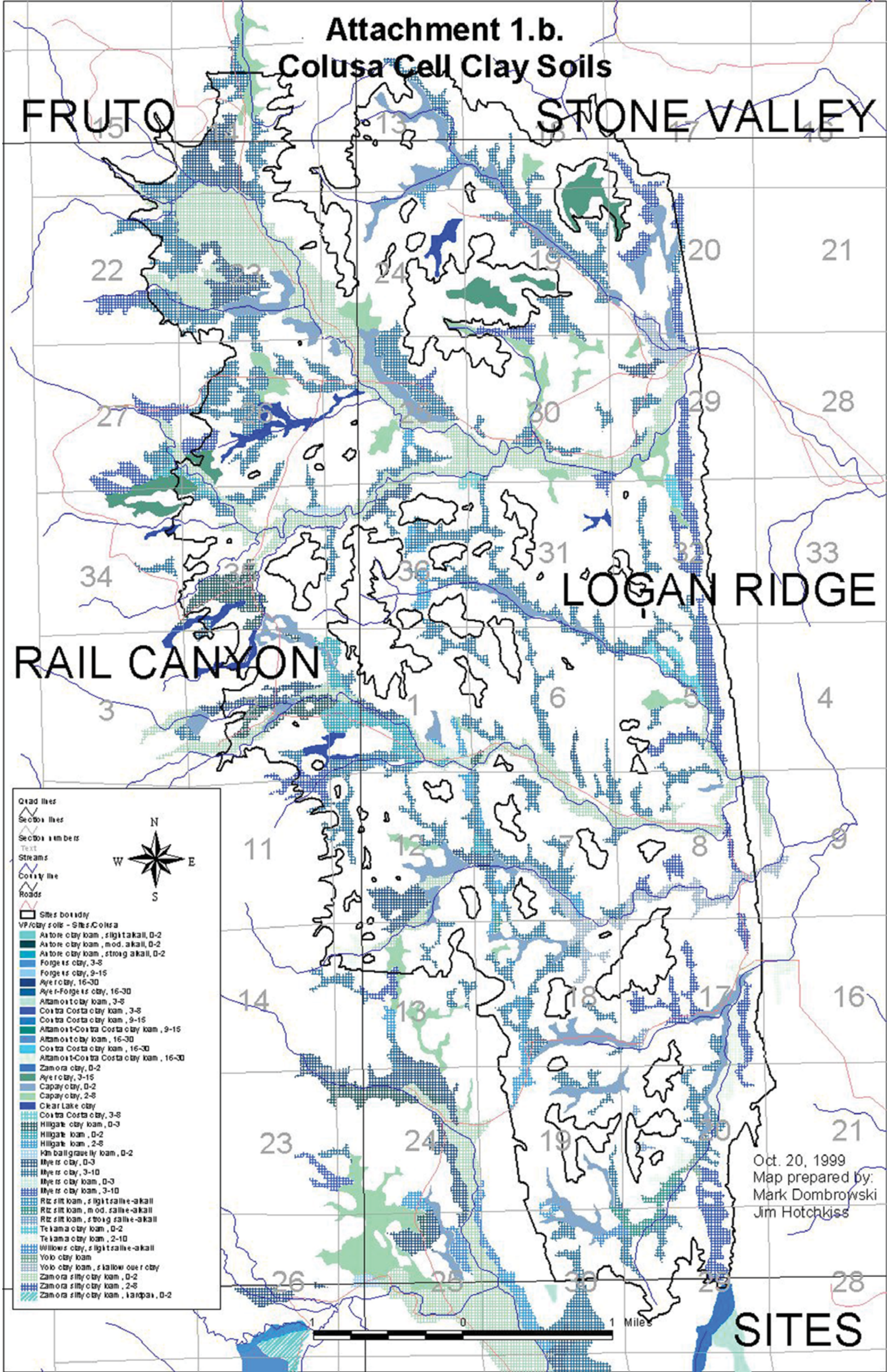
c. Newville Lodo shale and clay soil

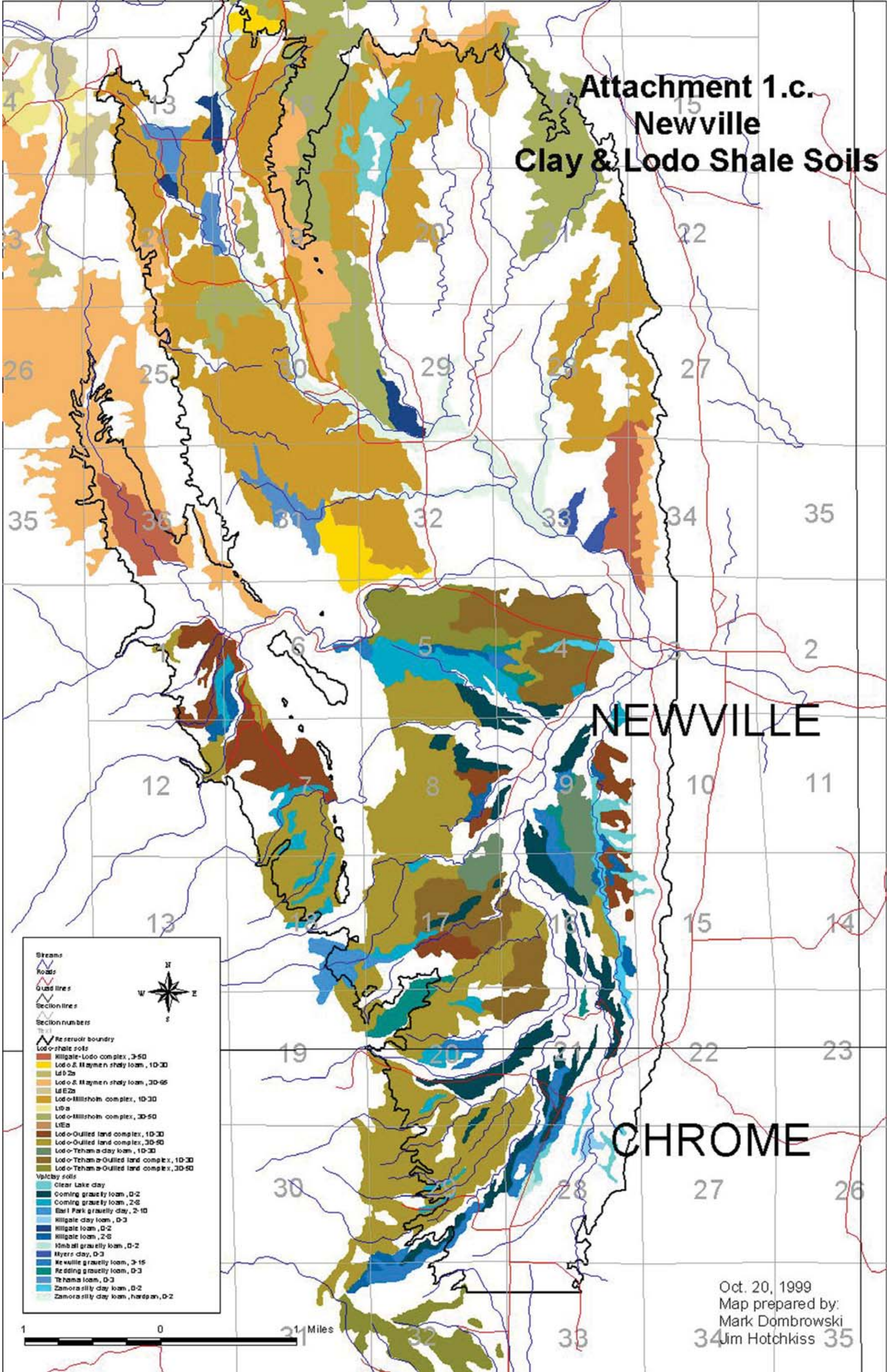
d. Red Bank Lodo shale and clay soil



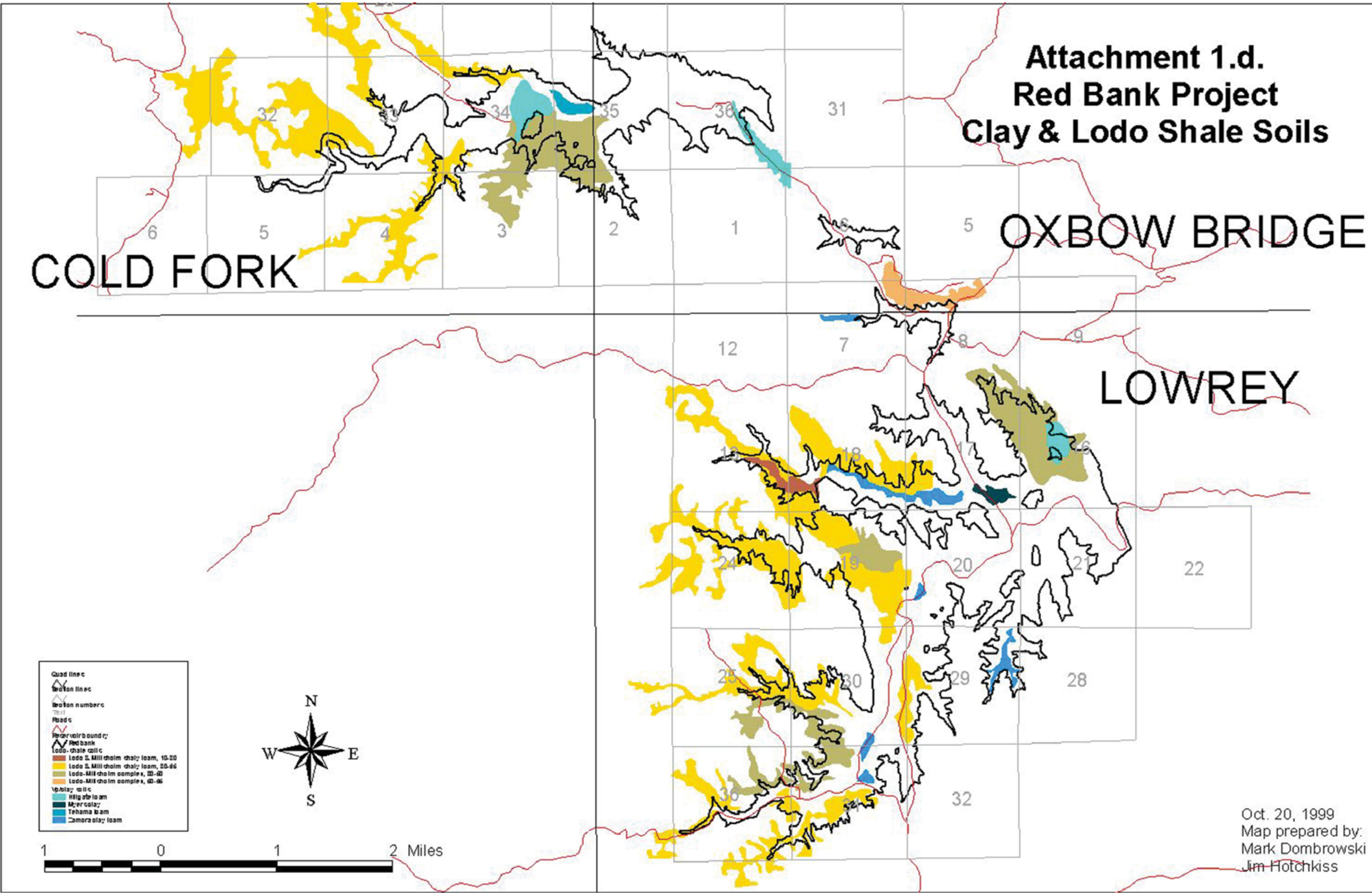
Attachment 1.a.
Sites Clay Soils
RAIL CANYON
LOGAN RIDGE
SITES
LODOGA
MANOR SLOUGH
Quad lines
Section lines
Section numbers
Text
Streams
County line
Roads
Sites boundry
VP/clay soils - Sites/Colusa
Antone clay loam, slight alkali, 0-2
Antone clay loam, mod. alkali, 0-2
Antone clay loam, strong alkali, 0-2
Forgeus clay, 3-8
Forgeus clay, 9-15
Ayer clay, 16-30
Ayer-Forgeus clay, 16-30
Altamont clay loam, 3-8
Contra Costa clay loam, 3-8
Contra Costa clay loam, 9-15
Altamont-Contra Costa clay loam, 9-15
Altamont clay loam, 16-30
Contra Costa clay loam, 16-30
Altamont-Contra Costa clay loam, 16-30
Zamora clay, 0-2
Ayer clay, 3-15
Capay clay, 0-2
Capay clay, 2-8
Clear Lake clay
Contra Costa clay, 3-8
Hillgate clay loam, 0-3
Hillgate loam, 0-2
Hillgate loam, 2-8
Kimball gravelly loam, 0-2
Myers clay, 0-3
Myers clay, 3-10
Myers clay loam, 0-3
Myers clay loam, 3-10
Ritz silt loam, slight saline-alkali
Ritz silt loam, mod. saline-alkali
Ritz silt loam, strong saline-alkali
Tehama clay loam, 0-2
Tehama clay loam, 2-10
Willows clay, slight saline-alkali
Yolo clay loam
Yolo clay loam, shallow over clay
Zamora silty clay loam, 0-2
Zamora silty clay loam, 2-8
Zamora silty clay loam, hardpan, 0-2
N
W
E
S
Oct. 20, 1999
Map prepared by:
Mark Dombrowski
Jim Hotchkiss
1 0 1 2 Miles

Attachment 1.b.
Colusa Cell Clay Soils





Attachment 1.c.
Newville
Clay & Lodo Shale Soils
NEWVILLE
CHROME
Streams
Roads
Quad lines
Section lines
Section numbers
Reservoir boundry
Lodo-shale soils
Millgate-Lodo complex, 3-50
Lodo & Maymen shaly loam, 10-30
LdD2a
Lodo & Maymen shaly loam, 30-65
LdE2a
Lodo-Millsholm complex, 10-30
LfDa
Lodo-Millsholm complex, 30-50
LfEa
Lodo-Gullied land complex, 10-30
Lodo-Gullied land complex, 30-50
Lodo-Tehama clay loam, 10-30
Lodo-Tehama-Gullied land complex, 10-30
Lodo-Tehama-Gullied land complex, 30-50
Vp/clay soils
Clear Lake clay
Corning gravelly loam, 0-2
Corning gravelly loam, 2-8
Earl Park gravelly clay, 2-10
Millgate clay loam, 0-3
Millgate loam, 0-2
Millgate loam, 2-8
Kimball gravelly loam, 0-2
Myers clay, 0-3
Newville gravelly loam, 3-15
Redding gravelly loam, 0-3
Tehama loam, 0-3
Zamora silty clay loam, 0-2
Zamora silty clay loam, hardpan, 0-2
1 0 1 Miles
Oct. 20, 1999
Map prepared by:
Mark Dombrowski
Jim Hotchkiss



Attachment 1.d.
Red Bank Project
Clay & Lodo Shale Soils
COLD FORK
OXBOW BRIDGE
LOWREY
Quad lines
Section lines
Section numbers
Roads
Reservoir boundary
Red bank
Lodo-shale soils
Lodo & Millsholm shaly loam, 10-30
Lodo & Millsholm shaly loam, 30-65
Lodo-Millsholm complex, 30-60
Lodo-Millsholm complex, 60-85
Vp/clay soils
Hillgate loam
Myers clay
Tehama loam
Zamora clay loam
N
W
E
S
1
0
1
2 Miles
Oct. 20, 1999
Map prepared by:
Mark Dombrowski
Jim Hotchkiss

January 4, 2000

ATTACHMENT 2.

OFFSTREAM STORAGE RESERVOIR INVESTIGATION:

Botanical survey personnel

Department of Water Resources
Red Bluff, California:

Barbara Castro
Fish and Wildlife Scientific Aid

Julie Cunningham
Environmental Specialist III

Lawrence Janeway
Fish and Wildlife Scientific Aid

Jenny Marr
Environmental Specialist III

Joyce Lacey-Rickert
Environmental Specialist IV

Caroline Warren
Fish and Wildlife Scientific Aid

Heidi West
Fish and Wildlife Scientific Aid

Natalie Wight
Graduate Student Assistant

Department of Water Resources
Sacramento, California:

Beth Hendrickson
Environmental Specialist III

Jean Witzman
Environmental Specialist III

January 4, 2000

ATTACHMENT 3.

OFFSTREAM STORAGE RESERVOIR INVESTIGATION:

1998-1999 Botanical field survey log

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
3/13/98	C	JM CW HW JL	36
4/6/98	C	JM CW JM	18
4/7/98	C	JM CW	18
4/8/98	C	JM CW	18
4/21/98	C	JM HW CW NW	36
4/22/98	C	JM HW JL JC	36
6/17/98	C	JM CW HW JC	36
6/23/98	C	HW CW NW JL	36
8/28/98	C	JM HW	18
9/2/98	C	HW +?	18
3/2/99	C	CW HW	18
3/3/99	C	JM CW MG BC	36
3/4/99	C	JM BC MG NW	36
3/16/99	C	HW BC	18
3/18/99	C	HW BC	18
3/30/99	C	JM BH	18
3/31/99	C	JM BC LJ HW	36
4/1/99	C	JM BH HW NW BC LJ	54
4/2/99	C	BH CW	18
4/6/99	C	CW MG	18
4/7/99	C	CW MG	18
4/8/99	C	MG NW	18
4/13/99	C	CW LJ MG	27
7/9/99	C	BH, JW	18
2/18/98	R/B	JM CW HW JC	36
4/1/98	R/B	JM CW HW JL	36
4/2/98	R/B	JM CW HW JC JL	45
4/27/98	R/B	JC HW CW	27

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
5/20/98	R/B	JM CW HW	27
5/21/98	R/B	JM HW JL	27
6/9/98	R/B	JM CW HW NW	36
6/15/98	R/B	JM HW CW NW	36
6/25/98	R/B	HW NW JC	27
7/2/98	R/B	JM HW CW NW JL	45
7/3/98	R/B	JM HW CW NW	36
7/6/98	R/B	JM HW CW JC NW	45
7/7/98	R/B	HW CW JC	27
7/8/98	R/B	JM CW	18
7/9/98	R/B	JM HW CW NW	36
8/21/98	R/B	HW CW JC NW	36
8/27/98	R/B	JM CW HW	27
9/23/98	R/B	HW CW??	18
9/24/98	R/B	JM HW CW	27
10/7/98	R/B	CW HW	18
10/8/98	R/B	CW JM	18
10/13/98	R/B	JM HW	18
10/20/98	R/B	JM HW CW	27
10/21/98	R/B	JM CW HW??	18
3/2/99	R/B	JM MG BC LJ	36
3/3/99	R/B	HW LJ	18
3/4/99	R/B	HW LJ	18
3/5/99	R/B	CW MG	18
3/16/99	R/B	LJ CW	18
3/18/99	R/B	LJ MG	18
3/22/99	R/B	LJ BC	18
3/23/99	R/B	LJ BC	18

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
3/25/99	R/B	BC LJ	18
3/29/99	R/B	BC LJ BH	27
4/7/99	R/B	BC HW	18
4/20/99	R/B	LJ HW	18
4/27/99	R/B	LJ CW	18
4/28/99	R/B	CW JM	18
4/29/99	R/B	HW NW JM	27
5/12/99	R/B	JM CW	18
5/18/99	R/B	BC LJ	18
5/19/99	R/B	JW BH BC LJ	36
5/20/99	R/B	BH JW	18
5/21/99	R/B	BH JW	18
5/24/99	R/B	BC LJ	18
5/27/99	R/B	JM BH	18
5/28/99	R/B	JM BH	18
6/1/99	R/B	LJ CW	18
6/3/99	R/B	BC LJ	18
6/8/99	R/B	BC CW LJ	27
6/9/99	R/B	BC LJ HW CW	36
6/10/99	R/B	BC LJ CW HW	36
6/14/99	R/B	BC LJ	18
6/15/99	R/B	LJ CW	18
6/21/99	R/B	BC LJ	18
6/24/99	R/B	JW BH BC LJ CW	45
8/11/99	R/B	JM LJ BC CW	36
5/13 99	R/B	BC NW	18
2/17/98	S	JM HW CW JL NW	45
3/2/98	S	JM CW HW JC	36

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
3/3/98	S	JM CW HW NW	36
3/6/98	S	JM CW JC	27
4/14/98	S	HW CW JM HW JL JC	54
4/15/98	S	HW JC	18
4/16/98	S	JW CW	18
5/4/98	S	JM CW JL HW	36
5/8/98	S	JM HW CW JL	36
5/26/98	S	HW CW JL JC	36
5/27/98	S	JM CW HW JC	36
6/11/98	S	JM HW CW NW	36
6/22/98	S	HW CW	18
7/1/98	S	JM HW CW	27
7/22/98	S	JM CW HW NW	36
8/3/98	S	CW HW NW	27
8/4/98	S	HW CW NW	27
8/5/98	S	HW CW JC	27
8/12/98	S	HW CW	18
8/18/98	S	HW NW	18
2/18/99	S	JM BH	18
2/22/99	S	BH CW	18
2/23/99	S	BH CW	18
2/25/99	S	JM BH JW NW	36
2/26/99	S	BH JW	18
3/2/99	S	BH JW	18
3/3/99	S	BH JW	18
3/4/99	S	BH JW	18
3/5/99	S	BH JW	18
3/8/99	S	BH	9

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
3/9/99	S	CW BH	18
3/10/99	S	CW BH	18
3/11/99	S	MG BH	18
3/12/99	S	BH MG	18
3/16/99	S	BH JW MG	27
3/17/99	S	JW BH	18
3/19/99	S	BH +?	18
3/23/99	S	BH HW	18
3/24/99	S	BH +?	18
3/25/99	S	BH HW NW	27
3/26/99	S	BH NW	18
4/7/99	S	BH JW	18
4/9/99	S	BH JW	18
4/12/99	S	BC BH LJ MG	36
4/19/99	S	JW BH	18
4/21/99	S	JW BH	18
4/22/99	S	JW BH	18
4/23/99	S	JW BH	18
5/3/99	S	BH JW	18
5/5/99	S	BH JW	18
5/6/99	S	BH JW	18
6/7/99	S	CW BH	
6/8/99	S	BH +?	18
7/7/99	S	BH JW	18
2/26/98	T/N	JM HW CW JL JC	45
2/27/98	T/N	JM CW JC	27
3/4/98	T/N	JM HW CW JC JL	45
3/5/98	T/N	JM HW CW	27

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
3/9/98	T/N	HW CW JL JC	36
3/10/98	T/N	JM CW HW JC	36
3/16/98	T/N	JM CW HW JC	36
3/17/98	T/N	JM CW HW JL JC	45
3/18/98	T/N	JM CW	18
3/19/98	T/N	JM CW HW JL	36
3/20/98	T/N	JM HW CW JL	36
3/26/98	T/N	JM CW JL JW JC	45
3/30/98	T/N	CW HW JC JL	36
4/6/98	T/N	HW JC	18
4/7/98	T/N	HW JC	18
4/8/98	T/N	HW JC	18
4/15/98	T/N	JM CW	18
4/20/98	T/N	JM CW JC JL	36
4/28/98	T/N	JM CW NW JC JL	45
4/29/98	T/N	JM HW CW JL JC	45
4/30/98	T/N	JM HW	18
5/11/98	T/N	JM CW JC	27
5/14/98	T/N	HW CW JC	27
5/18/98	T/N	JM HW CW	27
5/19/98	T/N	JM CW HW JL NW JC	54
6/1/98	T/N	JM HW CW NW	36
6/2/98	T/N	JM CW HW NW	36
6/5/98	T/N	HW CW NW	27
6/16/98	T/N	JM HW CW NW	36
6/18/98	T/N	JM CW NW JC	36
6/19/98	T/N	HW NW JC	27
7/14/98	T/N	JM HW CW JC NW	45

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
7/15/98	T/N	JM HW CW JL	36
7/29/98	T/N	JM CW NW	27
8/6/98	T/N	CW NW JC	27
8/11/98	T/N	HW CW NW	27
9/1/98	T/N	HW CW	18
2/23/99	T/N	JM, HW	18
2/24/99	T/N	JM, HW, CW	27
3/9/99	T/N	JM BC MG LJ	36
3/10/99	T/N	JM HW BC MG LJ	45
3/11/99	T/N	HW NW	18
3/17/99	T/N	JM CW LJ	27
3/18/99	T/N	JM NW	36
3/22/99	T/N	JM MG	18
3/23/99	T/N	JM MG CW	27
3/26/99	T/N	JM	9
4/6/99	T/N	LJ HW	18
4/7/99	T/N	JM LJ	18
4/9/99	T/N	BC MG	18
4/13/99	T/N	JM HW	18
4/14/99	T/N	JM BC BH CW LJ MG HW JW	72
4/15/99	T/N	BC BH CW LJ MG JW HW NW	72
4/16/99	T/N	BH BC	18
4/20/99	T/N	JM CW	18
4/21/99	T/N	JM HW LJ BC	36
4/22/99	T/N	LJ CW BC	27
4/26/99	T/N	CW LJ	18
4/28/99	T/N	BH BC	18
4/29/99	T/N	BH BC	18

APPENDIX 3.
Botany Survey Dates and Personnel

DATE	RESERVOIR	PERSONNEL	HOURS
5/4/99	T/N	CW BC LJ	27
5/5/99	T/N	HW CW BC LJ	36
5/6/99	T/N	NW HW BC LJ	36
5/10/99	T/N	BH BC LJ	27
5/11/99	T/N	BC LJ	18
5/12/99	T/N	BC LJ HW JW	36
5/13/99	T/N	LJ CW HW JW	36
6/1/99	T/N	BC HW	18
6/2/99	T/N	LJ CW BH HW	18
6/3/99	T/N	BH HW	18
6/9/99	T/N	BH JW	18
6/10/99	T/N	BH JW	18
6/14/99	T/N	BH HW	18
6/16/99	T/N	BH CW	18
6/17/99	T/N	BH LJ HW	27
6/18/99	T/N	HW BH	18
COLUSA	**TOTAL**	**HOURS**	**621**
RED BANK	**TOTAL**	**HOURS**	**1467**
SITES	**TOTAL**	**HOURS**	**1251**
THOMES-NEWVILLE	**TOTAL**	**HOURS**	**2214**
WORK	**COMPLETED**	**1998 & 1999**	**5553**

January 4, 2000

ATTACHMENT 4.

OFFSTREAM STORAGE RESERVOIR INVESTIGATION:

ArcView (ESRI 1998) mapped vegetation

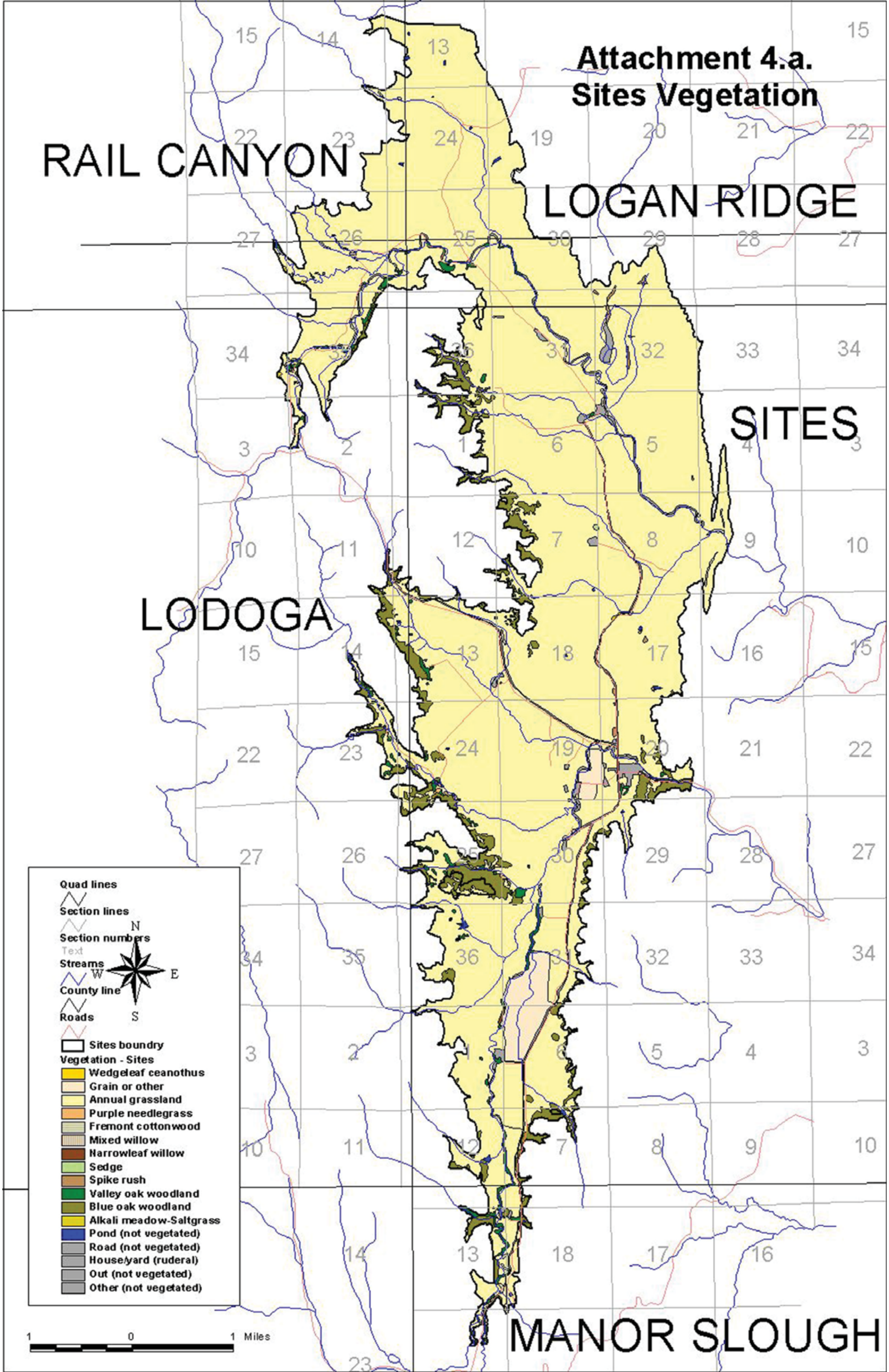
a. Sites Vegetation

b. Colusa cell Vegetation

c. Newville Vegetation

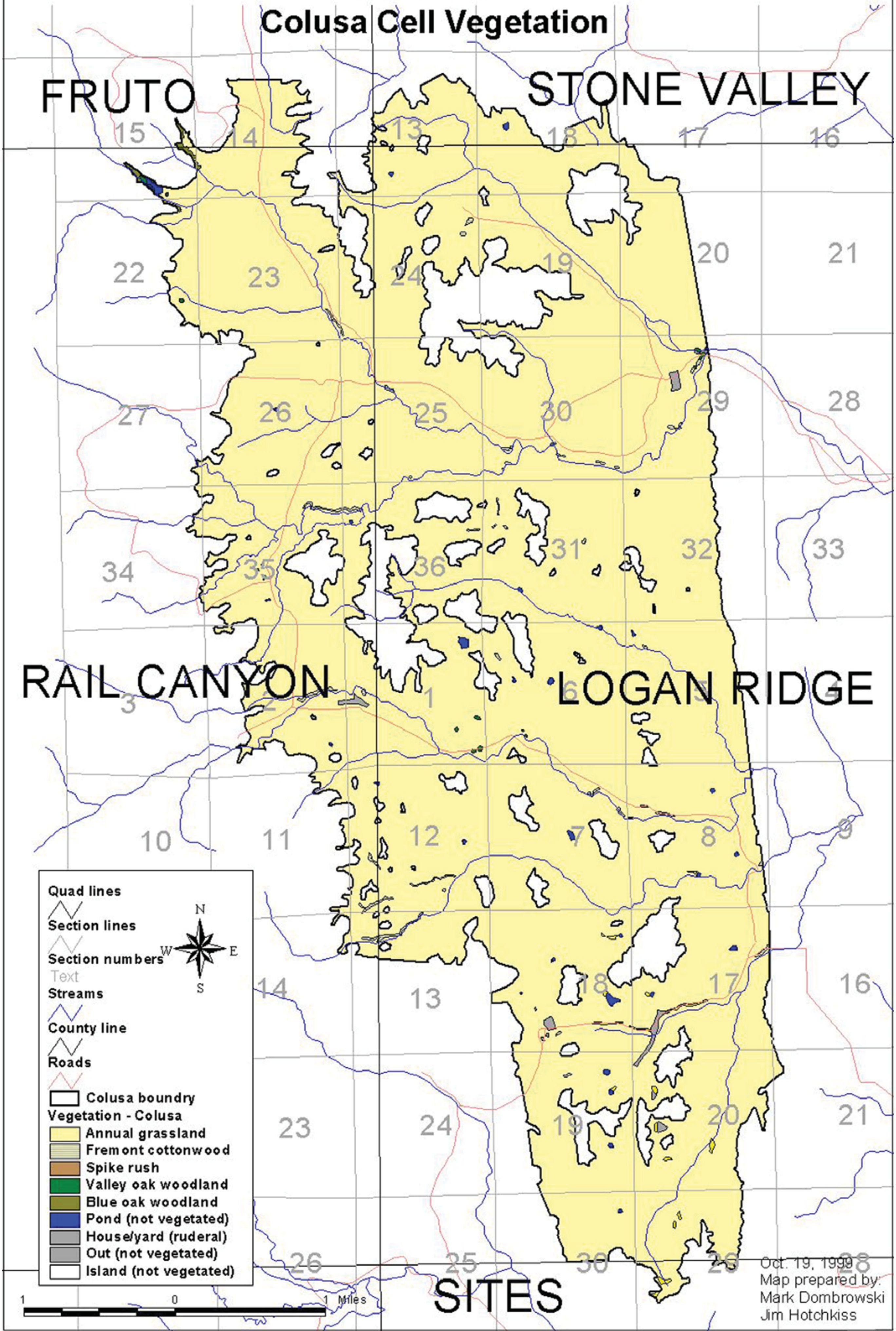
d. Schoenfield Vegetation

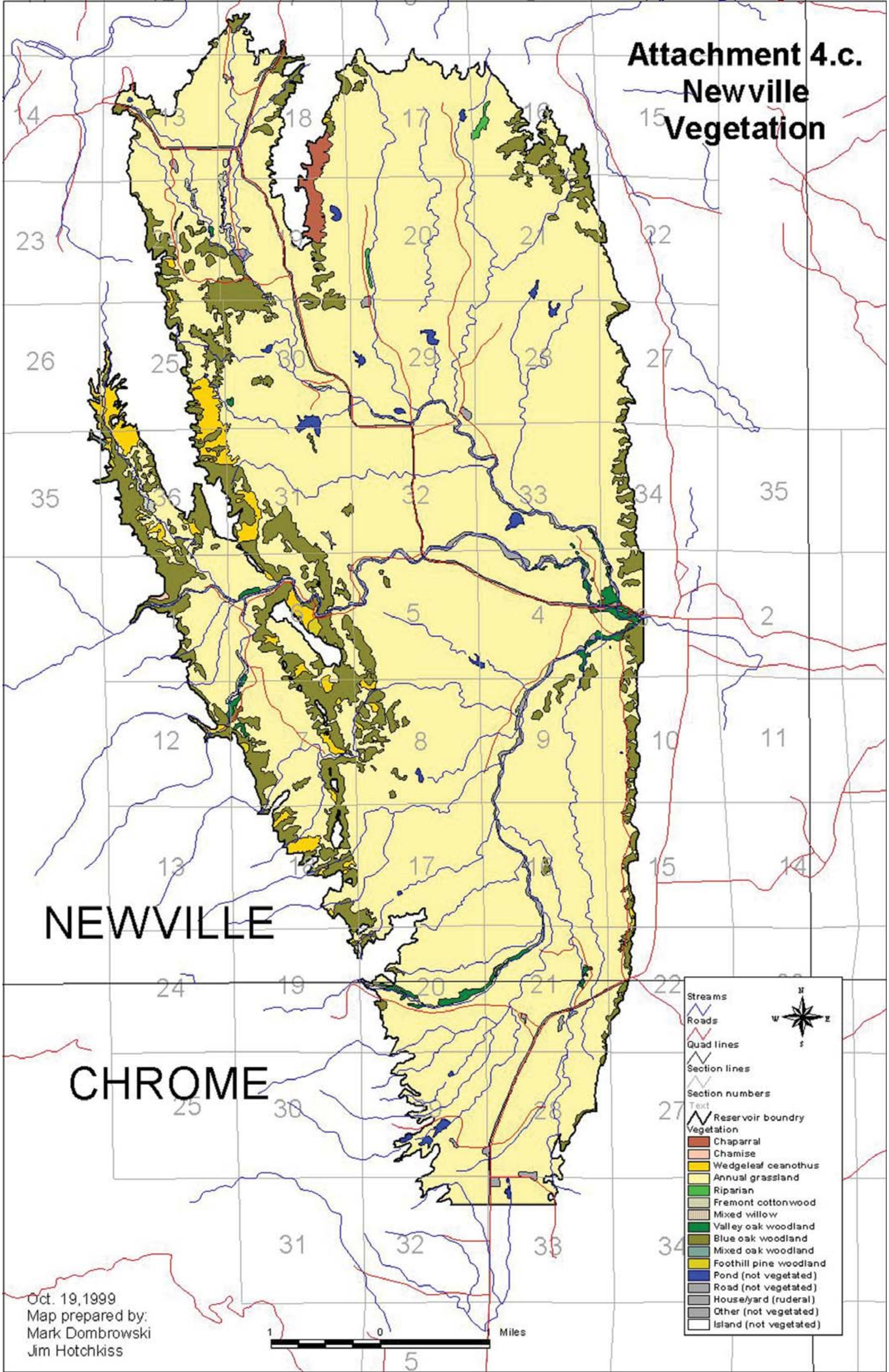
e. Dippingvat Vegetation

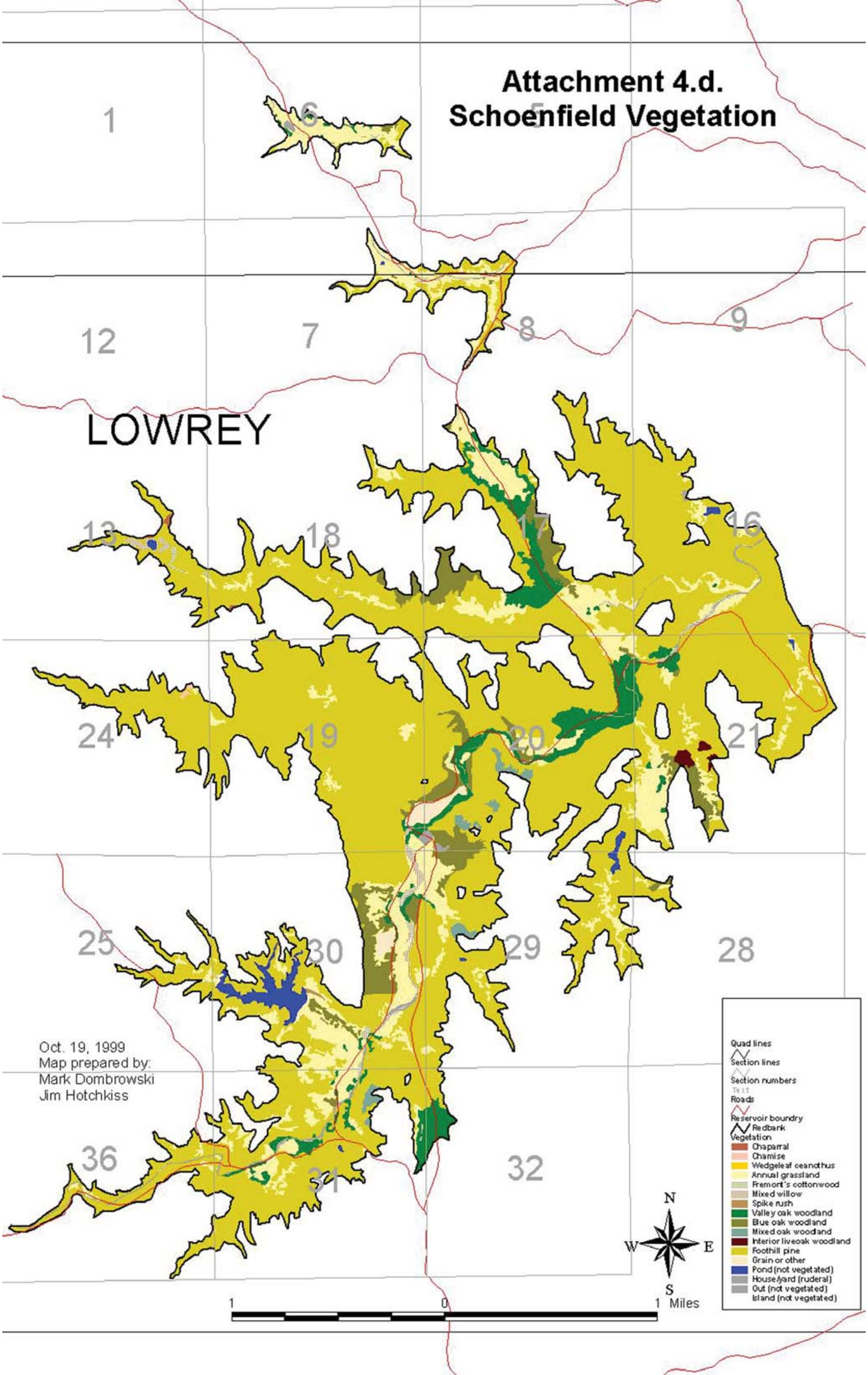


Attachment 4.a.
Sites Vegetation
RAIL CANYON
LOGAN RIDGE
SITES
LODOGA
MANOR SLOUGH
Quad lines
Section lines
Section numbers
Text
Streams
County line
Roads
Sites boundry
Vegetation - Sites
Wedgeleaf ceanothus
Grain or other
Annual grassland
Purple needlegrass
Fremont cottonwood
Mixed willow
Narrowleaf willow
Sedge
Spike rush
Valley oak woodland
Blue oak woodland
Alkali meadow-Saltgrass
Pond (not vegetated)
Road (not vegetated)
House/yard (ruderal)
Out (not vegetated)
Other (not vegetated)
N
W
E
S
1
0
1 Miles

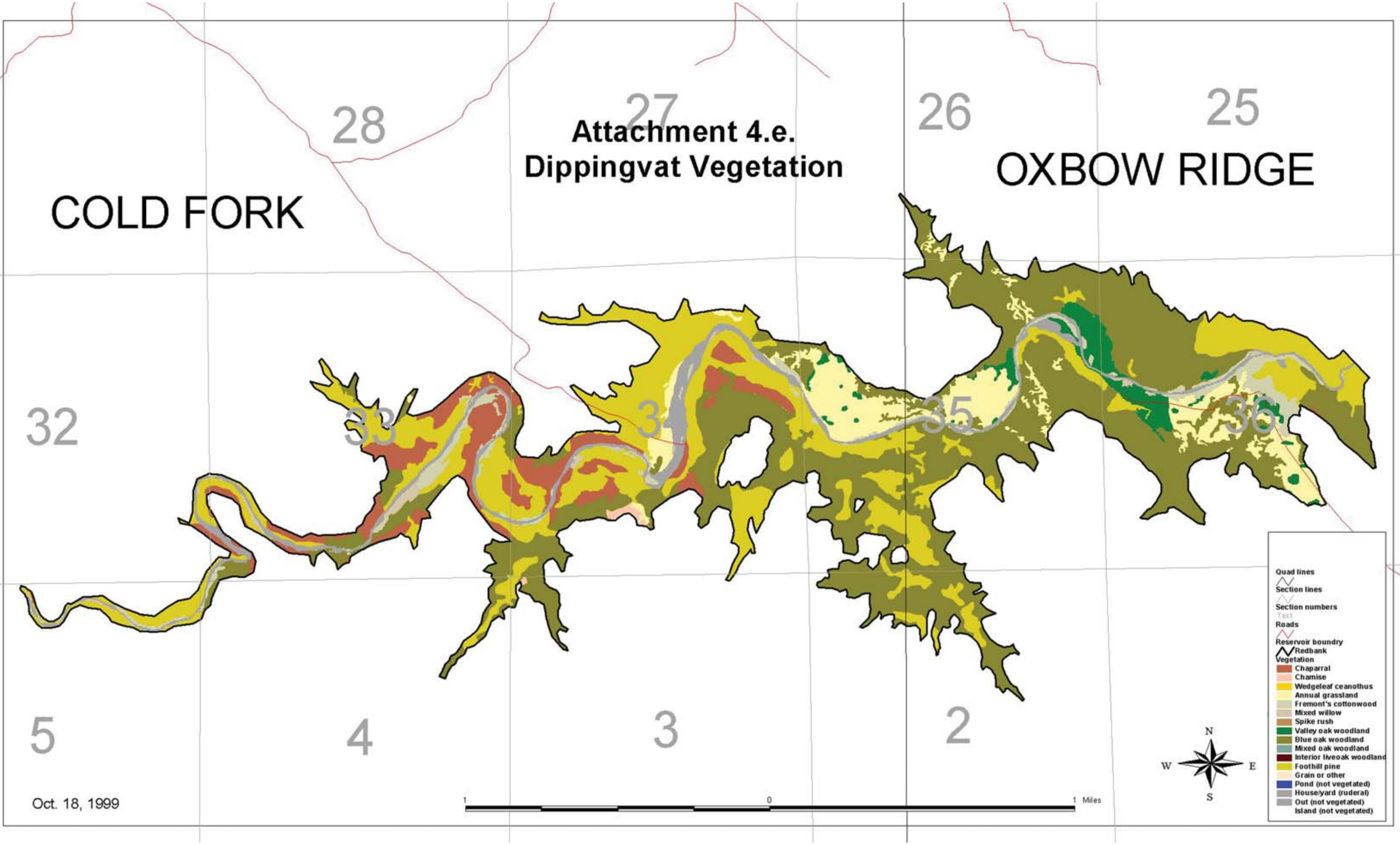
Attachment 4.b.
Colusa Cell Vegetation




Attachment 4.c.
Newville
Vegetation
NEWVILLE
CHROME
Streams
Roads
Quad lines
Section lines
Section numbers
Text
Reservoir boundry
Vegetation
Chaparral
Chamise
Wedgeleaf ceanothus
Annual grassland
Riparian
Fremont cottonwood
Mixed willow
Valley oak woodland
Blue oak woodland
Mixed oak woodland
Foothill pine woodland
Pond (not vegetated)
Road (not vegetated)
House/yard (ruderal)
Other (not vegetated)
Island (not vegetated)
1
0
1 Miles
Oct. 19,1999
Map prepared by:
Mark Dombrowski
Jim Hotchkiss


Attachment 4.d.
Schoenfield Vegetation
LOWREY
1
6
5
12
7
8
9
13
18
17
16
24
19
20
21
25
30
29
28
36
31
32
Oct. 19, 1999
Map prepared by:
Mark Dombrowski
Jim Hotchkiss
Quad lines
Section lines
Section numbers
Text
Roads
Reservoir boundry
Redbank
Vegetation
Chaparral
Chamise
Wedgeleaf ceanothus
Annual grassland
Fremont's cottonwood
Mixed willow
Spike rush
Valley oak woodland
Blue oak woodland
Mixed oak woodland
Interior liveoak woodland
Foothill pine
Grain or other
Pond (not vegetated)
House/yard (ruderal)
Out (not vegetated)
Island (not vegetated)
N
W
E
S
1
0
1 Miles

Attachment 4.e.
Dippingvat Vegetation



January 4, 2000

ATTACHMENT 5.

OFFSTREAM STORAGE RESERVOIR ALTERNATIVES:

1998-1999 plant species observed

FAMILY *Genus species*	**Common Name**	**Origin**	**Listing**
Sites			
ALISMATACEAE			
Alisma plantago-aquatica	Water-plantain	native	
Damasonium californicum	Fringed water-plantain	native	
AMARANTHACEAE			
Amaranthus blitoides	Mat amaranth	non	
ANACARDIACEAE			
Toxicodendron diversilobum	Poison oak	native	
APIACEAE			
Anthriscus caucalis	Bur-chervil	non	
Daucus pusillus	Rattlesnake-weed	native	
Eryngium castrense	Coyote thistle	native	
Lomatium marginatum var. *purpureum*	Purple lomatium	native	
Sanicula bipinnata	Poison sanicle	native	
Sanicula bipinnatifida	Purple sanicle	native	
Scandix pecten-veneris	Shepherd's needle	non	
Torilis arvensis	Common hedge-parsley	non	
Torilis nodosa	Knotted hedge-parsley	non	
Yabea microcarpa	False hedge-parsley	non	
ASCLEPIADACEAE			
Asclepias sp.	Milkweed	native	
ASTERACEAE			
Achillea millifolium	Yarrow	native	
Achyrachaena mollis	Blow-wives	native	
Agoseris heterophylla	Agoseris		
Ancistrocarphus filagineus	Woolly fishhooks	native	
Anthemis cotula	Mayweed	non	
Artemisia douglasiana	Mugwort	native	
Baccharis salicifolia	Mule fat	native	
Blennosperma nanum	Yellow carpet	native	
Calycadenia multiglandulosa	Sticky calycadenia	native	
Calycadenia pauciflora	Few-flowered calycadenia	native	
Carduus pycnocephalus	Italian plumeless-thistle	non	
Centaurea calcitrapa	Purple star-thistle	native	
Centaurea melitensis	Tocalote	native	
Centaurea solstitialis	Yellow star thistle	non	
Chamomilla suaveolens	Pineapple-weed	non	
Cichorium intybus	Chicory	non	
Cirsium occidentale var. *venustum*	Venus thistle	native	
Cirsium vulgare	Bull thistle	non	
Conyza floribunda	Many-flowered horseweed	non	
Cotula coronopifolia	Brass-buttons	non	

Eriophyllum lanatum		Woolly sunflower		native		
Eryngium castrense		Coyote thistle		native		
Filago gallica		Narrow-leaved filago		non		
Gnaphalium luteo-album		Weedy cudweed		non		
Gnaphalium palustre		Western marsh cudweed		native		
Grindelia camporum var. *camporum*		Valley gumplant		native		
Hemizonia congesta ssp. *luzulifolia*		Hayfield tarweed		native		
Hemizonia pungens ssp. *pungens*		Common spikeweed		native		
Hesperevax acaulis var. *robustior*		Robust evax		native		
Hesperevax caulescens		Hogwallow starfish		native		CNPS 4
Hesperevax sparsiflora		Sparse-flowered evax		native		
Heterotheca grandiflora		Telegraph-weed		non		
Hypochaeris glabra		Smooth cat's ear		non		
Hypochaeris radicata		Rough cat's-ear		non		
Lactuca saligna		Willow-leaved lettuce		non		
Lactuca serriola		Prickly lettuce		non		
Lagophylla glandulosa		Glandular hareleaf		native		
Lasthenia californica		California goldfields		native		
Lasthenia glaberrima		Smooth goldfields		native		
Layia chrysanthemoides		Smooth tidytips		native		
Layia fremontii		Tidytips		native		
Leontodon taraxacoides ssp. *taraxacoides*		Short-beaked hawkbit		non		
Lessingia nemaclada		Slender-stemmed lessingia		native		
Madia elegans ssp. *densifolia*		Common madia		native		
Madia exigua		Thread-stemmed madia		native		
Madia glomerata		Mountain tarweed		native		
Madia gracilis		Slender tarweed		native		
Malacothrix floccifera		Woolly malacothrix		native		
Micropus californicus var. *californicus*		Slender cottonweed		native		
Microseris douglasii ssp. *douglasii*		Douglas' microseris		native		
Microseris douglasii ssp. *tenella*						
Monolopia major				native		
Picris echioides		Bristly oxtongue		non		
Psilocarphus brevissimus var. *brevissimus*		Dwarf woolly marbles		native		
Psilocarphus tenellus var. *tenellus*		Slender woolly marbles		native		
Rigiopappus leptocladus		Rigiopappus		native		
Senecio vulgaris		Old-man-in-the-spring		non		
Silybum marianum		Milk-thistle		non		
Sonchus oleraceus		Sow-thistle		non		
Taraxacum officinale		Common dandelion		non		
Wyethia angustifolia		Narrow-leaved mule's ears		native		
Xanthium spinosum		Spiny cocklebur		native		
Xanthium strumarium		Cocklebur		native		
BETULACEAE						
Alnus rhombifolia		Alder		native		
BORAGINACEAE						
Amsinckia lycopsoides		Bugloss fiddleneck		native		

Amsinckia menziesii		Menzie's fiddleneck		native		
Cryptantha flaccida		Weak-stemmed cryptantha		native		
Cryptantha intermedia		Common cryptantha		native		
Heliotropium curassavicum		Wild heliotrope		native		
Heliotropium europaeum		European heliotrope		non		
Pectocarya pusilla		Little pectocarya		native		
Plagiobothrys bracteatus		Bracted popcornflower		native		
Plagiobothrys canescens		Valley popcornflower		native		
Plagiobothrys fulvus		Fulvous popcornflower		native		
Plagiobothrys greenei		Greene's popcornflower		native		
Plagiobothrys nothofulvus		Common popcornflower		native		
Plagiobothrys stipitatus var. *stipitatus*		Lg-flwd stalked popcornflower		native		
Plagiobothrys stipitatus var. *micranthus*		Sm-flwd stalked popcornflower		native		
BRASSICACEAE						
Athysanus pusillus		Petty athysanus		native		
Brassica nigra		Black mustard		non		
Capsella bursa-pastoris		Shepherd's purse		non		
Cardamine oligosperma		Western bittercress		non		
Draba verna		Spring whitlow-grass		native		
Erysimum capitatum		Western wallflower		native		
Lepidium latipes var. *latipes*		Dwarf peppergrass		native		
Lepidium nitidum var. *nitidum*		Shining peppergrass		native		
Lepidium strictum		Upright peppergrass		native		
Raphanus sativus		Radish		non		
Rorippa nasturtium-aquaticum		Water cress		native		
Thysanocarpus curvipes		Fringepod		native		
Thysanocarpus laciniatus				native		
Sisymbrium officinale		Hedge-mustard		non		
Tropidocarpum gracile		Slender tropidocarpum		native		
CALLITRICHACEAE						
Callitriche marginata		Water-starwort		native		
CAMPANULACEAE						
Downingia insignis		Harlequin downingia		native		
Githopsis specularioides		Common bluecup		native		
Nemacladus montanus		Mountain nemacladus		native		
CAPRIFOLIACEAE						
Sambucus mexicana		Blue elderberry		native		
CARYOPHYLLACEAE						
Herniaria hirsuta		Hairy herniaria		non		
Minuartia californica		California sandwort		native		
Minuartia douglasii		Douglas' sandwort		native		
Petrorhagia dubia		Grass-pink		non		
Sagina apetala		Dwarf pearlwort		native		
Sagina decumbens		Pearlwort		native		

Silene gallica		Windmill pink		non		
Spergularia marina		Salt marsh sandspurry		native		
Stellaria media		Common chickweed		non		
Stellaria nitens		Shiny starwort		native		
CHENOPODIACEAE						
Atriplex fruticulosa				native		
Atriplex rosea		Tumbling oracle		non		
Chenopodium album		Lamb's-quarters		non		
Chenopodium californicum		California goosefoot		native		
CONVOLVULACEAE						
Convolvulus arvensis		Bindweed		non		
Cressa truxillensis		Alkali weed		native		
CRASSULACEAE						
Crassula connata		Pygmy weed		native		
Dudleya cymosa ssp. *cymosa*		Canyon dudleya		native		
CUCURBITACEAE						
Marah fabaceus		California manroot		native		
CUPRESSACEAE						
Juniperus sp.		Juniper				
CYPERACEAE						
Carex sp.						
Cyperus eragrostis		Tall cyperus		native		
Eleocharis macrostachya		Spike-rush		native		
Scirpus acutus var. *occidentalis*		Hard-stemmed tule		native		
Scirpus americanus		American bulrush		native		
Scirpus californicus		California bulrush		native		
Scirpus maritimus		Saltmarsh bulrush		native		
Scirpus tuberosus		Tuberous bulrush		non		
ERICACEAE						
Arctostaphylos manzanita ssp. *manzanita*		Big manzanita		native		
EUPHORBIACEAE						
Chamaesyce glyptosperma		Rib-seeded spurge				
Chamaesyce ocellata		Valley spurge		native		
Chamaesyce seryillifolia ssp. *serpyllifolia*		Thyme-leaved spurge		native		
Eremocarpus setigerus		Turkey mullein		native		
Euphorbia spathulata		Warty spurge		native		
FABACEAE						
Astragalus gambelianus		Gambel's milkvetch		native		
Cercis occidentalis		Western redbud		native		
Glycyrrhiza lepidota		American licorice		native		

Lotus corniculatus		Birdfoot trefoil		non		
Lotus humistratus		Foothill lotus		native		
Lotus purshianus var. *purshianus*		Spanish lotus		native		
Lupinus albifrons var. *albifrons*		Silver bush lupine		native		
Lupinus bicolor		Bicolored lupine		native		
Lupinus latifolius var. *latifolius*		Broad-leaved lupine		native		
Lupinus microcarpus		Chick lupine		native		
Lupinus succulentus		Succulent lupine		native		
Medicago polymorpha		California bur-clover		non		
Melilotus officinalis		Yellow sweetclover		non		
Trifolium bifidum var. *bifidum*		Notch-leaved clover		native		
Trifolium bifidum var. *decipiens*		Deceptive clover		native		
Trifolium depauperatum var. *amplectans*		Involucrate cowbag clover		native		
Trifolium depauperatum var. *depauperatum*		Dwarf cowbag clover		native		
Trifolium fragiferum		Strawberry clover		non		
Trifolium fucatum		Sour clover		native		
Trifolium hirtum		Rose clover		non		
Trifolium obtusiflorum		Clammy clover		native		
Trifolium willdenovii		Tomcat clover		native		
Trifolium wormskioldii		Springbank clover		native		
Vicia benghalensis		Red-flowered vetch		non		
Vicia sativa		Garden vetch		non		
Vicia villosa ssp. *varia*		Winter vetch		non		
Vicia villosa ssp. *villosa*		Winter vetch		non		
FAGACEAE						
Quercus sp. (evergreen)		Live oak		native		
Quercus douglasii		Blue oak		native		
Quercus lobata		Valley oak		native		
FRANKENIACEAE						
Frankenia salina		Alkali heath		native		
GERANIACEAE						
Erodium botrys		Long-beaked stork's bill		non		
Erodium cicutarium		Red-stemmed filaree		non		
Erodiuim moschatum		White-stemmed filaree		non		
Geranium carolinianum		Carolina geranium		native		
Geranium dissectum		Cut-leaved geranium		non		
Geranium molle		Dove's-foot geranium		non		
HIPPOCASTANACEAE						
Aesculus californica		California buckeye		native		
HYDROPHYLLACEAE						
Eriodictyon californicum		California yerba santa		native		
Nemophila heterophylla		Variable-leaved nemophila		native		
Nemophila pedunculata		Meadow nemophila		native		
Phacelia egena		Rock phacelia		native		

Phacelia imbricata		Imbricate phacelia		native		
JUGLANDACEAE						
Juglans californica var. *hindsii*		Northern California black walnut		native		CNPS 1B
JUNCACEAE						
Juncus balticus		Baltic rush		native		
Juncus bufonius var. *bufonius*		Common toad rush		native		
Juncus bufonius var. *congestus*		Congested toad rush		native		
Juncus xiphioides		Iris-leaved rush		native		
LAMIACEAE						
Marrubium vulgare		Horehound		non		
Monardella sp.		Mint		native		
Salvia columbariae		Chia		native		
Salvia spathacea		Pitcher sage		native		
Stachys pycnantha		Short-spiked hedge-nettle		native		
Stachys ajugoides var. *ajugoides*		Hedge-nettle		native		
Trichostema lanceolatum		Vinegar weed		native		
LILIACEAE						
Allium amplectens		Clasping onion		native		
Allium serra		Serrate onion		native		
Brodiaea elegans ssp. *elegans*		Harvest brodiaea		native		
Calochortus luteus		Yellow mariposa lilly		native		
Chlorogalum pomeridianum		Soap plant		native		
Dichelostemma capitatum ssp. *capitatum*		Bluedicks		native		
Dichelostemma volubile		Twining ookow		native		
Muilla maritima		Common muilla		native		
Odontostomum hartwegii		Hartweg's odontostomum		native		
Triteleia hyacinthina		Wild hyacinth		native		
Triteleia laxa		Ithuriel's-spear		native		
LOASACEAE						
Mentzelia laevicaulis		Giant blazing star		native		
LYTHRACEAE						
Lythrum californicum		California loosestrife		native		
Lythrum hyssopifolium		Hyssop loosestrife		non		
Lythrum tribracteatum		Slender-fruited loosestrife		non		
MALVACEAE						
Malva parviflora		Little mallow		non		
Malvella leprosa		Alkali mallow		native		
Sidalcea diploscypha		Fringed sidalcea		native		
MARTYNIACEAE						
Proboscidea louisianica ssp. *louisianica*		Common unicorn plant		non		

MORACEAE						
Ficus carica		Edible fig		non		
OLEACEAE						
Olea europaea		Olive		non		
ONAGRACEAE						
Camissonia graciliflora		Hill suncup		native		
Clarkia affinis				native		
Clarkia purpurea ssp. *quadrivulnera*		Purple clarkia		native		
Epilobium cleistogamum		Cleistogamous spike-primrose		native		
Epilobium densiflorum		Dense-flowered spike-primrose		native		
Epilobium torreyi		Torrey's spike-primrose		native		
OROBANCHACEAE						
Orobanche fasciculata		Clustered broom-rape		native		
PAPAVERACEAE						
Eschscholzia caespitosa		Foothill poppy		native		
Eschscholzia californica		California poppy		native		
Eschscholzia lobbii		Fryingpans		native		
PINACEAE						
Pinus sabiniana		Foothill pine		native		
PLANTAGINACEAE						
Plantago coronopus		Cut-leaved plantain		non		
Plantago elongata		Elongate plantain		native		
Plantago erecta		Erect plantain		native		
Plantago ovata		Ovate plantain		native		
POACEAE						
Aegilops cylindrica		Jointed goatgrass		non		
Aegilops triuncialis		Barbed goatgrass		non		
Alopecurus saccatus		Vernal pool foxtail		native		
Aristida ternipes var. *hamulosa*		Hook three-awn		native		
Avena barbata		Slender wild oat		non		
Avena fatua		Wild oat		non		
Bromus diandrus		Ripgut grass		non		
Bromus hordeaceus		Softchess		non		
Bromus madritensis ssp. *rubens*		Foxtail chess		non		
Crypsis schoenoides		Swamp pricklegrass		non		
Cynodon dactylon		Bermuda grass		non		
Cynosurus echinatus		Hedgehog dogtail		non		
Deschampsia danthonioides		Annual hairgrass		native		
Distichlis spicata		Saltgrass		native		
Elymus glaucus		Wild rye		native		
Gastridium ventricosum		Nitgrass		non		
Hordeum brachyantherum ssp. *brachyantherum*		Meadow barley		native		

Hordeum marinum ssp. *gussoneanum*		Mediterranean barley		non		
Hordeum murinum ssp. *leporinum*		Hare wall barley				
Hordeum murinum ssp. *murinum*		Pale barley		non		
Koeleria macrantha		June grass		native		
Koeleria phleoides		Bristly Koeler's-grass		non		
Lolium multiflorum		Italian ryegrass		non		
Melica californica		California melic		native		
Muhlenbergia rigens		Deergrass		native		
Nassella cernua		Nodding needlegrass		native		
Nassella pulchra		Purple needlegrass		native		
Panicum capillare		Witchgrass		native		
Parapholis incurva		Sickle grass		non		
Paspalum dilatum		Dallisgrass		non		
Phalaris paradoxa		Paradox canary grass		non		
Poa annua		Annual bluegrass		non		
Poa bulbosa		Bulbous bluegrass		non		
Poa secunda ssp. *secunda*		One-sided bluegrass		native		
Polypogon maritimus		Mediterranean beardgrass		non		
Polypogon monspeliensis		Annual beardgrass		non		
Scribneria bolanderi		Scribner's grass		native		
Taeniatherum caput-medusae		Medusa-head		non		
Triticum aestivum		Bread wheat		non		
Vulpia bromoides		Six-weeks fescue		non		
Vulpia microstachys var. *ciliata*		Fringed fescue		native		
Vulpia myuros var. *myuros*		Rattail fescue		non		
POLEMONIACEAE						
Gilia tricolor		Bird's eye gilia		native		
Linanthus bicolor		Bicolored linanthus		native		
Linanthus ciliatus		Whiskerbrush		native		
Navarretia eriocephala		Hoary navarretia		native		CNPS 4
Navarretia heterandra		Tehama navarretia		native		CNPS 4
Navarretia intertexta		Needle-leaved navarretia		native		
Navarretia leucocephala ssp. *leucocephala*		White-flowered navarretia		native		
Navarretia nigelliformis ssp. *nigelliformis*		Adobe navarretia		native		
Navarretia pubescens		Downy navarretia		native		
Phlox gracilis		Slender phlox		native		
POLYGONACEAE						
Chorizanthe membranacea		Pink spineflower		native		
Eriogonum dasyanthemum		Wild buckwheat		native		
Eriogonum nudum var. *nudum*		Naked buckwheat		native		
Polygonum arenastrum		Common knotweed		non		
Pterostegia drymarioides		Pterostegia		native		
Rumex crispus		Curly dock		non		
Rumex salicifolius var. *salicifolius*		Willow dock		native		
PORTULACACEAE						
Calandrinia ciliata		Redmaids		native		

Claytonia exigua ssp. *exigua*		Little miner's lettuce		native		
Claytonia perfoliata		Common miner's lettuce		native		
Montia fontana		Water chickweed		native		
POTAMOGETONACEAE						
Potamogeton sp.		Pondweed				
PRIMULACEAE						
Anagallis arvensis		Scarlet pimpernel		non		
Androsace elongata ssp. *acuta*		Fairy candelabra		native		CNPS 4
Dodecatheon hendersonii		Henderson's shootingstar		native		
PTERIDACEAE						
Pellaea andromedifolia		Coffee fern		native		
Pentagramma triangularis ssp. *triangularis*		Goldbacked fern		native		
RANUNCULACEAE						
Delphinium hesperium ssp. *hesperium*		Pale larkspur		native		
Delphinium hesperium ssp. *pallescens*		Pale larkspur		native		
Delphinium variegatum ssp. *variegatum*		Royal larkspur		native		
Myosurus minimus		Common mousetail		native		
Ranunculus aquatilus		Water buttercup		native		
Ranunculus californicus		California buttercup		native		
Ranunculus hebecarpus		Pubescent-fruited buttercup		native		
Ranunculus muricatus		Prickle-seeded buttercup		non		
RHAMNACEAE						
Ceanothus cuneatus var. *cuneatus*		Buckbrush		native		
Rhamnus ilicifolia		Holly-leaved redberry		native		
ROSACEAE						
Adenostoma fasciculatum		Chamise		native		
Aphanes occidentalis		Western lady's-mantle		native		
Cercocarpus betuloides		Mountain-mahogany		native		
Heteromeles arbutifolia		Toyon		native		
Rosa californica		California rose		native		
Rubus sp.		Blackberry				
RUBIACEAE						
Crucianella angustifolia		Crosswort		non		
Galium aparine		Cleavers		native		
Galium parisiense		Wall bedstraw		non		
Galium porrigens var. *tenue*		Narrow-lvd climbing bedstraw		native		
Sherardia arvensis		Field-madder		non		
SALICACEAE						
Populus fremontii ssp. *fremontii*		Fremont cottonwood		native		
Salix exigua		Sandbar willow		native		
Salix goodingii		Black willow		native		

Salix laevigata	Red willow	native	
SAXIFRAGACEAE			
Lithophragma affine	San Francisco woodlandstar	native	
Saxifraga californica	California saxifrage	native	
SCROPHULARIACEAE			
Bellardia trixago		non	
Castilleja affinis ssp. *affinis*	Lay-and-Collie's Indian paintbrush	native	
Castilleja attenuata	Valley-tassels	native	
Castilleja exserta	Purple owl clover	native	
Collinsia sparsiflora var. *bruceae*	Bruce's few-flowered collinsia	native	
Collinsia sparsiflora var. *collina*	Few-flowered collinsia	native	
Collinsia sparsiflora var. *sparsiflora*	Few-flowered collinsia	native	
Kickxia elatine	Sharp-leaved fluellin	non	
Mimulus guttatus	Seep monkeyflower	native	
Mimulus latidens	Broad-toothed monkeyflower	native	
Penstemon heterophyllus var. *heterophyllus*	Foothill beardtongue		
Triphysaria eriantha ssp. *eriantha*	Butter-and-eggs	native	
Verbascum blattaria	Moth mullein	non	
Verbascum thapsus	Woolly mullein	non	
Veronica americana	American brookline	native	
Veronica anagallis-aquatica	Water speedwell	non	
Veronica peregrina ssp. *xalapensis*	Purslane speedwell	native	
Veronica persica	Persian speedwell	non	
SIMAROUBACEAE			
Ailanthus altissima	Tree-of-heaven	non	
SOLANACEAE			
Nicotiana glauca	Tree tobacco	non	
Lycopersicon esculentum	Garden tomato	non	
Physalis lancifolia	Lance-leaved ground-cherry	non	
Solanum parishii			
TYPHACEAE			
Typha angustifolia	Narrow-leaved cattail	native	
URTICACEAE			
Urtica urens	Dwarf nettle	non	
VALERIANACEAE			
Plectritis ciliosa ssp. *ciliosa*	Long-spurred pink plectritis	native	
Plectritis macrocera	White plectritis	native	
VERBENACEAE			
Phyla nodiflora var. *nodiflora*	Creeping lippia	native	
Verbena sp.			

FAMILY *Genus species*	**Common Name**	**Origin**	**Listing**	
Colusa				
ALISMATACEAE				
Alisma plantago-aquatica	Water plantain	native		
APIACEAE				
Anthriscus caucalis	Bur-chervil	non		
Daucus carota	Queen Anne's lace	non		
Daucus pusillus	Rattlesnake-weed	native		
Eryngium castrense	Coyote thistle	native		
Lomatium dasycarpum ssp. *tomentosum*	Woolly-fruited lomatium	native		
Lomatium marginatum var. *purpureum*	Margined lomatium	native		
Lomatium utriculatum	Bladder lomatium	native		
Sanicula bipinnata	Poison sanicle	native		
Sanicula bipinnatifida	Purple sanicle	native		
Torilis nodosa	Knotted hedge-parsley	non		
ASTERACEAE				
Achillea millifolium	Yarrow	native		
Achyrachaena mollis	Blow-wives	native		
Ancistrocarphus filagineus	Woolly fish-hooks	native		
Anthemis cotula	Mayweed	non		
Baccharis salicifolia	Mule fat	native		
Blennosperma nanum	Yellow carpet	native		
Calycadenia multiglandulosa	Sticky calycadenia	native		
Calycadenia pauciflora	Few-flowered calycadenia	native		
Carduus pycnocephalus	Italian plumeless-thistle	non		
Centaurea melitensis	Tocalote	native		
Centaurea solstitialis	Yellow star-thistle	non		
Chamomilla suaveolens	Pineapple-weed	non		
Cirsium occidentale var. *venustum*	Venus thistle	native		
Erigeron philadelphicus	Philadelphia daisy	native		
Eriophyllum lanatum	Woolly sunflower	native		
Filago gallica	Narrow-leaved filago	non		
Gnaphalium sp.	Cudweed			
Grindelia camporum var. *camporum*	Valley gumplant	native		
Helianthus annuus	Common sunflower	non		
Hemizonia pungens ssp. *pungens*	Common spikeweed	native		
Hesperevax acaulis var. *robustior*	Robust evax	native		
Hesperevax caulescens	Hogwallow starfish	native	CNPS 4	
Holocarpha virgata ssp. *virgata*	Wand tarweed	native		
Hypochaeris glabra	Smooth cat's ear	non		
Hypochaeris radicata	Rough cat's-ear	non		
Lactuca serriola	Prickly lettuce	non		
Lagophylla glandulosa	Glandular hareleaf	native		
Lasthenia glaberrima	Smooth goldfields	native		
Layia fremontii	Tidytips	native		
Lessingia nemaclada	Slender-stemmed lessingia	native		

Madia elegans ssp. *densifolia*	Common madia	native		
Madia glomerata	Mountain tarweed	native		
Madia gracilis	Slender tarweed	native		
Malacothrix floccifera	Woolly malacothrix	native		
Micropus californicus var. *californicus*	Slender cottonweed	native		
Microseris douglasii ssp. *douglasii*	Douglas' microseris	native		
Psilocarphus brevissimus ssp. *brevissimu*	Dwarf woolly-marbles	native		
Psilocarphus tenellus var. *tenellus*	Slender woolly-marbles	native		
Psilocarphus oregonus	Oregon woolly-marbles	native		
Rigiopappus leptocladus	Rigiopappus	native		
Senecio vulgaris	Old-man-in-the-spring	non		
Silybum marianum	Milk thistle	non		
Sonchus sp.	Sow-thistle			
Uropappus lindleyi	Silver puffs	native		
Wyethia glabra	Mule's ears	native		
Xanthium strumarium	Cocklebur	native		
BORAGINACEAE				
Amsinckia lycopsoides	Bugloss fiddleneck	native		
Amsinckia menziesii var. *menziesii*	Menzies' fiddleneck	native		
Cryptantha flaccida	Weak-stemmed cryptantha	native		
Cryptantha intermedia	Common cryptantha	native		
Pectocarya penicillata	Winged pectocarya	native		
Plagiobothrys bracteatus	Bracted popcornflower	native		
Plagiobothrys canescens	Valley popcornflower	native		
Plagiobothrys fulvus	Fulvous popcornflower	native		
Plagiobothrys greenei	Greene's popcornflower	native		
Plagiobothrys nothofulvus	Common popcornflower	native		
Plagiobothrys scriptus	Scribe's popcornflower	native		
Plagiobothrys stipitatus var. *micranthus*	Lg-flwd stalked popcornflower	native		
Plagiobothrys stipitatus var. *stipitatus*	Sm-flwd stalked popcornflower	native		
BRASSICACEAE				
Athysanus pusillus	Petty athysanus	native		
Brassica nigra	Black mustard	non		
Brassica rapa	Field mustard	non		
Capsella bursa-pastoris	Shepherd's purse	non		
Draba verna	Spring whitlow-grass	native		
Erysimum capitatum	Western wallflower	native		
Guillenia lasiophylla	Hairy-leaved guillenia	native		
Lepidium dictyotum var. *acutidens*	Sharp-toothed peppergrass	native		
Lepidium latipes var. *latipes*	Dwarf peppergrass	native		
Lepidium nitidum var. *nitidum*	Shining peppergrass	native		
Lepidium strictum	Upright peppergrass	native		
Rorippa nasturtium-aquaticum	Watercress	native		
Thysanocarpus curvipes	Fringepod	native		
Tropidocarpum gracile	Slender tropidocarpum	native		
Sisymbrium officinale	Hedge-mustard	non		
Streptanthus glandulosus ssp. *g.*	Glandular jewelflower	native		

Tropidocarpum gracile	Slender tropidocarpum	native		
CALLITRICHACEAE				
Callitriche marginata	Water starwort	native		
CAMPANULACEAE				
Downingia insignis	Harlequin downingia	native		
Triodanus perfoliata	Venus'-looking-glass	native		
CAPRIFOLIACEAE				
Sambucus mexicana	Blue elderberry	native		
Symphoricarpos sp.	Snowberry	native		
CARYOPHYLLACEAE				
Cerastium glomeratum	Sticky mouse-eared chickweed	non		
Minuartia californica	California sandwort	native		
Petrorhagia dubia	Grass-pink	non		
Sagina apetala	Dwarf pearlwort	native		
Silene gallica	Windmill pink	non		
Stellaria media	Common chickweed	non		
Stellaria nitens	Shiny starwort	native		
Stellaria pallida	Pale chickweed	non		
Velezia rigida	Velezia	non		
CHENOPODIACEAE				
Chenopodium californicum	California goosefoot	native		
CONVOLVULACEAE				
Convolvulus arvensis	Bindweed	non		
Cressa truxillensis	Alkali-weed	native		
CRASSULACEAE				
Crassula connata	Pygmy weed	native		
CUCURBITACEAE				
Marah fabaceus	California manroot	native		
CUPRESSACEAE				
Juniperus occidentalis var. *australis*	Western juniper	native		
CYPERACEAE				
Cyperus eragrostis	Tall cyperus	native		
Eleocharis acicularis	Spike-rush	native		
Eleocharis macrostachya	Pale spike-rush	native		
Scirpus acutus var. *occidentalis*	Hard-stemmed tule	native		
Scirpus maritimus	Saltmarsh bulrush	native		
ERICACEAE				
Arctostaphlos manzanita ssp. *manzanita*	Big manzanita	native		

EUPHORBIACEAE				
Eremocarpus setigerus	Turkey mullein	native		
Euphorbia spathulata	Warty spurge	native		
FABACEAE				
Astragalus gambelianus	Gambel's milkvetch	native		
Cercis occidentalis	Western redbud	native		
Lotus humistratus	Foothill lotus	native		
Lotus purshianus var. *purshianus*	Spanish lotus	native		
Lupinus albifrons var. *albifrons*	Silver bush lupine	native		
Lupinus bicolor	Bicolored lupine	native		
Lupinus latifolius var. *latifolius*	Broad-leaved lupine	native		
Lupinus microcarpus var. *densiflorus*	White-whorled lupine	native		
Medicago polymorpha var. *brevispina*	California burclover	non		
Melilotus officinalis	Yellow sweetclover	non		
Trifolium bifidum var. *bifidum*	Notch-leaved clover	native		
Trifolium fragiferum	Strawberry clover	non		
Trifolium fucatum	Sour clover	native		
Trifolium hirtum	Rose clover	non		
Trifolium depauperatum var. *d.*	Dwarf cowbag clover	native		
Trifolium depauperatum *var. amplectans*	Involucrate cowbag clover	native		
Trifolium willdenovii	Tomcat clover	native		
Vicia benghalensis	Red-flowered vetch	non		
FAGACEAE				
Quercus sp. (evergreen)	Live oak			
Quercus douglasii	Blue oak	native		
Quercus lobata	Valley oak	native		
FRANKENIACEAE				
Frankenia salina	Alkali heath	native		
GERANIACEAE				
Erodium botrys	Long-beaked stork's bill			
Erodium cicutarium	Red-stemmed filaree	non		
Erodium moschatum	White-stemmed filaree			
Geranium dissectum	Cut-leaved geranium	non		
Geranium molle	Dove's foot geranium	non		
HIPPOCASTANACEAE				
Aesculus californicus	California buckeye	native		
HYDROPHYLLACEAE				
Eriodictyon californicum	California yerba santa	native		
Nemophylla heterophylla	Variable-leaved nemophylla	native		
Phacelia sp.				
IRIDACEAE				
Iris sp.	Iris			

JUGLANDACEAE				
Juglans californica var. *hindsii*	Northern California black walnut	native	CNPS 1B	
JUNCACEAE				
Juncus balticus	Baltic rush	native		
Juncus bufonius var. *bufonius*	Common toadrush	native		
Juncus mexicanus	Mexican juncus	native		
Juncus xiphioides	Iris-leaved rush	native		
LAMIACEAE				
Marrubium vulgare	Horehound	non		
Monardella sp.	Mint	native		
Salvia columbariae	Chia	native		
Stachys stricta	Sonoma hedge-nettle	native		
LILIACEAE				
Allium amplectans	Clasping onion	native		
Allium serra	Serrate onion	native		
Brodiaea elegans ssp. *elegans*	Elegant brodiaea	native		
Calochortus luteus	Yellow mariposa lilly	native		
Chlorogalum sp.	Soaproot	native		
Dichelostemma capitatum ssp. *capitatum*	Bluedicks	native		
Dichelostemma volubile	Twining ookow	native		
Muilla maritima	Common muilla	native		
Odontostomum hartwegii	Hartweg's odontostomum	native		
Triteleia laxa	Ithuriel's spear	native		
LINACEAE				
Hesperolinon spergulinum	Dwarf flax	native		
LOASACEAE				
Mentzelia albicaulis	White-stemmed blazingstar	native		
Mentzelia laevicaulis	Giant blazing star	native		
LYTHRACEAE				
Lythrum californicum	California loosestrife	native		
Lythrum hyssopifolium	Hyssop loosestrife	non		
Lythrum tribracteatum	Slender-fruited loosestrife	non		
MALVACEAE				
Malva parviflora	Little mallow	non		
Malvella leprosa	Alkali mallow	native		
Sidalcea diploscypha	Fringed sidalcea	native		
MARTYNIACEAE				
Proboscidea louisianica ssp. *louisianica*	Common unicorn plant	non		

MORACEAE					
Ficus carica	Edible fig	non			
OLEACEAE					
Olea europaea	Olive	non			
ONAGRACEAE					
Camissonia graciliflora	Hill suncup	native			
Clarkia affinis		native			
Clarkia concinna ssp. *concinna*	Red ribbons	native			
Clarkia gracilis ssp. gracilis	Slender clarkia	native			
Epilobium cleistogamum	Cleistogamous spike-primrose	native			
Epilobium densiflorum	Dense-flowered spike-primrose	native			
OROBANCHACEAE					
Orobanche fasciculata	Clustered broom-rape	native			
PAPAVERACEAE					
Eschscholzia caespitosa	Foothill poppy	native			
Eschscholzia californica	California poppy	native			
Eschscholzia lobbii	Fryingpans	native			
PINACEAE					
Pinus sabiniana	Foothill pine	native			
PLANTAGINACEAE					
Plantago coronopus	Cut-leaved plantain	non			
Plantago elongata	Elongate plantain	native			
Plantago erecta	Erect plantain	native			
Plantago ovata	Ovate plantain	native			
POACEAE					
Aegilops cylindrica	Jointed goatgrass	non			
Aegilops triuncialis	Barbed goatgrass	non			
Avena barbata	Slender wild oat	non			
Avena fatua	Wild oat	non			
Aristida ternipes var. *hamulosa*	Hook three-awn	native			
Briza minor	Lesser quaking grass	non			
Bromus diandrus	Ripgut grass	non			
Bromus hordeaceus	Softchess	non			
Bromus japonicus	Japanese chess	non			
Bromus madritensis ssp. *rubens*	Foxtail chess	non			
Cynosurus echinatus	Hedgehog dogtail	non			
Deschampsia danthonioides	Annual hairgrass	native			
Distichlis spicata	Saltgrass	native			
Gastridium ventricosum	Nitgrass	non			
Hordeum brachyantherum ssp. *b.*	Meadow barley	native			
Hordeum brachyantherum ssp. *californicu*	California meadow barley	native			
Hordeum marinum ssp. *gussoneanum*	Mediterranean barley	non			

Hordeum murinum ssp. *leporinum*	Hare wall barley	non		
Hordeum murinum ssp. *murinum*	Wall barley	non		
Koeleria macrantha	June grass	native		
Koeleria phleoides	Bristly Koeler's-grass	non		
Lolium multiflorum	Italian ryegrass	non		
Melica californica	California melic	native		
Muhlenbergia rigens	Muhly	native		
Nassella cernua	Nodding needlegrass	native		
Nassella pulchra	Purple needlegrass	native		
Parapholis incurva	Sickle grass	non		
Phalaris paradoxica	Paradox canary grass	non		
Poa annua	Annual bluegrass	non		
Poa bulbosa	Bulbous bluegrass	non		
Polypogon sp.				
Taeniatherum caput-medusae	Medusa-head	non		
Triticum aestivum	Bread wheat	non		
Vulpia bromoides	Six-weeks fescue	non		
Vulpia microstachys var. *ciliata*	Fringed fescue	native		
Vulpia microstachys var. *confusa*	Hairy-leaved fescue	native		
Vulpia myuros var. *hirsuta*	Foxtail fescue	non		
Vulpia myuros var. *myuros*	Rattail fescue	non		
POLEMONIACEAE				
Gilia tricolor	Bird's eye gilia	native		
Linanthus bicolor	Bicolored linanthus	native		
Linanthus ciliatus	Whiskerbrush	native		
Linanthus dichotomus	Evening snow	native		
Linanthus parviflorus	Cherokee linanthus	native		
Navarretia eriocephala	Hoary navarretia	native	CNPS 4	
Navarretia heterandra	Tehama navarretia	native	CNPS 4	
Navarretia nigelliformis ssp. *nigelliformis*	Adobe navarretia	native		
Navarretia pubescens	Downy navarretia	native		
Phlox gracilis	Slender phlox	native		
POLYGONACEAE				
Chorizanthe membranaceae	Pink spineflower	native		
Eriogonum dasyanthemum	Wild buckwheat	native		
Polygonum arenastrum	Common knotweed	non		
Pterostegia drymarioides	Pterostegia	native		
Rumex crispus	Curly dock	non		
PORTULACACEAE				
Calandrinia ciliata	Redmaids	native		
Claytonia exigua	Little miner's lettuce	native		
Claytonia parviflora ssp. *parviflora*	Miner's lettice	native		
Claytonia perfoliata	Common miner's lettuce	native		
Montia fontana	Water chickweed	native		
PRIMULACEAE				

Anagallis arvensis	Scarlet pimpernel	non		
Androsace elongata ssp. *acuta*	Fairy candelabra	native	CNPS 4	
PTERIDACEAE				
Pentagramma triangularis ssp. *t.*	Gold-backed fern	native		
RANUNCULACEAE				
Delphinium hesperium ssp. *hesperium*	Pale larkspur	native		
Delphinium hesperium ssp. *pallescens*	Pale larkspur	native		
Myosurus minimus	Common mousetail	native		
Ranunculus aquatilus	Water buttercup	native		
Ranunculus californicus	California buttercup	native		
Ranunculus hebecarpus	Pubescent-fruited buttercup	native		
Ranunculus muricatus	Prickle-seeded buttercup	non		
Ranunculus occidentalis	Western buttercup	native		
RHAMNACEAE				
Ceanothus cuneatus var. *cuneatus*	Buckbrush	native		
ROSACEAE				
Aphanes occidentalis	Western lady's mantle	native		
Holodiscus discolor	Oceanspray	native		
Rosa californica	California rose	native		
RUBIACEAE				
Crucianella angustifolia	Crosswort	non		
Galium aparine	Cleavers	native		
Galium parisiense	Wall bedstraw	non		
SALICACEAE				
Populus fremontii ssp. *fremontii*	Fremont cottonwood	native		
Salix sitchensis	Sitka willow	native		
SAXIFRAGACEAE				
Saxifraga californica	California saxifrage	native		
SCROPHULARIACEAE				
Bellardia trixago		non		
Castilleja attenuata	Valley-tassels	native		
Castilleja exserta	Purple owl clover	native		
Collinsia sparsifolia var. *collina*	Few-flowered collinsia	native		
Mimulus guttatus	Seep monkey flower	native		
Penstemon heterophyllus var. *heterophyl*	Foothill beardtongue	native		
Triphysaria eriantha ssp. *eriantha*	Butter and eggs	native		
Verbascum thapsus	Woolly mullein	non		
Veronica peregrina ssp. *xalapensis*	Purslane speedwell	native		
SIMARUBACEAE				
Ailanthus altissima	Tree-of-heaven	non		

SOLANACEAE				
Nicotiana glauca	Tree tobacco	non		
TYPHACEAE				
Typha sp.	Cattail	native		
VALERIANACEAE				
Plectritis ciliosa ssp. *ciliosa*	Ciliate plectritis	native		
Plectritis macrocera	White plectritis	native		
VERBENACEAE				
Phyla nodiflora	Creeping lippia	native		

V	FAMILY *Genus species*		Common Name	Origin	Listing
	Newville				
	ACERACEAE				
	Acer macrophyllum		Big-leaved maple	native	
	ALISMATACEAE				
	Alisma plantago-aquatica ssp. *brevipes*		Water-plantain	native	
*	*Damasonium californicum*		Fringed water-plantain	native	
	Echinodorus berteroi		Burhead	native	
	Sagittaria montevidensis ssp. *calycina*		Montevideo arrowhead	native	
	AMARANTHACEAE				
*	*Amaranthus albus*		Tumbleweed	non	
	Amaranthus blitoides		Mat amaranth	native	
	ANACARDIACEAE				
	Rhus trilobata		Skunkbrush	native	
	Toxicodendron diversilobum		Western poison oak	native	
	APIACEAE				
*	*Anthriscus caucalis*		Bur-chervil	non	
	Daucus carota		Queen Anne's lace	non	
*	*Daucus pusillus*		Rattlesnake-weed	native	
*	*Eryngium castrense*		Coyote thistle	native	
	Foeniculum vulgare		Fennel	non	
*	*Lomatium dasycarpum* ssp. *dasycarpum*		Hairy-fruited lomatium	native	
*	*Lomatium dasycarpum* ssp. *tomentosum*		Woolly-fruited lomatium	native	
*	*Lomatium marginatum* var. *marginatum*		Margined lomatium	native	
*	*Lomatium marginatum* var. *purpureum*		Margined lomatium	native	
*	*Lomatium utriculatum*		Bladder lomatium	native	
*	*Perideridia kelloggii*		Kellogg's yampah	native	
	Sanicula bipinnata		Poison sanicle	native	
	Sanicula bipinnatifida		Purple sanicle	native	
	Sanicula crassicaulis		Pacific sanicle	native	
*	*Torilis arvensis* ssp. *arvensis*		Common hedge-parsley	non	
*	*Torilis nodosa*		Knotted hedge-parsley	non	
	Yabea microcarpa		California hedge-parsley	native	
	APOCYNACEAE				
	Apocynum cannabinum		Indian-hemp	native	
	ARISTOLOCHIACEAE				
	Aristolochia californica		California pipevine	non	
	ASCLEPIADACEAE				
	Asclepias eriocarpa		Indian milkweed	native	
	Asclepias fascicularis		Narrow-leaved milkweed	native	

	ASTERACEAE			
	Achillea millifolium	Yarrow	native	
	Achyrachaena mollis	Blow-wives	native	
*	*Agoseris heterophylla*	Annual agoseris	native	
*	*Ancistrocarphus filagineus*	Woolly fishhooks	native	
	Anthemis cotula	Mayweed	non	
	Artemisia douglasiana	Mugwort	native	
	Baccharis salicifolia	Mule fat	native	
	Bellis perennis	English daisy	non	
	Blepharipappus scaber	Rough eyelash	native	
	Brickellia californica	California brickellbush	native	
*	*Calycadenia multiglandulosa*	Sticky calycadenia	native	
*	*Centaurea melitensis*	Tocalote	native	
	Centaurea solstitialis	Yellow star-thistle	non	
	Chaenactis glabriscula var. *glabriscula*	Yellow pincushion	native	
*	*Chaenactis glabriuscula* var. *heterocarpha*	Yellow pincushion	native	
*	*Chaenactis glabriuscula* var. *megacephala*	Yellow pincushion	native	
	Chamomilla suaveolens	Pineapple weed	non	
	Cichorium intybus	Chicory	non	
*	*Cirsium occidentale* var. *venustum*	Venus thistle	native	
	Cirsium vulgare	Bull thistle	non	
*	*Crocidium multicaule*	Spring gold	native	
*	*Ericameria linearifolia*	Interior goldenbush	native	
*	*Eriophyllum lanatum* var. *achillaeoides*	Yarrow woolly sunflower	native	
*	*Eriophyllum lanatum* var. *aphanactis*	Rayless woolly sunflower	native	
*	*Eriophyllum lanatum* var. *grandiflorum*	Large-flowered woolly sunflower	native	
*	*Filago gallica*	Narrow-leaved filago	non	
	Gnaphalium palustre	Everlasting	native	
*	*Gnaphalium luteo-album*	Weedy cudweed	non	
	Grindelia camporum var. *camporum*	Valley gumplant	native	
	Helianthus annuus	Common sunflower	native	
	Helianthus bolanderi	Bolander's sunflower	native	
	Hemizonia congesta ssp. *luzulifolia*	Hayfield tarweed	native	
*	*Hemizonia fitchii*	Fitch's spikeweed	native	
	Hemizonia pungens ssp. *pungens*	Common spikeweed	native	
*	*Hesperevax caulescens*	Hogwallow starfish	native	CNPS 4
*	*Holocarpha obconica*	Tar plant	native	
*	*Holocarpha virgata* ssp. *virgata*	Wand tarweed	native	
*	*Hypochaeris glabra*	Smooth cat's-ear	non	
*	*Hypochaeris radicata*	Rough cat's ear	non	
	Lactuca serriola	Prickly lettuce	non	
*	*Lagophylla glandulosa*	Glandular hareleaf	native	
*	*Lagophylla minor*	Lesser hareleaf	native	
*	*Lagophylla ramosissima* ssp. *ramosissima*	Slender hareleaf	native	
*	*Lasthenia californica*	California goldfields	native	
	Lasthenia glaberrima	Smooth goldfields	native	
*	*Layia fremontii*	Fremont's tidytips	native	
	Leontodon taraxacoides	Hawkbit	non	
	Lessingia filaginifolia var. *californica*	California aster	native	
*	*Lessingia nana*	Dwarf lessingia	native	
*	*Lessingia nemaclada*	Slender-stemmed lessingia	native	

	Machaeranthera gracilis		Slender macheranthera	native	
*	*Madia elegans* ssp. *densifolia*		Dense-leaved madia	native	
*	*Madia exigua*		Thread-stemmed madia	native	
	Madia glomerata		Mountain tarweed	native	
*	*Madia gracilis*		Slender tarweed	native	
*	*Malacothrix floccifera*		Woolly malacothrix	native	
*	*Micropus californicus* var. *californicus*		Slender cottonweed	native	
*	*Microseris acuminata*		Sierra foothill microseris	native	
*	*Microseris douglasii* ssp. *douglasii*		Douglas' microseris	native	
*	*Monolopia gracilens*		Slender monolopia	native	
	Picris echioides		Bristly ox-tongue	non	
*	*Psilocarphus brevissimus* var. *brevissimus*		Dwarf woolly-heads	native	
*	*Psilocarphus oregonus*		Oregon woolly-heads	native	
*	*Psilocarphus tenellus* var. *tenellus*		Slender woolly-marbles	native	
*	*Rafinesquia californica*		California chicory	native	
*	*Rigiopappus leptocladus*		Rigiopappus	native	
	Senecio vulgaris		Groundsel	non	
	Silybum marianum		Milk-thistle	non	
*	*Sonchus asper* ssp. *asper*		Spiny-leaved sow-thistle	non	
*	*Stephanomeria* sp.			native	
	Taraxacum officinale		Dandelion	non	
*	*Uropappus lindleyi*		Silver puffs	native	
*	*Wyethia angustifolia*		Narrow-leaved mule's ears	native	
*	*Wyethia helenioides/glabra*		Gray-green mule's ears	native	
	Wyethia mollis		Woolly mule's-ears	native	
	Xanthium strumarium		Cocklebur	native	
	BETULACEAE				
	Alnus rhombifolia		White alder	native	
	BLECHNACEAE				
	Blechnum spicant		Deer fern	native	
	BORAGINACEAE				
	Amsinckia eastwoodiae		Eastwood's fiddleneck	native	
	Amsinckia lycopsoides		Bugloss fiddleneck	native	
	Amsinckia menziesii var. *intermedia*		Common fiddleneck	native	
*	*Amsinckia menziesii* var. *menziesii*		Menzie's fiddleneck	native	
*	*Cryptantha flaccida*		Weak-stemmed cryptantha	native	
*	*Cryptantha intermedia*		Common cryptantha	native	
	Cryptantha muricata		Prickle-seeded cryptantha	native	
	Heliotropium curassavicum		Wild heliotrope	native	
	Heliotropium europaeum		European heliotrope	non	
	Pectocarya penicillata		Winged pectocarya	native	
	Pectocarya pusilla		Little pectocarya	native	
	Plagiobothrys bracteatus		Bracted popcornflower	native	
*	*Plagiobothrys fulvus*		Fulvous popcornflower	native	
*	*Plagiobothrys greenei*		Greene's popcornflower	native	
*	*Plagiobothrys nothofulvus*		Perennial popcornflower	native	
*	*Plagiobothrys stipitatus* var. *micranthus*		Small-flwd stalked popcornflower	native	
	Plagiobothrys stipitatus var. *stipitatus*		Large-flwd stalked popcornflower	native	
*	*Plagiobothrys tenellus*		Slender popcornflower	native	

*	*Plagiobothrys undulatus*		Coast popcornflower	native	
	BRASSICACEAE				
	Athysanus pusillus		Petty athysanus	native	
	Brassica sp.		Mustard	non	
	Capsella bursa-pastoris		Shepherd's purse	non	
*	*Cardamine oligosperma*		Bitter-cress	native	
*	*Cardaria chalapensis*		Lens-podded hoarycress	non	
	Draba verna		Spring whitlow-grass	native	
	Lepidium latifolium		White-top	non	
*	*Lepidium latipes* var. *latipes*		Dwarf peppergrass	native	
*	*Lepidium nitidum* var. *nitidum*		Shining peppergrass	native	
	Lepidium nitidum var. *oreganum*		Oregon shining peppergrass	native	
	Lepidium oblongum var. *oblongum*			native	
*	*Lepidium strictum*		Upright peppergrass	native	
	Raphanus sp.		Wild radish	non	
*	*Rorippa nasturtium-aquaticum*		Watercress	native	
*	*Sisymbrium officinale*		Hedge-mustard	non	
*	*Streptanthus glandulosus* ssp. *glandulosus*		Jewelflower	native	
*	*Thysanocarpus curvipes*		Lacepod	native	
	Thysanocarpus laciniatus		Fringepod	native	
*	*Tropidocarpum gracile*		Slender tropidocarpum	native	
	CALLITRICHACEAE				
	Callitriche marginata		Water starwort	native	
	CALYCANTHACEAE				
	Calycanthus occidentalis		Western spicebush	native	
	CAMPANULACEAE				
	Downingia insignis		Harlequin downingia	native	
*	*Githopsis specularioides*		Bluecup	native	
	Heterocodon rariflorum		Heterocodon	native	
*	*Nemocladus montanus*		Mountain nemocladus	native	
	Triodanis biflora		Small Venus'-looking-glass	native	
	CAPRIFOLIACEAE				
*	*Lonicera hispidula* var. *vacillans*		Hairy honeysuckle	native	
*	*Lonicera interrupta*		Chaparral honeysuckle	native	
	Sambucus mexicana		Blue elderberry	native	
	Symphoricarpos albus var. *laevigatus*		Common snowberry	native	
	CARYOPHYLLACEAE				
	Cerastium glomeratum		Mouse-ear chickweed	non	
	Minuartia californica		California sandwort	native	
*	*Minuartia douglasii*		Douglas' sandwort	native	
	Moenchia erecta ssp. *erecta*		Upright chickweed	non	
	Petrorhagia dubia		Grass-pink	non	
*	*Sagina apetala*		Dwarf pearlwort	native	
	Sagina decumbens ssp. *occidentalis*		Western pearlwort	native	
*	*Scleranthus annuus* ssp. *annuus*		Knawel weed	non	
*	*Silene gallica*		Catch-fly	non	

	Spergularia bocconii		Boccone's sandspurry	non	
*	*Spergularia marina*		Sandspurry	native	
	Stellaria media		Common chickweed	non	
	Stellaria nitens		Shining chickweed	native	
*	*Velezia rigida*		Velezia	non	
	CHENOPODIACEAE				
	Chenopodium foliosum		Leafy goosefoot	non	
	CONVOLVULACEAE				
	Calystegia occidentalis ssp. *occidentalis*		Western morning-glory	native	
	Convolvulus arvensis		Field bindweed	non	
	CRASSULACEAE				
*	*Crassula aquatica*		Water pygmyweed	native	
	Crassula connata		Pygmy-weed	native	
*	*Crassula tillaea*		Mossy pygmyweed	native	
	CUCURBITACEAE				
	Marah fabaceus		California man-root	native	
	CUPRESSACEAE				
*	*Juniperus californicus*		California juniper	native	
	CYPERACEAE				
*	*Carex nudata*		Torrent sedge	native	
*	*Carex praegracilis*		Clustered field sedge	native	
*	*Carex serratodens*		Saw-toothed sedge	native	
*	*Carex nebrascensis*		Nebraska sedge	native	
	Cyperus eragrostis		Tall cyperus	native	
*	*Cyperus squarrosus*		Awned cyperus	native	
*	*Eleocharis obtusa* var. *englemannii*		Englemann's spikerush	native	
	Eleocharis macrostachya		Pale spike-rush	native	
*	*Scirpus acutus* var. *occidentalis*		Hard-stemmed tule	native	
*	*Scirpus pungens*		Common threesquare	native	
	DATISCACEAE				
	Datisca glomerata		Durango root	native	
	DENNSTAEDTIACEAE				
	Pteridium aquilinum var. *pubescens*		Bracken fern	native	
	ELATINACEAE				
*	*Elatine californica*		California waterwort	native	
	ERICACEAE				
*	*Arctostaphylos manzanita* ssp. *manzanita*		Big manzanita	native	
	Arctostaphylos viscida ssp. *viscida*		White-leaved manzanita	native	
	EQUISETACEAE				
*	*Equisetum hyemale* ssp. *affine*		Common scouring-rush	native	
	Equisetum laevigatum		Smooth scouring-rush	native	

	Equisetum telmateia ssp. *braunii*	Giant horsetail		
	EUPHORBIACEAE			
	Chamaesyce glyptosperma	Rib-seeded spurge	native	
*	*Chamaesyce ocellata* ssp. *ocellata*	Valley spurge	native	
	Chamaesyce ocellata ssp. *ocellata* x *C. ocellata* ssp. *rattanii*		native	
	Chamaesyce ocellata ssp. *rattanii*	Stony Creek spurge	native	CNPS 4
	Eremocarpus setigerus	Turkey mullein	native	
*	*Euphorbia spathulata*	Warty spurge	native	
	FABACEAE			
*	*Astragalus gambelianus*	Gambel's milkvetch	native	
*	*Astragalus rattanii* var. *jepsonianus*	Jepson's milkvetch	native	SC/1B
	Cercis occidentalis	Western redbud	native	
	Glycyrrhiza lepidota	American licorice	native	
	Lotus corniculatus	Bird-foot trefoil	non	
*	*Lotus humistratus*	Foothill lotus	native	
	Lotus purshianus var. *purshianus*	Spanish lotus	native	
*	*Lotus wrangelianus*	Wrangel lotus	native	
*	*Lupinus affinis*	Fleshy lupine	native	
*	*Lupinus albifrons* var. *albifrons*	Silver bush lupine	native	
*	*Lupinus bicolor*	Miniature lupine	native	
	Lupinus latifolius var. *latifolius*	Broad-leaved lupine	native	
	Lupinus luteolus	Butter lupine	native	
*	*Lupinus densiflorus*	White-whorled lupine	native	
	Lupinus microcarpus var. *microcarpus*	Chick lupine	native	
	Lupinus nanus	Sky lupine	native	
*	*Lupinus succulentus*	Succulent lupine	native	
	Medicago polymorpha	California bur-clover	non	
*	*Melilotus indicus*	Sourclover	non	
	Melilotus officinalis	Yellow sweetclover	non	
	Trifolium albopurpureum var. *albopurpureum*	Indian clover	native	
*	*Trifolium bifidum* var. *bifidum*	Notch-leaved clover	native	
*	*Trifolium bifidum* var. *decipiens*	Deceptive clover	native	
	Trifolium campestre	Hop clover	non	
*	*Trifolium ciliolatum*	Foothill clover	native	
*	*Trifolium depauperatum* var. *amplectans*	Involucrate cowbag clover	native	
*	*Trifolium depauperatum* var. *depauperatum*	Dwarf cowbag clover	native	
*	*Trifolium dubium*	Little hop clover	non	
	Trifolium fragiferum	Strawberry clover	non	
*	*Trifolium fucatum*	Sour clover	native	
*	*Trifolium gracilentum* var. *gracilentum*	Slender clover	native	
*	*Trifolium hirtum*	Rose clover	non	
*	*Trifolium microcephalum*	Small-headed clover	native	
	Trifolium monanthum var. *monanthum*	Carpet clover	native	
	Trifolium oliganthum	Lanky clover	native	
*	*Trifolium subterraneum*	Subterranean clover	non	
*	*Trifolium variegatum*	White-tipped clover	native	
*	*Trifolium willdenovii*	Tomcat clover	native	
*	*Trifolium wormskioldii*	Springbank clover	native	
	Vicia sativa ssp. *sativa*	Spring vetch	non	
	Vicia villosa ssp. *varia*	Hairy vetch	non	

	Vicia villosa ssp. *villosa*	Hairy winter vetch	non	
	FAGACEAE			
	Quercus berberidifolia	Scrub oak	native	
	Quercus chrysolepis	Canyon live oak	native	
	Quercus douglasii	Blue oak	native	
	Quercus lobata	Valley oak	native	
	GENTIANACEAE			
*	Centaurium tricanthum	Alkali centaury	native	
	Centaurium venustum	Canchalagua	native	
*	*Cicendia quadrangularis*	Timwort	native	
	GERANIACEAE			
	Erodium botrys	Long-beaked stork's bill	non	
*	*Erodium cicutarium*	Red-stemmed filaree	non	
	Erodium moschatum	White-stemmed filaree	non	
	Geranium dissectum	Cut-leaved geranium	non	
	Geranium molle	Dove's foot geranium	non	
	HIPPOCASTANACEAE			
	Aesculus californicus	California buckeye	native	
	HYDROPHYLLACEAE			
	Eriodictyon californicum	California yerba santa	native	
*	*Nemophila heterophylla*	Variable-leaved nemophila	native	
	Nemophila menziesii ssp. *menziesii*	Baby blue eyes	native	
	Nemophila pedunculata	Meadow nemophila	native	
*	*Phacelia distans*	Common phacelia	native	
*	*Phacelia egena*	Rock phacelia	native	
	Phacelia imbricata ssp. *imbricata*	Imbricate phacelia	native	
	Phacelia ramosissima var. *latifolia*		native	
*	*Phacelia ramosissima* var. *ramosissima*	Branched phacelia	native	
	HYPERICACEAE			
	Hypericum anagalloides	Tinker's penny	native	
	ISOETACEAE			
	Isoetes sp.	Quillwort	native	
	JUGLANDACEAE			
	Juglans californica var. *hindsii*	Northern California black walnut	native	CNPS 1B
	JUNCACEAE			
*	*Juncus balticus*	Baltic rush	native	
*	*Juncus bufonius* var. *bufonius*	Common toadrush	native	
*	*Juncus bufonius* var. *congestus*	Congested toadrush	native	
	Juncus capitatus	Leafy-bracted dwarf rush	non	
*	*Juncus mexicanus*	Mexican rush	native	
*	*Juncus xiphioides*	Iris-leaved rush	native	
	LAMIACEAE			

	Agastache urticifolia	Horsemint	native	
	Marrubium vulgare	Horehound	non	
*	*Monardella sheltonii*	Shelton's coyote-mint	native	
	Pogogyne douglasii	Douglas' pogogyne	native	
*	*Pogogyne zizyphoroides*	Sacramento Valley pogogyne	native	
*	*Salvia columbariae*	Chia	native	
	Scutellaria californica	California skullcap	native	
	Scutellaria siphocampyloides	Gray-leaved skullcap		
	Stachys ajugoides	Hedge-nettle	native	
	Stachys stricta	Sonoma hedge-nettle	native	
	LILIACEAE			
	Allium amplectens	Clasping onion	native	
*	*Allium falcifolium*		native	
*	*Allium serra*	Serrate onion	native	
	Brodiaea elegans ssp. *elegans*	Elegant brodiaea	native	
*	*Calochortus luteus*	Yellow mariposa-lily	native	
	Chlorogalum angustifolium	Narrow-leaved soap plant	native	
	Chlorogalum pomeridianum var. *pomeridianum*	Wavy-leaved soap plant	native	
	Dichelostemma capitatum ssp. *capitatum*	Bluedicks	native	
*	*Dichelostemma congestum*	Fork-toothed ookow	native	
*	*Dichelostemma multiflorum*	Round-toothed ookow	native	
	Dichelostemma volubile	Twining ookow	native	
	Fritillaria pluriflora	Adobe lily	native	SC/1B
	Odontostomum hartwegii	Hartweg's ookow	native	
*	*Triteleia hyacinthina*	Wild hyacinth	native	
*	*Triteleia laxa*	Ithuriel's spear	native	
	Triteleia peduncularis	Long-rayed brodiaea	native	
	Zigadenus fremontii	Fremont's zigadene	native	
	LIMNANTHACEAE			
	Limnanthes douglasii ssp. *nivea*	Coast Range meadowfoam	native	
	LINACEAE	Dwarf flax		
*	*Hesperolinon spergulinum*		native	
	Hesperolinon tehamense	Tehama dwarf-flax	native	SC/1B
	LOASACEAE			
	Mentzelia laevicaulis	Giant blazingstar	native	
	LYTHRACEAE			
*	*Ammannia coccinea*	Valley redstem	native	
	Ammannia robusta	Robust redstem	native	
*	*Lythrum hyssopifolium*	Hyssop loosestrife	non	
	Lythrum portula	Water purslane	non	
	Lythrum tribracteatum	Slender-fruited loosestrife	non	
*	*Rotala ramosior*	Lowland toothcup	native	
	MALVACEAE			
	Malva parviflora	Cheeseweed	non	
*	*Sidalcea calycosa* ssp. *calycosa*	Annual sidalcea	native	
	Sidalcea hartwegii	Hartweg's sidalcea	native	

*	*Sidalcea hirsuta*		Hairy sidalcea	native		
	MARSILEACEAE					
*	*Marsilea vestita* ssp. *vestita*		Hairy pepperwort	native		
	MARTYNIACEAE					
	Proboscidea louisianica ssp. *louisianica*		Common unicorn plant	non		
	MOLLUGINACEAE					
*	*Mollugo verticillata*		Indian chickweed	non		
	MORACEAE					
	Ficus carica		Edible fig	non		
	MYRTACEAE					
	Eucalyptus sp.		Gum tree	non		
	ORCHIDACEAE					
	Epipactis gigantea		Stream orchid	native		
	OLEACEAE					
	Olea europea		Olive	non		
	ONAGRACEAE					
*	*Camissonia graciliflora*		Hill suncup	native		
*	*Camissonia hirtella*		Hairy evening-primrose	native		
	Camissonia intermedia			native		
*	*Clarkia affinis*			native		
*	*Clarkia concinna* ssp. *concinna*		Redribbons	native		
*	*Clarkia gracilis* ssp. *gracilis*		Slender clarkia	native		
*	*Clarkia lassenensis/gracilis*		Lassen/slender clarkia	native		
*	*Clarkia modesta*			native		
*	*Clarkia purpurea* ssp. *quadrivulnera*		Purple clarkia	native		
	Clarkia rhomboidea		Diamond clarkia	native		
	Epilobium brachycarpum		Tall annual willowherb	native		
	Epilobium cleistogamum		Cleistogamous spike-primrose	native		
*	*Epilobium densiflorum*		Dense-flowered spike-primrose	native		
*	*Epilobium minutum*		Chaparral willowherb	native		
*	*Epilobium pygmaeum*		Smooth spike-primrose	native		
*	*Epilobium torreyi*		Torrey's spike-primrose	native		
	Ludwigia sp.		False loosestrife			
	ORCHIDACEAE					
	Epipactis gigantea		Stream orchid	native		
	OROBANCHACEAE					
*	*Orobanche fasciculata*		Clustered broom-rape	native		
	Orobanche uniflora		Naked broom-rape	native		
	PAPAVERACEAE					
*	*Eschscholzia caespitosa*		Foothill poppy	native		
*	*Eschscholzia californica*		California poppy	native		

	Eschscholzia lobbii		Fryingpans	native		
	Platystemon californicus		Cream cups	native		
	PINACEAE					
	Pinus sabiniana		Gray pine	native		
	PLANTAGINACEAE					
	Plantago coronopus		Cut-leaved plantain	non		
	Plantago elongata		Elongate plantain	native		
*	*Plantago erecta*		Erect plantain	native		
	Plantago lanceolata		English plantain	non		
	Plantago ovata		Ovate plantain	native		
	POACEAE					
	Aira caryophyllea		Silver European hairgrass	non		
*	*Alopecurus aequalis*		Short-awned foxtail	native		
	Alopecurus saccatus		Vernal pool foxtail	native		
*	*Aristida ternipes* var. *hamulosa*		Hook three-awn	native		
*	*Avena barbata*		Slender wild oat	non		
	Avena fatua		Wild oat	non		
	Briza minor		Lesser quaking grass	non		
	Bromus diandrus		Ripgut grass	non		
	Bromus hordeaceus		Softchess	non		
	Bromus japonicus		Japanese brome	non		
*	*Bromus madritensis* ssp. *rubens*		Foxtail chess	non		
*	*Crypsis schoenoides*		Swamp pricklegrass	non		
	Cynodon dactylon		Bermuda grass	non		
	Cynosurus echinatus		Hedgehog dogtail	non		
	Deschampsia danthonioides		Annual hairgrass	native		
	Digitaria ischaemum		Smooth crabgrass	non		
	Digitaria sanguinalis		Hairy crabgrass	non		
	Distichlis spicata		Saltgrass	native		
	Echinochloa crus-galli		Barnyard grass	non		
	Elymus elymoides		Squirreltail	native		
	Elymus glaucus		Wild-rye	native		
	Festuca idahoensis		Idaho fescue	native		
*	*Gastridium ventricosum*		Nitgrass	non		
*	*Hordeum brachyantherum* ssp. *brachyantherum*		Meadow barley	native		
*	*Hordeum marinum* ssp. *gussoneanum*		Mediterranean barley	non		
	Hordeum murinum ssp. *leporinum*		Hare wall barley	non		
	Koeleria macrantha		Junegrass	native		
	Koeleria phleoides		Bristly Koeler's grass	non		
*	*Leymus triticoides*		Alkali ryegrass	native		
	Lolium multiflorum		Italian ryegrass	non		
*	*Melica californica*		California melic	native		
*	*Melica harfordii*		Harford's melica	native		
	Muhlenbergia rigens		Muhly	native		
*	*Nassella cernua*		Nodding needlegrass	native		
*	*Nassella pulchra*		Purple needlegrass	native		
	Paspalum dilatum		Dallisgrass	non		
	Phalaris arundinacea		Reed canarygrass	native		
*	*Phalaris minor*		Lesser canarygrass	non		

*	*Phalaris paradoxa*	Paradox canarygrass	non	
*	*Piptatherum miliaceum*	Smilo grass	non	
	Poa annua	Annual bluegrass	non	
	Poa bulbosa	Bulbous bluegrass	non	
*	*Poa secunda* ssp. *secunda*	One-sided bluegrass	native	
	Polypogon interruptus	Ditch beardgrass	non	
	Polypogon maritimus	Mediterranean beardgrass	non	
*	*Polypogon monspeliensis*	Annual beardgrass	non	
	Sorghum halepense	Johnsongrass	non	
*	*Taeniatherum caput-medusae*	Medusa-head	non	
*	*Vulpia bromoides*	Six-weeks fescue	non	
*	*Vulpia microstachys* var. *ciliata*	Fringed fescue	native	
*	*Vulpia microstachys* var. *pauciflora*	Few-flowered fescue	native	
*	*Vulpia myuros* var. *hirsuta*	Foxtail fescue	non	
*	*Vulpia myuros* var. *myuros*	Rattail fescue	non	
	POLEMONIACEAE			
*	*Allophyllum gilioides* ssp. *gilioides*		native	
	Collomia tinctoria	Yellow-staining collomia	native	
*	*Gilia capitata* ssp. *capitata*	Globe gilia	native	
	Gilia capitata ssp. *staminea/pedemontana*	Foothill globe gilia	native	
*	*Gilia tricolor* ssp. *tricolor*	Bird's-eye gilia	native	
*	*Linanthus acicularis*	Bristly linanthus	native	
*	*Linanthus bicolor*	Bicolored linanthus	native	
*	*Linanthus bolanderi*	Bolander's linanthus	native	
*	*Linanthus ciliatus*	Whiskerbrush	native	
*	*Linanthus dichotomus*	Evening-snow	native	
*	*Linanthus parviflorus*	Cherokee linanthus	native	
*	*Linanthus pygmaeus* ssp. *continentalis*	Pygmy linanthus	native	
*	*Navarretia heterandra*	Tehama navarretia	native	CNPS 4
	Navarretia intertexta ssp. *intertexta*	Needle-leaved navarretia	native	
*	*Navarretia leucocephala* var. *leucocephala*	White-flowered navarretia	native	
	Navarretia nigelliformis ssp. *nigelliformis*	Adobe navarretia	native	
*	*Navarretia pubescens*	Downy navarretia	native	
*	*Navarretia tagetina*	Marigold navarretia	native	
*	*Phlox gracilis*	Slender phlox	native	
	POLYGONACEAE			
*	*Chorizanthe membranacea*	Pink spineflower	native	
*	*Eriogonum dasyanthemum*	Wild buckwheat	native	
	Eriogonum nudum	Buckwheat	native	
*	*Eriogonum wrightii* var. *trachygonum*	Wright's buckwheat	native	
	Polygonum arenastrum	Common knotweed	native	
*	*Polygonum californicum*	California knotweed	native	
	Polygonum douglasii	Douglas' knotweed	native	
*	*Pterostegia drymarioides*	Pterostegia	native	
	Rumex crispus	Curly dock	non	
*	*Rumex pulcher*	Fiddle dock	non	
	PORTULACACEAE			
	Calandrinia ciliata	Redmaids	non	
	Claytonia exigua ssp. *exigua*	Little miner's lettuce	native	

	Claytonia parviflora		Small-flowered miner's lettuce	native		
	Claytonia perfoliata		Common miner's lettuce	native		
	Lewisia rediviva		Bitter-root	native		
	Montia fontana		Water chickweed	native		
	POTAMOGETONACEAE					
	Potamogeton pectinatus		Fennel-leaved pondweed	native		
	PRIMULACEAE					
	Anagallis arvensis		Poor man's weatherglass	non		
	Androsace elongata ssp. *acuta*		Fairy candelabra	native		CNPS 4
	Dodecatheon clevelandii ssp. *patulum*		Lowland shootingstar	native		
	PTERIDACEAE					
*	*Pellaea andromedifolia*		Coffee fern	native		
*	*Pellaea mucronata* var. *mucronata*		Bird's-foot fern	native		
	Pentagramma triangularis ssp. *triangularis*		Gold-backed fern	native		
	RANUNCULACEAE					
	Clematis sp.			native		
*	*Delphinium hesperium* var. *pallescens*		Pale larkspur	native		
*	*Delphinium patens* ssp. *patens*		Spreading larkspur	native		
*	*Delphinium variegatum* ssp. *variegatum*		Royal larkspur	native		
*	*Myosurus minimus*		Common mousetail	native		
*	*Ranunculus aquatilis* var. *hispidulus*		Water buttercup	native		
*	*Ranunculus californicus*		California buttercup	native		
	Ranunculus canus		Sacramento Valley buttercup	native		
*	*Ranunculus hebecarpus*		Pubescent-fruited buttercup	native		
*	*Ranunculus muricatus*		Prickle-seeded buttercup	non		
	RHAMNACEAE					
	Ceanothus cuneatus var. *cuneatus*		Buck brush	native		
*	*Rhamnus ilicifolia*		Holly-leaf redberry	native		
	Rhamnus tomentella ssp. *crassifolia*		Hoary coffeeberry	native		
	ROSACEAE					
*	*Aphanes occidentalis*		Western lady's mantle	native		
	Cercocarpus betuloides		Mountain mahogany	native		
	Heteromeles arbutifolia		Toyon	native		
	Malus sylvestris		Apple	non		
	Prunus communis		Almond	non		
*	*Rubus discolor*		Hymalayan blackberry	non		
	RUBIACEAE					
*	*Galium aparine*		Goosegrass	native		
*	*Galium parisiense*		Wall bedstraw	non		
	Galium porrigens var. *tenue*		Narrow-leaved climbing bedstraw	native		
	Sherardia arvensis		Field madder	non		
	SALICACEAE					
	Populus fremontii ssp. *fremontii*		Fremont cottonwood	native		
	Salix breweri		Brewer's willow	native		

	Salix exigua	Sandbar willow	native	
	Salix laevigata	Red Willow	native	
	Salix sitchensis	Sitka willow	native	
	SAURURACEAE			
	Anemopsis californica	California anemopsis	native	
	SAXIFRAGACEAE			
*	*Lithophragma affine*	Woodland star	native	
	Lithophragma campanulatum	Bell-shaped woodland star	native	
*	*Lithophragma parviflorum* var. *parviflorum*	Small-flowered woodland star	native	
	Saxifraga californica	California saxifrage	native	
	SCROPHULARIACEAE			
	Antirrhinum subcordatum	Dimorphic snapdragon	native	CNPS 1B
	Bacopa rotundifolia	Water-hyssop	non	
*	*Castilleja affinis* ssp. *affinis*	Lay and Collie's Indian paintbrush	native	
*	*Castilleja attenuata*	Valley-tassels	native	
*	*Castilleja exserta* ssp. *exserta*	Purple owl-clover	native	
	Castilleja foliolosa	Woolly Indian paintbrush	native	
*	*Collinsia sparsiflora* var. *bruceae*	Bruce's few-flowered collinsia	native	
*	*Collinsia sparsiflora* var. *collina*	Collinsia	native	
*	*Collinsia sparsiflora* var. *sparsiflora*	Few-flowered collinsia	native	
	Gratiola ebracteata	Bractless hedge-hyssop	native	
	Kickxia elatine	Sharp-leaved fluellin	non	
	Mimulus androsaceus		native	
	Mimulus cardinalis	Scarlet monkeyflower	native	
	Mimulus douglasii	Purple mouse-ears	native	
	Mimulus guttatus	Seep monkeyflower	native	
*	*Mimulus kelloggii*	Kellogg's monkeyflower	native	
*	*Penstemon heterophyllus var. purdyi*	Purdy's beardtongue	native	
*	*Tonella tenella*	Small-flowered tonella	native	
	Triphysaria eriantha ssp. *eriantha*	Butter-and-eggs	native	
	Verbascum thapsus	Woolly mullein	non	
	Veronica catenata	Chain speedwell	non	
*	*Veronica anagallis-aquatica*	Great water speedwell	non	
	Veronica peregrina ssp. *xalapensis*	Purslane speedwell	native	
	SELAGINELLACEAE			
	Selaginella sp.	Spikemoss	native	
	SIMARUBACEAE			
	Ailanthus altissima	Tree-of-heaven	non	
	SOLANACEAE			
	Physalis lancifolia	Lance-leaved ground-cherry	non	
	Solanum rostratum	Buffalo-berry	non	
	TAMARICACEAE			
	Tamarix sp.	Tamarisk	non	
	TYPHACEAE			

	Typha angustifolia		Narrow-leaved cattail	native		
	Typha latifolia		Broad-leaved cattail	native		
	VALERIANACEAE					
*	*Plectritis ciliosa* ssp. *ciliosa*		Long-spurred pink plectritis	native		
*	*Plectritis macrocera*		White plectritis	native		
	VERBENACEAE					
*	*Phyla nodiflora* var. *nodiflora*		Creeping lippia	native		
	VIOLACEAE					
	Viola douglasii		Douglas' violet	native		
	VISCACEAE					
	Arceuthobium occidentale		Gray pine dwarf mistletoe	native		
*	*Phoradendron densum*		Dense mistletoe	native		
	Phoradendron juniperinum		Juniper mistletoe	native		
	Phorodendron macrophyllum		Big-leaved mistletoe	native		
	Phoradendron villosum		Hairy mistletoe	native		
	VITACEAE					
	Vitis californica		California wild grape	native		

FAMILY *Genus species*	Common Name	Origin	Listing
Red Bank			
ACERACEAE			
Acer macrophyllum	Big-leaved maple	native	
ALISMATACEAE			
Echinodorus berteroi	Burhead	native	
AMARANTHACEAE			
Amaranthus albus	Tumbleweed	non	
Amaranthus retroflexus	Red-rooted amaranth	non	
ANACARDIACEAE			
Rhus trilobata	Skunkbrush	native	
Toxicodendron diversilobum	Poison oak	native	
APIACEAE			
Anthriscus caucalis	Bur-chervil	non	
Daucus pusillis	Rattlesnake weed	native	
Levisticum officinale	Lovage	non	
Lomatium caruifolium var. *denticulatum*	Foothill lomatium	native	
Lomatium dasycarpum ssp. *tomentosum*	Woolly-fruited lomatium	native	
Lomatium macrocarpum	Large-fruited lomatium	native	
Lomatium marginatum var. *purpureum*	Margined lomatium	native	
Lomatium utriculatum	Bladder lomatium	native	
Perideridia bolanderi ssp. *bolanderi*	Bolander's yampah	native	
Perideridia kelloggii	Kellogg's yampah	native	
Sanicula bipinnata	Poison sanicle	native	
Sanicula bipinnatifida	Purple sanicle	native	
Sanicula crassicaulis	Pacific sanicle	native	
Sanicula tuberosa	Turkey-pea	native	
Torilis arvensis	Common hedge-parsley	non	
Yabea microcarpa	False hedge-parsley	native	
APOCYNACEAE			
Apocynum cannabinum	Indian-hemp	native	
ASCLEPIADACEAE			
Asclepias californica	California milkweed	native	
Asclepias eriocarpa	Indian milkweed	native	
Asclepias fascicularis	Narrow-leaf milkweed	native	
Asclepius speciosa	Showy milkweed	native	
ASTERACEAE			
Achillea millefolium	Yarrow	native	
Achyrachaena mollis	Blow-wives	native	
Agoseris heterophylla	Annual agoseris	native	
Ambrosia sp.	Ragweed		

Ancistrocarphus filagineus	Woolly fishooks	native	
Antennaria sp.	Pussy-toes	native	
Anthemis cotula	Mayweed	non	
Artemisia douglasiana	Mugwort	native	
Baccharis salicifolia	Mule's fat	native	
Balsamorhiza sp.	Balsam-root	native	
Blepharipappus scaber	Rough eyelash	native	
Brickellia californica	California brickellbush	native	
Calycadenia fremontii	Fremont's calycadenia	native	
Calycadenia multiglandulosa	Sticky calycadenia	native	
Calycadenia pauciflora	Few-flowered calycadenia	native	
Calycadenia truncata ssp. *scabrella*	Rosinweed	native	
Centaurea cyanus	Bachelor buttons	native	
Centaurea melitensis	Tocalote	non	
Centaurea solstitialis	Yellow star-thistle	non	
Chaenactis glabriuscula var. *heterocarpha*	Yellow pincushion	native	
Chamomilla suaveolens	Common pineapple-weed	non	
Cirsium occidentale var. *venustum*	Venus thistle	native	
Conyza canadensis	Horseweed	native	
Erigeron divergens	Spreading daisy	notive	
Erigeron philadelphicus	Philadelphia daisy	native	
Eriophyllum lanatum var. *achillaeoides*	Woolly sunflower	native	
Eriophyllum lanatum var. *grandiflorum*	Woolly sunflower	native	
Euthamia occidentalis	Western goldenrod	native	
Filago sp.	Herba impia		
Gnaphalium luteo-album	Weedy cudweed	native	
Gnaphalium palustre	Western marsh cudweed	native	
Gnaphalium stramineum	Cotton-batting cudweed	native	
Helenium bigelovii	Sneezeweed	native	
Helenium puberulum	Rosilla	native	
Helianthella californica var. *nevadensis*	California helianthella	native	
Helianthus annuus	Common sunflower	native	
Helianthus bolanderi	Bolander's sunflower	native	
Hemizonia congesta ssp. *clevelandii*	Cleveland's tarweed	native	
Hesperevax acaulis var. *robustior*	Robust evax	native	
Heterotheca oregona var. *compacta*	Compact oregon golden-aster	native	
Heterotheca oregona var. *rudis*	Oregon golden-aster	native	
Hypochaeris glabra	Smooth cat's ear	non	
Hypochaeris radicata	Rough cat's ear	non	
Lagophylla glandulosa	Glandular hareleaf	native	
Lagophylla minor	Lesser hareleaf	native	
Lagophylla ramosissima ssp. *ramosissima*	Slender hareleaf	native	
Lessingia nemoclada	Slender-stemmed lessingia	native	
Madia citriodora	Lemon-scented tarweed	native	
Madia elegans ssp. *vernalis*	Spring madia	native	
Madia exigua	Thread-stemmed madia	native	
Madia gracilis	Slender tarweed	native	
Madia minima	Dwarf madia	native	
Malacothrix floccifera	Woolly malacothrix	native	

Micropus californicus var. *californicus*	Slender cottonweed	native	
Microseris douglasii ssp. *douglasii*	Douglas' microseris	native	
Psilocarphus oregonus	Oregon woolly marbles	native	
Psilocarphus tenellus var. *tenellus*	Slender woolly marbles	native	
Rafinesquia californica	California chicory	native	
Rigiopappus leptocladus	Riggiopappus	native	
Senecio vulgaris	Old-man-of-spring	non	
Solidago californica	California goldenrod	native	
Sonchus asper ssp. *asper*	Spiny-leaved sow-thistle	non	
Stephanomeria elata	Santa Barbara stephanomeria	native	
Stephanomeria virgata ssp. *pleurocarpa*	Wand stephanomeria	native	
Wyethia angustifolia	Narrow-leaved mule's ears	native	
Wyethia glabra	Smooth mule's ears	native	
Wyethia helenioides	Gray mule's ears	native	
Xanthium strumarium	Cocklebur	native	
BETULACEAE			
Alnus rhombifolia	White alder	native	
BORAGINACEAE			
Amsinckia lycopsoides	Bugloss fiddleneck	native	
Amsinckia menziesii var. *intermedia*	Common fiddleneck	native	
Amsinkia menziesii var. *menziesii*	Common fiddleneck	native	
Cryptantha flaccida	Weak-stemmed cryptantha	native	
Cryptantha intermedia	Common cryptantha	native	
Cynoglossum grande	Hound's tongue		
Heliotropium curassavicum	Wild heliotrope	native	
Heliotropium europaeum	European heliotrope	non	
Pectocarya pusilla	Little pectocarya	native	
Plagiobothrys glyptocarpus var. *glyptocarpus*	Sculptured popcornflower	native	
Plagiobothrys fulvus	Fulvous popcornflower		
Plagiobothrys nothofulvous	Common popcornflower	native	
Plagiobothrys scriptus	Scribe's popcornflower	native	
Plagiobothrys tenellus	Slender popcornflower	native	
BRASSICACEAE			
Arabis breweri var. *breweri*	Brewer's rockcress	native	
Athysanus pusillus	Petty athysanus	native	
Brassica nigra	Black mustard	non	
Capsella bursa-pastoris	Shepherd's purse	non	
Cardamine oligosperma	Western bittercress	native	
Draba verna	Spring whitlow-grass	non	
Erysimum capitatum ssp. *capitatum*	Western wallflower	native	
Lepidium latifolium	Tall white-top	non	
Lepidium latipes var. *latipes*	Dwarf peppergrass	native	
Lepidium nitidum var. *nitidum*	Shining peppergrass	native	
Lepidium strictum	Upright peppergrass	native	
Rorippa nasturtium-aquaticum	Watercress	native	
Sisymbrium officianale	Hedge-mustard	non	

Streptanthus drepanoides	Jewelflower	native	CNPS 4
Thysanocarpus curvipes	Fringepod	native	
Tropidocarpum gracile	Slender tropidocarpum	native	
CALLITRICHACEAE			
Callitriche marginata	Winged water-starwort	native	
CAMPANULACEAE			
Githopsis specularioides	Common bluecup	native	
Heterocodon rariflorum	Heterocodon	native	
Nemacladus montanum		native	
Triodanis biflora	Small Venus'-looking-glass	native	
CAPRIFOLIACEAE			
Lonicera interrupta	Chaparral honeysuckle	native	
Sambucus mexicana	Blue elderberry	native	
Symphoricarpus albus var. *laevigatus*	Common snowberry	native	
CARYOPHYLLACEAE			
Cerastium glomeratum	Sticky mouse-eared chickweed	non	
Herniaria hirsuta ssp. *hirsuta*	Gray herniaria	non	
Herniaria hirsuta ssp. *cinerea*		non	
Minuartia californica	California sandwort	native	
Minuartia douglasii	Douglas' sandwort	native	
Petrorhagia dubia	Grass pink	non	
Scleranthus annuus ssp. *annuus*	Knawel weed	non	
Silene californica	Indian pink	native	
Spergularia marina	Salt-marsh sandspurry	native	
Spergularia rubra	Ruby sandspurry	non	
Stellaria media	Common chickweed	non	
Stellaria nitens	Shiny starwort	native	
CHENOPODIACEAE			
Chenopodium botrys	Jerusalem-oak	non	
Chenopodium californicum	California goosefoot	native	
Chenopodium foliosum	Leafy goosefoot	non	
CONVOLVULACEAE			
Calystegia occidentalis ssp. *occidentalis*	Western morning-glory	native	
Convolvulus arvensis	Field bindweed	non	
CORNACEAE			
Cornus glabrata	Brown dogwood	native	
CRASSULACEAE			
Crassula connata	Pygmy weed	native	
CUCURBITACEAE			
Marah fabaceus	California manroot	native	

CUPRESSACEAE			
Calocedrus decurrens	Incense cedar	native	
Juniperus californica	California juniper	native	
CYPERACEAE			
Carex nudata	Torrent sedge	native	
Cyperus eragrostis	Tall cyperus	native	
Eleocharis macrostachya	Pale spikerush	native	
Scirpus pungens	Common threesquare	native	
DATISCACEAE			
Datisca glomerata	Durango root	native	
DIPSACEAE			
Dipsacus fullonum	Wild teasel	non	
EQUISETACEAE			
Equisetum arvense	Common horsetail	native	
Equisetum laevigatum	Smooth scouring-rush	native	
ERICACEAE			
Arctostaphylos manzanita ssp. *manzanita*	Manzanita	native	
Arctostaphylos manzanita ssp. *wieslanderi*	Manzanita	native	
EUPHORBIACEAE			
Chamaesyce glyptosperma	Rib-seeded spurge		
Chamaesyce maculata	Spotted spurge	non	
Chamaesyce ocellata ssp. *rattanii*	Stony Creek spurge	native	CNPS 4
Chamaesyce serpyllifolia ssp. *serpyllifolia*	Thyme-leaved spurge	native	
Eremocarpus setigerus	Turkey mullein	native	
Euphorbia crenulata	Chinese caps	native	
Euphorbia spathulata	Warty spurge	native	
FABACEAE			
Astragalus gambelianus	Gambel's milkvetch	native	
Astragalus rattanii var. *jepsonianus*	Jepson's milkvetch	native	CNPS 1B
Cercis occidentalis	Western redbud	native	
Lathyrus cicera	Chick pea	non	
Lotus humistratus	Foothill lotus	native	
Lotus purshianus var. *purshianus*	Spanish lotus	native	
Lupinus bicolor	Bicolored lupine	native	
Lupinus microcarpus var. *densiflorus*	White-whorled lupine	native	
Lupinus nanus	Sky lupine	native	
Medicago lupulina	Black medic	non	
Medicago polymorpha	Common bur-clover	non	
Melilotus alba	White sweetclover	non	
Melilotus indica	Sourclover	non	
Melilotus officinalis	Yellow sweetclover	non	

Trifolium albopurpurpeum var. *albopurpureum*	Indian clover	native	
Trifolium bifidum var. *bifidum*	Notch-leaved clover	native	
Trifolium bifidum var. *decipiens*	Deceptive clover	native	
Trifolium campestre	Hop clover	non	
Trifolium ciliolatum	Foothill clover	native	
Trifolium depauperatum ssp. *depauperatum*	Dwarf cowbag clover	native	
Trifolium fucatum	Sour clover	native	
Trifolium hirtum	Rose clover	non	
Trifolium monanthum var. *monanthum*	Carpet clover	native	
Trifolium obtusiflorum	Clammy clover	native	
Trifolium variegatum	White-tipped clover	native	
Trifolium willdenovii	Tomcat clover	native	
Trifolium wormskioldii	Springbank clover	native	
Vicia sativa ssp. *sativa*	Spring vetch	non	
FAGACEAE			
Quercus agrifolia var. *agrifolia*	Coast live oak	native	
Quercus berberidifolia	Scrub oak	native	
Quercus chrysolepis	Canyon live oak	native	
Quercus douglasii	Blue oak	native	
Quercus lobata	Valley oak	native	
Quercus wislizenii var. *wislizenii*	Interior live oak	native	
GARRYACEAE			
Garrya congdonii	Congdon's silk tassel	native	
Garrya elliptica	Elliptic silk tassel	native	
GENTIANACEAE			
Centaurium muhlenbergii	June centaury	native	
Centaurium trichanthum	Alkali centaury	native	
Centaurium venustum	Canchalagua	native	
GERANIACEAE			
Erodium botrys	Long-beaked stork's bill	non	
Erodium cicutarium	Red-stemmed filaree	non	
Erodium moschatum	White-stemmed filaree	non	
Geranium dissectum	Cut-leaved geranium	non	
Geranium molle	Dove's-foot geranium	non	
HIPPOCASTANACEAE			
Aesculus californica	California buckeye	native	
HYDROCHARITACEAE			
Najas guadalupensis	Common water-nymph	native	
HYDROPHYLLACEAE			
Eriodictyon californicum	California yerba santa	native	
Nemophila heterophylla	Variable-leaved nemophila	native	
Nemophila pedunculata	Meadow nemophila	native	

Phacelia ramosissima var. *ramosissima*	Branched phacelia	native	
HYPERICACEAE			
Hypericum formosum var. *scouleri*	Scouler's St. John's wort	native	
Hypericum perforatum	Klamath weed	non	
IRIDACEAE			
Iris sp.	Iris	native	
Sisyrinchium bellum	Blue-eyed grass	native	
Sisyrinchium douglasii var. *douglasii*	Purple-eyed grass	native	
JUGLANDACEAE			
Juglans californica var. *hindsii*	California walnut	native	CNPS 1B
JUNCACEAE			
Juncus bufonius var. *bufonius*	Common toadrush	native	
Juncus xiphioides	Iris-leaved rush	native	
LAMIACEAE			
Lamium amplexicaule	Giraffehead	non	
Marrubium vulgare	Horehound	non	
Mentha arvensis var. *canadensis*	American wild mint	native	
Mentha pulegium	Pennyroyal	non	
Mentha spicata var. *spicata*	Spearmint	non	
Monardella sheltonii	Shelton's coyote-mint	native	
Salvia columbariae	Chia	native	
Scutellaria antirrhinoides	Skullcap	native	
Scutellaria siphocampyloides	Gray-leaved skullcap	native	
Stachys ajugoides var. *rigida*	Rigid hedge-nettle	native	
Stachys stricta	Sonoma hedge-nettle	native	
Trichostema laxum	Turpentine weed	native	
LAURACEAE			
Unbellaria californica	California bay	native	
LILIACEAE			
Allium peninsulare var. *peninsulare*	Mexican onion	native	
Brodiaea elegans ssp. *elegans*	Elegant brodiaea	native	
Brodiaea californica var. *californica*	California brodiaea	native	
Calochortus albus	Fairy lantern	native	
Calochortus amabilis	Diogene's lantern	native	
Calochortus luteus	Yellow mariposa lily	native	
Chlorogalum pomeridianum	Soap plant	native	
Dichelostemma capitatum ssp. *capitatum*	Bluedicks	native	
Dichelostemma multiflorum	Round-toothed ookow	native	
Dichelostemma volubile	Climbing brodiaea	native	
Erythronium californicum	Trout lily	native	
Fritillaria affinis var. *affinis*	Checkered fritillary	native	
Fritillaria pluriflora	Adobe lily	native	SC/1B

Odontostomum hartwegii	Hartweg's odontostomum	native	
Triteleia ixioides ssp. *scabra*	Golden brodiaea	native	
Triteleia laxa	Ithuriel's spear	native	
Triteleia hyacinthina	Wild hyacinth	native	
Zigadenus fremontii	Fremont's zigadene	native	
LIMNANTHACEAE			
Limnanthes douglasii ssp. *nivea*	Table mountain meadowfoam	native	
Limnanthes floccosa ssp. *floccosa*	Woolly meadowfoam	native	CNPS 4
LINACEAE			
Hesperolinon californicum	California western flax	native	
Hesperolinon disjunctum		native	
Hesperolinon micranthum	Small-flowered dwarf flax	native	
Hesperolinon spergulinum	Dwarf flax	native	
LOASACEAE			
Mentzelia laevicaulis	Giant blazingstar	native	
LYTHRACEAE			
Lythrum hyssopifolium	Hyssop loosestrife	non	
MALVACEAE			
Malacothamnus fremontii	Bush mallow	native	
Sidalcea hartwegii	Hartweg's sidalcea	native	
Sidalcea hirsuta	Hairy sidalcea	native	
OLEACEAE			
Fraxinus dipetala	California ash	native	
ONAGRACEAE			
Camissonia graciliflora	Hill sun cup	native	
Clarkia concinna ssp. *concinna*	Red ribbons	native	
Clarkia gracilis ssp. *gracilis*	Slender clarkia	native	
Clarkia lassenensis	Mt. Lassen clarkia	native	
Clarkia modesta		native	
Clarkia purpurea ssp. *purpurea*	Purple clarkia	native	
Clarkia purpurea ssp.*quadrivulnera*	Purple clarkia	native	
Clarkia rhomboidea	Diamond clarkia	native	
Epilobium brachycarpum	Tall annual willowherb	native	
Epilobium ciliatum ssp. *ciliatum*	Fringed willowherb	native	
Epilobium cleistogamum	Cleistogamous spike-primrose	native	
Epilobium foliosum	Small-flowered willowherb	native	
Epilobium minutum	Chaparral willowherb	native	
ORCHIDACEAE			
Piperia sp.	Piperia	native	
Spiranthes porrifolia	Western ladies-tresses	native	

OROBANCHACEAE			
Orobanche fasciculata	Clustered broomrape	native	
Orobanche uniflora	Naked broom-rape	native	
PAPAVERACEAE			
Eschscholzia caespitosa	Foothill poppy	native	
Eschscholzia californica	California poppy	native	
Eschscholzia lobbii	Fryingpans	native	
Platystemon californicus	California creamcups	native	
PHILADELPHACEAE			
Philadelphus lewisii	Mock orange	native	
PINACEAE			
Pinus sabiniana	Foothills pine	native	
PLANTAGINACEAE			
Plantago erecta	Erect plantain	native	
Plantago lanceolata	English plantain	non	
POACEAE			
Achnatherum lemmonii	Lemmon's needlgrass	native	
Aegilops cylindrica	Jointed goatgrass	non	
Agrostis exarata	Spiked bentgrass	native	
Aira caryophyllea	Silver European hairgrass	non	
Avena fatua	Wild oat	non	
Briza minor	Lesser quaking-grass	non	
Bromus diandrus	Ripgut brome	non	
Bromus hordeaceus	Softchess	non	
Bromus japonicus	Japanese brome	non	
Bromus laevipes	Woodland brome	native	
Bromus madritensis ssp. *madritensis*	Foxtail chess	non	
Bromus madritensis ssp. *rubens*	Red brome	non	
Bromus tectorum	Cheatgrass	non	
Crypsis schoenoides	Swamp pricklegrass	non	
Cynodon dactylon	Bermuda grass	non	
Cynosurus echinatus	Hedgehog dogtail	non	
Deschampsia danthonioides	Annual hairgrass	native	
Echinochloa crus-galli	Barnyard grass	non	
Elymus glaucus ssp. *glaucus*	Blue wild-rye	native	
Elymus multisetus	Big squirreltail	native	
Elymus trachycaulis ssp. *subsecundus*	Wheatgrass	native	
Elytrigia elongata	Elongate wheatgrass	non	
Elytrigia pontica ssp. *pontica*	Tall wheatgrass	non	
Gastridium ventricosum	Nitgrass	non	
Hordeum marinum ssp. *gussoneanum*	Mediterranean barley	non	
Hordeum murinum ssp. *leporinum*	Hare wall barley	non	
Leymus sp.	Ryegrass	native	
Lolium multiflorum	Italian ryegrass	non	

Melica californica	California melic	native	
Melica torreyana	Torrey's melica	native	
Muhlenbergia rigens	Muhly	native	
Nassella cernua	Nodding needlegrass	native	
Nassella lepida	Small-flowered needlegrass	native	
Nassella pulchra	Purple needlegrass	native	
Panicum capillare	Witchgrass	native	
Phalaris aquatica	Harding-grass	non	
Phalaris minor	Lesser canary grass	non	
Piptatherum miliaceum	Smilograss	non	
Poa annua	Annual bluegrass	non	
Poa bulbosa	Bulbous bluegrass	non	
Poa secunda ssp. *secunda*	One-sided bluegrass	native	
Polypogon maritimus	Mediterranean beardgrass	non	
Taeniatherum caput-medusae	Medusa-head	non	
Vulpia microstachys var. *ciliata*	Fringed fescue	native	
Vulpia microstachys var. *pauciflora*	Few-flowered fescue	native	
Vulpia myuros var. *hirsuta*	Foxtail fescue	non	
POLEMONIACEAE			
Eriastrum abramsii	Abram's eriastrum	native	
Eriastrum brandegeae	Brandegee's eriastrum	native	SC/1B
Gilia capitata ssp. *capitata*	Globe gilia	native	
Gilia tricolor	Bird's-eye gilia	native	
Linanthus bicolor	Bicolored linanthus	native	
Linanthus bolanderi	Bolander's linanthus	native	
Linanthus ciliatus	Whiskerbrush	native	
Linanthus dichotomus	Evening snow	native	
Linanthus parviflorus	Cherokee linanthus	native	
Navarretia heterandra	Tehama navarretia	native	CNPS 4
Navarretia intertexta ssp. *intertexta*	Needle-leaved navarretia	native	
Navarretia jepsonii	Jepson's navarretia	native	CNPS 4
Navarretia pubescens	Downy navarretia	native	
Navarretia tagetina	Marigold navarretia	native	
Navarretia viscidula	Sticky navarretia	native	
Phlox gracilis	Slender phlox	native	
POLYGONACEAE			
Chorizanthe membranacea	Pink spineflower	native	
Eriogonum compositum var. *compositum*	Arrow-leaved buckwheat	native	
Eriogonum dasyanthemum	Wild buckwheat	native	
Eriogonum nudum var. *nudum*	Naked buckwheat	native	
Eriogonum nudum var. *oblongifolium*	Hairy-stemmed buckwheat	native	
Polygonum arenastrum	Common knotweed	non	
Rumex crispus	Curly dock	native	
Rumex salicifolius var. *denticulatus*	Smooth-valved willow dock	native	
PORTULACACEAE			
Calandrinia ciliata	Redmaids	native	

Claytonia exigua ssp. *exigua*	Little miner's lettuce	native	
Claytonia parviflora ssp. *parviflora*	Miner's lettuce	native	
Claytonia perfoliata	Common miner's lettuce	native	
Montia fontana	Water montia	native	
Portulaca oleracea	Common purslane	non	
POTAMOGETONACEAE			
Potamogeton pectinatus	Fennel-leaf pondweed	native	
PRIMULACEAE			
Anagallis arvensis	Scarlet pimpernel	non	
Androsace elongata ssp. *acuta*	Fairy candelabra	native	CNPS 4
Dodecatheon hendersonii	Henderson's shootingstar	native	
PTERIDACEAE			
Adiantum jordanii	California maidenhair	native	
Pellaea andromedifolia	Coffee fern	native	
Pentagramma triangularis ssp. *triangularis*	Gold-backed fern	native	
RANUNCULACEAE			
Clematis lasiantha	Chaparral clematis	native	
Clematis ligusticifolia	Virgin's-bower	native	
Delphinium hansenii ssp. *hansenii*	Hansen's larkspur	native	
Delphinium hesperium ssp. *pallescens*	Pale larkspur	native	
Delphinium patens ssp. *patens*	Spreading larkspur	native	
Ranunculus californicus	California buttercup	native	
Ranunculus hebecarpus	Pubescent-fruited buttercup	native	
Ranunculus muricatus	Prickle-seeded buttercup	non	
Ranunculus occidentalis	Western buttercup	native	
Thalictrum fendleri var. *polycarpum*	Many-fruited meadow-rue	native	
RHAMNACEAE			
Ceanothus cuneatus var. *cuneatus*	Buckbrush	native	
Ceanothus integerrimus	Deerbrush	native	
Rhamnus californica	California coffeeberry	native	
Rhamnus ilicifolia	Holly-leaved redberry	native	
Rhamnus tomentella ssp. *tomentella*	Hoary coffeeberry	native	
ROSACEAE			
Adenostoma fasciculatum	Chamise	native	
Aphanes occidentalis	Western lady's-mantle	non	
Cercocarpus betuloides var. *betuloides*	Birch-leaved mountain mahogany	native	
Heteromeles arbutifolia	Toyon	native	
Prunus sp.	Cherry		
Rosa californica	California rose	native	
Rosa woodsii var. *ultramontanus*	Interior rose	native	
Rubus discolor	Blackberry	non	
RUBIACEAE			

Crucianella angustifolia	Crosswort	non	
Galium aparine	Cleavers	native	
Galium parisiense	Wall bedstraw	non	
Galium porrigens var. *tenue*	Narrow-leaved climbing bedstraw	native	
Sherardia arvensis	Field-madder	non	
SALICACEAE			
Populus fremontii ssp. *fremontii*	Fremont's cottonwood	native	
Salix exigua	Sandbar willow	native	
Salix laevigata	Red willow	native	
Salix lasiolepis	Arroyo willow	native	
Salix lucida ssp. *lasiandra*	Shining willow	native	
SAXIFRAGACEAE			
Lithophragma parviflorum var. *parviflorum*	Small-flowered woodland star	native	
Saxifraga californica	California saxifrage	native	
SCROPHULARIACEAE			
Antirrhinum cornutum	Spurred snapdragon	native	
Antirrhinum subcordatum	Dimorphic snapdragon	native	CNPS 1B
Castilleja affinis ssp. *affinis*	Lay-and-Collie's Indian paintbrush	native	
Castilleja attenuata	Valley tassels	native	
Castilleja campestris ssp. *campestris*	Field owl-clover	native	
Castillja foliolosa	Woolly Indian paintbrush	native	
Castilleja rubicundula ssp. *lithospermoides*	Cream sacs	native	
Collinsia sparsiflora var. *collina*	Collinsia	native	
Collinsia sparsiflora var. *sparsiflora*	Few-flowered collinsia	native	
Keckiella corymbosa	Redwood keckiella	native	
Keckiella lemmonii	Lemmon's keckiella	native	
Mimulus cardinalis	Scarlet monkeyflower	native	
Mimulus floribundus	Floriferous monkeyflower	native	
Mimulus guttatus	Seep monkeyflower	native	
Mimulus kelloggii	Kellogg's monkeyflower	native	
Mimulus moschatus	Musk monkeyflower	native	
Mimulus pilosus	Downy mimetanthe	native	
Penstemon heterophyllus var. *heterophyllus*	Foothill beardtongue	native	
Penstemon heterophyllus var. *purdyi*	Foothill beardtongue	native	
Scrophularia californica	California figwort	native	
Tonella tenella	Small-flowered tenella	native	
Triphysaria eriantha ssp. *eriantha*	Johnnytuck	native	
Triphysaria pusilla	Dwarf owl-clover	native	
Verbascum blattaria	Moth mullein	non	
Verbascum thapsus	Woolly mullein	non	
Veronica anagallis-aquatica	Great water speedwell	non	
Veronica catenata	Chain speedwell	non	
Veronica peregrina ssp. *xalapensis*	Purslane speedwell	native	
SOLANACEAE			
Nicotiana quadrivalvis	Indian tobacco	native	

Solanum nigrum	Black nightshade	non	
Solanum parishii	Parish's nightshade	native	
STYRACACEAE			
Styrax officinalis var. *redivivus*	Snowdrop bush	native	
TAMARICACEAE			
Tamarix gallica	French tamarisk	non	
Tamarix ramosissima	Branched tamarisk	non	
VALERIANACEAE			
Plectritis ciliosa ssp. *ciliosa*	Long-spurred pink plectritis	native	
Plectritis macrocera	White plectritis	native	
VERBENACEAE			
Verbena hastata	Halberd-leaved vervain	native	
Verbena lasiostachys var. *scabrida*	Western vervain	native	
Verbena lasiostachys var. *lasiostachys*	Western vervain	native	
VISCACEAE			
Arceuthobium occidentale	Gray pine dwarf-mistletoe	native	
Phoradendron villosum	Oak mistletoe	native	
VITACEAE			
Vitis californica	California wild grape	native	

January 4, 2000

ATTACHMENT 6.

OFFSTREAM STORAGE RESERVOIR ALTERNATIVES:

1998-1999 plant voucher collection

Plant Voucher -- plant specimen collected and preserved as proof for species named on this list.					
FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
ACERACEAE					
Acer macrophyllum	Red Bank	99-134	14-Jun	B. Castro	
ALISMATACEAE					
Damasonium californicum	Sites	98-1	1-Jul	J. Marr	
Damasonium californicum	Newville	98-708	1-Jul	C. Warren	
Echinodorus berteroi	Red Bank	98-852	7-Jul	J. Cunningham	
Echinodorus berteroi	Newville	99-135	1-Jun	B. Castro	
AMARANTHACEAE					
Amarathus albus	Newville	98-2	15-Jul	J. Marr	
Amarathus albus	Red Bank	98-853	7-Jul	J. Cunningham	
ANACARDIACEAE					
Rhus trilobata	Newville	99-40	9-Jun	J. Witzman	
APIACEAE					
Undetermined	Newville	98-709	30-Mar	C. Warren	
Undetermined	Newville	98-710	11-May	C. Warren	
Anthriscus caucalis	Newville	98-854	27-Apr	J. Cunningham	
Daucus pusillus	Newville	98-855	28-Apr	J. Cunningham	
Daucus pusillus	Newville	98-856	14-May	J. Cunningham	
Daucus pusillus	Newville	98-857	14-May	J. Cunningham	
Daucus pusillus	Sites	98-3	4-May	J. Marr	
Daucus pusillus	Newville	98-4	30-Apr	J. Marr	
Eryngium castrense	Sites	99-301	1-Jul	J. Marr	
Eryngium castrense	Newville	98-5	14-Jul	J. Marr	
Levisticum officinale	Red Bank	98-6	9-Jun	J. Marr	
Lomatium sp.	Sites	99-302	18-Feb	J. Marr	
Lomatium carvifolium	Sites	99-39	23-Mar	B. Hendrickson	
Lomatium carvifolium var. *denticulatum*	Red Bank	99-136	18-May	B. Castro	
Lomatium dasycarpum ssp. *dasycarpum*	Newville	98-7	29-Apr	J. Marr	
Lomatium dasycarpum ssp. *tomentosum*	Newville	98-8	20-Mar	J. Marr	
Lomatium dasycarpum ssp. *tomentosum*	Newville	98-9	20-Mar	J. Marr	
Lomatium macrocarpum	Red Bank	98-10	2-Apr	J. Marr	
Lomatium marginatum var. *marginatum*	Newville	98-11	19-Mar	J. Marr	
Lomatium marginatum var. *marginatum*	Newville	98-12	29-Apr	J. Marr	
Lomatium marginatum var. *purpureum*	Newville	98-13	20-Mar	J. Marr	
Lomatium marginatum var. *purpureum*	Newville	99-137	9-Apr	B. Castro	
Lomatium marginatum var. *purpureum*	Sites	99-138	12-Apr	B. Castro	

FAMILY ***Genus species***	**Reservoir**	**Voucher**	**Date**	**Collector**	
Lomatium utriculatum	Newville	98-14	20-Apr	J. Marr	
Lomatium utriculatum	Newville	98-15	28-Mar	J. Marr	
Lomatium utriculatum	Newville	99-280	5-May	B. Castro	
Lomatium utriculatum	Newville	99-139	4-May	B. Castro	
Perideridia bolanderi ssp. *bolanderi*	Red Bank	98-711	27-Aug	C. Warren	
Perideridia kelloggii	Red Bank	98-16	3-Jul	J. Marr	
Perideridia kelloggii	Red Bank	98-17	15-Jun	J. Marr	
Perideridia kelloggii	Red Bank	98-18	27-Aug	J. Marr	
Perideridia kelloggii	Red Bank	98-645	27-Aug	H. West	
Perideridia kelloggii	Red Bank	99-140	21-Jun	B. Castro	
Sanicula crassicaulis	Red Bank	99-303	28-Apr	J. Marr	
Sanicula tuberosa	Red Bank	99-141	23-Mar	B. Castro	
Sanicula tuberosa	Red Bank	99-304	28-Apr	J. Marr	
Torilis arvensis	Newville	98-19	29-Apr	J. Marr	
Torilis arvensis	Newville	98-20	17-Apr	J. Marr	
Torilis nodosa	Sites	98-21	27-May	J. Marr	
Torilis nodosa	Newville	98-22	11-May	J. Marr	
Torilis nodosa	Newville	98-859	4-May	J. Cunningham	
Torilis nodosa	Newville	98-860	18-May	J. Cunningham	
Yabea microcarpa	Red Bank	98-23	20-May	J. Marr	
Yabea microcarpa	Sites	99-1	21-Apr	B. Hendrickson	
Yabea microcarpa	Newville	99-142	14-Apr	B. Castro	
APOCYANACEAE					
Apocyanum cannabinum	Red Bank	99-2		B. Hendrickson	
Apocyanum cannabinum	Newville	99-41	9-Jun	J. Witzman	
Apocyanum cannabinum	Red Bank	99-306	27-May	J. Marr	
ASCLEPIADACEAE					
Asclepias eriocarpa	Red Bank	99-69	10-Apr	L. Janeway	
Asclepias eriocarpa	Newville	99-143	1-Jun	B. Castro	
Asclepias fascicularis	Red Bank	98-24	2-Jul	J. Marr	
Asclepias fascicularis	Red Bank	98-25	8-Jul	J. Marr	
Asclepias fascicularis	Red Bank	98-861	25-Jun	J. Cunningham	
Asclepias speciosa	Red Bank	99-70	14-Apr	L. Janeway	
ASTERACEAE					
Undetermined	Red Bank	98-26	13-Oct	J. Marr	
Undetermined	Red Bank	98-651	27-Apr	H. West	
Undetermined	Red Bank	98-34	9-Jun	J. Marr	
Undetermined	Red Bank	98-712	27-Apr	C. Warren	
Undetermined	Newville	98-862	14-May	J. Cunningham	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Undetermined	Colusa	99-307	1-Apr	J. Marr	
Undetermined	Newville	99-308	20-Apr	J. Marr	
Agoseris heterophylla	Red Bank	99-309	27-May	J. Marr	
Agoseris heterophylla	Red Bank	98-863	27-Apr	J. Cunningham	
Agoseris heterophylla	Newville	98-864	29-Apr	J. Cunningham	
Agoseris heterophylla	Newville	98-27	30-Apr	J. Marr	
Agoseris heterophylla	Red Bank	98-28	1-Apr	J. Marr	
Agoseris heterophylla	Newville	98-29	20-Mar	J. Marr	
Agoseris heterophylla	Sites	98-30	8-May	J. Marr	
Agoseris heterophylla	Sites	98-31	14-Apr	J. Marr	
Agoseris heterophylla	Sites	98-32	14-Apr	J. Marr	
Agoseris heterophylla	Newville	98-33	19-May	J. Marr	
Agoseris heterophylla	Newville	99-71	21-Apr	L. Janeway	
Ancistrocarphus filagineus	Newville	99-72	6-Apr	L. Janeway	
Ancistrocarphus filagineus	Newville	98-35	17-Apr	J. Marr	
Ancistrocarphus filagineus	Sites	98-36	14-Apr	J. Marr	
Ancistrocarphus filagineus	Red Bank	99-144	7-Apr	B. Castro	
Anthemis cotula	Red Bank	98-866	7-Jul	J. Cunningham	
Artemisia douglasiana	Red Bank	98-655	21-Aug	H. West	
Artemisia douglasiana	Red Bank	98-670	27-Aug	H. West	
Artemisia douglasiana	Red Bank	98-37	27-Aug	J. Marr	
Baccharis sp.	Red Bank	98-713	24-Sep	C. Warren	
Baccharis salicifolia	Red Bank	98-38	9-Jun	J. Marr	
Baccharis salicifolia	Red Bank	98-39	13-Oct	J. Marr	
Blennosperma nanum var. *nanum*	Colusa	98-40	6-Apr	J. Marr	
Brickellia californica	Red Bank	98-41	27-Aug	J. Marr	
Brickellia californica	Red Bank	99-310	9-Jul	J. Marr	
Calycadenia sp.	Red Bank	98-42	9-Jun	J. Marr	
Calycadenia sp.	Newville	98-43	2-Jun	J. Marr	
Calycadenia sp.	Red Bank	98-44	9-Jul	J. Marr	
Calycadenia fremontii	Red Bank	98-45	8-Jul	J. Marr	
Calycadenia fremontii	Red Bank	98-672	13-Oct	H. West	
Calycadenia fremontii	Red Bank	98-867	25-Jun	J. Cunningham	
Calycadenia fremontii	Red Bank	99-145	8-Jun	B. Castro	
Calycadenia fremontii	Red Bank	99-285	11-Aug	B. Castro	
Calycadenia fremontii	Red Bank	99-311	27-May	J. Marr	
Calycadenia multiglandulosa	Newville	98-46	16-Jun	J. Marr	
Calycadenia multiglandulosa	Red Bank	98-47	27-Aug	J. Marr	
Calycadenia multiglandulosa	Red Bank	98-48	9-Jun	J. Marr	
Calycadenia pauciflora	Red Bank	98-868	25-Jun	J. Cunningham	
Calycadenia pauciflora	Red Bank	98-49	2-Jul	J. Marr	
Calycadenia pauciflora	Sites	98-50	27-May	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Calycadenia pauciflora	Colusa	98-51	17-Jun	J. Marr	
Calycadenia pauciflora	Red Bank	98-52	8-Jul	J. Marr	
Calycadenia pauciflora	Red Bank	98-53	8-Jul	J. Marr	
Calycadenia pauciflora	Red Bank	99-73	4-Apr	L. Janeway	
Calycadenia pauciflora	Red Bank	99-146	14-Jun	B. Castro	
Calycadenia truncata	Red Bank	99-147	9-Jun	B. Castro	
Calycadenia truncata	Red Bank	98-54	2-Jul	J. Marr	
Calycadenia truncata	Red Bank	98-55	3-Jul	J. Marr	
Calycadenia truncata	Red Bank	98-714	6-Jul	C. Warren	
Calycadenia truncata	Red Bank	98-715	3-Jul	C. Warren	
Calycadenia truncata	Red Bank	98-56	8-Jul	J. Marr	
Calycadenia truncata ssp. *scabrella*	Red Bank	98-57	8-Jul	J. Marr	
Calycadenia truncata ssp. *scabrella*	Red Bank	99-74	9-Jun	L. Janeway	
Carduus pycnocephalus	Sites	98-58	4-May	J. Marr	
Centaurea melitensis	Colusa	98-59	17-Jun	J. Marr	
Centaurea melitensis	Newville	98-60	16-Jun	J. Marr	
Centaurea melitensis	Sites	98-61	4-May	J. Marr	
Chaenactis glabriuscula var. *heterocarpha*	Red Bank	98-62	15-Jun	J. Marr	
Chaenactis glabriuscula var. *heterocarpha*	Red Bank	98-63	3-Jul	J. Marr	
Chaenactis glabriuscula var. *heterocarpha*	Newville	98-871	14-May	J. Cunningham	
Chaenactis glabriuscula var. *heterocarpha*	Red Bank	99-312	29-Apr	J. Marr	
Chaenactis glabriuscula var. *megacephala*	Newville	98-870	19-May	J. Cunningham	
Cirsium occidentale var. *venustum*	Newville	98-64	29-Apr	J. Marr	
Conyza canadensis	Red Bank	98-65	27-Aug	J. Marr	
Conyza canadensis	Red Bank	99-284	11-Aug	B. Castro	
Cotula coronopifolia	Sites	98-66	11-Jun	J. Marr	
Cotula coronopifolia	Sites	98-716	11-Jun	C. Warren	
Crocidium multicaule	Newville	98-67	19-Mar	J. Marr	
Crocidium multicaule	Newville	99-313	23-Mar	J. Marr	
Erigeron divergens	Red Bank	99-300	11-Aug	L. Janeway	
Erigeron philadelphicus	Colusa	98-69	22-Apr	J. Marr	
Erigeron philadelphicus	Red Bank	99-148	24-Jun	B. Castro	
Ericameria linearifolia	Newville	98-70	28-Apr	J. Marr	
Ericameria linearifolia	Newville	98-717	11-May	C. Warren	
Ericameria linearifolia	Newville	98-872	19-May	J. Cunningham	
Ericameria linearifolia	Newville	98-873	28-Apr	J. Cunningham	
Eriophyllum lanatum	Newville	98-718	14-May	C. Warren	
Eriophyllum lanatum var. *achillaeoides*	Newville	98-71	18-Jun	J. Marr	
Eriophyllum lanatum var. *achillaeoides*	Newville	98-72	16-Jun	J. Marr	
Eriophyllum lanatum var. *achillaeoides*	Newville	98-874	19-May	J. Cunningham	
Eriophyllum lanatum var. *achillaeoides*	Red Bank	98-875	25-Jun	J. Cunningham	
Eriophyllum lanatum var. *achillaeoides*	Red Bank	99-314	28-May	J. Marr	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Eriophyllum lanatum var. *aphanactis*	Newville	99-149	12-May	B. Castro	
Euthamia occidentalis	Red Bank	98-68	24-Sep	J. Marr	
Euthamia occidentalis	Red Bank	98-706	13-Oct	H. West	
Filago gallica	Newville	98-73	20-Apr	J. Marr	
Filago gallica	Sites	98-74	7-Apr	J. Marr	
Filago gallica	Colusa	98-75	8-Apr	J. Marr	
Filago gallica	Newville	98-719	28-Apr	C. Warren	
Gnaphalium luteo-album	Red Bank	98-76	20-May	J. Marr	
Gnaphalium luteo-album	Newville	98-77	14-Jul	J. Marr	
Gnaphalium luteo-album	Red Bank	98-78	9-Jul	J. Marr	
Gnaphalium luteo-album	Newville	98-79	16-Jun	J. Marr	
Gnaphalium luteo-album	Red Bank	98-80	2-Jul	J. Marr	
Gnaphalium luteo-album	Newville	99-75	5-May	L. Janeway	
Gnaphalium stramineum	Red Bank	99-76	24-Jun	L. Janeway	
Grindelia sp.	Newville	99-150	21-Apr	B. Castro	
Helenium puberulum	Red Bank	98-81	27-Aug	J. Marr	
Helenium puberulum	Red Bank	98-661	27-Aug	H. West	
Helenium puberulum	Red Bank	98-666	21-Aug	H. West	
Helianthella californica var. *nevadensis*	Red Bank	99-151	3-Jun	B. Castro	
Hemizonia sp.	Red Bank	98-82	23-Sep	J. Marr	
Hemizonia congesta	Red Bank	98-652	25-Jun	H. West	
Hemizonia congesta ssp. *clevelandii*	Red Bank	99-77	4-Jun	L. Janeway	
Hemizonia congesta ssp. *clevelandii*	Red Bank	99-152	3-Jun	B. Castro	
Hemizonia congesta ssp. *clevelandii*	Red Bank	99-153	24-Jun	B. Castro	
Hemizonia congesta ssp. *luzulifolia*	Sites	98-83	22-Jul	J. Marr	
Hemizonia fitchii	Newville	98-84	18-Jun	J. Marr	
Hesperevax acaulis var. *robustior*	Colusa	98-85	18-Apr	J. Marr	
Hesperevax acaulis var. *robustior*	Red Bank	98-707	27-Apr	H. West	
Hesperevax acaulis var. *robustior*	Red Bank	99-315	29-Apr	J. Marr	
Hesperevax caulescens	Colusa	99-316	30-Mar	J. Marr	
Hesperevax caulescens	Newville	99-317	21-Apr	J. Marr	
Hesperevax caulescens	Sites	98-86	14-Apr	J. Marr	
Hesperevax caulescens	Newville	98-87	29-Apr	J. Marr	
Hesperevax caulescens	Colusa	99-154	1-Apr	B. Castro	
Hesperevax sparsiflora	Sites	98-88	8-May	J. Marr	
Heterotheca oregona var. *compacta*	Red Bank	98-704	21-Aug	H. West	
Heterotheca oregona var. *compacta*	Red Bank	99-287	11-Aug	B. Castro	
Heterotheca oregona var. *rudis*	Red Bank	98-701	13-Oct	H. West	
Heterotheca oregona var. *rudis*	Red Bank	98-89	13-Oct	J. Marr	
Holocarpha obconica	Newville	98-720	18-Jun	C. Warren	
Holocarpha virgata ssp. *virgata*	Colusa	98-90	17-Jun	J. Marr	
Holocarpha virgata ssp. *virgata*	Newville	98-91	18-Jun	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Hypochaeris glabra	Colusa	98-92	17-Jun	J. Marr	
Hypochaeris glabra	Newville	98-93	29-Apr	J. Marr	
Hypochaeris glabra	Red Bank	98-721	27-Apr	C. Warren	
Hypochaeris glabra	Red Bank	98-876	27-Apr	J. Cunningham	
Hypochaeris glabra	Newville	98-877	28-Apr	J. Cunningham	
Hypochaeris glabra	Newville	98-878	11-May	J. Cunningham	
Hypochaeris glabra	Colusa	99-318	30-Mar	J. Marr	
Hypochaeris radicata	Newville	99-319	20-Apr	J. Marr	
Hypochaeris radicata	Newville	98-94	7-Apr	J. Marr	
Hypochaeris radicata	Red Bank	98-95	9-Jun	J. Marr	
Lactuca saligna	Sites	98-96	22-Jul	J. Marr	
Lactuca saligna	Sites	98-671	29-Oct	H. West	
Lagophylla sp.	Newville	98-97	28-Apr	J. Marr	
Lagophylla glandulosa	Newville	98-98	30-Apr	J. Marr	
Lagophylla glandulosa	Newville	98-99	30-Apr	J. Marr	
Lagophylla glandulosa	Newville	98-120	2-Jun	J. Marr	
Lagophylla glandulosa	Newville	99-155	4-May	B. Castro	
Lagophylla minor	Red Bank	98-100	15-Jun	J. Marr	
Lagophylla minor	Newville	98-101	29-Apr	J. Marr	
Lagophylla minor	Red Bank	98-879	7-Jul	J. Cunningham	
Lagophylla minor	Newville	98-880	11-May	J. Cunningham	
Lagophylla ramosissima ssp. *ramosissima*	Newville	98-881	11-May	J. Cunningham	
Lagophylla ramosissima ssp. *ramosissima*	Red Bank	98-882	27-Apr	J. Cunningham	
Lagophylla ramosissima ssp. *ramosissima*	Newville	98-883	14-May	J. Cunningham	
Lagophylla ramosissima ssp. *ramosissima*	Red Bank	98-884	25-Jun	J. Cunningham	
Lagophylla ramosissima ssp. *ramosissima*	Red Bank	98-102	15-Jun	J. Marr	
Lagophylla ramosissima ssp. *ramosissima*	Red Bank	99-156	3-Jun	B. Castro	
Lasthenia californica	Newville	99-157	12-Apr	B. Castro	
Lasthenia californica	Newville	98-103	20-Apr	J. Marr	
Lasthenia californica	Newville	98-104	29-Apr	J. Marr	
Lasthenia californica	Newville	98-105	26-Mar	J. Marr	
Lasthenia californica	Newville	98-106	17-Apr	J. Marr	
Lasthenia californica	Newville	98-700	6-Apr	H. West	
Lasthenia californica	Newville	98-722	30-Mar	C. Warren	
Lasthenia californica	Newville	98-885	11-May	J. Cunningham	
Lasthenia californica	Sites	99-3	7-Apr	B. Hendrickson	
Lasthenia californica	Newville	99-320	23-Mar	J. Marr	
Lasthenia glaberrima	Newville	98-107	28-Apr	J. Marr	
Lasthenia glaberrima	Newville	99-158	1-Jun	B. Castro	
Layia chrysanthemoides	Sites	98-108	8-May	J. Marr	
Layia chrysanthemoides	Sites	98-109	8-May	J. Marr	
Layia fremontii	Newville	98-110	28-Apr	J. Marr	

FAMILY ***Genus species***	**Reservoir**	**Voucher**	**Date**	**Collector**	
Layia fremontii	Newville	98-111	29-Apr	J. Marr	
Layia fremontii	Newville	99-321	14-Apr	J. Marr	
Lessingia sp.	Newville	98-112	19-May	J. Marr	
Lessingia sp.	Colusa	98-114	17-Jun	J. Marr	
Lessingia sp.	Newville	98-115	11-May	J. Marr	
Lessingia nana	Newville	98-702	15-Jul	H. West	
Lessingia nana	Newville	98-121	15-Jul	J. Marr	
Lessingia nemoclada	Red Bank	98-113	27-Aug	J. Marr	
Lessingia nemoclada	Red Bank	98-116	2-Jul	J. Marr	
Lessingia nemoclada	Red Bank	98-117	2-Jul	J. Marr	
Lessingia nemoclada	Red Bank	98-118	9-Jul	J. Marr	
Lessingia nemoclada	Red Bank	98-119	9-Jul	J. Marr	
Lessingia nemoclada	Red Bank	98-886	7-Jul	J. Cunningham	
Lessingia nemoclada	Newville	99-159	10-May	B. Castro	
Madia elegans ssp. *densifolia*	Newville	98-122	14-Jul	J. Marr	
Madia elegans ssp. *densifolia*	Newville	98-123	15-Jul	J. Marr	
Madia elegans ssp. *densifolia*	Newville	98-887	14-May	J. Cunningham	
Madia elegans ssp. *vernalis*	Red Bank	98-124	9-Jun	J. Marr	
Madia exigua	Red Bank	99-161	18-May	B. Castro	
Madia exigua	Newville	99-160	4-May	B. Castro	
Madia exigua	Red Bank	98-125	8-Jul	J. Marr	
Madia exigua	Red Bank	98-126	8-Jul	J. Marr	
Madia exigua	Newville	98-723	14-May	C. Warren	
Madia exigua	Red Bank	98-888	26-May	J. Cunningham	
Madia exigua	Newville	98-889	11-May	J. Cunningham	
Madia exigua	Newville	98-890	11-May	J. Cunningham	
Madia gracilis	Red Bank	98-891	27-Apr	J. Cunningham	
Madia gracilis	Red Bank	98-892	27-Apr	J. Cunningham	
Madia gracilis	Newville	98-127	19-May	J. Marr	
Madia gracilis	Sites	98-128	27-May	J. Marr	
Madia gracilis	Newville	98-129	30-Apr	J. Marr	
Madia gracilis	Red Bank	99-162	18-May	B. Castro	
Malacothrix floccifera	Newville	98-130	17-Apr	J. Marr	
Malacothrix floccifera	Newville	98-131	19-Mar	J. Marr	
Micropus californicus var. *californicus*	Sites	98-132	7-Apr	J. Marr	
Micropus californicus var. *californicus*	Colusa	98-133	8-Apr	J. Marr	
Micropus californicus var. *californicus*	Colusa	98-134	21-Apr	J. Marr	
Micropus californicus var. *californicus*	Newville	98-135	20-Apr	J. Marr	
Micropus californicus var. *californicus*	Colusa	98-136	6-Apr	J. Marr	
Micropus californicus var. *californicus*	Sites	98-137	14-Apr	J. Marr	
Micropus californicus var. *californicus*	Colusa	98-138	7-Apr	J. Marr	
Micropus californicus var. *californicus*	Colusa	98-139	7-Apr	J. Marr	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Micropus californicus var. *californicus*	Newville	98-140	28-Apr	J. Marr	
Micropus californicus var. *californicus*	Newville	98-724	14-May	C. Warren	
Microseris acuminata	Newville	98-893	29-Apr	J. Cunningham	
Microseris douglasii ssp. *douglasii*	Newville	98-894	11-May	J. Cunningham	
Microseris douglasii ssp. *douglasii*	Red Bank	98-895	27-Apr	J. Cunningham	
Microseris douglasii ssp. *douglasii*	Newville	98-141	20-Apr	J. Marr	
Microseris douglasii ssp. *douglasii*	Newville	98-142	30-Apr	J. Marr	
Microseris douglasii ssp. *douglasii*	Colusa	98-667	22-Apr	H. West	
Microseris douglasii ssp. *douglasii*	Newville	99-322	7-Apr	J. Marr	
Microseris douglasii ssp. *tenella*	Sites	98-143	8-May	J. Marr	
Monolopia gracilens	Newville	98-726	14-May	C. Warren	
Monolopia major	Sites	98-144	8-May	J. Marr	
Psilocarphus brevissimus var. *brevissimus*	Newville	99-163	1-Jun	B. Castro	
Psilocarphus oregonus	Colusa	98-145	21-Apr	J. Marr	
Psilocarphus oregonus	Newville	98-146	29-Apr	J. Marr	
Psilocarphus oregonus	Newville	98-147	28-Apr	J. Marr	
Psilocarphus oregonus	Newville	98-727	28-Apr	C. Warren	
Psilocarphus tenellus	Sites	98-728	8-May	C. Warren	
Psilocarphus tenellus var. *tenellus*	Sites	98-148	14-Apr	J. Marr	
Psilocarphus tenellus var. *tenellus*	Newville	98-149	17-Apr	J. Marr	
Psilocarphus tenellus var. *tenellus*	Newville	98-150	20-Apr	J. Marr	
Psilocarphus tenellus var. *tenellus*	Newville	98-896	11-May	J. Cunningham	
Psilocarphus tenellus var. *tenellus*	Red Bank	99-78	20-Apr	L. Janeway	
Rafinesquia californica	Newville	98-897	19-May	J. Cunningham	
Rafinesquia californica	Red Bank	98-151	20-May	J. Marr	
Rafinesquia californica	Newville	99-164	10-May	B. Castro	
Rigiopappus leptocladus	Newville	98-152	28-Apr	J. Marr	
Rigiopappus leptocladus	Newville	98-153	20-Apr	J. Marr	
Rigiopappus leptocladus	Sites	98-154	8-May	J. Marr	
Rigiopappus leptocladus	Newville	98-155	30-Apr	J. Marr	
Rigiopappus leptocladus	Red Bank	98-156	6-Jul	J. Marr	
Rigiopappus leptocladus	Newville	98-703	19-May	H. West	
Rigiopappus leptocladus	Newville	98-898	11-May	J. Cunningham	
Rigiopappus leptocladus	Newville	98-899	11-May	J. Cunningham	
Rigiopappus leptocladus	Newville	99-165	22-Apr	B. Castro	
Rigiopappus leptocladus	Newville	99-323	20-Apr	J. Marr	
Rigiopappus leptocladus	Newville	99-324	20-Apr	J. Marr	
Solidago californica	Red Bank	98-705	13-Oct	H. West	
Solidago californica	Red Bank	98-157	13-Oct	J. Marr	
Sonchus asper ssp. *asper*	Newville	98-158	14-Jul	J. Marr	
Sonchus asper ssp. *asper*	Red Bank	99-326	28-May	J. Marr	
Stephanomeria sp.	Newville	98-159	18-Jun	J. Marr	

FAMILY ***Genus species***	**Reservoir**	**Voucher**	**Date**	**Collector**	
Stephanomeria sp.	Red Bank	98-160	3-Jul	J. Marr	
Stephanomeria elata	Red Bank	98-161	9-Jul	J. Marr	
Stephanomeria virgata ssp. *pleurocarpa*	Red Bank	98-162	13-Oct	J. Marr	
Stephanomeria virgata ssp. *pleurocarpa*	Red Bank	99-286	11-Aug	B. Castro	
Uropappus lindleyi	Newville	99-166	15-Apr	B. Castro	
Uropappus lindleyi	Newville	98-163	29-Apr	J. Marr	
Uropappus lindleyi	Newville	98-164	17-Apr	J. Marr	
Uropappus lindleyi	Colusa	98-165	6-Apr	J. Marr	
Uropappus lindleyi	Newville	98-166	26-Mar	J. Marr	
Wyethia angustifolia	Newville	98-167	28-Apr	J. Marr	
Wyethia angustifolia	Newville	98-730	14-May	C. Warren	
Wyethia angustifolia	Red Bank	98-900	25-Jun	J. Cunningham	
Wyethia angustifolia	Newville	98-901	14-May	J. Cunningham	
Wyethia angustifolia	Sites	99-42	6-May	J. Witzman	
Wyethia angustifolia	Newville	99-167	12-May	B. Castro	
Wyethia glabra	Colusa	99-4	1-Apr	B. Hendrickson	
Wyethia helenioides	Newville	99-168	12-May	B. Castro	
Wyethia helenioides	Red Bank	99-326	28-Apr	J. Marr	
Xanthium spinosum	Sites	98-731	11-Jun	C. Warren	
BETULACEAE					
Alnus rhombifolia	Red Bank	98-168	21-May	J. Marr	
Alnus rhombifolia	Red Bank	99-327	28-May	J. Marr	
BORAGINACEAE					
Undetermined	Newville	99-328	23-Mar	J. Marr	
Amsinckia sp.	Colusa	98-169	6-Apr	J. Marr	
Amsinckia lycopsoides	Colusa	99-169	31-Mar	B. Castro	
Amsinckia lycopsoides	Colusa	99-329	31-Mar	J. Marr	
Amsinckia menziesii	Newville	98-171	20-Apr	J. Marr	
Amsinckia menziesii var. *menziesii*	Colusa	98-170	7-Apr	J. Marr	
Amsinckia menziesii var. *menziesii*	Newville	98-902	11-May	J. Cunningham	
Amsinckia menziesii var. *menziesii*	Newville	98-903	11-May	J. Cunningham	
Cryptantha sp.	Red Bank	98-904	27-Apr	J. Cunningham	
Cryptantha sp.	Red Bank	99-332	28-Apr	J. Marr	
Cryptantha flaccida	Newville	98-172	28-Apr	J. Marr	
Cryptantha flaccida	Newville	98-173	20-Apr	J. Marr	
Cryptantha flaccida	Colusa	98-174	21-Apr	J. Marr	
Cryptantha flaccida	Newville	98-175	30-Apr	J. Marr	
Cryptantha flaccida	Newville	98-732	14-May	C. Warren	
Cryptantha flaccida	Newville	98-905	28-Apr	J. Cunningham	
Cryptantha flaccida	Newville	98-906	28-Apr	J. Cunningham	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Cryptantha flaccida	Newville	98-907	19-May	J. Cunningham	
Cryptantha flaccida	Newville	98-908	14-May	J. Cunningham	
Cryptantha flaccida	Newville	98-909	11-May	J. Cunningham	
Cryptantha flaccida	Newville	98-910	19-May	J. Cunningham	
Cryptantha flaccida	Red Bank	98-911	25-Jun	J. Cunningham	
Cryptantha intermedia	Red Bank	98-912	25-Jun	J. Cunningham	
Cryptantha intermedia	Newville	98-913	11-May	J. Cunningham	
Cryptantha intermedia	Newville	98-914	19-May	J. Cunningham	
Cryptantha intermedia	Red Bank	98-915	6-Jul	J. Cunningham	
Cryptantha intermedia	Newville	98-176	16-Jun	J. Marr	
Cryptantha intermedia	Newville	98-177	28-Apr	J. Marr	
Cryptantha intermedia	Red Bank	98-178	2-Jul	J. Marr	
Cryptantha intermedia	Newville	98-179	17-Apr	J. Marr	
Cryptantha intermedia	Newville	98-180	20-Apr	J. Marr	
Cryptantha intermedia	Red Bank	98-657	21-Aug	H. West	
Cryptantha intermedia	Newville	98-699	5-Jun	H. West	
Cryptantha intermedia	Newville	98-733	11-May	C. Warren	
Cryptantha intermedia	Red Bank	98-734	15-Jun	C. Warren	
Cryptantha intermedia	Newville	98-735	11-May	C. Warren	
Cryptantha intermedia	Newville	98-736	14-May	C. Warren	
Cryptantha intermedia	Newville	99-79	5-May	L. Janeway	
Cryptantha intermedia	Red Bank	99-292	18-May	B. Castro	
Cryptantha intermedia	Colusa	99-333	31-Mar	J. Marr	
Cryptantha muricata	Newville	99-170	15-Apr	B. Castro	
Heliotropium europaeum	Red Bank	98-916	7-Jul	J. Cunningham	
Heliotropium europaeum	Newville	99-171	1-Jun	B. Castro	
Pectocarya penicillata	Colusa	99-80	31-Mar	L. Janeway	
Pectocarya pusilla	Sites	99-5	21-Apr	B. Hendrickson	
Pectocarya pusilla	Sites	99-6	7-Apr	B. Hendrickson	
Pectocarya pusilla	Red Bank	99-172	7-Apr	B. Castro	
Pectocarya pusilla	Red Bank	99-334	28-Apr	J. Marr	
Plagiobothrys sp.	Newville	98-213	26-Mar	J. Marr	
Plagiobothrys sp.	Red Bank	99-330	28-Apr	J. Marr	
Plagiobothrys sp.	Colusa	99-331	30-Mar	J. Marr	
Plagiobothrys sp.	Colusa	99-335	1-Apr	J. Marr	
Plagiobothrys bracteatus	Colusa	99-173	31-Mar	B. Castro	
Plagiobothrys canescens	Sites	99-7	21-Apr	B. Hendrickson	
Plagiobothrys canescens	Colusa	99-8	30-Mar	B. Hendrickson	
Plagiobothrys fulvus	Red Bank	98-917	27-Apr	J. Cunningham	
Plagiobothrys fulvus	Newville	98-181	26-Mar	J. Marr	
Plagiobothrys fulvus	Sites	98-182	27-May	J. Marr	
Plagiobothrys fulvus	Colusa	98-183	7-Apr	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Plagiobothrys fulvus	Newville	98-184	26-Mar	J. Marr	
Plagiobothrys fulvus	Sites	98-185	8-May	J. Marr	
Plagiobothrys fulvus	Newville	98-186	26-Mar	J. Marr	
Plagiobothrys greenii	Newville	98-187	29-Apr	J. Marr	
Plagiobothrys greenii	Colusa	98-188	6-Apr	J. Marr	
Plagiobothrys greenii	Newville	98-189	29-Apr	J. Marr	
Plagiobothrys greenii	Sites	98-190	14-Apr	J. Marr	
Plagiobothrys greenii	Colusa	98-191	7-Apr	J. Marr	
Plagiobothrys greenii	Newville	98-192	29-Apr	J. Marr	
Plagiobothrys greenii	Sites	98-193	8-May	J. Marr	
Plagiobothrys greenii	Newville	98-194	20-Apr	J. Marr	
Plagiobothrys greenii	Colusa	98-195	7-Apr	J. Marr	
Plagiobothrys greenii	Sites	98-196	16-Apr	J. Marr	
Plagiobothrys nothofulvus	Colusa	98-197	7-Apr	J. Marr	
Plagiobothrys nothofulvus	Newville	98-198	29-Apr	J. Marr	
Plagiobothrys nothofulvus	Newville	98-199	17-Apr	J. Marr	
Plagiobothrys nothofulvus	Newville	98-200	30-Apr	J. Marr	
Plagiobothrys nothofulvus	Newville	98-201	30-Apr	J. Marr	
Plagiobothrys nothofulvus	Colusa	98-202	7-Apr	J. Marr	
Plagiobothrys nothofulvus	Newville	98-737	28-Apr	C. Warren	
Plagiobothrys nothofulvus	Newville	98-738	30-Mar	C. Warren	
Plagiobothrys nothofulvus	Newville	98-918	11-May	J. Cunningham	
Plagiobothrys nothofulvus	Newville	98-919	28-Apr	J. Cunningham	
Plagiobothrys nothofulvus	Newville	98-920	28-Apr	J. Cunningham	
Plagiobothrys nothofulvus	Red Bank	98-921	27-Apr	J. Cunningham	
Plagiobothrys nothofulvus	Newville	98-922	19-May	J. Cunningham	
Plagiobothrys nothofulvus	Newville	98-923	14-May	J. Cunningham	
Plagiobothrys nothofulvus	Newville	99-336	28-Apr	J. Marr	
Plagiobothrys stipitatus	Newville	99-290	21-Apr	B. Castro	
Plagiobothrys stipitatus var. *micranthus*	Newville	98-924	11-May	J. Cunningham	
Plagiobothrys stipitatus var. *micranthus*	Newville	98-925	19-May	J. Cunningham	
Plagiobothrys stipitatus var. *micranthus*	Colusa	98-203	6-Apr	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Sites	98-204	8-May	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Newville	98-205	14-Jul	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Sites	98-206	1-Jul	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Sites	98-207	11-Jun	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Sites	98-208	16-Apr	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Newville	98-698	6-Apr	H. West	
Plagiobothrys stipitatus var. *micranthus*	Sites	99-9	25-Mar	B. Hendrickson	
Plagiobothrys stipitatus var. *micranthus*	Newville	99-290	21-Apr	B. Castro	
Plagiobothrys stipitatus var. *micranthus*	Newville	99-337	28-Apr	J. Marr	
Plagiobothrys stipitatus var. *micranthus*	Newville	99-338	1-Jun	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Plagiobothrys stipitatus var. *stipitatus*	Colusa	99-10	1-Apr	B. Hendrickson	
Plagiobothrys stipitatus var. *stipitatus*	Sites	98-209	14-Apr	J. Marr	
Plagiobothrys stipitatus var. *stipitatus*	Sites	98-210	16-Apr	J. Marr	
Plagiobothrys tenellus	Newville	98-211	20-Mar	J. Marr	
Plagiobothrys tenellus	Newville	98-212	30-Apr	J. Marr	
Plagiobothrys tenellus	Red Bank	98-739	27-Apr	C. Warren	
Plagiobothrys tenellus	Red Bank	98-740	27-Apr	C. Warren	
Plagiobothrys undulatus	Newville	99-174	1-Jun	B. Castro	
BRASSICACEAE					
Undetermined	Colusa	98-214	7-Apr	J. Marr	
Undetermined	Newville	98-230	17-Mar	J. Marr	
Arabis breweri var. *breweri*	Red Bank	99-175	24-Jun	B. Castro	
Athysanus pusillus	Sites	99-339	25-Feb	J. Marr	
Cardamine oligosperma	Newville	98-215	26-Mar	J. Marr	
Cardamine oligosperma	Sites	99-340	25-Feb	J. Marr	
Cardaria chalepensis	Newville	99-81	12-May	L. Janeway	
Cardaria chalepensis	Newville	99-291	12-May	B. Castro	
Draba verna	Newville	99-341	14-Apr	J. Marr	
Lepidium dictyotum var. *acutidens*	Colusa	99-82	13-Apr	L. Janeway	
Lepidium latifolium	Red Bank	99-176	14-Jun	B. Castro	
Lepidium latipes var. *latipes*	Newville	99-297	5-May	B. Castro	
Lepidium latipes var. *latipes*	Newville	98-216	17-Apr	J. Marr	
Lepidium latipes var. *latipes*	Sites	98-217	14-Apr	J. Marr	
Lepidium latipes var. *latipes*	Newville	98-218	26-Mar	J. Marr	
Lepidium latipes var. *latipes*	Newville	98-741	26-Mar	C. Warren	
Lepidium nitidum var. *nitidum*	Newville	98-219	29-Apr	J. Marr	
Lepidium strictum	Colusa	98-220	6-Apr	J. Marr	
Lepidium strictum	Sites	98-221	11-Jun	J. Marr	
Lepidium strictum	Colusa	98-222	21-Apr	J. Marr	
Lepidium strictum	Sites	98-742	11-Jun	C. Warren	
Lepidium strictum	Newville	99-83	6-May	L. Janeway	
Lepidium strictum	Red Bank	99-342	29-Apr	J. Marr	
Rorippa nasturtium-aquaticum	Newville	98-223	19-Mar	J. Marr	
Sisymbrium officianale	Newville	98-743	14-May	C. Warren	
Sisymbrium officianale	Newville	98-926	14-May	J. Cunningham	
Strepthanthus sp.	Newville	98-927	19-May	J. Cunningham	
Strepthanthus drepanoides	Red Bank	98-224	3-Jul	J. Marr	
Strepthanthus drepanoides	Red Bank	99-84	27-Apr	L. Janeway	
Strepthanthus glandulosus	Newville	98-225	26-Feb	J. Marr	
Strepthanthus glandulosus ssp. *glandulosus*	Newville	98-226	19-Mar	J. Marr	
Strepthanthus glandulosus ssp. *glandulosus*	Newville	98-227	17-Apr	J. Marr	

FAMILY ***Genus species***	**Reservoir**	**Voucher**	**Date**	**Collector**	
Strepthanthus glandulosus ssp. *glandulosus*	Sites	99-36	14-Apr	B. Hendrickson	
Strepthanthus glandulosus ssp. *glandulosus*	Newville	99-177	14-Apr	B. Castro	
Thysanocarpus curvipes	Newville	98-744	20-Mar	C. Warren	
Tropidocarpum gracile	Newville	98-228	19-Mar	J. Marr	
Tropidocarpum gracile	Newville	98-229	18-Mar	J. Marr	
Tropidocarpum gracile	Newville	98-928	28-Apr	J. Cunningham	
Tropidocarpum gracile	Newville	99-85	22-Apr	L. Janeway	
Tropidocarpum gracile	Colusa	99-178	31-Mar	B. Castro	
Tropidocarpum gracile	Red Bank	99-179	7-Apr	B. Castro	
Tropidocarpum gracile	Newville	99-343	14-Apr	J. Marr	
CALLITRICHACEAE					
Callitriche longipedunculata	Newville	98-929	11-May	J. Cunningham	
Callitriche marginata	Red Bank	99-344	28-Apr	J. Marr	
CALYCANTHACEAE					
Calycanthus occidentalis	Newville	99-43	9-Jun	J. Witzman	
CAMPANULACEAE					
Downingia insignis	Sites	98-753	8-May	C. Warren	
Githopsis specularioides	Newville	98-231	30-Apr	J. Marr	
Githopsis specularioides	Newville	98-697	29-Apr	H. West	
Heterocodon rariflorum	Red Bank	98-754	2-Jul	C. Warren	
Heterocodon rariflorum	Red Bank	99-180	3-Jun	B. Castro	
Nemocladus sp.	Newville	98-930	19-May	J. Cunningham	
Nemocladus sp.	Red Bank	99-345	2-Apr	J. Marr	
Nemocladus montanus	Red Bank	99-86	9-Jun	L. Janeway	
Triodanis biflora	Red Bank	98-233	8-Jul	J. Marr	
CAPRIFOLIACEAE					
Lonicera hispidula	Newville	99-295	4-May	B. Castro	
Lonicera interrupta	Newville	98-234	16-Jun	J. Marr	
Lonicera interrupta	Red Bank	99-181	19-May	B. Castro	
Sambucus mexicana	Newville	99-182	28-Apr	B. Castro	
CARYOPHYLLACEAE					
Undetermined	Newville	98-239	16-Mar	J. Marr	
Hernaria hirsuta ssp. *cinerea*	Red Bank	98-639	21-Aug	H. West	
Minuartia sp.	Colusa	99-44	30-Mar	J. Witzman	
Minuartia californica	Newville	99-346	13-Apr	J. Marr	
Minuartia californica	Newville	99-347	7-Apr	J. Marr	
Minuartia douglasii	Red Bank	98-240	15-Jun	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Minuartia douglasii	Newville	98-241	28-Apr	J. Marr	
Minuartia douglasii	Newville	98-540	29-Apr	J. Marr	
Minuartia douglasii	Sites	99-11	7-Apr	B. Hendrickson	
Minuartia douglasii	Newville	99-348	20-Apr	J. Marr	
Sagina apetala	Colusa	99-349	1-Apr	J. Marr	
Sagina apetala	Newville	98-242	11-May	J. Marr	
Sagina apetala	Colusa	98-243	14-Apr	J. Marr	
Sagina apetala	Colusa	99-87	1-Apr	L. Janeway	
Sagina apetala	Newville	99-293	21-Apr	B. Castro	
Sagina decumbens ssp. *occidentalis*	Sites	99-12	22-Apr	B. Hendrickson	
Scleranthus annuus	Newville	98-244	17-Apr	J. Marr	
Scleranthus annuus	Newville	98-748	26-Mar	C. Warren	
Scleranthus annuus	Red Bank	98-749	27-Apr	C. Warren	
Scleranthus annuus	Red Bank	99-350	28-Apr	J. Marr	
Silene gallica	Newville	98-245	20-Apr	J. Marr	
Silene gallica	Newville	98-232	29-Apr	J. Marr	
Silene gallica	Colusa	98-246	22-Apr	J. Marr	
Silene gallica	Newville	98-750	11-May	C. Warren	
Silene gallica		98-751		C. Warren	
Spergularia marina	Newville	98-247	2-Jun	J. Marr	
Spergularia marina	Colusa	98-248	7-Apr	J. Marr	
Spergularia marina	Sites	98-752	8-May	C. Warren	
Spergularia marina	Red Bank	98-931	7-Jul	J. Cunningham	
Stellaria nitens	Colusa	99-88	1-Apr	L. Janeway	
Stellaria nitens	Colusa	99-13	30-Mar	B. Hendrickson	
Stellaria pallida	Colusa	99-183	3-Mar	B. Castro	
Velezia rigida	Newville	98-932	11-May	J. Cunningham	
Velezia rigida	Newville	98-933	28-Apr	J. Cunningham	
Velezia rigida	Newville	98-249	28-Apr	J. Marr	
Velezia rigida	Newville	98-755	11-May	C. Warren	
Velezia rigida	Newville	98-653	14-May	H. West	
CHENOPODIACEAE					
Chenopodium sp.	Newville	98-756	29-Jul	C. Warren	
Chenopodium album	Sites	98-757	11-Jun	C. Warren	
Chenopodium album	Sites	98-677	11-Jun	H. West	
Chenopodium botrys	Red Bank	98-235	13-Oct	J. Marr	
Chenopodium botrys	Red Bank	98-665	13-Oct	H. West	
Chenopodium botrys	Red Bank	99-89	14-Jun	L. Janeway	
Chenopodium californicum	Red Bank	98-236	1-Apr	J. Marr	
Hernaria hirsuta ssp. *hirsuta*	Red Bank	98-758	21-Aug	C. Warren	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
CONVOLVULACEAE					
Cressa truxillensis	Sites	98-237	11-Jun	J. Marr	
CORNACEAE					
Cornus glabrata	Red Bank	99-184	14-Jun	B. Castro	
CRASSULACEAE					
Crassula aquatica	Newville	99-298	5-May	B. Castro	
Crassula connata	Newville	99-351	28-Apr	J. Marr	
Crassula tillaea	Newville	98-238	17-Mar	J. Marr	
CUPRESSACEAE					
Juniperus californica	Colusa	99-294	18-Mar	B. Castro	
Juniperus californica	Newville	99-296	4-May	B. Castro	
Juniperus occidentalis	Colusa	99-14	30-Mar	B. Hendrickson	
CUSCUTACEAE					
Cuscuta sp.	Colusa	99-352	17-Jun	J. Marr	
CYPERACEAE					
Carex sp.	Newville	98-250	17-Mar	J. Marr	
Carex sp.	Newville	98-251	20-Mar	J. Marr	
Carex nebrascensis	Newville	98-252	17-Mar	J. Marr	
Carex nudata	Newville	98-759	30-Mar	C. Warren	
Carex praegracilis	Newville	98-760	30-Mar	C. Warren	
Carex serratodens	Newville	98-253	16-Jun	J. Marr	
Carex serratodens	Newville	98-254	26-Mar	J. Marr	
Carex serratodens	Newville	98-761	20-Mar	C. Warren	
Carex serratodens	Newville	99-45	9-Jun	J. Witzman	
Cyperus eragrostis	Colusa	98-255	21-Jul	J. Marr	
Cyperus eragrostis	Red Bank	98-640	21-Aug	H. West	
Cyperus squarrosus	Newville	98-934	14-Jul	J. Cunningham	
Eleocharis sp.	Newville	98-935	8-Apr	J. Cunningham	
Eleocharis sp.	Newville	98-936	11-May	J. Cunningham	
Eleocharis sp.	Newville	98-256	14-Jul	J. Marr	
Eleocharis sp.	Colusa	98-257	6-Apr	J. Marr	
Eleocharis macrostachya	Sites	98-258	1-Jul	J. Marr	
Eleocharis macrostachya	Red Bank	98-259	27-Aug	J. Marr	
Eleocharis macrostachya	Red Bank	99-90	24-Jun	L. Janeway	
Eleocharis macrostachya	Colusa	99-91	13-Apr	L. Janeway	
Eleocharis macrostachya	Colusa	99-15	1-Apr	B. Hendrickson	
Eleocharis obtusa var. *engelmannii*	Newville	98-937	14-Jul	J. Cunningham	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Eleocharis obtusa var. *engelmannii*	Newville	98-696	14-Jul	H. West	
Scirpus acutus var. *occidentalis*	Newville	98-260	2-Jun	J. Marr	
Scirpus acutus var. *occidentalis*	Colusa	98-261	22-Jul	J. Marr	
Scirpus maritimus	Sites	98-668	22-Jul	H. West	
Scirpus maritimus	Sites	98-262	11-Jun	J. Marr	
Scirpus maritimus	Colusa	98-263	22-Jul	J. Marr	
Scirpus maritimus	Sites	98-762	11-Jun	C. Warren	
Scirpus pungens	Red Bank	99-92	14-Jun	L. Janeway	
Scirpus pungens	Newville	99-46	9-Jun	J. Witzman	
Scirpus pungens	Newville	99-185	1-Jun	B. Castro	
Scirpus pungens	Red Bank	99-353	13-Oct	J. Marr	
DATISCACEAE					
Datisca glomerata	Red Bank	98-264	9-Jul	J. Marr	
Datisca glomerata	Red Bank	99-186	3-Jun	B. Castro	
ELATINACEAE					
Elatine californica	Newville	98-938	14-Jul	J. Cunningham	
EQUISETACEAE					
Equisetum arvense	Red Bank	98-269	27-Aug	J. Marr	
Equisetum arvense	Red Bank	98-656	27-Aug	H. West	
Equisetum hyemale ssp. *affine*	Newville	98-270	20-Mar	J. Marr	
Equisetum telmateia ssp. *braunii*	Newville	99-47	9-Jun	J. Witzman	
ERICACEAE					
Arctostaphylos sp.	Colusa	98-265	8-Apr	J. Marr	
Arctostaphylos sp.	Red Bank	98-266	3-Jul	J. Marr	
Arctostaphylos manzanita	Colusa	98-267	17-Jun	J. Marr	
Arctostaphylos manzanita ssp. *manzanita*	Red Bank	98-684	20-May	H. West	
Arctostaphylos manzanita ssp. *manzanita*	Newville	99-187	4-May	B. Castro	
Arctostaphylos viscida	Newville	98-268	19-May	J. Marr	
EUPHORBIACEAE					
Chamaesyce sp.	Red Bank	98-271	21-May	J. Marr	
Chamaesyce sp.	Red Bank	98-939	25-Jun	J. Cunningham	
Chamaesyce glyptosperma	Red Bank	98-272	27-Aug	J. Marr	
Chamaesyce glyptosperma	Sites	98-644	29-Oct	H. West	
Chamaesyce glyptosperma	Red Bank	98-654	21-Aug	H. West	
Chamaesyce maculata	Red Bank	98-273	27-Aug	J. Marr	
Chamaesyce maculata	Red Bank	99-93	21-Jun	L. Janeway	
Chamaesyce ocellata	Newville	98-274	15-Jul	J. Marr	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Chamaesyce ocellata	Sites	98-763	21-Aug	C. Warren	
Chamaesyce ocellata	Newville	98-765	1-Sep	C. Warren	
Chamaesyce ocellata ssp. *rattanii*	Red Bank	98-275	3-Jul	J. Marr	
Chamaesyce ocellata ssp. *rattanii*	Red Bank	98-276	27-Aug	J. Marr	
Chamaesyce ocellata ssp. *rattanii*	Red Bank	99-94	9-Jun	L. Janeway	
Chamaesyce ocellata ssp. *rattanii*	Red Bank	99-188	21-Jun	B. Castro	
Chamaesyce serpyllifolia	Red Bank	99-95	21-Jun	L. Janeway	
Chamaesyce serpyllifolia ssp. *serpyllifolia*	Red Bank	98-277	13-Oct	J. Marr	
Euphorbia crenulata	Red Bank	99-189	21-Jun	B. Castro	
Euphorbia spathulata	Colusa	98-278	17-Jun	J. Marr	
Euphorbia spathulata	Newville	98-279	19-May	J. Marr	
Euphorbia spathulata	Red Bank	98-940	27-Apr	J. Cunningham	
FABACEAE					
Astragalus gambelianus	Colusa	98-280	7-Apr	J. Marr	
Astragalus gambelianus	Newville	98-281	19-Mar	J. Marr	
Astragalus rattanii var. *jepsonianus*	Newville	98-282	19-May	J. Marr	
Astragalus rattanii var. *jepsonianus*	Newville	98-283	17-Apr	J. Marr	
Astragalus rattanii var. *jepsonianus*	Red Bank	99-96	18-May	L. Janeway	
Glycyrrhiza lepidota	Newville	99-190	1-Jun	B. Castro	
Lotus corniculatus	Sites	98-284	11-Jun	J. Marr	
Lotus corniculatus	Sites	98-766	11-Jun	C. Warren	
Lotus humistratus	Newville	98-285	26-Mar	J. Marr	
Lotus humistratus	Red Bank	98-828	6-Jul	C. Warren	
Lotus humistratus	Red Bank	98-941	6-Jul	J. Cunningham	
Lotus purshianus var. *purshianus*	Red Bank	98-286	2-Jul	J. Marr	
Lotus purshianus var. *purshianus*	Red Bank	98-287	9-Jul	J. Marr	
Lotus wrangelianus	Newville	98-288	2-Jun	J. Marr	
Lotus wrangelianus	Newville	98-289	19-Mar	J. Marr	
Lupinus affinis	Newville	98-767	14-May	C. Warren	
Lupinus albifrons var. *albifrons*	Newville	98-694	30-Apr	H. West	
Lupinus albifrons var. *albifrons*	Newville	98-942	19-May	J. Cunningham	
Lupinus bicolor	Newville	98-290	19-Mar	J. Marr	
Lupinus bicolor	Newville	98-292	26-Mar	J. Marr	
Lupinus bicolor	Newville	98-695	30-Mar	H. West	
Lupinus bicolor	Red Bank	98-768	1-Apr	C. Warren	
Lupinus bicolor	Newville	98-769	26-Mar	C. Warren	
Lupinus latifolius	Colusa	98-291	8-Apr	J. Marr	
Lupinus luteolus	Newville	99-191	14-Apr	B. Castro	
Lupinus luteolus	Newville	99-192	28-Apr	B. Castro	
Lupinus microcarpus	Newville	98-770	28-Apr	C. Warren	
Lupinus microcarpus	Newville	98-771	14-May	C. Warren	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Lupinus microcarpus	Newville	98-943	11-May	J. Cunningham	
Lupinus microcarpus	Newville	98-944	19-May	J. Cunningham	
Lupinus microcarpus var. *densiflorus*	Red Bank	99-193	18-May	B. Castro	
Lupinus microcarpus var. *densiflorus*	Red Bank	99-194	18-May	B. Castro	
Lupinus microcarpus var. *microcarpus*	Newville	98-293	28-Apr	J. Marr	
Lupinus microcarpus var. *microcarpus*	Newville	98-294	29-Apr	J. Marr	
Lupinus microcarpus var. *microcarpus*	Newville	98-295	19-May	J. Marr	
Lupinus nanus	Newville	98-296	26-Mar	J. Marr	
Lupinus succulentus	Sites	99-48	19-Apr	J. Witzman	
Lupinus succulentus	Newville	99-195	4-May	B. Castro	
Medicago lupulina	Red Bank	98-647	21-Aug	H. West	
Medicago lupulina	Red Bank	99-97	14-Jun	L. Janeway	
Medicago polymorpha	Newville	98-772	26-Mar	C. Warren	
Trifolium sp.	Red Bank	98-297	2-Jul	J. Marr	
Trifolium albopurpureum var. *albopurpureum*	Red Bank	98-773	27-Apr	C. Warren	
Trifolium albopurpureum var. *albopurpureum*	Red Bank	98-774	1-Apr	C. Warren	
Trifolium albopurpureum var. *albopurpureum*	Newville	99-196	14-Apr	B. Castro	
Trifolium bifidum	Newville	98-775	28-Apr	C. Warren	
Trifolium bifidum var. *bifidum*	Colusa	99-197	18-Mar	B. Castro	
Trifolium bifidum var. *bifidum*	Newville	98-298	28-Apr	J. Marr	
Trifolium bifidum var. *bifidum*	Newville	98-299	20-Apr	J. Marr	
Trifolium bifidum var. *bifidum*	Red Bank	98-945	27-Apr	J. Cunningham	
Trifolium bifidum var. *decipiens*	Newville	98-946	11-May	J. Cunningham	
Trifolium bifidum var. *decipiens*	Sites	98-300	14-Apr	J. Marr	
Trifolium campestre	Red Bank	98-301	9-Jun	J. Marr	
Trifolium campestre	Newville	98-947	11-May	J. Cunningham	
Trifolium ciliolatum	Red Bank	98-948	27-Apr	J. Cunningham	
Trifolium ciliolatum	Newville	98-949	28-Apr	J. Cunningham	
Trifolium ciliolatum	Newville	98-302	28-Apr	C. Warren	
Trifolium depauperatum	Newville	98-310	17-Mar	J. Marr	
Trifolium depauperatum var. *amplectans*	Newville	98-303	19-Mar	J. Marr	
Trifolium depauperatum var. *amplectans*	Newville	98-776	30-Mar	C. Warren	
Trifolium depauperatum var. *depauperatum*	Newville	98-304	19-Mar	J. Marr	
Trifolium dubium	Newville	98-305	28-Apr	J. Marr	
Trifolium fragiferum	Sites	98-306	11-Jun	J. Marr	
Trifolium fragiferum	Colusa	98-307	22-Jul	J. Marr	
Trifolium fucatum	Newville	98-308	28-Apr	J. Marr	
Trifolium fucatum	Newville	98-777	30-Mar	C. Warren	
Trifolium fucatum	Newville	98-778	28-Apr	C. Warren	
Trifolium gracilentum var. *gracilentum*	Newville	98-309	28-Apr	J. Marr	
Trifolium hirtum	Newville	98-779	30-Mar	C. Warren	
Trifolium hirtum	Newville	98-311	19-Mar	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Trifolium hirtum	Newville	98-950	11-May	J. Cunningham	
Trifolium microcephalum	Newville	98-312	2-Jun	J. Marr	
Trifolium monanthum var. *monanthum*	Red Bank	98-780	6-Jul	C. Warren	
Trifolium obtusiflorum	Red Bank	98-313	2-Jul	J. Marr	
Trifolium obtusiflorum	Red Bank	98-314	9-Jun	J. Marr	
Trifolium obtusiflorum	Red Bank	98-315	27-Aug	J. Marr	
Trifolium obtusiflorum	Sites	99-49	6-May	J. Witzman	
Trifolium obtusiflorum	Red Bank	99-198	3-Jun	B. Castro	
Trifolium subterraneanum	Newville	98-316	29-Apr	J. Marr	
Trifolium subterraneanum	Newville	98-317	19-Mar	J. Marr	
Trifolium variegatum	Newville	98-318	8-May	J. Marr	
Trifolium variegatum	Newville	98-951	14-May	J. Cunningham	
Trifolium variegatum	Newville	98-952	14-May	J. Cunningham	
Trifolium variegatum	Newville	98-953	11-May	J. Cunningham	
Trifolium willdenovii	Newville	98-319	28-Apr	C. Warren	
Trifolium willdenovii	Newville	98-320	8-May	J. Marr	
Trifolium willdenovii	Newville	98-321	29-Apr	J. Marr	
Trifolium willdenovii	Newville	98-322	20-Apr	J. Marr	
Trifolium wormskioldii	Newville	98-781	11-May	C. Warren	
Trifolium wormskioldii	Newville	98-954	11-May	J. Cunningham	
Trifolium wormskioldii	Newville	98-955	28-Apr	J. Cunningham	
Trifolium wormskioldii	Newville	98-956	28-Apr	J. Cunningham	
Vicia benghalensis	Sites	98-782	11-Jun	C. Warren	
Vicia villosa ssp. *villosa*	Sites	98-323	14-Apr	J. Marr	
FAGACEAE					
Quercus sp.	Red Bank	98-957	25-Jun	J. Cunningham	
Quercus sp.	Red Bank	98-328	9-Jul	J. Marr	
Quercus agrifolia var. *agrifolia*	Red Bank	98-324	20-May	J. Marr	
Quercus agrifolia var. *agrifolia*	Red Bank	98-325	9-Jul	J. Marr	
Quercus agrifolia var. *agrifolia*	Red Bank	98-326	3-Jul	J. Marr	
Quercus berberidifolia	Red Bank	98-327	15-Jun	J. Marr	
Quercus berberidifolia	Red Bank	98-329	2-Jul	J. Marr	
Quercus berberidifolia	Red Bank	98-330	2-Jul	J. Marr	
Quercus berberidifolia	Newville	99-98	4-May	L. Janeway	
Quercus berberidifolia	Newville	99-199	5-May	B. Castro	
Quercus chrysolepis	Red Bank	98-331	9-Jul	J. Marr	
Quercus chrysolepis	Red Bank	98-332	9-Jul	J. Marr	
Quercus chrysolepis	Newville	99-50	9-Jun	J. Witzman	
Quercus chrysolepis	Newville	99-51	9-Jun	J. Witzman	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
FRANKENIACEAE					
Frankenia salina	Sites	98-783	11-Jun	C. Warren	
Frankenia salina	Sites	98-784	21-Jun	C. Warren	
Frankenia salina	Colusa	99-99	13-Apr	L. Janeway	
GARRYACEAE					
Garrya sp.	Red Bank	98-958	25-Jun	J. Cunningham	
Garrya congdonii	Red Bank	99-100	19-May	L. Janeway	
Garrya congdonii	Red Bank	99-200	19-May	B. Castro	
Garrya elliptica	Red Bank	98-333	20-May	J. Marr	
Garrya elliptica	Red Bank	98-334	20-May	J. Marr	
GENTIANACEAE					
Centaurium muehlenbergii	Colusa	98-785	24-Jun	C. Warren	
Centaurium trichantum	Red Bank	98-786	7-Jul	C. Warren	
Centaurium trichantum	Red Bank	98-335	3-Jul	J. Marr	
Centaurium trichantum	Red Bank	98-648	21-Aug	H. West	
Centaurium trichantum	Red Bank	99-201	3-Jun	B. Castro	
Centaurium venustum	Red Bank	98-336	2-Jul	J. Marr	
Centaurium venustum	Red Bank	98-959	6-Jul	J. Cunningham	
Cicendia quadrangularis	Newville	98-337	1-Jun	J. Marr	
GERANIACEAE					
Erodium sp.	Red Bank	98-339	15-Jun	J. Marr	
Erodium cicutarium	Newville	98-338	17-Mar	J. Marr	
Geranium carolinianum	Sites	99-16	22-Apr	B. Hendrickson	
HYDROCHARITACEAE					
Najas guadalupensis	Red Bank	98-960	7-Apr	J. Cunningham	
HYDROPHYLLACEAE					
Nemophila sp.	Sites	99-18	21-Apr	B. Hendrickson	
Nemophila heterophylla	Newville	98-340	19-May	J. Marr	
Nemophila heterophylla	Colusa	99-101	1-Apr	L Janeway	
Nemophila menziesii ssp. *menziesii*	Newville	99-202	28-Apr	B. Castro	
Nemophila pedunculata	Red Bank	98-787	1-Apr	C. Warren	
Nemophila pedunculata	Newville	99-17	29-Apr	B. Hendrickson	
Nemophila pedunculata	Newville	99-203	10-Mar	B. Castro	
Nemophila pulchella var. *fremontii*	Sites	99-38	23-Mar	B. Hendrickson	
Phacelia distans	Newville	98-788	11-May	C. Warren	
Phacelia egena	Newville	98-341	28-Apr	J. Marr	
Phacelia egena	Sites	99-19	12-Apr	B. Hendrickson	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Phacelia imbricata ssp. *imbricata*	Newville	99-102	12-May	L Janeway	
Phacelia ramosissima var. *ramosissima*	Newville	98-342	29-Apr	J. Marr	
Phacelia ramosissima var. *ramosissima*	Newville	98-804	14-May	C. Warren	
Phacelia ramosissima var. *ramosissima*	Newville	98-961	14-May	J. Cunningham	
Phacelia ramosissima var. *ramosissima*	Newville	99-204	12-May	B. Castro	
Phacelia ramosissima var. *ramosissima*	Newville	99-205	14-Apr	B. Castro	
HYPERICACEAE					
Hypericum sp.	Red Bank	98-346	20-May	J. Marr	
Hypericum formosum var. *scouleri*	Red Bank	98-343	27-Aug	J. Marr	
Hypericum formosum var. *scouleri*	Red Bank	98-344	2-Apr	J. Marr	
Hypericum formosum var. *scouleri*	Red Bank	98-345	2-Jul	J. Marr	
Hypericum formosum var. *scouleri*	Red Bank	99-282	11-Aug	B. Castro	
Hypericum perforatum	Red Bank	98-662	27-Aug	H. West	
JUGLANDACEAE					
Juglans californica var. *hindsii*	Newville	99-206	28-Apr	B. Castro	
JUNCACEAE					
Juncus sp.	Colusa	98-350	7-Apr	J. Marr	
Juncus balticus	Newville	98-962	29-Apr	J. Cunningham	
Juncus balticus	Sites	98-347	4-May	J. Marr	
Juncus balticus	Newville	98-348	16-Jun	J. Marr	
Juncus balticus	Sites	98-349	11-Jun	J. Marr	
Juncus bufonius	Sites	98-789	14-Apr	C. Warren	
Juncus bufonius var. *bufonius*	Sites	98-351	11-Jun	J. Marr	
Juncus bufonius var. *bufonius*	Red Bank	98-352	2-Jul	J. Marr	
Juncus bufonius var. *bufonius*	Newville	98-353	2-Jun	J. Marr	
Juncus bufonius var. *bufonius*	Colusa	98-354		J. Marr	
Juncus bufonius var. *bufonius*	Sites	98-355	14-Apr	J. Marr	
Juncus bufonius var. *congestus*	Newville	98-356		J. Marr	
Juncus xiphioides	Red Bank	98-357	9-Jun	J. Marr	
Juncus xiphioides	Colusa	98-358	22-Jul	J. Marr	
Juncus xiphioides	Red Bank	98-359	27-Aug	J. Marr	
Juncus xiphioides	Newville	98-790	14-May	C. Warren	
Juncus xiphioides	Newville	99-207	1-Jun	B. Castro	
LAMIACEAE					
Undetermined	Red Bank	98-360	9-Jun	J. Marr	
Menthe pulegium	Red Bank	98-361	21-Oct	J. Marr	
Menthe spicata var. *spicata*	Red Bank	98-362	24-Sep	J. Marr	
Monardella sheltonii	Newville	98-692	5-Jun	H. West	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Monardella sheltonii	Red Bank	98-363	27-Aug	J. Marr	
Monardella sheltonii	Red Bank	98-963	25-Jun	J. Cunningham	
Monardella sheltonii	Red Bank	99-210	24-Jun	B. Castro	
Pogogyne zizyphoroides	Newville	98-364	1-Jun	J. Marr	
Pogogyne zizyphoroides	Newville	98-365	29-Apr	J. Marr	
Salvia columbariae	Newville	98-366	17-Apr	J. Marr	
Salvia columbariae	Red Bank	98-367	3-Jul	J. Marr	
Salvia columbariae	Newville	98-368	19-Mar	J. Marr	
Salvia columbariae	Colusa	99-208	1-Apr	B. Castro	
Scuttelaria antirrhinoides	Red Bank	98-369	21-May	J. Marr	
Scuttelaria californica	Newville	99-52	9-Jun	J. Witzman	
Scuttelaria siphocampyloides	Newville	99-53	9-Jun	J. Witzman	
Scuttelaria siphocampyloides	Red Bank	98-370	3-Jul	J. Marr	
Scuttelaria siphocampyloides	Red Bank	98-371	2-Jul	J. Marr	
Scuttelaria siphocampyloides	Red Bank	98-964	7-Jul	J. Cunningham	
Scuttelaria siphocampyloides	Red Bank	99-211	3-Jun	B. Castro	
Stachys ajugoides	Newville	99-64	10-Jun	J. Witzman	
Stachys ajugoides var. *ajugoides*	Sites	98-791	11-Jun	C. Warren	
Stachys ajugoides var. *rigida*	Red Bank	98-649	9-Jul	H. West	
Stachys pycnantha	Colusa	98-372	22-Jul	J. Marr	
Stachys stricta	Newville	99-103	17-Jun	L. Janeway	
Stachys stricta	Newville	99-212	6-May	B. Castro	
Trichostemma lanceolatum	Sites	98-650	29-Oct	H. West	
Trichostemma laxum	Red Bank	98-643	21-Aug	H. West	
Trichostemma laxum	Red Bank	99-213	9-Jun	B. Castro	
Trichostemma laxum	Red Bank	99-214	24-Jun	B. Castro	
Trichostemma laxum	Red Bank	99-215	10-Jun	B. Castro	
LILIACEAE					
Allium sp.	Colusa	98-376	6-Apr	J. Marr	
Allium amplectans	Sites	98-673	15-Apr	H. West	
Allium amplectans	Newville	98-690	6-Apr	H. West	
Allium amplectans	Newville	98-792	26-Mar	C. Warren	
Allium falcifolium	Newville	98-373	26-Mar	J. Marr	
Allium falcifolium	Newville	98-374	26-Mar	J. Marr	
Allium peninsulare var. *peninsulare*	Red Bank	98-375	20-May	J. Marr	
Allium peninsulare var. *peninsulare*	Red Bank	98-965	25-Jun	J. Cunningham	
Allium serra	Colusa	98-377	21-Apr	J. Marr	
Allium serra	Sites	98-378	4-May	J. Marr	
Allium serra	Newville	99-104	22-Apr	L. Janeway	
Allium serra	Newville	99-216	4-May	B. Castro	
Calochortus amabilis	Red Bank	99-217	18-May	B. Castro	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Calochortus luteus	Newville	98-379	30-Apr	J. Marr	
Calochortus luteus	Sites	98-380	8-May	J. Marr	
Calochortus luteus	Newville	99-218	4-May	B. Castro	
Chloragalum angustifolium	Newville	99-219	29-Apr	B. Castro	
Chloragalum angustifolium	Newville	99-20	29-Apr	B. Hendrickson	
Dichelostemma congestum	Newville	98-381	19-May	J. Marr	
Dichelostemma multiflorum	Newville	98-382	19-May	J. Marr	
Dichelostemma multiflorum	Newville	98-383	29-Apr	J. Marr	
Triteleia hyacinthina	Newville	98-384	2-Jun	J. Marr	
Triteleia hyacinthina	Sites	98-385	8-May	J. Marr	
Triteleia laxa	Newville	98-691	30-Mar	H. West	
Triteleia laxa	Newville	98-693	6-Apr	H. West	
Triteleia peduncularis	Newville	99-55	10-Jun	J. Witzman	
LIMNANTHACEAE					
Limnanthes douglasii ssp. *nivea*	Newville	99-105	6-Apr	L. Janeway	
Limnanthes douglasii ssp. *nivea*	Red Bank	99-21		B. Hendrickson	
LINACEAE					
Hesperolinon californicum	Red Bank	99-106	8-Jun	L. Janeway	
Hesperolinon disjunctum	Red Bank	98-386	6-Jul	J. Marr	
Hesperolinon disjunctum	Red Bank	98-966	25-Jun	J. Cunningham	
Hesperolinon disjunctum	Red Bank	98-967	7-Jul	J. Cunningham	
Hesperolinon micranthum	Red Bank	98-793	2-Jul	C. Warren	
Hesperolinon spurgulinum	Newville	98-794	11-May	C. Warren	
LOASACEAE					
Mentzelia laevicaulis	Red Bank	98-388	13-Oct	J. Marr	
LYTHRACEAE					
Ammania coccinea	Newville	98-795	15-Jul	C.Warren	
Ammania coccinea	Newville	98-968	14-Jul	J. Cunningham	
Lythrum californicum	Colusa	98-389	22-Jul	J. Marr	
Lythrum hyssopifolium	Red Bank	98-390	3-Jul	J. Marr	
Lythrum hyssopifolium	Sites	98-391	1-Jul	J. Marr	
Lythrum hyssopifolium	Newville	98-392	14-Jul	J. Marr	
Lythrum hyssopifolium	Red Bank	98-393	2-Jul	J. Marr	
Lythrum hyssopifolium	Sites	98-394	11-Jun	J. Marr	
Lythrum hyssopifolium	Sites	98-395	11-Jun	J. Marr	
Lythrum hyssopifolium	Red Bank	99-220	3-Jun	B. Castro	
Lythrum tribracteatum	Sites	98-796	22-Jun	C.Warren	
Lythrum tribracteatum	Sites	98-396	1-Jul	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Lythrum tribracteatum	Newville	99-221	1-Jun	B. Castro	
Rotala ramosior	Newville	98-797	15-Jul	C.Warren	
Rotala ramosior	Newville	98-798	14-Jul	C.Warren	
MALVACEAE					
Malacothamnus fremontii	Red Bank	99-222	9-Jun	B. Castro	
Malvella leprosa	Colusa	98-397	21-Jul	J. Marr	
Malvella leprosa	Sites	98-398	1-Jul	J. Marr	
Sidalcea calycosa ssp. *calycosa*	Newville	98-399	2-Jun	J. Marr	
Sidalcea hirsuta	Red Bank	98-400	9-Jun	J. Marr	
Sidalcea hirsuta	Newville	98-401	2-Jun	J. Marr	
Sidalcea hirsuta	Red Bank	98-402	2-Jul	J. Marr	
Sidalcea hirsuta	Newville	98-403	19-May	J. Marr	
MARSILEACEAE					
Marsilea vestita ssp. *vestita.*	Newville	98-404	30-Apr	J. Marr	
Marsilea vestita ssp. *vestita.*	Newville	98-405	16-Mar	J. Marr	
MOLLUGONACEAE					
Mollugo verticillata	Newville	98-406	15-Jul	J. Marr	
OLEACEAE					
Fraxinus dipetala	Red Bank	99-223	10-Jun	B. Castro	
Fraxinus dipetala	Red Bank	99-224	10-Jun	B. Castro	
Fraxinus dipetala	Red Bank	99-225	9-Jun	B. Castro	
ONAGRACEAE					
Camissonia graciliflora	Newville	98-407	28-Apr	J. Marr	
Camissonia graciliflora	Newville	98-408	29-Apr	J. Marr	
Camissonia graciliflora	Sites	99-107	12-Apr	L. Janeway	
Camissonia graciliflora	Colusa	99-108	1-Apr	L. Janeway	
Camissonia graciliflora	Red Bank	99-109	20-Apr	L. Janeway	
Camissonia graciliflora	Colusa	99-22	30-Mar	B. Hendrickson	
Camissonia graciliflora	Sites	99-23	13-Apr	B. Hendrickson	
Camissonia hirtella	Newville	98-849	18-Jun	C. Warren	
Clarkia sp.	Newville	98-969	14-May	J. Cunningham	
Clarkia affinis	Newville	98-409	29-Apr	J. Marr	
Clarkia affinis	Newville	98-410	28-Apr	J. Marr	
Clarkia affinis	Sites	98-411	4-May	J. Marr	
Clarkia affinis	Sites	98-412	8-May	J. Marr	
Clarkia affinis	Newville	98-799	14-May	C. Warren	
Clarkia affinis	Newville	98-970	19-May	J. Cunningham	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Clarkia affinis	Newville	98-972	28-Apr	J. Cunningham	
Clarkia concinna ssp. *concinna*	Newville	98-973	18-May	J. Cunningham	
Clarkia concinna ssp. *concinna*	Red Bank	98-413	20-May	J. Marr	
Clarkia gracilis ssp. *gracilis*	Newville	98-414	30-Apr	J. Marr	
Clarkia gracilis ssp. *gracilis*	Colusa	98-415	17-Jun	J. Marr	
Clarkia gracilis ssp. *gracilis*	Newville	98-416	29-Apr	J. Marr	
Clarkia gracilis ssp. *gracilis*	Newville	98-974	14-May	J. Cunningham	
Clarkia gracilis ssp. *gracilis*	Newville	99-226	4-May	B. Castro	
Clarkia gracilis ssp. *gracilis*	Newville	99-228	28-Apr	B. Castro	
Clarkia lassenensis	Newville	99-227	14-Apr	B. Castro	
Clarkia modesta	Newville	98-975	14-May	J. Cunningham	
Clarkia modesta	Newville	98-800	14-May	C. Warren	
Clarkia purpurea ssp. *quadrivulnera*	Newville	98-801	4-May	C. Warren	
Clarkia purpurea ssp. *quadrivulnera*	Newville	98-417	18-May	J. Marr	
Clarkia purpurea ssp. *quadrivulnera*	Red Bank	98-418	9-Jun	J. Marr	
Clarkia purpurea ssp. *quadrivulnera*	Sites	98-419	8-May	J. Marr	
Clarkia purpurea ssp. *quadrivulnera*	Newville	98-971	11-May	J. Cunningham	
Clarkia purpurea ssp. *quadrivulnera*	Newville	98-976	19-May	J. Cunningham	
Clarkia purpurea ssp. *quadrivulnera*	Newville	98-977	28-Apr	J. Cunningham	
Clarkia rhomboidea	Red Bank	98-420	2-Jul	J. Marr	
Clarkia rhomboidea	Red Bank	98-421	9-Jun	J. Marr	
Epilobium brachycarpum	Red Bank	98-422	23-Sep	J. Marr	
Epilobium brachycarpum	Red Bank	98-423	23-Sep	J. Marr	
Epilobium ciliatum ssp. *ciliatum*	Red Bank	98-424	27-Aug	J. Marr	
Epilobium ciliatum ssp. *ciliatum*	Red Bank	98-641	21-Aug	H. West	
Epilobium cleistogamum	Red Bank	98-425	2-Jul	J. Marr	
Epilobium cleistogamum	Sites	98-426	1-Jul	J. Marr	
Epilobium cleistogamum	Colusa	98-427	22-Jul	J. Marr	
Epilobium cleistogamum	Red Bank	98-802	7-Jul	C. Warren	
Epilobium densiflorum	Colusa	98-428	21-Jul	J. Marr	
Epilobium densiflorum	Newville	98-851	5-Jun	C. Warren	
Epilobium foliosum	Red Bank	98-683	20-May	H. West	
Epilobium minutum	Red Bank	98-429	15-Jun	J. Marr	
Epilobium minutum	Newville	98-430	16-Jun	J. Marr	
Epilobium minutum	Red Bank	98-431	9-Jun	J. Marr	
Epilobium minutum	Red Bank	98-432	8-Jul	J. Marr	
Epilobium minutum	Newville	98-433	19-May	J. Marr	
Epilobium pygmaeum	Newville	98-434	2-Jun	J. Marr	
Epilobium torreyi	Newville	98-803	5-Jun	C. Warren	
ORCHIDACEAE					
Epipactis gigantea	Newville	99-56	9-Jun	J. Witzman	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Spiranthes porrifolia	Red Bank	99-110	24-Jun	L. Janeway	
OROBANCHEACEAE					
Orobanche fasciculata	Newville	98-435	29-Apr	J. Marr	
Orobanche fasciculata	Red Bank	98-978	25-Jun	J. Cunningham	
PAPAVERACEAE					
Eschscholzia sp.	Newville	98-979	28-Apr	J. Cunningham	
Eschscholzia caespitosa	Sites	98-436	4-May	J. Marr	
Eschscholzia caespitosa	Newville	98-437	19-Mar	J. Marr	
Eschscholzia californica	Newville	98-438	28-Apr	J. Marr	
Eschscholzia californica	Red Bank	98-980	27-Apr	J. Cunningham	
Platystemon californicis	Red Bank	98-981	27-Apr	J. Cunningham	
PHILADELPHACEAE					
Philadelphus lewisii	Red Bank	99-258	21-Jun	B. Castro	
PLANTAGINACEAE					
Plantago coronopus	Colusa	98-439	6-Apr	J. Marr	
Plantago coronopus	Sites	98-440	11-Jun	J. Marr	
Plantago elongata	Colusa	98-441	21-Apr	J. Marr	
Plantago elongata	Sites	98-442	16-Apr	J. Marr	
Plantago elongata	Colusa	98-443	7-Apr	J. Marr	
Plantago erecta	Sites	98-444	14-Apr	J. Marr	
Plantago erecta	Colusa	98-445	6-Apr	J. Marr	
Plantago erecta	Colusa	98-446	14-Apr	J. Marr	
Plantago erecta	Newville	98-447	20-Apr	J. Marr	
Plantago erecta	Sites	98-448	8-May	J. Marr	
Plantago erecta	Sites	98-449	4-May	J. Marr	
POACEAE					
Undetermined	Red Bank	98-805	2-Jul	C. Warren	
Achnatherum lemmonii	Red Bank	98-450	23-Sep	J. Marr	
Achnatherum lemmonii	Red Bank	98-986	25-Jun	J. Cunningham	
Achnatherum lemmonii	Red Bank	99-229	10-Jun	B. Castro	
Aegilops cylindrica	Sites	98-806	8-May	C. Warren	
Agrostis exarata	Red Bank	98-865	25-Jun	J. Cunningham	
Aira caryophyllea	Red Bank	98-451	1-Apr	J. Marr	
Alopecurus aequalis	Newville	98-452	1-Jun	J. Marr	
Alopecurus saccatus	Sites	98-453	16-Apr	J. Marr	
Alopecurus saccatus	Newville	99-230	5-May	B. Castro	
Aristida ternipes var. *hamulosa*	Sites	98-454	27-May	J. Marr	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Aristida ternipes var. *hamulosa*	Newville	98-987	14-May	J. Cunningham	
Avena barbata	Colusa	98-455	17-Jun	J. Marr	
Avena barbata	Newville	98-456	28-Apr	J. Marr	
Avena barbata	Colusa	98-457	7-Apr	J. Marr	
Avena fatua	Sites	98-458	14-Apr	J. Marr	
Bromus diandrus	Red Bank	98-459	2-Jul	J. Marr	
Bromus japonicus	Red Bank	98-460	21-May	J. Marr	
Bromus japonicus	Colusa	98-461	6-Apr	J. Marr	
Bromus laevipes	Red Bank	98-462	9-Jul	J. Marr	
Bromus madritensis ssp. *rubens*	Newville	98-463	16-Jun	J. Marr	
Bromus madritensis ssp. *rubens*	Newville	98-464	19-Mar	J. Marr	
Bromus madritensis ssp. *rubens*	Sites	98-465	14-Apr	J. Marr	
Crypsis schoenoides	Newville	98-466	15-Apr	J. Marr	
Crypsis schoenoides	Red Bank	98-467	21-Jul	J. Marr	
Crypsis schoenoides	Sites	98-660	29-Oct	H. West	
Cynodon dactylon	Red Bank	99-111	24-Jun	L. Janeway	
Cynosurus echinatus	Red Bank	98-988	25-Jun	J. Cunningham	
Deschampsia danthonioides	Sites	98-468	8-May	J. Marr	
Deschampsia danthonioides	Sites	98-469	8-May	J. Marr	
Deschampsia danthonioides	Newville	99-231	5-May	B. Castro	
Elymus glaucus	Newville	99-57	9-Jun	J. Witzman	
Elymus multisetus	Red Bank	99-232	14-Jun	B. Castro	
Elymus trachycaulis ssp. *subsecundus*	Red Bank	98-807	9-Jul	C. Warren	
Elytrigia pontica ssp. *pontica*	Red Bank	98-470	24-Sep	J. Marr	
Elytrigia pontica ssp. *pontica*	Red Bank	98-471	24-Sep	J. Marr	
Gastridium ventricosum	Colusa	98-472	17-Jun	J. Marr	
Gastridium ventricosum	Newville	98-473	16-Jun	J. Marr	
Gastridium ventricosum	Red Bank	98-474	9-Jun	J. Marr	
Gastridium ventricosum	Newville	98-475	15-Jul	J. Marr	
Gastridium ventricosum	Sites	98-476	8-May	J. Marr	
Gastridium ventricosum	Newville	98-989	11-May	J. Cunningham	
Hordeum brachyantherum ssp. *brachyantherum*	Newville	98-477	14-Jun	J. Marr	
Hordeum brachyantherum ssp. *californicum*	Colusa	98-478	21-Apr	J. Marr	
Hordeum marinum ssp. *gussoneanum*	Sites	98-808	8-May	C. Warren	
Hordeum marinum ssp. *gussoneanum*	Newville	98-990	11-May	J. Cunningham	
Hordeum murinum ssp. *leporinum*	Colusa	98-479	8-Apr	J. Marr	
Hordeum murinum ssp. *murinum*	Sites	98-480	16-Apr	J. Marr	
Hordeum murinum ssp. *murinum*	Colusa	99-233	18-Mar	B. Castro	
Koeleria macrantha	Colusa	98-481	7-Apr	J. Marr	
Koeleria phleoides	Colusa	98-482	7-Apr	J. Marr	
Leymus triticoides	Newville	98-483	16-Jun	J. Marr	
Lolium multiflorum	Colusa	98-484	8-Apr	J. Marr	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Melica californica	Red Bank	98-485	15-Jun	J. Marr	
Melica californica	Newville	98-486	1-May	J. Marr	
Melica californica	Newville	98-487	29-Apr	J. Marr	
Melica californica	Colusa	98-488	17-Jun	J. Marr	
Melica californica	Sites	98-489	27-May	J. Marr	
Melica californica	Newville	98-490	30-Apr	J. Marr	
Melica harfordii	Newville	98-991	14-May	J. Cunningham	
Melica harfordii	Newville	98-995	28-Apr	J. Cunningham	
Melica torreyana	Red Bank	98-491	9-Jul	J. Marr	
Muhlenbergia rigens	Sites	99-24	25-Mar	B. Hendrickson	
Nasella cernua	Sites	98-492	27-May	J. Marr	
Nasella cernua	Colusa	98-493	17-Jun	J. Marr	
Nasella cernua	Sites	98-494	8-May	J. Marr	
Nasella cernua	Newville	98-809	11-May	C. Warren	
Nasella cernua	Newville	99-234	4-May	B. Castro	
Nasella cernua	Newville	99-235	11-May	B. Castro	
Nasella lepida	Red Bank	98-993	27-Apr	J. Cunningham	
Nasella pulchra	Newville	98-994	11-May	J. Cunningham	
Nasella pulchra	Newville	98-810	14-May	C. Warren	
Nasella pulchra	Sites	98-495	4-May	J. Marr	
Nasella pulchra	Newville	98-496	16-Jun	J. Marr	
Nasella pulchra	Newville	98-497	16-Jun	J. Marr	
Nasella pulchra	Sites	98-498	16-Apr	J. Marr	
Nasella pulchra	Red Bank	98-499	15-Jun	J. Marr	
Nasella pulchra	Newville	98-500	30-Apr	J. Marr	
Panicum capillare	Red Bank	98-501	24-Sep	J. Marr	
Panicum capillare	Red Bank	98-658	21-Aug	H. West	
Panicum capillare	Red Bank	98-659	27-Aug	H. West	
Parapholis incurva	Sites	98-502	1-Jun	J. Marr	
Paspalum dilatatum	Newville	99-112	17-Jun	L. Janeway	
Phalaris aquatica	Red Bank	98-503	9-Jun	J. Marr	
Phalaris minor	Newville	98-504	14-Jul	J. Marr	
Phalaris minor	Red Bank	98-505	9-Jul	J. Marr	
Phalaris paradoxa	Colusa	98-506	17-Jun	J. Marr	
Phalaris paradoxa	Sites	98-507	11-Jun	J. Marr	
Phalaris paradoxa	Newville	98-508	2-Jun	J. Marr	
Phalaris paradoxa	Sites	98-509	11-Jun	J. Marr	
Phalaris paradoxa	Sites	98-510	8-May	J. Marr	
Phalaris paradoxa	Sites	98-811	8-May	C. Warren	
Piptatherum miliaceum	Red Bank	98-812	21-Aug	C. Warren	
Piptatherum miliaceum	Red Bank	99-113	24-Jun	L. Janeway	
Poa sp.	Newville	99-58	9-Jun	J. Witzman	

FAMILY ***Genus species***	**Reservoir**	**Voucher**	**Date**	**Collector**	
Poa secunda ssp. *secunda*	Red Bank	98-813	27-Apr	C. Warren	
Poa secunda ssp. *secunda*	Newville	98-814	20-Mar	C. Warren	
Poa secunda ssp. *secunda*	Newville	98-511	30-Apr	J. Marr	
Poa secunda ssp. *secunda*	Red Bank	98-512	1-Apr	J. Marr	
Poa secunda ssp. *secunda*	Red Bank	98-994	27-Apr	J. Cunningham	
Poa secunda ssp. *secunda*	Newville	98-996	29-Apr	J. Cunningham	
Polypogon interruptus	Newville	99-59	9-Jun	J. Witzman	
Polypogon maritimus	Red Bank	98-513	2-Jul	J. Marr	
Polypogon maritimus	Red Bank	98-815	7-Jul	C. Warren	
Polypogon maritimus	Sites	98-816	8-May	C. Warren	
Polypogon monspeliensis	Sites	98-514	1-Jul	J. Marr	
Polypogon monspeliensis	Sites	98-515	11-Jun	J. Marr	
Polypogon monspeliensis	Sites	98-669	27-May	H. West	
Polypogon monspeliensis	Sites	98-674	29-Oct	H. West	
Polypogon monspeliensis	Newville	98-687	2-Jun	H. West	
Scribneria bolanderi	Sites	98-729	11-Jun	C. Warren	
Taeniatherum caput-medusae	Newville	98-997	29-Apr	J. Cunningham	
Taeniatherum caput-medusae	Newville	98-998	11-May	J. Cunningham	
Vulpia bromoides	Newville	98-999	29-Apr	J. Cunningham	
Vulpia bromoides	Newville	98-1000	11-May	J. Cunningham	
Vulpia bromoides	Colusa	98-516	6-Apr	J. Marr	
Vulpia bromoides	Colusa	98-517	7-Apr	J. Marr	
Vulpia microstachys var. *ciliata*	Newville	98-518	20-Apr	J. Marr	
Vulpia microstachys var. *ciliata*	Sites	98-519	8-May	J. Marr	
Vulpia microstachys var. *ciliata*	Newville	98-520	28-Apr	J. Marr	
Vulpia microstachys var. *ciliata*	Newville	98-521	29-Apr	J. Marr	
Vulpia microstachys var. *ciliata*	Newville	98-522	20-Apr	J. Marr	
Vulpia microstachys var. *ciliata*	Newville	98-1001	29-Apr	J. Cunningham	
Vulpia microstachys var. *confusa*	Colusa	98-523	7-Apr	J. Marr	
Vulpia microstachys var. *pauciflora*	Newville	98-524	28-Apr	J. Marr	
Vulpia microstachys var. *pauciflora*	Newville	98-525	20-Apr	J. Marr	
Vulpia microstachys var. *pauciflora*	Newville	98-526	17-Apr	J. Marr	
Vulpia microstachys var. *pauciflora*	Newville	98-817	26-Mar	C. Warren	
Vulpia microstachys var. *pauciflora*	Red Bank	98-818	27-Apr	C. Warren	
Vulpia myuros var. *hirsuta*	Newville	98-527	26-Mar	J. Marr	
Vulpia myuros var. *hirsuta*	Newville	98-528	19-Mar	J. Marr	
Vulpia myuros var. *hirsuta*	Colusa	98-529	7-Apr	J. Marr	
Vulpia myuros var. *hirsuta*	Red Bank	98-530	1-Apr	J. Marr	
Vulpia myuros var. *myuros*	Colusa	98-531	6-Apr	J. Marr	
Vulpia myuros var. *myuros*	Newville	98-1002	11-May	J. Cunningham	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
POLEMONIACEAE					
Allophyllum gilioides	Newville	98-1003	28-Apr	J. Cunningham	
Eriastrum abramsii	Red Bank	98-541	6-Jul	J. Marr	
Eriastrum brandegeae	Red Bank	99-114	4-Jun	L. Janeway	
Gilia capitata ssp. *capitata*	Newville	98-819	28-Apr	C. Warren	
Gilia capitata ssp. *capitata*	Newville	98-688	30-Mar	H.West	
Gilia capitata ssp. *capitata*	Newville	98-1004	14-May	J. Cunningham	
Gilia capitata ssp. *staminea*	Newville	99-236	14-Apr	B. Castro	
Gilia tricolor ssp. *tricolor*	Newville	98-827	26-Mar	C. Warren	
Linanthus acicularis	Newville	98-820	26-Mar	C. Warren	
Linanthus bicolor	Newville	98-821	26-Mar	C. Warren	
Linanthus bolanderi	Red Bank	98-533	15-Jun	J. Marr	
Linanthus bolanderi	Newville	98-1005	11-May	J. Cunningham	
Linanthus bolanderi	Newville	98-1006	28-Apr	J. Cunningham	
Linanthus ciliatus	Newville	98-1007	28-Apr	J. Cunningham	
Linanthus ciliatus	Newville	98-1008	11-May	J. Cunningham	
Linanthus ciliatus	Colusa	98-534	7-Apr	J. Marr	
Linanthus ciliatus	Newville	98-535	20-Apr	J. Marr	
Linanthus ciliatus	Sites	98-536	14-Apr	J. Marr	
Linanthus ciliatus	Newville	98-537	28-Apr	J. Marr	
Linanthus dichotomous	Newville	98-538	29-Apr	J. Marr	
Linanthus dichotomous	Red Bank	99-237	25-Mar	B. Castro	
Linanthus dichotomous	Newville	99-238	14-Apr	B. Castro	
Linanthus parviflorus	Newville	98-822	15-Apr	C. Warren	
Linanthus parviflorus	Red Bank	98-1009	27-Apr	J. Cunningham	
Linanthus parviflorus	Newville	98-387	20-Mar	J. Marr	
Linanthus pygmaeus ssp. *continentalis*	Newville	98-539	11-Apr	J. Marr	
Navarretia eriocephala	Colusa	98-542	17-Jun	J. Marr	
Navarretia eriocephala	Sites	98-543	8-May	J. Marr	
Navarretia heterandra	Newville	98-544	2-Jun	J. Marr	
Navarretia heterandra	Sites	98-545	8-May	J. Marr	
Navarretia heterandra	Newville	98-823	11-May	C. Warren	
Navarretia heterandra	Newville	99-239	4-May	B. Castro	
Navarretia intertexta ssp. *intertexta*	Red Bank	98-824	7-Jul	C. Warren	
Navarretia intertexta ssp. *intertexta*	Red Bank	98-1010	7-Jul	J. Cunningham	
Navarretia jepsonii	Red Bank	98-681	6-Jul	H.West	
Navarretia jepsonii	Red Bank	99-115	21-Jun	L. Janeway	
Navarretia jepsonii	Red Bank	99-240	3-Jun	B. Castro	
Navarretia jepsonii	Red Bank	99-241	9-Jun	B. Castro	
Navarretia jepsonii	Red Bank	99-242	14-Jun	B. Castro	
Navarretia leucocephala	Sites	98-825	1-Jul	C. Warren	
Navarretia leucocephala ssp. *leucocephala*	Newville	98-546	1-Jun	J. Marr	

FAMILY *Genus species*	Reservoir	Voucher	Date	Collector	
Navarretia leucocephala ssp. *leucocephala*	Newville	98-547	14-Jul	J. Marr	
Navarretia leucocephala ssp. *leucocephala*	Sites	98-548	1-Jul	J. Marr	
Navarretia leucocephala ssp. *leucocephala*	Newville	98-549	30-Apr	J. Marr	
Navarretia leucocephala ssp. *leucocephala*	Newville	98-1011	14-Jul	J. Cunningham	
N. nigelliformis ssp. *nigelliformis*	Colusa	98-550	17-Jun	J. Marr	
N. nigelliformis ssp. *nigelliformis*	Sites	98-551	8-May	J. Marr	
Navarretia prolifera ssp. *prolifera*	Red Bank	98-552	6-Jul	J. Marr	
Navarretia pubescens	Red Bank	98-553	15-Jun	J. Marr	
Navarretia pubescens	Sites	98-554	8-May	J. Marr	
Navarretia pubescens	Newville	98-685	1-Jun	H.West	
Navarretia pubescens	Newville	98-826	11-May	C. Warren	
Navarretia pubescens	Red Bank	99-243	9-Jun	B. Castro	
Navarretia pubescens	Red Bank	99-244	10-Jun	B. Castro	
Navarretia tagetina	Red Bank	98-555	2-Jul	J. Marr	
Navarretia tagetina	Red Bank	98-556	8-Jul	J. Marr	
Navarretia tagetina	Newville	98-557	1-Jun	J. Marr	
Navarretia viscidula	Red Bank	98-558	8-Jul	J. Marr	
Navarretia viscidula	Red Bank	98-682	6-Jul	H.West	
Navarretia viscidula	Red Bank	98-680	25-Jun	H.West	
Navarretia viscidula	Red Bank	98-829	6-Jul	C. Warren	
Navarretia viscidula	Red Bank	98-1012	25-Jun	J. Cunningham	
Navarretia viscidula	Red Bank	98-1013	6-Jul	J. Cunningham	
Navarretia viscidula	Red Bank	99-116	15-Jun	L. Janeway	
Phlox gracilis	Colusa	99-25	30-Mar	B. Hendrickson	
POLYGONACEAE					
Chorizanthe membranacea	Newville	98-560	28-Apr	J. Marr	
Chorizanthe membranacea	Sites	98-676	26-May	H. West	
Chorizanthe membranacea	Newville	98-982	14-May	J. Cunningham	
Chorizanthe membranacea	Newville	98-983	19-May	J. Cunningham	
Chorizanthe membranacea	Newville	99-245	12-May	B. Castro	
Eriogonum dasyanthemum	Red Bank	99-246	9-Jun	B. Castro	
Eriogonum dasyanthemum	Newville	98-984	14-May	J. Cunningham	
Eriogonum dasyanthemum	Sites	98-675	26-May	H. West	
Eriogonum dasyanthemum	Colusa	98-561	17-Jun	J. Marr	
Eriogonum dasyanthemum	Red Bank	98-562	15-Jun	J. Marr	
Eriogonum dasyanthemum	Newville	98-563	16-Jun	J. Marr	
Eriogonum dasyanthemum	Red Bank	98-564	3-Jul	J. Marr	
Eriogonum dasyanthemum	Red Bank	98-565	3-Jul	J. Marr	
Eriogonum dasyanthemum	Red Bank	98-566	21-May	J. Marr	
Eriogonum dasyanthemum	Red Bank	98-646	21-Aug	H. West	
Eriogonum dasyanthemum	Red Bank	98-830	6-Jul	C. Warren	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Eriogonum dasyanthemum	Red Bank	99-247	24-Jun	B. Castro	
Eriogonum nudum var. *nudum*	Red Bank	98-567	13-Oct	J. Marr	
Eriogonum nudum var. *oblongifolium*	Red Bank	98-568	3-Jul	J. Marr	
Eriogonum nudum var. *oblongifolium*	Red Bank	98-569	9-Jul	J. Marr	
Eriogonum wrightii var. *trachygonum*	Red Bank	99-248	3-Jun	B. Castro	
Eriogonum wrightii var. *trachygonum*	Red Bank	99-249	9-Jun	B. Castro	
Eriogonum wrightii var. *trachygonum*	Red Bank	99-250	21-Jun	B. Castro	
Eriogonum wrightii var. *trachygonum*	Red Bank	99-289	11-Aug	B. Castro	
Polygonum sp.	Red Bank	98-573	3-Jul	J. Marr	
Polygonum arenastrum	Sites	98-559	4-May	J. Marr	
Polygonum arenastrum	Sites	98-570	11-Jun	J. Marr	
Polygonum arenastrum	Red Bank	99-299	11-Aug	L. Janeway	
Polygonum californicum	Newville	98-571	15-Jul	J. Marr	
Polygonum californicum	Newville	98-572	2-Jun	J. Marr	
Pterostegia drymarioides	Newville	98-574	29-Apr	J. Marr	
Pterostegia drymarioides	Newville	98-575	18-Jun	J. Marr	
Pterostegia drymarioides	Sites	98-831	4-May	C. Warren	
Pterostegia drymarioides	Newville	98-985	14-May	J. Cunningham	
Pterostegia drymarioides	Newville	99-251	12-May	B. Castro	
Rumex pulcher	Newville	98-576	18-May	J. Marr	
Rumex salicifolius var. *denticulatus*	Red Bank	98-832	21-Oct	C. Warren	
Rumex salicifolius var. *denticulatus*	Red Bank	98-577	21-Oct	J. Marr	
Rumex salicifolius var. *denticulatus*	Red Bank	99-252	1-Jun	B. Castro	
PORTULACACEAE					
Claytonia exigua ssp. *exigua*	Newville	99-117	22-Apr	L. Janeway	
Lewisia rediviva	Newville	99-118	6-Apr	L. Janeway	
Montia fontana	Newville	98-532	16-Mar	J. Marr	
Portulaca oleraceae	Red Bank	98-642	21-Aug	H. West	
PRIMULACEAE					
Androsace elongata ssp. *acuta*	Newville	99-119	22-Apr	L. Janeway	
Androsace elongata ssp. *acuta*	Colusa	99-120	13-Apr	L. Janeway	
Androsace elongata ssp. *acuta*	Newville	99-253	4-May	B. Castro	
Androsace elongata ssp. *acuta*	Newville	99-254	16-Apr	B. Castro	
PTERIDACEAE					
Adiantum jordanii	Red Bank	99-255	21-Jun	B. Castro	
Pellaea andromedifolia	Red Bank	98-578	9-Jun	J. Marr	
Pellaea andromedifolia	Newville	98-1014	19-May	J. Cunningham	
Pellaea andromedifolia	Newville	99-26	14-Apr	B. Hendrickson	
Pellaea andromedifolia	Sites	99-27	16-Mar	B. Hendrickson	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Pellaea andromedifolia	Newville	99-60	9-Jun	J. Witzman	
Pellaea andromedifolia	Newville	99-256	10-May	B. Castro	
Pellaea mucronata var. mucronata	Newville	98-1015	14-May	J. Cunningham	
Pentagramma triangularis ssp. *triangularis*	Newville	99-61	9-Jun	J. Witzman	
RANUNCULACEAE					
Undetermined	Newville	98-593	19-Mar	J. Marr	
Clematis sp.	Red Bank	98-580	9-Jul	J. Marr	
Clematis ligusticifolia	Red Bank	98-579	27-Aug	J. Marr	
Delphinium patens ssp. *patens*	Newville	98-581	26-Mar	J. Marr	
Delphinium hesperian ssp. *pallescens*	Colusa	98-582	21-Apr	J. Marr	
Delphinium variegatum ssp. *variegatum*	Sites	98-583	14-Apr	J. Marr	
Delphinium variegatum ssp. *variegatum*	Sites	98-584	14-Apr	J. Marr	
Delphinium variegatum ssp. *variegatum*	Newville	98-689	29-Apr	H. West	
Delphinium variegatum ssp. *variegatum*	Newville	98-1016	11-May	J. Cunningham	
Myosaurus minimus	Newville	98-833	26-Mar	C. Warren	
Myosaurus minimus	Newville	99-259	21-Apr	B. Castro	
Ranunculus aquatilis	Newville	98-585	18-Mar	J. Marr	
Ranunculus californicus	Newville	98-586	17-Mar	J. Marr	
Ranunculus californicus	Newville	98-834	16-Mar	C. Warren	
Ranunculus canus	Newville	99-121	6-Apr	L. Janeway	
Ranunculus hebecarpus	Newville	98-587	20-Mar	J. Marr	
Ranunculus hebecarpus	Newville	98-588	17-Mar	J. Marr	
Ranunculus muricatus	Newville	98-589	26-Mar	J. Marr	
Ranunculus muricatus	Colusa	98-590	8-Apr	J. Marr	
Ranunculus occidentalis	Colusa	98-591	6-Apr	J. Marr	
Thalictrum fendleri	Red Bank	98-592	3-Jul	J. Marr	
Thalictrum fendleri var. *polycarpum*	Red Bank	99-260	9-Jun	B. Castro	
Thalictrum fendleri var. *polycarpum*	Red Bank	99-305	28-Apr	J. Marr	
RHAMNACEAE					
Rhamnus ilicifolia	Newville	99-122	11-May	L. Janeway	
Rhamnus tomentella ssp. *crassifolia*	Newville	99-62	9-Jun	J. Witzman	
Rhamnus tomentella ssp. *tomentella*	Red Bank	98-594	2-Jul	J. Marr	
Rhamnus tomentella ssp. *tomentella*	Red Bank	99-288	11-Aug	B. Castro	
ROSACEAE					
Aphanes occidentalis	Newville	98-595	26-Feb	J. Marr	
Cercocarpus betuloides	Red Bank	98-835	27-Apr	C. Warren	
Cercocarpus betuloides var. *betuloides*	Red Bank	98-596	2-Jul	J. Marr	
Cercocarpus betuloides var. *betuloides*	Newville	99-261	5-May	B. Castro	
Heteromeles arbutifolia	Red Bank	98-597	9-Jul	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Heteromeles arbutifolia	Red Bank	98-598	2-Jul	J. Marr	
Heteromeles arbutifolia	Red Bank	98-1017	25-Jun	J. Cunningham	
Rosa californica	Sites	98-599	4-May	J. Marr	
Rosa californica	Red Bank	99-262	14-Jun	B. Castro	
RUBIACEAE					
Crucianella angustifolia	Red Bank	98-600	21-May	J. Marr	
Galium sp.	Newville	99-63	9-Jun	J. Witzman	
Galium aparine	Newville	98-836	30-Mar	C. Warren	
Galium aparine	Colusa	98-601	8-Apr	J. Marr	
Galium parisiense	Newville	98-602	11-May	J. Marr	
Galium parisiense	Sites	98-603	27-May	J. Marr	
Galium parisiense	Newville	98-837	26-Mar	C. Warren	
Galium parisiense	Newville	98-838	11-May	C. Warren	
Galium parisiense	Newville	98-1018	28-Apr	J. Cunningham	
Galium parisiense	Red Bank	99-263	21-Jun	B. Castro	
Galium porrigens var. *tenue*	Newville	99-264	10-May	B. Castro	
SALICACEAE					
Salix sp.	Newville	99-64	9-Jun	J. Witzman	
Salix exigua	Red Bank	98-604	9-Jul	J. Marr	
Salix exigua	Red Bank	98-605	3-Jul	J. Marr	
Salix laevigata	Red Bank	98-606	13-Oct	J. Marr	
Salix laevigata	Red Bank	98-607	27-Aug	J. Marr	
Salix laevigata	Red Bank	98-608	21-Oct	J. Marr	
Salix laevigata	Red Bank	98-839	24-Sep	C. Warren	
Salix laevigata	Newville	99-123	6-Apr	L. Janeway	
Salix laevigata	Sites	99-28	12-Apr	B. Hendrickson	
Salix laevigata	Newville	99-65	10-Jun	J. Witzman	
Salix laevigata	Red Bank	99-265	10-Jun	B. Castro	
Salix lasiolepis	Red Bank	98-609	13-Oct	J. Marr	
Salix lasiolepis	Red Bank	98-663	29-Oct	H. West	
Salix lucida ssp. *lasiandra*	Red Bank	98-610	9-Jul	J. Marr	
Salix lucida ssp. *lasiandra*	Red Bank	98-611	13-Oct	J. Marr	
SAXIFRAGACEAE					
Lithofragma affine	Newville	98-612	30-Apr	J. Marr	
Lithofragma heterophylla	Sites	99-37	23-Mar	B. Hendrickson	
Saxifraga californica	Colusa	99-124	1-Apr	L. Janeway	
SCROPHULARIACEAE					
Antirrhinum subcordatum	Red Bank	99-125	15-Jun	L. Janeway	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Bellarida trixago	Sites	98-613	8-May	J. Marr	
Castilleja affinis	Sites	99-30	17-Mar	B. Hendrickson	
Castilleja affinis ssp. *affinis*	Newville	99-126	10-Mar	L. Janeway	
Castilleja affinis ssp. *affinis*	Newville	99-266	4-May	B. Castro	
Castilleja affinis ssp. *affinis*	Newville	99-267	14-Apr	B. Castro	
Castilleja attenuata	Sites	98-614	14-Apr	J. Marr	
Castilleja attenuata	Newville	98-615	26-Mar	J. Marr	
Castilleja attenuata	Newville	98-840	26-Mar	C. Warren	
Castilleja exerta ssp. *exerta*	Newville	98-616	19-Mar	J. Marr	
Castilleja foliolosa	Red Bank	98-618	9-Jul	J. Marr	
Castilleja foliolosa	Newville	98-686	19-May	H. West	
Castilleja foliolosa	Red Bank	99-127	10-Jun	L. Janeway	
Castilleja rubicundula ssp. *lithospermoides*	Red Bank	98-619	8-Jul	J. Marr	
Castilleja rubicundula ssp. *lithospermoides*	Red Bank	98-1019	25-Jun	J. Cunningham	
Collinsia sparsiflora var. *bruceae*	Newville	99-268	10-Mar	B. Castro	
Collinsia sparsiflora var. *collina*	Newville	98-841	26-Mar	C. Warren	
Collinsia sparsiflora var. *collina*	Newville	98-842	26-Mar	C. Warren	
Collinsia sparsiflora var. *collina*	Newville	99-128	10-Mar	L. Janeway	
Collinsia sparsiflora var. *collina*	Colusa	99-29	2-Apr	B. Hendrickson	
Collinsia sparsiflora var. *sparsiflora*	Newville	98-620	20-Mar	J. Marr	
Collinsia sparsiflora var. *sparsiflora*	Colusa	99-31	30-Mar	B. Hendrickson	
Keckiella corymbosa	Red Bank	99-269	21-Jun	B. Castro	
Keckiella corymbosa	Red Bank	99-283	11-Aug	B. Castro	
Keckiella lemmonii	Red Bank	98-621	3-Jul	J. Marr	
Keckiella lemmonii	Red Bank	99-270	10-Jun	B. Castro	
Mimulus androsace	Newville	98-1020	28-Apr	J. Cunningham	
Mimulus douglasii	Newville	99-271	15-Apr	B. Castro	
Mimulus floribundus	Red Bank	98-617	27-Aug	J. Marr	
Mimulus latidens	Sites	98-843	4-May	C. Warren	
Mimulus moschatus	Red Bank	99-281	11-Aug	B. Castro	
Mimulus pilosus	Red Bank	99-273	21-Jun	B. Castro	
Mimulus kelloggii	Red Bank	98-622	1-Apr	J. Marr	
Mimulus kelloggii	Newville	98-623	29-Apr	J. Marr	
Penstemon sp.	Newville	98-624	29-Apr	J. Marr	
Penstemon heterophyllus var *heterophyllus*	Red Bank	98-625	9-Jul	J. Marr	
Penstemon heterophyllus var *heterophyllus*	Sites	98-626	4-May	J. Marr	
Penstemon heterophyllus var. *purdyi*	Red Bank	98-627	3-Jul	J. Marr	
Penstemon heterophyllus var. *purdyi*	Newville	99-129	13-May	L. Janeway	
Penstemon heterophyllus var. *purdyi*	Red Bank	99-274	9-Jun	B. Castro	
Penstemon heterophyllus var. *purdyi*	Red Bank	99-275	3-Jun	B. Castro	
Tonella tenella	Red Bank	99-276	23-Mar	B. Castro	
Tonella tenella	Newville	98-628	17-Apr	J. Marr	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Triphysaria eriantha	Red Bank	98-844	27-Apr	C. Warren	
Triphysaria pusilla	Red Bank	99-130	27-Apr	L. Janeway	
Verbascum thapsus	Red Bank	98-664	27-Aug	H. West	
Veronica anagallis-aquatica	Red Bank	98-845	9-Jul	C. Warren	
Veronica anagallis-aquatica	Newville	98-846	5-Jun	C. Warren	
Veronica anagallis-aquatica	Red Bank	98-1021	7-Jul	J. Cunningham	
Veronica anagallis-aquatica	Newville	99-131	5-May	L. Janeway	
Veronica anagallis-aquatica	Newville	99-277	1-Jun	B. Castro	
Veronica catenata	Red Bank	98-679	9-Jul	H. West	
Veronica persica	Sites	99-32	25-Mar	B. Hendrickson	
SOLANACEAE					
Nicotiana guadrivalvis	Red Bank	98-629	13-Oct	J. Marr	
Physalis lancifolia	Sites	98-847	1-Jul	C. Warren	
Solanum sp.	Sites	99-33	17-Mar	B. Hendrickson	
Solanum nigrum	Red Bank	98-630	13-Oct	J. Marr	
Solanum parishii	Red Bank	98-631	20-May	J. Marr	
Solanum rostratum	Newville	99-66	10-Jun	J. Witzman	
URTICACEAE					
Urtica urens	Sites	98-635	14-Apr	J. Marr	
VALERIANACEAE					
Plectritis sp.	Colusa	98-632	21-Apr	J. Marr	
Plectritis ciliosa	Newville	98-633	20-Mar	J. Marr	
Plectritis ciliosa ssp. *ciliosa*	Newville	98-634	26-Mar	J. Marr	
Plectritis macrocera	Newville	98-1022	7-Apr	J. Cunningham	
Plectritis macrocera	Colusa	99-34	30-Mar	B. Hendrickson	
Plectritis macrocera	Colusa	99-35	1-Apr	B. Hendrickson	
Plectritis macrocera	Newville	99-278	22-Apr	B. Castro	
VERBENACEAE					
Phyla nodiflora var. *nodiflora*	Newville	98-848	18-Jun	C. Warren	
Phyla nodiflora var. *nodiflora*	Sites	98-638	4-May	J. Marr	
Verbena lasiostachys var. *lasiostachys*	Red Bank	98-636	9-Jul	J. Marr	
Verbena lasiostachys var. *lasiostachys*	Red Bank	98-678	21-Aug	H. West	
Verbena lasiostachys var. *scabrida*	Red Bank	98-850	21-Aug	C. Warren	
Verbena lasiostachys var. *scabrida*	Red Bank	98-637	13-Oct	J. Marr	
Verbena lasiostachys var. *scabrida*	Red Bank	99-279	3-Jun	B. Castro	
VISCACEAE					
Arceuthobium occidentale	Red Bank	99-132	18-Mar	L. Janeway	

FAMILY *Genus species*	**Reservoir**	**Voucher**	**Date**	**Collector**	
Arceuthobium occidentale	Newville	99-67	9-Jun	J. Witzman	
Phoradendron densum	Newville	98-1023	28-Apr	J. Cunningham	
Phoradendron villosum	Newville	99-133	10-Mar	L. Janeway	

January 4, 2000

ATTACHMENT 7.

OFFSTREAM STORAGE RESERVOIR INVESTIGATION:

a. Explanation of prioritized plant species name and spreadsheet column acronyms

b. 1998-1999 prioritized plant species population occurrence records

Acronyms found in Attachment B, 1998-1999 Prioritized Plant Species Population Occurrence Records, are spelled out below.

1) Prioritized Plant Species Names

Acronym	Species name
ANELA	*Androsace elongata* ssp. *acuta*
ANSU	*Antirrhinum subcordatum*
ASRAJ	*Astragalus rattanii* var. *jepsonianus*
CHOCR	*Chamaesyce ocellata* ssp. *rattanii*
ERBR	*Eriastrum brandegeae*
FRPL	*Fritillaria pluriflora*
HECA	*Hesperevax caulescens*
HETE	*Hesperolinon tehamense*
JUCAH	*Juglans californica* var. *hindsii*
LIFLF	*Limnanthes floccosa* ssp. *floccosa*
NAER	*Navarretia eriocephala*
NAHE	*Navarretia heterandra*
NAJE	*Navarretia jepsonii*
STDR	*Streptanthus drepanoides*

2) Attachment B Column Headings

Column Heading	Explanation
1. Site	Proposed reservoir sites; C=Colusa, N=Newville, RB=Red Bank, S=Sites
2. Sp	Species
3. Date	Date of discovery
4. Other Dates	Revisit or other discovery dates
5. Co.	County
6. Quad	USGS &.5' quadrangle map
7. T	Township
8. R	Range
9. Elev	Elevation (ft.)
10. Veg	# of plants in Vegetative state
11. Fl	# of plants in Flower
12. Fr	# of plants in Fruit
13. Tot	Total # of plants in occurrence
14. Rep	Reporter
15. Habitat	Plant community
16. Soil	General soil type
17. Slope	Angle of hillside in degrees
18. Aspect	Direction of exposure
19. Dom	Dominant plant species within occurrence
20. Assoc	Associated plant species within occurrence

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
C	**ANELA**	03/30/99		GLENN	RAIL CYN	19N	5W	500	unk	unk	unk	unk	BH JM	annual grassland	shale	60	N	none	DRVE, HECA, PHGR,Plagiobo-thrys sp., STNI, Vulpia sp.
C	**ANELA**	04/13/99		GLENN	LOGAN RIDGE	18N	4W	650	0	0	50	50	MAG LJ CW	annual grassland	shale	steep	NW	none	ANFI, Eriogonum spp., LIBI, PHGR, TRWI, Vulpia sp.
C	**HECA**	03/30/99		GLENN	RAIL CYN	19N	5W	580	0	50	0	50	BH JM	annual grassland	clay	65	N	TACAM	ANELA, Bromus sp., COSP
C	**HECA**	04/01/99		GLENN	RAIL CYN	19N	5W	540	200	800	0	1000	BC LJ	blue oak woodland	clay	45-60	ESE/ENE	QUDO	Erodium spp., CAGR, CESO, CLGR, LIBI
C	**NAER**	06/17/98		GLENN	RAIL CYN	19N	5W	520	unk	unk	unk	100	JM HW	annual grassland	clay	15	E, NE	CESO, Avena sp.	LOMU, Bromus spp., Erodium spp., NANI, KOMI
C	**NAHE**	06/17/98		GLENN	RAIL CYN	19N	5W	550	unk	unk	unk	250	JM HW	blue oak woodland	clay	20	NE	Avena sp., Erodium spp.	CESO, Clarkia affinis, NAPU
N	**ANELA**	03/18/99		GLENN	NEWVILLE	22N	6W	770	0	100	0	100	JM NW	annual grassland	clay-shale	70	N	none	COSPS, DRVE, Plagiobothrys sp., STNI, Vulpia sp.
N	**ANELA**	03/23/99		GLENN	NEWVILLE	22N	6W	720-800	0	400-500	0	400-500	JM MAG CW	annual grassland/ blue oak savanna	shale	65-70	N	none	COSP, DRVE, Plagiobothrys sp., Vulpia sp
N	**ANELA**	04/13/99	04/14/99	TEH	NEWVILLE	23N	7W; 6W	800-1000	0	50	950	1000 [19 colo-nies]	JM HW	annual grassland/ blue oak savanna	shale	60-80	N	none	BRMAR, GITR, LUNA, DRVE, TRER, MICA, PLER, VERI, LICI, CECU, Arctostaphylos sp., Cerco-carpus sp.
N	**ANELA**	04/14/99		GLENN	CHROME	22N	6W	1040	0	0	3	3	LJ MAG CW	annual grassland	pebbly conglom-erate	steep	NW	QUDO, annual grasses	ATPU, CENI, Erodium sp., Galium sp., LUBI, PHGR, MICA, SEVU

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
N	**ANELA**	04/14/99		TEH	NEWVILLE	23N	6W	760	0	0	150	150	JM HW	grassland/ chaparral/ foothill pine woodland	crumbly shale	80	N	none	LUNA, GITR, TRER, LENI, Plagiobothrys sp.
N	**ANELA**	04/15/99		GLENN	CHROME	22N	6W	1040	0	0	1000	1000	MAG	annual grassland	shale	50	N	none	CLEX, GITR, LAFR,PHGR, Plantago sp.
N	**ANELA**	04/16/99		GLENN	NEWVILLE	22N	6W	840	0	0	250	250	BH BC	annual grassland	shale	steep slope	N	none	LOMA,TRER, PHGR, DRVE, ANFI, MICA, SNI, CLEX, ATPU,CAGR, LIBI, PEPU
N	**ANELA**	04/20/99		GLENN	NEWVILLE	22N	6W	960	0	0	50	50	JM CW	annual grassland	clay	slope	N	none	CHMO, Avena sp., COSPC, MICA, Plectritis sp., TRER
N	**ANELA**	04/21/99		GLENN	CHROME	22N	6W	915	5	0	270	275 [9 colo-nies]	JM HW	annual grassland	shale	45	N, NE, NW	Clarkia sp., Vulpia sp.	ANFI, BRMA, DRVE, Erodium spp., HECA, LICI
N	**ANELA**	04/21/99		GLENN	NEWVILLE	22N	6W	740; 840-880	0; 0; 0	0; 0; 0	>1000; 100; >100	>1000; 100; >100	BC LJ	blue oak woodland	shale	steep	N	QUDO	ANFI, CAGR, Clarkia sp.,CLEX, COSP, Erodium sp., LUAL, MICA, Phacelia sp., TRLA
N	**ANELA**	04/22/99		GLENN	NEWVILLE	22N	6W	800-850; 920-980	0	0	1000's	1000's	LJ BC	annual grassland/ blue oak savanna	shale	steep	N, NE	none	APOC, CAGR, COSPB, GITR, LIBI, MICA, RILE, TRER
N	**ANELA**	05/04/99		TEH	NEWVILLE	23N	6W	920-1020	0	0	300-400	300-400	BC LJ	annual grassland/s hrubby blue oak savanna	shale	60	N	QUDO	MIDO, DRVE, COSP, RILE, CAGR
N	**ANELA**	05/12/99		TEH	NEWVILLE	23N	6W	820-880	0	0	<600	<600	HW, JW	annual grassland	shale	40	N, NE	Avena sp., ERNU	ANFI, Clarkia sp., Erodium sp., PLER, Vulpia sp.
N	**ANSU**	05/19/98	05/13/99	TEH	NEWVILLE	23N	6W	920-960	18	30	0	48; 0 in 1999 revisit	JL-R HW	blue oak woodland	shale/ other soil	45-55	SW	Avena sp.	ERLA, ESCA, BRMA, MAFL, LOHU, LUMI

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
N	**ANSU**	05/19/98		TEH	NEWVILLE	23N	6W	950	unk	unk	unk	160	JC NW	chaparral	shale	35-40	SSE	Quercus sp.	ACMO, Avena sp., DACA, Chia, fern
N	**ANSU**	06/16/98		GLENN	CHROME	22N	6W	1060	>1000	>1000	0	>2000 [in 4 colonies]	JM NW	foothill pine/ chaparral ecotone, annual grassland	shale	slopes	E, S	PISA, CECU, Quercus sp.	CAOCOC, CLGRGR, Eriogonum sp., ESCA,VERI, MAFL, LOHU, SACO, GICA
N	**ANSU**	06/18/98		TEH	NEWVILLE	23N	6W	1000	0	3	0	3	JC NW	open blue oak woodland	gravelly clay	40	W, NW	QUDO, CECU	Avena sp., VERI, TACAM, ACMI, Galium sp.
N	**ANSU**	06/18/98		GLENN	NEWVILLE	22N	6W	880-950	0; 2	1; 10	0; 0	1; 12	JM CW	open blue oak woodland	shale	45	W	QUDO	CECU, Linanthus sp., SACO, VERI, VUMY, PHRA
N	**ANSU**	06/19/98		GLENN	CHROME	22N	6W	1200-1240	230-295	115- 150	0	345- 445	JC HW NW	foothill pine/ chaparral ecotone, annual grassland	reddish gravelly clay	30- 45	S, SE	PISA, scrub oak	ERLA, Arctostaphylos sp., Avena sp., CESO, Melica sp., PISA
N	**ANSU**	05/10/99	05/11/99	TEH	NEWVILLE	23N	6W	880-1000	140	69	0	209 (partial revisit, Sec. 21)	BC LJ BH	chaparral	crumbly clay/ shale	50	SE - SW	QUBE	PHEG, GAPO, PEAN, SACO, CEME, MECA, Marah
N	**ASRAJ**	04/15/98	05/19/98	TEH	NEWVILLE	23N	7W	1000	0	500	0	500	JM CW	chaparral/ foothill pine woodland	shale	slope	S	ASRAJ	MAFL,LOHU, ASGA, VERI
N	**CHOCR**	07/15/98		GLENN	NEWVILLE	22N	6W	800	0	15	15	30	JM	annual grassland	clay	0	0	grasses	Lessingia nana
N	**CHOCR**	08/11/98		GLENN	NEWVILLE	22N	6W	760	unk	unk	unk	unk	CW HW NW	dried VP in annual grassland	gravelly bare soil	0	0	none	Lythrum, Trifolium, grass spp.
N	**CHOCR**	06/01/99		TEH	NEWVILLE	23N	6W	665	unk	unk	unk	unk	HW	creek bank in annual grassland	lodo shale	steep	S	unk	unk
N	**CHOCR**	06/02/99	06/03/99	GLENN; TEH	NEWVILLE	22N; 23N	6W; 7W	800-920	250-300	600	0	850-900	HW BH	annual grassland/ foothill pine woodland	shale	50	S, SE	grasses and QULO; PISA	Avena sp.
N	**CHOCR**	06/09/99		GLENN	NEWVILLE	22N	7W	950	60	540	0	600	JW BH	annual grassland	shale	45-70	S,SSW	none	AVFA, BRMAR, CESO, Cryptantha sp.

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (o)	ASPECT	DOM	ASSOC
N	**CHOCR**	06/10/99		GLENN	NEWVILLE	22N	6W	880	0	0	8	8	BH JW	unk	shale	very steep	SW	none	Avena sp.
N	**CHOCR**	06/16/99		TEH	NEWVILLE	23N	7W	920	0	202	202	4; 400	BH CW	creek banks	shale	slope	S	none	none (very low veg cover)
N	**FRPL**	02/27/98	02/26/98 03/10/99	GLENN	NEWVILLE	22N	6W	640; 755	1;500	5; 500	0; 0	6; 1000-2000	JM CW HW	annual grassland	clay	slope	N	ZIFR	graminoid spp.
N	**FRPL**	03/04/98		GLENN	CHROME	22N	6W	880-1000	115	115	0	230	JC JM CW HW	annual grassland	clay	0	0	grasses, Erodium spp.	ZIFR, LENI, Lupinus sp., Plagiobothrys sp.
N	**FRPL**	03/17/98	04/14/99	GLENN	CHROME	22N	6W	850	61; 15 in 1999	2; 6 in 1999	0	63; 21 in 1999	CW HW; LJ MAG CW	annual grassland	clay	10	E, SW	grasses CESO	TRER
N	**FRPL**	03/30/98		GLENN	NEWVILLE	22N	6W	680	unk	unk	unk	125-150; 250-500; 10	JC CW HW	annual grassland	clay	30-40	NE, NW	none	graminoid spp., ZIFR
N	**FRPL**	04/06/98		GLENN	NEWVILLE	22N	6W	840	3	1	1	5	HW JC	annual grassland	clay	25	N, NE	ZIFR	graminoid spp., TRER, TRLA
N	**FRPL**	04/07/98		GLENN	NEWVILLE	22N	6W	720	unk	unk	unk	21	JC HW	annual grassland	unk	30	N	unk	BRELEL, graminoids, ZIFR
N	**FRPL**	04/30/98	03/26/99	TEH	NEWVILLE	23N	6W	680	166; 300 in 1999	0; 100 in 1999	2; 0 in 1999	168; 400 in 1999	JM HW GP	annual grassland	Meyers clay	25-35	N	CESO, TACAME	Avena sp., Bromus sp., GEMO, PHGR, Lupinus sp.
N	**FRPL**	03/10/99		TEH	NEWVILLE	23N	6W	1000	2	2	0	4	BC LJ JM MAG	blue oak woodland	clay	50	N	Arcto-staphylos sp., JUCA, QUDO	Chlorogalum sp., ZIFR
N	**FRPL**	04/07/99		TEH	NEWVILLE	23N	6W	680-720	217	4	0	221 (range ext)	LJ JM	annual grassland	clay	35- 45	N	grasses	CESO, TACA,TRLA, Bromus sp.
N	**FRPL**	04/14/99		GLENN	CHROME	22N	6W	890	475	0	25	500	MAG LJ	annual grassland	clay	gentle	N	unk	CESO
N	**FRPL**	04/22/99		GLENN	NEWVILLE	22N	6W	970	85	0	0	85	BC LJ	annual grassland	clay	0-5	N	grasses	CEGL, CHPO, GAVE,TACAM, ZIFR
N	**FRPL**	05/04/99		TEH	NEWVILLE	23N	6W	940	3	0	0	3	BC CW LJ	blue oak woodland	clay	0-5	NNW	QUDO	Madia, Vulpia, Micropus spp., AVBA, CLPU
N	**HECA**	02/27/98		GLENN	NEWVILLE	22N	6W	650-750	unk	unk	unk	unk	CW JM JC	annual grassland	shale	slope	N	none	NEME, Phacelia sp., PLCA, STNI, CLEX

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
N	**HECA**	03/17/98	03/16/98	GLENN	NEWVILLE	22N	6W	840-880	all	0	0	unk	HW CW	annual grassland	unk	0-20	W	unk	grasses, occ. QUDO
N	**HECA**	04/29/98		GLENN	NEWVILLE	22N	6W	760	50	50	0	100	JM	annual grassland	crumbly clay/ shale	45	W	none	BRMAR, Clarkia sp., Plagiobothrys sp.
N	**HECA**	04/21/99		GLENN	CHROME	22N	6W	950	0	50	0	50	JM	annual grassland	clay	60	N	none	ANELA, ANFI, Bromus sp., MICA, MIDOD, TRER
N	**HETE**	06/16/98	06/19/98	GLENN	CHROME	22N	6W	1060; 1280	135; unk	15; 1333	0; unk	150; 4000	JM NW; JC HW NW	foothill pine woodland/ chaparral with annual grassland	heneke shale; reddish rocky clay and shale	50-60	E; ENE	PISA, QUDO, Arctosta-phylos sp.	LEFI, ERCA, HEAR, Monardella sp., grasses, Cryptantha sp.
N	**HETE**	06/19/98		GLENN	CHROME	22N	6W	1280	900	450	0	1350	JC HW NW	foothill pine woodland	rocky clay	45-55	E, NE	ERCA, PISA, TODI	Avena sp., Clarkia sp., Eriogonum sp., Lessingia sp.
N	**JUCAH**	04/28/99		GLENN	NEWVILLE	22N	6W	780	0	4	0	4	BC BH	riparian floodplain within annual grassland	clay/silt	0	0	JUCAH, QULO, cotton-wood	graminoids
N	**NAHE**	05/11/98		TEH	NEWVILLE	23N	6W	850-950	unk	unk	unk	unk	CW JM JC	annual grassland	unk	unk	unk	unk	Cirsium sp., Hesperolinon sp., NAPU
N	**NAHE**	06/01/98		GLENN	NEWVILLE	22N	6W	740	0	300	0	300	JM CW HW	annual grassland	gravelly clay	30	NE to NW	Avena sp., BRHO	Clarkia sp., TACAME, Vulpia sp.,CALU, NAPU, HOMU
N	**NAHE**	06/16/98		TEH	NEWVILLE	23N	6W	920	0	500-1000	0	500- 1000	CW HW	blue oak woodland	gravelly clay with shale	15	S	Avena sp., QUDO	GAVE, Lessingia sp., NATA, TACAME, VERI
N	**NAHE**	06/19/98		GLENN	CHROME	22N	6W	1200	0	500-1000	0	500- 1000	JC HW NW	annual grassland	clay	45	NE	BRHO, LOMU	Avena sp., CULU, Lessingia sp.
N	**NAHE**	05/04/99		TEH	NEWVILLE	23N	6W	920	0	100	0	100	BC	blue oak woodland	clay	40-50	NNW	QUDO	shrubs, grasses, FRPL
N	**NAHE**	05/06/99		TEH	NEWVILLE	23N	6W	970	0	500-1000	0	500-1000	BC	annual grassland	clay	0-20	NNW	low grasses	Castilleja exserta

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
N	**NAHE**	05/12/99	05/06/99	TEH	NEWVILLE	23N	6W	720-760	98;10	2;10	0;0	100; 20 [2 colonies]	HW NW ; HW JW	annual grassland	lodo shale and clay	0-10	0 to E	TACAM	Amsinckia sp., ANFI, Avena sp., BRHO, HYGL, NAPU
RB	**ANELA**	04/29/99		TEH	LOWREY	26N	6W	920	0	0	4	4	JM	blue/valley oak woodland	shale	70	N	QUDO QULO	COSP, RAHE, Vulpia sp.
RB	**ANSU**	05/20/98		TEH	COLD FORK	27N	7W	1300; 1120	unk	unk	unk	112	JM CW HW	blue oak woodland	shale	40-50	SW	QUDO	Avena sp., Bromus spp., CESO, ERLA, LOHU, Lupinus sp., Madia sp., MECA
RB	**ANSU**	05/21/98		TEH	OXBOW BRIDGE, COLD FORK	27N	7W	1300, 1160	200; unk	0; unk	0; unk	200; 40	JL JM HW	blue oak woodland	shale	40-50	SW	QUDO	Avena sp., Bromus spp., CESO, ERLA, LOHU, Lupinus sp., Madia sp., MECA
RB	**ANSU**	06/09/98		TEH	LOWREY	26N	6W	975	unk	unk	unk	1173	CW HW	foothill pine woodland	gravelly clay, shale	25-35	NE	PISA, TODI, Avena sp.	Arctostaphylos sp., CESO, Ceanothus sp., PEDU, QUDO
RB	**ANSU**	06/15/98		TEH	LOWREY	26N	6W	1000	0	1000	0	1000	CW HW	foothill pine woodland/ chaparral interface	shale	30-45	SW	Avena sp., Nasella sp., PEDU	Bromus spp., ESLO, LOHU, MECA, MEFL
RB	**ANSU**	06/15/98		TEH	LOWREY	26N	6W; 7W	1000	0	0	100	100	JM CW HW	chaparral/ foothill pine woodland	crumbly shale	steep	SW	none	unk
RB	**ANSU**	06/25/98		TEH	OXBOW BRIDGE	27N	7W	1100 - 1200	1290	3010	0	4300	JC HW NW	blue oak/ foothill pine woodland/ chaparral	loamy shale	45-55	W/SW	QUDO, Avena sp., CECU, TODI	CEOC, CESO, HESP, PISA
RB	**ANSU**	07/02/98		TEH	LOWREY	26N	6W	940	650	1850	0	2500	CW NW	blue oak woodland	shale	55-60	S	PISA	CECU, QUBE, HEAR, ERLA, MOSH
RB	**ANSU**	07/02/98	07/03/98	TEH	LOWREY	26N	6W	850-1200	220; unk	1080; unk	0; unk	1300; 22250	JM HW CW NW	foothill pine woodland/ chaparral interface	shale	40-60	S/SE/SW	Scrub oak, Arcto-staphylos sp., CESO, PISA	Avena sp., Cryptantha sp., Eriogonum sp., MAFL, PEDU, TODI, ERLA, BRHO, Ceanothus sp.

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
RB	**ANSU**	07/06/98		TEH	COLD FORK	27N	7W	1280	unk	unk	unk	50	JM JC CW HW	chaparral	shale	slope	S	CECU, CEOC, TODI	Scrub oak, ERAB, HEDI, ERCA
RB	**ANSU**	07/08/98		TEH	LOWREY	26N	6W	950-1000	unk	unk	unk	624	JM CW	chaparral	shale	slope	S	Cercocar-pus sp., Quercus sp. (scrub)	Calycadenia sp., Hemizonia sp., PISA, Salvia sp.
RB	**ANSU**	07/09/98		TEH	LOWREY	26N	6W	1060; 960	unk	unk	unk	150- 200	JM CW	chaparral/ foothill pine woodland	crumbly tan shale	slope	S	PISA, Scrub oak, Arcto-staphylos sp.	CESO, ADFA
RB	**ANSU**	05/12/99		TEH	LOWREY	26N	6W	1000	1	0	0	1	JM CW	chaparral/ foothill pine woodland	tan crumbly shale	45	NW	CECU, PISA	unk
RB	**ANSU**	05/13/99		TEH	LOWREY	26N	7W	1000	11	0	0	11	BC NW	chaparral/ blue oak woodland	crumbly clay/ shale	steep	S	PISA QUDO, CECU, ARMA	QUBE, GAPO, PEAN, CLRH, YAMI, ERLA, Marah
RB	**ANSU**	05/20/99		TEH	COLD FORK	27N	7W	1100	360	40	0	400	JW BH	chaparral	shaley soil	steep	S,SW, SE, W	QUBE	CEBE, GACO,QUDO, STDR, CHOCR, ASRAJ, Eriophyllum sp.
RB	**ANSU**	05/21/99		TEH	COLD FORK	27N	7W	1150	200	200	0	400	JW BH	chaparral	shaley clay	slope	S	CECU, Arcto-staphylos sp.	BRMAR, VUMY, SACO, ERCA, QUBE
RB	**ANSU**	05/24/99	06/01/99 06/08/99	TEH	OXBOW BRIDGE	27N	7W	1150-1200	40+	60+	0	100+	BC LJ CW	chaparral	loose shale	steep	S-SW	QUBE, CECU, RHIL, GACO	DIVO,GAPO, TODI, Phacelia sp., Nasella sp., ERNU, annual grasses
RB	**ANSU**	05/27/99		TEH	LOWREY	26N	7W	1040	150	150	0	300+ ["100's"]	JM BH	chaparral/ riparian	tan crumbly shale	very steep	S	Chamise, willow	ERBR
RB	**ANSU**	06/03/99		TEH	COLD FORK	27N	7W	1200	18	4	2	24	BC LJ	chaparral/ blue oak woodland	crumbly clay/ shale	steep	S-SW	QUBE	QUBE, TODI, AVBA, CRAN, FICA, Daucus sp.
RB	**ANSU**	06/09/99		TEH	LOWREY	26N	7W	1040	unk	unk	unk	unk	LJ BC	chaparral	loose shale	steep	SW	QUDO, PISA	QUBE, GACO, near CHOCR

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
RB	**ANSU**	06/10/99		TEH	LOWREY	26N	7W	1040	0	15	135	150	HW, CW	foothill pine woodland/chaparral	shale	40	S	PISA, ADFA	Interior live oak, Arctostaphylos sp., Avena sp., ERLA
RB	**ANSU**	06/14/99	06/15/99	TEH	COLD FORK	27N	7W	1120-1200	0	1000+	0	1000+	LJ BC CW	open chaparral	crum-bly clay/ shale	steep	S	QUBE	CECU, ARMA
RB	**ANSU**	06/21/99	06/24/99	TEH	COLD FORK	27N; 26N	7W	1150-1200	0	100+	0	100+	LJ BC	open chaparral	crum-bly clay/ shale	steep	S	QUBE	JUCA, GACO, CEBE, CECU, CHOCR
RB	**ANSU**	06/24/99		TEH	COLD FORK	27N	7W	1160	0	15	60	75	JW BH	chaparral	shale	steep	S	QUBE	CESO, BRMAR,AVFA
RB	**ASRAJ**	04/27/98		TEH	LOWREY	26N	6W	815	unk	unk	unk	25	JC HW CW	foothill pine wood-land	shale	5	S	PISA	Arctostaphylos sp., graminoids, PEDU, QUDO
RB	**ASRAJ**	05/21/98		TEH	COLD FORK/OX-BOW BRIDGE	27N	7W	960	unk	unk	unk	2	JL JM HW	blue oak woodland	shale	20	S	none	ASGA, LOHU, CESO,PEDU
RB	**ASRAJ**	06/09/98		TEH	LOWREY	26N	6W	940	1	33	0	34	CW HW	foothill pine woodland	shale	0	0	PISA, TODI	Arctostaphylos sp., Avena sp., CESO, PEDU, QUDO
RB	**ASRAJ**	07/02/98		TEH	LOWREY	26N	6W	880	0	1	0	1	JM HW	floodplain	sand/ gravel	0	0	CESO, LUMI	BRDI, LOHU, PEDU
RB	**ASRAJ**	04/27/99	05/18/99	TEH	LOWREY	26N	6W	1040	0	17	17	34	CW LJ BC	blue oak/ foothill pine woodland	shale	mod. steep	SW	PISA	MAFL, STGL, ESCA, LUMID, BRHO
RB	**ASRAJ**	04/28/99		TEH	LOWREY	26N	6W	940	5	5	0	10	LJ JM CW	creek, gravel bed	shale	0-5	0	none	Cryptantha sp., SAEX, SALA, SIBE, WYHE, ERCA
RB	**ASRAJ**	05/12/99		TEH	LOWREY	26N	6W	1000	0	1	1	1	JM CW	riparian	stony cobbles/gravel	0	0	PofR, SALA	BRDI
RB	**ASRAJ**	05/20/99		TEH	COLD FORK	27N	7W	1050	2	10	3	15	JW BH	grassy creekside	unk	flat	NE	CECU	BRHO, POBU, CESO, PLER, Lupinus sp.
RB	**CHOCR**	05/21/98		TEH	COLD FORK	27N	7W	1020	30	24	6	60	JM HW CW	chaparral/ foothill pine woodland	shale	steep	S	none	ANSU
RB	**CHOCR**	07/03/98		TEH	LOWREY	26N	7W	1020	<25	<20	5	<50	JM CW HW	chaparral/ foothill pine woodland	crumbly pale shale	70	S	none	none (very low veg cover)

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
RB	**CHOCR**	08/27/98		TEH	LOWREY	26N	7W	1000	<35	13	2	<50	JM HW CW	shale slope in grassy area	shale	80	S	none	ERDA, MAFL, BRMAR
RB	**CHOCR**	05/20/99		TEH	COLD FORK	27N	7W	1180	6	1	0	7	JW BH	chaparral	shale	slope	SW	none	Crucianella angustifolia, Avena barbata
RB	**CHOCR**	06/09/99		TEH	LOWREY	26N	6W	1150	unk	unk	unk	unk	HW	unk	shale	45	S	unk	unk
RB	**CHOCR**	06/09/99	06/10/99	TEH	LOWREY	26N	6W	960-1040	50	200	0	250	HW LJ BC CW	foothill pine woodland nr creek	shale	45-60	S-SW	PISA, ARMA, QUDO, GACO	graminoids, ERLA,ERNU, MAFL, SACO
RB	**CHOCR**	06/21/99		TEH	COLD FORK	27N	7W	1150-1200	0	32	0	32	LJ BC	chaparral/ foothill pine woodland	shale	35-50	S	PISA, QUBE	ERNU, ERLA, ERDA, CLEX, ERCA, grasses
RB	**CHOCR**	06/24/99		TEH	COLD FORK	27N	7W	1080	0	4	0	4	BH JM CW	creek bank	shale	slope	S	unk	unk
RB	**CHOCR**	08/11/99		TEH	COLD FORK	27N	7W	1100	0	16	16	16	LJ BC CW JM	high creek bank	crumbly shale	very steep	S	none	MELA, CHBO, ERNU, ERDA, STVI
RB	**ERBR**	05/27/99		TEH	LOWREY	26N	7W	1040	150+	150+	0	300+	JM BH	disturbed area in chaparral/ riparian	shale	0-5	S	Chamise, willow	ANSU
RB	**ERBR**	06/03/99		TEH	COLD FORK	27N	7W	1200	0	12	8	20	LJ BC	grassy opening in chaparral/ foothill pine woodland	hard shaley soil	gentle	SW	QUDO, PISA, CECU, ARMA	short annual grasses, PLER, Lessingia sp.
RB	**ERBR**	06/24/99		TEH	COLD FORK	27N	6W	1160-1200	0	1	14	15	LJ BC	grassy opening in chaparral/ foothill pine woodland	hard clay/ shale soil	0-20	E	PISA, QUBE, CEBE, GACO, ADFA	AICA, BRMA, PLER, Filago sp.
RB	**FRPL**	04/01/98		TEH	LOWREY	26N	6W	960	unk	unk (grazed)	unk (grazed)	17	JL-R CW	opening nr blue oak woodland	clay	slope	N	CECU	ZIFR, MICA
RB	**FRPL**	03/05/99		TEH	LOWREY	26N	6W	940	29	1	0	30	MAG CW	open blue oak woodland	unk	slope	W	Arcto-staphylos sp., QUDO	Quercus sp. (live), graminoids

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
RB	FRPL	03/05/99	04/27/99 revisit	TEH	LOWREY	26N	6W	1010-1040	1000+	unk	unk	1075	CW MAG LJ	meadow in blue oak woodland	clay	0	0	QUDO, PISA	CESO, Perlagrass, Nasella sp., Sisyrhynchium
RB	FRPL	03/29/99		TEH	LOWREY	26N	6W	820	35	2	0	37 (revisit/ exten-sion of 040198 site)	MAG BC LJ	grassy opening nr blue oak savanna	clay	20-40	SE to NE	QUDO	ZIFR, CESO, TACA,RAOC, SIBE, CLEX, Lupinus sp., Nasella sp.
RB	FRPL	04/27/99		TEH	LOWREY	26N	6W	1100	17	0	3	20	CW LJ	grass by blue oak woodland	unk	slope	N	ZIFR	CESO,RAOC, TRLA, grasses
RB	LIFLF	04/29/99		TEH	LOWREY	26N	6W	890-910	0	10	990	1000	JM HW NW	valley oak woodland	shale	5	W	QULO, Arctosta-phylos sp.	PISA, TACAME, Vulpia sp.
RB	NAHE	05/21/98		TEH	COLD FORK	27N	7W	1120	unk	unk	unk	1000	HW	open grass in blue oak woodland	clay	15	SE	none	unk
RB	NAHE	06/09/98		TEH	LOWREY	26N	6W	950	unk	unk	unk	100	CW HW	blue oak woodland	clay	0	0	QUDO, BRHO	CESO, MICA, PEDU
RB	NAHE	06/15/98		TEH	LOWREY	26N	6W	950	unk	unk	unk	500	HW	annual grassland	clay	0	0	Avena sp., Bromus spp.	ANAR, CLAF, NAPU
RB	NAHE	07/03/98		TEH	LOWREY	26N	6W	850-900	unk	unk	unk	200	HW	foothill pine woodland	unk	0	0	PISA, Arcto-staphylos sp., CESO	Avena sp., Bromus spp., PEDU
RB	NAHE	07/06/98		TEH	COLD FORK	27N	7W	1100-1200	unk	unk	unk	1400	JC JM CW HW	chaparral, blue oak woodland	gravelly clay	0	0	QUDO, CECU, PISA	BLSC,NAPU, PEDU, NAJE, Clarkia sp.
RB	NAHE	07/07/98		TEH	OXBOW BRIDGE	27N	7W	1020-1040	unk	unk	unk	400; 700	JC CW HW	blue oak woodland	clay	0-25	S/SE	QUDO, CESO, TECA	Bromus spp., LYHY, MICA, NAPU
RB	NAHE	07/09/98		TEH	LOWREY	26N	7W	1000	unk	unk	unk	100	HW	foothill pine woodland	shale	15	E	Arcto-staphylos sp., CESO, PISA	Avena sp., BRHO, CECU,PEDU, QUDO
RB	NAHE	05/24/99		TEH	COLD FORK	26N; 27N	7W	1160-1370	0	500	0	500	BC LJ	old roadbed, blue oak savanna	clay	0-5	SE	QUDO	Erodium sp., Hordeum sp., other grasses

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
RB	**NAHE**	06/08/99		TEH	OXBOW BRIDGE	27N	7W	1070	20	60	20	100	BC	grassy edge, blue oak woodland	clay	0-5	SW	QUDO	Vulpia spp.
RB	**NAHE**	06/09/99		TEH	LOWREY	26N	6W	920	0	30-60	20-40	50-100	BC LJ	open foothill pine woodland	clay	0	0	PISA	CECU, NAPU, Eriogonum wrightii var. trachygonum
RB	**NAHE**	06/09/99		TEH	LOWREY	26N	6W	1100	63	116	0	179 [3 colo- nies]	HW CW	grassy opening in foothill pine woodland	gravelly clay	0	0 to W	PISA	Bromus sp, Avena sp.
RB	**NAJE**	07/06/98		TEH	COLD FORK	27N	7W	1100-1250	unk	unk	unk	500- 1000	HW	chaparral edges	gravelly clay	0	0	CECU, PISA	NAHE, NAPU, Clarkia sp.
RB	**NAJE**	05/20/99		TEH	COLD FORK	27N	7W	1160	0	15	0	15	JW BH	grassland	clay	gentle	S	none	BRHO, TACAM, CLPU, BRMAR
RB	**NAJE**	06/03/99		TEH	COLD FORK	27N	7W	1000-1050	240-300	320-400	240-300	800-1000	BC LJ	grassy opening in chaparral/ blue oak woodland	shaley clay	0-10	0	PISA, QUDO, GACO, QUBE, CEBE	HEAR, CAPA, LENE, BRHO
RB	**NAJE**	06/09/99		TEH	LOWREY	26N	6W	880	0	50-60	0	50-60	BC LJ	old roadbed, riparian/ foothill pine savanna	hard stony clay	0	0	PISA, PofR	AICA
RB	**NAJE**	06/10/99		TEH	LOWREY	26N	7W	1000	unk	unk	unk	120	BC LJ	grassy terrace, chaparral/ foothill pine woodland	clay	0-5	S	PISA, ADFA	BRHO, PLER, Calycadenia sp.
RB	**NAJE**	06/14/99		TEH	COLD FORK	27N	7W	1140	0	100	100	200	BC LJ	grassy flat, chaparral/ foothill pine woodland	clay	0-5	S/0	PISA, JUCA, QUBE	short annual grasses, SABI, CAPA, Lessingia sp.
RB	**NAJE**	06/21/99		TEH	COLD FORK	27N	7W	1160	0	200	0	200	LJ BC	grassy ridge, chaparral/ foothill pine woodland	clay/ shale	gentle	N	QUDO, PISA	short grasses, scattered shrubs
RB	**NAJE**	06/24/99		TEH	COLD FORK	27W	7W	1180	0	135	15	150	JW CW BH	opening in chaparral/ foothill pine woodland	unk	gentle	E	none	dried grasses, CAPA,CESO, Sanicula sp.

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
RB	**STDR**	07/03/98		TEH	LOWREY	26N	6W	880	unk	unk	unk	<50	JM HW CW	chaparral/ foothill pine woodland	shale	very steep	N	none	ANSU
RB	**STDR**	04/27/99	05/18/99	TEH	LOWREY	26W	6W	1020-1040	21; 0	9; 30+	0; 30+	30; 60+	LJ CW BC	foothill pine woodland	shale	very steep	S/SW	PISA, QUDO	ESCA, MAFL, Cryptantha sp.
RB	**STDR**	05/20/99	05/20/98	TEH	COLD FORK	27N	7W	1000	8	72	0	80	HW (in 1998); JW BH	unk	shale	steep	S	none	ERNU,BRMAR, SACO, ERLA, MAFL
RB	**STDR**	06/10/99		TEH	LOWREY	26N	6W	880	3	0	0	3	LJ BC HW CW	creek bank in open foothill pine savanna	shale	very steep	S	none	CHOCR
S	**ANELA**	04/19/99		COL	SITES	18N	4W	500	0	0	200- 300	200- 300	JW BH	annual grassland	crumbly shale	slope	N	none	STNI, CLEX, LIBI, PLER, COSP, Clarkia sp., Galium sp.
S	**ANELA**	04/23/99		COL	LODOGA	17N	5W	440; 480	0	0	17; 150	17; 150 [2 colonies]	JW BH	creek bank in annual grassland/ oak savanna	crumbly clay/ rocky shale	steep	N	none	ANFI, LUBI, CLPE, DRVE, ATPU, PLER, LIBI, STNI, Pectocarya sp.
S	**ANELA**	05/05/99		COL	SITES	17N	4W	500	0	0	6	6	JW BH	annual grassland	crumbly clay/ shale	slope	N	none	STNI, PLER, MICA, ANFI
S	**HECA**	03/06/98		COL	SITES	16N	5W	400	25	25	0	50	JC JM CW	annual grassland	clay	20	E	Bromus sp.	DRVE, HOBR, PLST, NAER, NAHE
S	**HECA**	04/14/98		COL	LODOGA	18N	5W	520	0	<50	0	<50	JM	annual grassland	clay	0	0	grasses	ERBO, LENI, LOMU, AVFA, Lupinus sp., Psilocarphus sp.
S	**HECA**	05/08/98		COL	SITES	17N	5W	400	25	25	0	50	JM CW HW	annual grassland	clay	20	E	Bromus sp.	DRVE, HOBR, PLST, NAER, NAHE
S	**NAER**	05/08/98		COL	SITES	17N	5W	375-420	unk	unk	unk	unk	JM HW	annual grassland	unk	gentle	NE	none	NAPU, NANI, NAHE, CLAF
S	**NAHE**	05/08/98		COL	SITES	17N	5W; 4W	375	unk	unk	unk	unk	JM HW	annual grassland	unk	gentle	NE	none	NAPU, NANI, NAER, CLAF
S	**NAHE**	05/26/98	05/27/98	COL	SITES	17N; 16N	4W	400-480	unk	unk	unk	>1000	CW HW	annual grassland	clay	5-35	W, N, NW	grasses	BRMAR, Avena sp., CALU, MICA, ACMO, BRHO, NANI

SITE	SP	DATE	OTHER DATES	CO.	QUAD	T	R	ELEV (ft)	VEG	FL	FR	TOT	REP	HABITAT	SOIL	SLOPE (°)	ASPECT	DOM	ASSOC
S	**NAHE**	05/27/98		COL	SITES	17N	5W	400	unk	unk	unk	"large pop"	HW JM JC CW	annual grassland	clay	10-15	E	grasses	QUDO, TECAM, CESO, BRRU, Micropus sp.

January 4, 2000

ATTACHMENT 7

OFFSTREAM STORAGE RESERVOIR INVESTIGATION:

c. Explanation of prioritized plant species name and spreadsheet column acronyms

d. 1998-1999 prioritized plant species population occurrence records

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January 4, 2000

ATTACHMENT 8.

OFFSTREAM STORAGE RESERVOIR INVESTIGATION:

1998-1999 Photographs of prioritized plants and vegetation communities

Antirrhinum subcordatum

Antirrhinum subcordatum habitat under scrub oak

Astragalus rattanii var. jepsonianus

Astragalus rattanii var. jepsonianus habitat

Chamaesyce occellata spp. rattanii

CHOCR habitat on south-facing, bare shale slopes

Eriastrum brandegeae

ERBR habitat on bare, rocky open slope

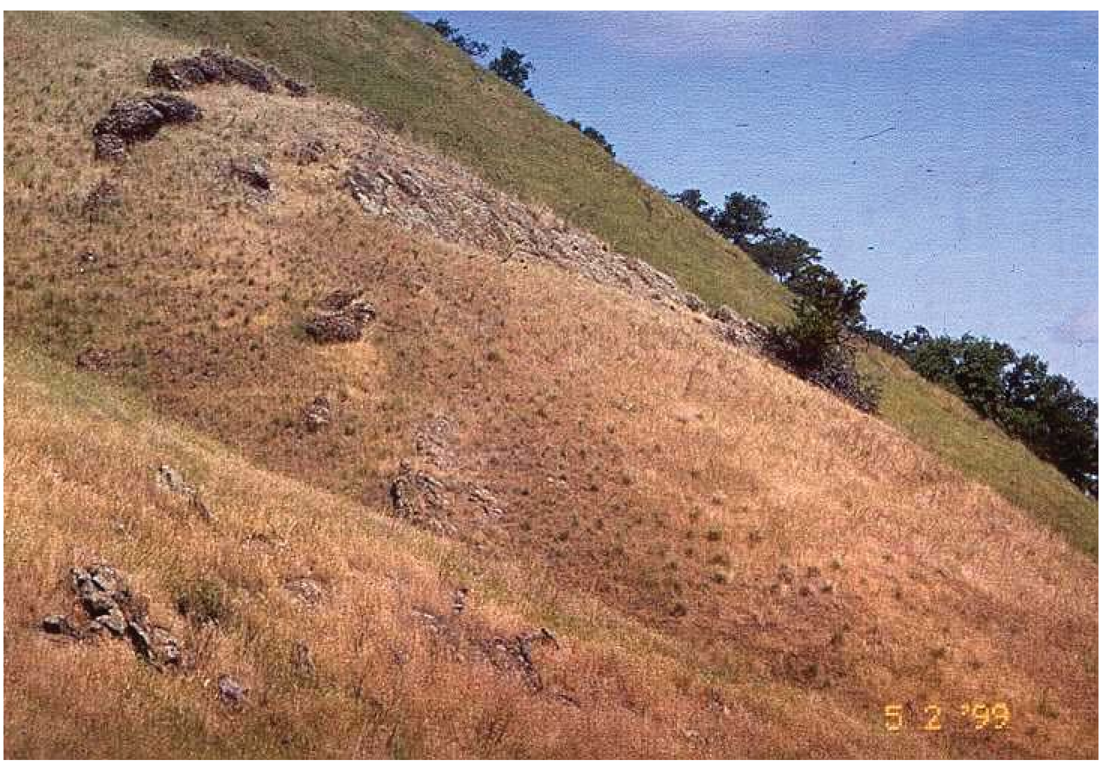
Valley oak (*Quercus lobata*) at Thomes-Newville Reservoir

Salt Creek and associated wetland vegetation at Thomes-Newville Reservoir

Grasslands and grazing cattle at Thomes-Newville Reservoir

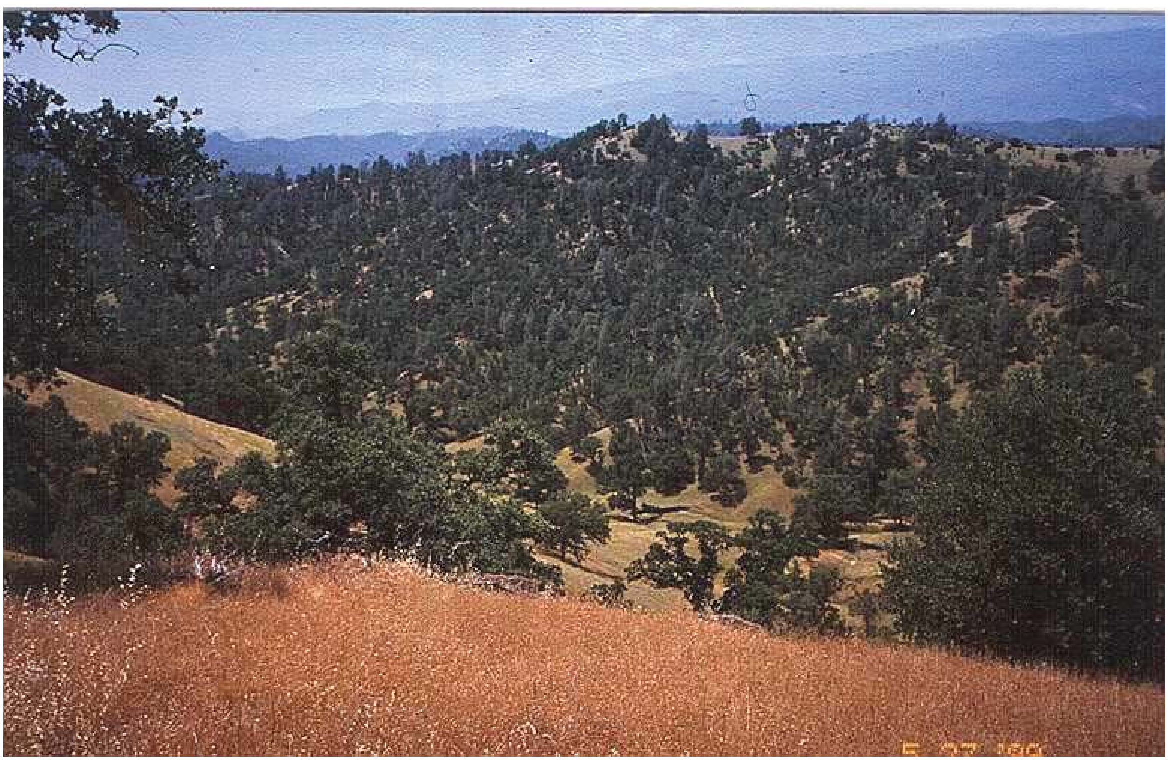
Riparian willow scrub vegetation at Thomes-Newville Reservoir

Blue oak woodland and north-facing shale slope at Thomes-Newville Reservoir



Native bunchgrasses at Thomes-Newville Reservoir

Grassland opening on valley floor at Red Bank Reservoir



Blue oak woodlands at Red Bank Reservoir

Chamise chaparral vegetation at Red Bank Reservoir

Blue oak and grey pine woodland at Red Bank Reservoir

Steep Lodo Shale slope at Red Bank Reservoir

Red Bank Creek with associated riparian vegetation

State of California, Gray Davis, Governor
The Resources Agency, Mary D. Nichols, Secretary for Resources
Department of Water Resources, Thomas M. Hannigan, Director

Steve Macaulay, Chief Deputy Director
Raymond D. Hart, Deputy Director
L. Lucinda Chipponeri, Assistant Director for Legislation
Susan N. Weber, Chief Counsel

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The Resources Agency
Department of Water Resources
Division of Planning and Local Assistance

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North of the Delta
Offstream Storage Investigation

Progress Report Appendix B:

Wetland Delineation Field Studies Report

April 2000

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Progress Report Appendix B:

Wetland Delineation Field Studies Report

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April 2000

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Wetland Delineation Field Studies Report

Introduction

Section 404 of the Clean Water Act requires the U.S. Army Corps of Engineers' authorization for projects involving the placement of "fill" material into any "waters of the United States." The decision to grant such a permit is based on a review of the project's impacts to a number of economic and environmental factors, including the quantity and types of wetlands. The Corps defines wetlands as "areas that are periodically or permanently inundated by surface or groundwater and support vegetation adapted for life in saturated soil."

This report summarizes the two-year survey of wetlands and other waters of the U.S. within the footprint of the four potential offstream storage reservoir locations: Sites Reservoir, Colusa Cell, Thomes-Newville Reservoir, and the Red Bank Project (Figure 1).

Methods

Stereo pairs of 1:12,000 and 1:6,000 scale color aerial photos were reviewed for wetland types prior to field studies. All aerial photography used in the wetland identifications were taken in late spring to differentiate seasonal wetlands from annual grassland cover. Wetland types were identified on the photographs, and representative types were selected throughout each reservoir for field verification. Selection of representative types was based on soil types and aerial photo wetland vegetation "signatures." Field visits were conducted during and after rainfall events in order to observe hydrology conditions. These representative sites and additional sites were revisited later in the season when wetland vegetation was identifiable to the species level. Wetland delineations were made using the "routine method," as described in the 1987 *Corps of Engineers Wetland Delineation Manual*. This method involves a field review of the hydrology conditions, plant species' composition, and hydric soil indicators. The Corps' regulatory specialists were also consulted for guidance on field sampling and data presentation.

Results of the wetland delineations and field verifications were used to produce a draft map of jurisdictional wetlands. Stereo pairs of aerial photos for the inundation areas of each reservoir were studied, and all areas that matched signatures of field-verified wetland types were mapped as jurisdictional wetlands. Questionable areas were also identified as wetlands and marked for future field verification. All wetland polygons were mapped and acreage was calculated.

Other waters of the U.S. were also identified on the aerial photos. These included stock ponds, small reservoirs, and tributaries. All drainages were identified as either main tributaries (i.e., width of streambed equal to or wider than 15 feet and generally perennial) or tributaries (i.e., width of streambed less than 15 feet and drainages usually ephemeral, possibly perennial). Stream width measurements were made throughout the project sites. Drainages with wetlands or jurisdictional riparian areas were classified as wetlands.

All waters of the U.S. were mapped using the procedure outlined above. The acreages for all waters of the U.S. and linear distances (miles) of all drainages were then calculated. Attachment A shows the stream width measurement data for drainages within the proposed reservoir sites.

The Corps' regulatory specialists have not verified these maps. Field verification of these maps will involve site visits to each wetland delineation site by the Corps' regulatory specialist.

Results

Areas identified as jurisdictional wetlands represent approximately 2 percent of the surface area of each reservoir footprint. The acreage and wetland types within each reservoir area are presented in Tables 1 through 4. Information on other waters of the U.S. is also included in these tables. The waters of the U.S. acreage for all reservoir locations are summarized in Table 5. Throughout this report, all data are presented with the most southern reservoir location first (i.e., Sites Reservoir) and the northern reservoir last (i.e., Red Bank Project).

Discussion

The wetland type, quality, and quantity within a given location are dependent on a number of factors, including soil types, site geology (evidence of faulting and springs), and land management. The three southern reservoir locations were similar in dominant wetland types and distribution patterns. The Red Bank Project is dominated by steep, well-drained slopes, which supported few seasonal or emergent wetland areas. Wetland types will be addressed in general terms and site-specific information given for each reservoir area.

Sites Reservoir and Colusa Cell

Seasonal wetlands account for over 75 percent of the jurisdictional wetlands identified within the Sites Reservoir footprint and 84 percent of the Colusa Cell jurisdictional wetlands (Tables 1 and 2). This very common wetland type is inundated by surface water or saturated by groundwater during the winter and spring months. Most of these seasonal wetlands were dry by early summer and are strongly associated with low-lying areas of clay or clay loam soils (Tables 6 and 7). Many of the plants found in these wetlands are dry and brown during the summer months, making the wetlands almost indistinguishable from the surrounding annual grasslands. Dominant plant species include *Eleocharis* *macrostachya* (spike rush), *Hordeum marinum* ssp, *Gussoneanum* (Mediterranean baryle), and *Rumes* spp (dock).

Table 1. Sites Reservoir Waters of the U.S.

Wetlands and Other Waters	Acres	Linear Distance (Miles)
Wetlands	201	
Other Waters	175	
Total Waters of the U.S.	**376**	
Total Reservoir Area	**14,162**	
Wetland Types		
Alkaline	19	
Emergent	2	
Riparian	22	
Seasonal	153	
Vernal Pools	5	
Total	**201**	
Other Waters		
Major Tributaries	82	25
Tributaries	77	123
Ponds/Small Reservoirs	16	
Total	**175**	**148**

Table 2. Colusa Cell Waters of the U.S.

Wetlands and Other Waters	Acres	Linear Distance (Miles)
Wetlands	312	
Other Waters	135	
Total Waters of the U.S.	**447**	
Total Reservoir Area	**13,664**	
Wetland Types		
Alkaline	35	
Emergent	0	
Riparian	11	
Seasonal	263	
Vernal Pools	3	
Total	**312**	
Other Waters		
Major Tributaries	30	15
Tributaries	81	143
Ponds/Small Reservoirs	24	
Total	**135**	**158**

Table 3. Newville Reservoir Waters of the U.S.

Wetlands and Other Waters	Acres	Linear Distance (Miles)
Wetlands	413	
Other Waters	231	
Total Waters of the U.S.	**644**	
Total Reservoir Area	**17,073**	
Wetland Types		
Alkaline	3	
Emergent	6	
Riparian	77	
Seasonal	304	
Vernal Pools	23	
Total	**413**	
Other Waters		
Major Tributaries	59	17
Tributaries	106	223
Ponds/Small Reservoirs	66	
Total	**231**	**148**

Table 4. Red Bank Project Waters of the U.S.

Wetlands and Other Waters	Acres	Linear Distance (Miles)
Wetlands	83	
Other Waters	152	
Total Waters of the U.S.	**235**	
Total Reservoir Area	**4,905**	
Wetland Types		
Emergent/Seasonal	7	
Riparian	76	
Total	**83**	
Other Waters		
Major Tributaries	71	17
Tributaries	47	110
Ponds/Small Reservoirs	34	
Total	**152**	**127**

Table 5. Offstream Storage Waters of the U.S.

Reservoir Site	Reservoir Size (Acres)	Waters of the U.S. (Acres)	Wetlands (Acres)
Sites	14,162	376	201
Colusa Cell	13,664	447	312
Newville	17,073	644	413
Red Bank Project	4,905	235	83

Table 6. Sites Reservoir Seasonal Wetlands Soil Type

Pool Number	Date Pool Visited	Soil Name	Soil Sample Color
S-1	4/14/98	Altamont-Contra Costa clay loam	
S-2	5/8/98	Altamont-Contra Costa clay loam, slightly eroded, hilly, 16-30% slopes	5Y 3/1
S-3	5/8/98	Altamont clay loam, slightly eroded; hilly	5Y 4/1
S-3	5/8/98	Altamont clay loam, slightly eroded; hilly	5Y 3/1
S-4	5/26/98	Contra Costa clay loam, slightly eroded, very steep	
S-5	5/26/98	Forgeus clay, undulating	5Y 3/1
S-5	5/26/98	Forgeus clay, undulating	5Y 4/1
S-6	6/5/98	Myers clay, 0-3% slopes	5Y 4/1
S-6	6/5/98	Myers clay, 0-3% slopes	10YR 3/3
S-6	6/5/98	Myers clay, 0-3% slopes	10YR 6/6
S-6	6/5/98	Myers clay, 0-3% slopes	5Y 4/1
S-6	6/5/98	Myers clay, 0-3% slopes	5Y 4/1
S-7	6/5/98	Antone clay loam, strong alkali	2.5Y 4/0
S-7	6/5/98	Antone clay loam, strong alkali	5Y 4/1
S-7	6/5/98	Antone clay loam, strong alkali	10YR 5/8
S-8	6/5/98	Antone clay loam, strong alkali	10YR 5/8
S-8	6/5/98	Antone clay loam, strong alkali	10YR 4/1
S-8	6/5/98	Antone clay loam, strong alkali	10YR 3/3
S-9	6/9/98	Myers clay loam, 0-3% slopes	
S-10	6/9/98	Altamont-Contra Costa clays, 15-30% slopes	
S-11	6/9/98	Zamora silty clay loam, 0-2% slopes	10 YR 4/2
S-11	6/9/98	Zamora silty clay loam, 0-2% slopes	10 YR 3/2
S-11	6/9/98	Zamora silty clay loam, 0-2% slopes	10 YR 5/6
S-12	10/15/98	Altamont clay loam, slightly eroded; undulating to rolling	10 YR 3/2+3
S-13	10/15/98	Altamont clay loam, slightly eroded; undulating to rolling	10 YR 3/2
S-13	10/15/98	Altamont clay loam, slightly eroded; undulating to rolling	10 YR 2/2
S-13	10/15/98	Altamont clay loam, slightly eroded; undulating to rolling	5 YR 5/8
S-14	10/15/98	Altamont-Contra Costa clay loam, slightly eroded, hilly, 16-30% slopes	5 Y 4/2
S-14	10/15/98	Altamont-Contra Costa clay loam, slightly eroded, hilly, 16-30% slopes	5 YR 5/8
S-15	10/15/98	Myers clay loam, gently undulating, 0-2% slopes	10 YR 3/2
S-15	10/15/98	Myers clay loam, gently undulating, 0-2% slopes	10 Y 5/8
S-16	3/4/99	Altamont clay loam, slightly eroded; undulating to rolling	2.5 Y 4/2
S-17	3/4/99	Contra Costa clay loam, slightly eroded, steep	2.5 YR 4/2
S-18	3/5/99	Altamont clay loam, slightly eroded; hilly	10 YR 3/2
S-18	3/5/99	Altamont clay loam, slightly eroded; hilly	10 YR 6/8
S-18	3/5/99	Altamont clay loam, slightly eroded; hilly	10 YR 4/2
S-18	3/5/99	Altamont clay loam, slightly eroded; hilly	5 YR 5/8
S-18	3/5/99	Altamont clay loam, slightly eroded; hilly	10 YR 3/2
S-19	3/5/99	Contra Costa clay loam, slightly eroded, steep	10 YR 3/1
S-20	3/25/99	Myers clay, gently undulating, 0-2% slopes	10 YR 4/1
S-20	3/25/99	Myers clay, gently undulating, 0-2% slopes	10 YR 4/2
S-20	3/25/99	Myers clay, gently undulating, 0-2% slopes	10 YR 7/6

Table 7. Colusa Reservoir Seasonal Wetlands Soil Type

Pool Number	Date Pool Visited	Soil Name	Soil Sample Color
C-1	4/22/98	Myers clay, 0-3% slopes	
C-2	4/22/98	Kimball gravelly loam, 2-10% slopes	10YR 5/2
C-2	4/22/98	Kimball gravelly loam, 2-10% slopes	10YR 4/1
C-3	6/9/98	Altamont soils, 30-65% slopes	
C-4	6/9/98	Capay clay, 0-2% slopes	2.5 Y 4/2
C-4	6/9/98	Capay clay, 0-2% slopes	2.5Y 6/4
C-4	6/9/98	Capay clay, 0-2% slopes	5Y 4/1
C-4	6/9/98	Capay clay, 0-2% slopes	2.5 Y 3/2
C-4	6/9/98	Capay clay, 0-2% slopes	5Y 4/1
C-5	6/15/98	Yolo clay loam, shallow over clay	5 YR 2.5/1
C-5	6/15/98	Yolo clay loam, shallow over clay	10 YR 6/8
C-5	6/15/98	Yolo clay loam, shallow over clay	10 YR 3/2
C-5	6/15/98	Yolo clay loam, shallow over clay	10 YR 6/8
C-6	6/15/98	Zamora silty clay loam, 2-8% slopes	10 YR 3/3
C-6	6/15/98	Zamora silty clay loam, 2-8% slopes	10 YR 3/1
C-6	6/15/98	Zamora silty clay loam, 2-8% slopes	10 YR 3/1
C-6	6/15/98	Zamora silty clay loam, 2-8% slopes	10 YR 3/3
C-7	6/23/98	Myers clay, 0-3% slopes	5Y 4/1
C-7	6/23/98	Myers clay, 0-3% slopes	5Y 4/2
C-8	4/1/99	Nacimiento soils, 30-50% slopes	
C-9	4/1/99	Nacimiento soils, 30-50% slopes	
C-10	4/1/99	Nacimiento-Contra Costa association, 15-30% slopes	

Most of the alkaline wetlands are also seasonal but are vastly different in plant species composition. The annual and perennial species in these areas are tolerant of alkali conditions. The majority of these wetlands are dominated by *Distichlis spicata* (salt grass), with a varity of other species including *Parapholis incurva* (sickle grass), *Frankenia salina* (alkali heath), *Cressa truxillensis* (alkali weed), and *Scirpus martimus* (slat marsh bulrush). The alkaline wetlands within the Sites Reservoir and Colusa Cell are along a linear zone of deformation potentially associated with the Salt Lake fault.

Impacts to the alkaline wetlands may be considered significant by regulatory agencies during the environmental review of these projects. These alkaline areas could provide habitat for a number of sensitive plant and animal species, although no sensitive species were identified during the current field studies. The Colusa Cell alkaline wetlands could serve as potential mitigation for the alkaline wetlands inundated by the Sites Reservoir. These wetlands could be enhanced using various land management methods.

A very small quantity (2 acres) of emergent wetlands was identified within the Sites Reservoir; this wetland type was present within the Colusa Cell in several small areas, but these were not measurable using aerial photo interpretation. Emergent wetlands have typical wetland species, such as *Scirpus acutus* (hard-stemmed tule), *Scirpus californicus* (California bulrush) and *Typha angustifolia* (cattails), and are associated with existing reservoir shorelines and drainages. Drainages with emergent wetlands were often protected from grazing animals by fences.

The riparian areas found within these two reservoir alternatives are rarely well developed or large in size. Many of the drainages are downcut and do not support wetland species along the banks. Small strands of *Populus fremintii* (cottonwood), *Quercus lobata* (valley oak), and *Salix* spp (willows) occur as isolated units throughout the area. The largest concentration of riparian habitat is within the southern portion of the Sites Reservoir. Potential riparian creation sites occur throughout the surrounding area.

Many of the vernal pools found within these reservoir alternatives are "manmade" (e.g., drainages blocked by roads or disturbed areas within heavy clay soils) and have very low plant species diversities. Pools occurring along the northeastern edge of the Sites Reservoir tended to be larger in size and higher in plant species diversity. One similar area also occurs within the Colusa Cell. Typical species include *Eryngium castrense* (coyote thistle), *Plagiobothrys* ssp (popcorn flower), and *Lythrum hussopifolium* (loosestrife).

Newville Reservoir

Seasonal wetlands also dominate the wetlands of the Newville Reservoir inundation area (Table 3). Some of the wetland areas are very large in size and may form complexes with other types of wetlands, including riparian. This area also has significant quantities of other wetland types. The seasonal wetlands are closely associated with clay soils (Table 8). The seasonal wetlands within this area tended to be more diverse in both subtypes and plant species composition. Common species included those listed under the Sites/Colusa discussion, as well as *Trifolium* ssp (clovers), *Juncus* ssp (rushes), *Mimulus guttatus* (monkeyflower), and *Rorippa nasturium-aquaticum* (watercress).

Riparian areas account for over 18 percent of the reservoir area's wetlands. Well-developed riparian habitat occurs along a number of the main tributaries, although patches of the invasive non-native *Ailanthus altissima* (tree of heaven) occur within some of these strands. Riparian wetlands in this reservoir area cover about 77 acres, which may be considered significant by regulatory agencies.

One small area of alkaline wetland was identified within the Salt Creek drainage. Other areas adjacent to Salt Creek and some of its tributaries supported alkaline species, but were too narrow to map. The areas identified as alkaline are within a zone, which was identified as an inferred fault area during a 1980 geological study of the area *(Seismic and Fault Activity Study, Proposed Glenn Reservoir Complex*. Prepared for DWR by Earth Sciences Associates). The alkaline wetlands of this area have not been site checked.

Table 8. Newville Reservoir Seasonal Wetlands Soil Type

Pool Number	Date Pool Visited	Soil Name	Soil Sample Color
N-1	3/4/98	Altamont clay, 3-15% slopes	
N-2	3/17/98	Altamont clay, 3-15% slopes	
N-3	3/19/98	Lodo-Millsholm complex, 30-50% slopes	
N-4	3/19/98	Zamora loam, 0-3% slopes	
N-5	3/19/98	Lodo-Millsholm complex, 10-30% slopes	
N-6	3/20/98	Lodo-Gullied land complex, 10-30% slopes	
N-7	3/20/98	Tehama clay loam, 2-10% slopes	
N-8	3/26/98	Terrace escarpments	
N-9	4/7/99	Zamora loam, 0-3% slopes	
N-10	4/7/99	Hillgate loam, 0-3% slopes	
N-11	4/7/99	Hillgate loam, 0-3% slopes	
N-12	4/7/99	Lodo-Millsholm complex, 10-30% slopes	
N-13	4/20/98	Zamora loam, 0-3% slopes	5Y 4/1
N-14	4/20/98	Zamora loam, 0-3% slopes	5Y 4/1
N-15	4/20/98	Lodo-Millsholm complex, 10-30% slopes	
N-16	4/20/98	Lodo-Millsholm complex, 10-30% slopes	
N-17	4/20/98	Hillgate loam, 0-3% slopes	5Y 4/1, 5Y 3/2
N-18	4/20/98	Lodo-Millsholm complex, 10-30% slopes	5Y 4/1
N-19	4/20/98	Pleasanton gravelly loam, 1-10% slopes	5Y 4/1
N-20	4/20/98	Tehama loam, 3-8% slopes	
N-21	4/20/98	Pleasanton gravelly loam, 1-10% slopes	
N-22	4/28/98	Hillgate-Millsholm complex, 3-30% slopes	5Y 4/1
N-23	4/28/98	Lodo-Milsholm complex, 30-50% slopes	5Y 4/1
N-24	4/28/98	Clear Lake clay	N4/
N-25	4/28/98	Clear Lake clay	5Y 4/1
N-26	4/29/98	Hillgate-Gullied land complex, 2-10% slopes	
N-27	4/29/98	Corning gravelly loam, 0-2% slopes	
N-28	4/29/98	Clear Lake clay	5Y 4/1
N-29	4/29/98	Millsholm clay loam-Gullied land complex, 10-30% slopes	5Y 4/1
N-30	5/19/98	Hillgate-Millsholm complex, 3-30% slopes	
N-31	5/19/98	Hillgate-Millsholm complex, 3-30% slopes	
N-32	6/1/98	Zamora loam, 0-3% slopes	5Y 3/2
N-33	6/2/98	Zamora loam, 0-3% slopes	5Y 4/1
N-34	6/2/98	Zamora loam, 0-3% slopes	5Y 2.5/1-2
N-35	6/2/98	Zamora loam, 0-3% slopes	10YR 3/2
N-36	6/2/98	Zamora loam, 0-3% slopes	5Y 3/2
N-36	6/2/98	Zamora loam, 0-3% slopes	5Y 3/1
N-36	6/2/98	Zamora loam, 0-3% slopes	5Y 6/2-3
N-37	6/11/98	Lodo-Tehama-Gullied land complex, 10-30% slopes	5Y 4/1
N-38	6/12/98	Terrace escarpments	
N-39	6/12/98	Lodo-Tehama-Gullied land complex, 10-30% slopes	5Y 4/1
N-40	6/12/98	Lodo-Tehama-Gullied land complex, 30-50% slopes	5Y 4/1
N-40	6/12/98	Lodo-Tehama-Gullied land complex, 30-50% slopes	10YR 5/8

Vernal pool complexes, areas of concentrated pools and connecting swales, were found in several locations within the reservoir area. They were usually associated with terrace deposits occurring between streambeds. The pools of this reservoir alternative were of an overall higher quality than those of the Sites/ Colusa Cell location.

Red Bank Project

Seasonal and emergent wetlands make up less than 9 percent of the wetland total for the Red Bank Project (Table 4). Many of these wetlands are located within or adjacent to small stockponds or are associated with saturated spring-fed areas. Clay soils are relatively rare within the steep terrain that dominates both the Schoenfield and Dippingvat Reservoirs (Table 9).

Table 9. Red Bank Project Seasonal Wetlands Soil Type

Pool Number	Date Pool Visited	Soil Name	Soil Sample Color
R-1	4/1/98	Hillgate loam, shaly substrate, 0-8% slopes	Soil saturated
R-2	4/1/98	Hillgate loam, shaly substrate, 0-8% slopes	
R-3	5/21/98	Zamora clay loam, 0-3% slopes	
R-4	5/21/98	Riverwash	
R-5	5/21/98	Zamora clay loam, 0-3% slopes	
R-6	7/2/98	Lodo and Maymen shaly loams, 10-30% slopes, eroded	10 YR 3/2
R-7	7/2/98	Lodo and Maymen shaly loams, 10-30% slopes, eroded	
R-8	7/3/98	Cortina gravelly fine sandy loam	
R-9	7/3/98	Cortina gravelly fine sandy loam	

Riparian areas dominate the wetlands of this area. Riparian areas can be found throughout the larger reservoirs of the project but are best developed along the South Fork of Cottonwood and Red Bank Creeks. The typical species are similar to the species outlined in the Sites/Colusa discussion, except many of the riparian stands are dominated by *Alnus rhombifolia* (white alder).

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Offstream Storage Investigation

Progress Report

Appendix C: Survey for the Valley Elderberry Longhorn Beetle at Four Proposed Offstream Storage Reservoir Locations

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Appendix C: Survey for the Valley Elderberry Longhorn Beetle at Four Proposed Offstream Storage Reservoir Locations

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June 2000

Integrated
Storage
Investigations

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PROGRAM

Summary

This report summarizes an assessment of the valley elderberry longhorn beetle within the Sites, Colusa Cell, Newville, and Red Bank reservoir sites in 1998 and 1999.

The valley elderberry longhorn beetle is listed by the U.S. Fish and Wildlife Service as "threatened, with Critical Habitat". Although there were no known populations within the proposed reservoir sites, habitat exists and known populations occur nearby.

Surveys focused on identifying potential habitat for VELB, the number of elderberry stems found measuring 1 inch or more, and the presence of exit holes. Aerial photos were used to determine which drainages should be field checked within the grassland habitats of the Sites, Colusa Cell, and Newville reservoir areas. All drainages were field checked within the Red Bank Reservoir site.

Habitat for VELB occurs at each of the four proposed reservoir sites. VELB emergence holes were found within the proposed Sites and Newville reservoir areas. No emergence holes were found within the proposed Colusa and Red Bank project areas. No adult beetles were observed at any of the proposed reservoir sites.

Surveys are valid for a two-year period according to U.S. Fish and Wildlife guidelines. Potential reservoir sites will need to be resurveyed before a final report is produced. Areas not surveyed prior to this report, such as areas with restricted access, conveyance routes, road relocations, recreational areas etc., will need to be surveyed. Analyses will also be needed to predict how possible changes in flow regimes within the channels and associated savannas downstream will affect elderberry survival and distribution.

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Introduction

The Department of Water Resources is currently evaluating the feasibility of constructing an offstream water supply reservoir at one of four locations on the west side of the Sacramento Valley in cooperation with CALFED. These locations include Sites Reservoir in western Colusa County, Colusa Reservoir in western Glenn and Colusa Counties, Thomes-Newville Project in western Tehama and Glenn Counties, and the Red Bank Project in western Tehama County (Figure 1).

The valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* Fisher, was listed by the U.S. Fish and Wildlife Service as “threatened, with Critical Habitat” on August 10, 1980 (Federal Register 45:52803-52807) (Figure 2). The beetle is endemic to riparian systems along the margins of rivers and streams, occasional seeps, and in adjacent grassy savannas in the Sacramento and San Joaquin Valleys. VELB feeds on two species of elderberry (*Sambucus mexicana* Presl. - Figure 3 and 4, and *S. racemosa* L. var. *microbotrys* Rydb.). The adult female beetle deposits eggs in the crevices of the bark of living plants. The larvae bore into the pith of the larger elderberry stems where the majority of the animal’s life span is spent. Following pupation in the spring, the adult beetle opens an emergence hole in the bark through which it exits (Figure 5). Adults feed on foliage and are present from March through early June. Because the adult stage is short lived, surveys techniques focus on the presence of emergence holes for evidence of VELB. VELB emergence holes have been observed in shoots or branches with diameters as small as 0.5 inches (13mm) but are more common in older branches (Barr 1991, USFWS 1984). Barr (1991) found exit holes most often in older mature healthy plants and rarely in young or stressed individuals. Exit holes are circular or slightly oval and are usually 7-10 mm in diameter. VELB is the only insect species known to inhabit live elderberry wood and/or make exit holes of a similar size and shape in the Central Valley (Barr 1991).

The VELB is known to occur throughout the California Central Valley and it is associated foothills from the valley floor up to 3,000-foot elevation. Although there were no known VELB populations within the proposed reservoirs, habitat was known to exist within the project area and known VELB locations were recorded nearby. According to Jones and Stokes (1986) “potential VELB habitat is defined by the presence of mature and immature elderberry shrubs (*Sambucus* spp.).”

The State and federal Endangered Species Acts require that any analysis of a project that could result in a “take “ of a State or federally “listed” species include an evaluation of alternatives, consultation with the respective regulatory agencies, and the development of mitigation and avoidance measures. This not only includes the individual species but their habitats as well. Surveys for VELB are valid for a period of two years. All beetle habitat that cannot be avoided will be considered impacted and appropriate mitigation, as set forth in the Mitigation Guidelines for the Valley Elderberry Longhorn Beetle (USFWS 1996) and in consultation with the USFWS, must be implemented.

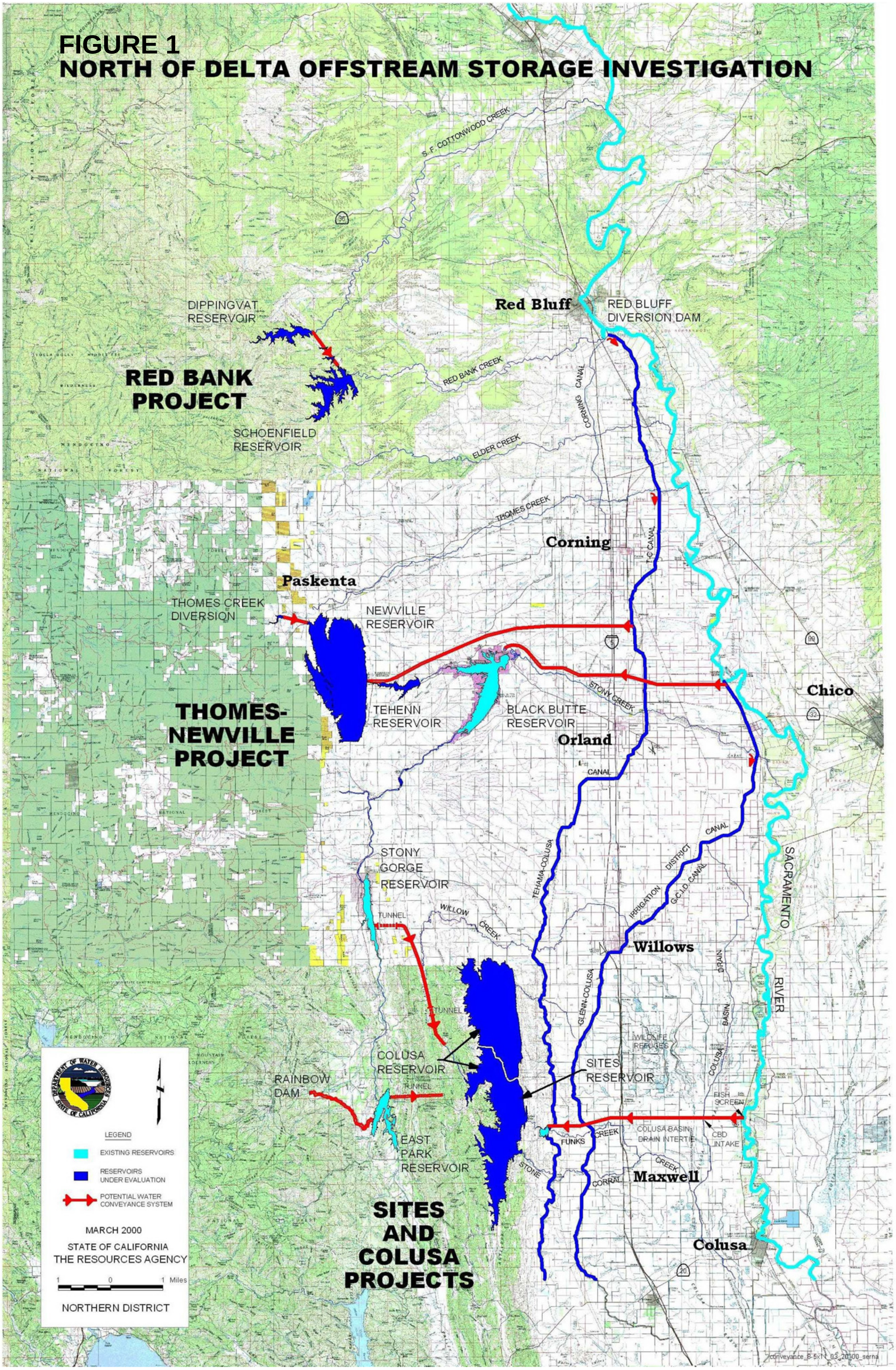

FIGURE 1
NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION
S.F. COTTONWOOD CREEK
Red Bluff
RED BLUFF DIVERSION DAM
DIPPINGVAT RESERVOIR
RED BANK PROJECT
RED BANK CREEK
CORNING CANAL
SCHOENFIELD RESERVOIR
ELDER CREEK
THOMES CREEK
Corning
T-C CANAL
Paskenta
THOMES CREEK DIVERSION
NEWVILLE RESERVOIR
STONY CREEK
Chico
THOMES-NEWVILLE PROJECT
TEHENN RESERVOIR
BLACK BUTTE RESERVOIR
Orland
CANAL
STONY GORGE RESERVOIR
TUNNEL
WILLOW CREEK
TEHAMA-COLUSA
IRRIGATION DISTRICT CANAL
G-C.I.D. CANAL
SACRAMENTO RIVER
Willows
DRAIN
GLENN-COLUSA
BASIN
COLUSA
WILDLIFE REFUGES
COLUSA RESERVOIR
SITES RESERVOIR
RAINBOW DAM
FISH SCREEN
COLUSA BASIN DRAIN INTERTIE
CBD INTAKE
FUNKS CREEK
EAST PARK RESERVOIR
STONE
CORRAL CREEK
Maxwell
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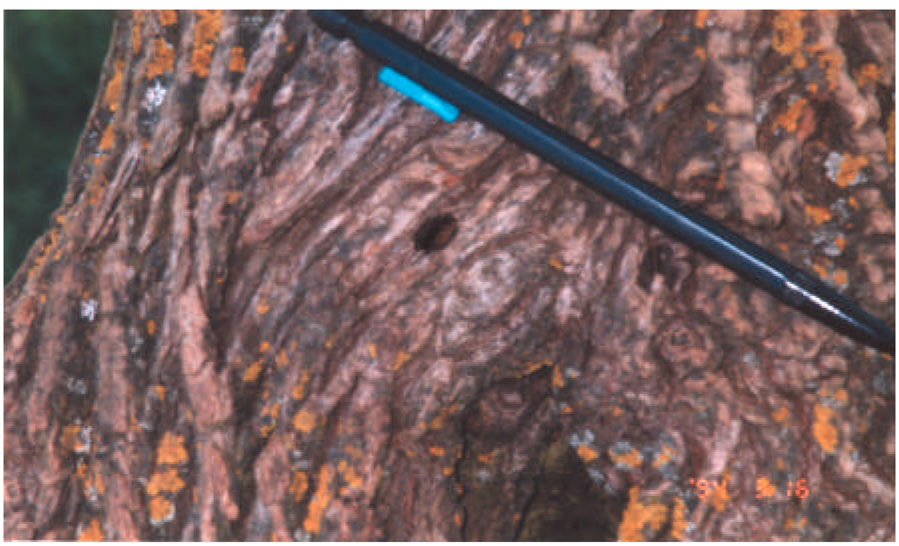
Colusa
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
POTENTIAL WATER CONVEYANCE SYSTEM
MARCH 2000
STATE OF CALIFORNIA
THE RESOURCES AGENCY
1 0 1 Miles
NORTHERN DISTRICT

Figure 2. Valley Elderberry Longhorn Beetle

Figure 3. Elderberry Plant With a Single Trunk

Figure 4. Elderberry Stand

Figure 5. Valley Elderberry Longhorn Beetle Emergence Hole



Methods

A survey of all potential reservoir sites for the VELB and its habitat was conducted during the periods January through July 1998 and April through June 1999. Surveys focused on identifying potential habitat for VELB, the number of elderberry stems found measuring more than one inch, and the presence of exit holes. A total of 45 days was spent field surveying the drainages.

Sites, Colusa, and Newville proposed reservoir areas are comprised mainly of non-native grassland with scattered oak woodland on the upland areas. Riparian vegetation along stream channels is sparse, especially within the Colusa

Reservoir. The larger streams at Sites and Newville reservoir areas are bordered by scattered stands of mature cottonwood, oak, willow, and elderberry. However, the majority of stream channels lacks any riparian vegetation and consists mainly of grassland vegetation with an occasional cottonwood or willow. Aerial photographs were used to identify the drainages, or portions thereof, in the proposed project areas with potential VELB habitat. All drainage areas and the adjacent savannas were walked and checked for the presence of VELB habitat, with the exception of those drainages bordered solely by grasslands and those areas restricted by landowners.

Within the proposed Red Bank Project area, foothill woodland habitat, with moderate to dense canopy cover, comprises 81 percent of the area. Riparian habitat along the major stream channels is more continuous than that at the proposed Sites, Colusa, and Newville reservoir areas. Vegetation along the lesser channels consists of scattered oaks, cottonwoods, willows, or elderberries. All the stream channels and adjacent savannas within the Red Bank Project area were walked and checked for the presence of VELB habitat except for portions where access was restricted by landowners.

According to VELB survey procedures outlined in the USFWS 1996 report on mitigation guidelines, all stems measuring 1 inch or more at ground level were recorded and checked for emergence holes. The elderberry plants were examined by scanning the foliage and branches for adult beetles and the trunks and branches for exit holes. Growth forms of elderberry plants throughout the project area are varied. A stand may consist of a single individual with multiple trunks, several individuals growing in close proximity, or a tree-like individual with a single large trunk. Multiple trunks were counted as individual stems if it was apparent that the branching was off the root mass and exposed due to recent erosion.

Results

Habitat for VELB occurs at each of the four proposed reservoir sites. VELB emergence holes were found within the proposed Sites and Newville reservoir areas. No emergence holes were found within the proposed Colusa and Red Bank project areas. No adult beetles were observed, although the majority of surveys were conducted during the time the adult beetles would be present. The physical condition of the elderberry plants varied from poor to good. Table 1 lists the number of stems counted at each reservoir site, and the number and percentage of stems with emergence holes.

Sites Project Area

Six hundred seventy-two stems were counted within the proposed Sites Project area. Emergence holes were found on 18 individual stems. The plants within this area tend to be individuals with multiple trunks and range from unhealthy stressed plants to occasional large healthy individuals. The majority of plants at this site and the riparian vegetation in general tend to be in poor condition.

Colusa Project Area

Only one stand of elderberry was found within the proposed Colusa Cell. This stand consisted of 38 stems and was found near a seep on a steep slope at the reservoir's eastern edge. Drainages where elderberry plants would typically be found were too dry and degraded due to natural causes or downcutting to support elderberry plants. Very few associated riparian species (cottonwood and willow) were found along the drainages.

Newville Project Area

Five hundred fifty-two stems have been counted in the proposed Newville project area. Emergence holes have been found in 42 stems. The plants at this site tend to be large healthy individuals with single or multiple trunks. Most occurred along the major drainages, but some individuals were found at the edges of associated grassy savannas and even upslope along the dryer margins.

Table 1. Number of Elderberry Stems and Emergence Holes Found Within Each Proposed Reservoir Site

Reservoir Site	Number of elderberry stems	Number of stems with emergence holes	Percentage of stems with emergence holes
Sites	672	18	2.7
Colusa	38	0	0
Newville	552	42	7.6
Red Bank	1,001	0	0
Schoenfield	791	0	0
Lanyan	0	0	0
Bluedoor	0	0	0
Dippingvat	210	0	0

Red Bank Project Area

Dippingvat. Two hundred ten individuals were found at the proposed Dippingvat reservoir area. No emergence holes were found. Individuals at this site tend to be older with a single trunk and in good condition.

Bluedoor and Lanyan. No elderberry plants were found at either of these proposed reservoir sites; however, potential elderberry habitat does exist at both areas.

Schoenfield. Seven hundred ninety-one individual stems were counted at the proposed Schoenfield Reservoir site. No emergence holes were found. The majority of plants are healthy and consist of both single individuals with multiple trunks and tree-like individuals. They tend to occur along the savannas and edges of Red Bank Creek but some were found upslope on the dryer hillsides and drainages.

Mitigation Guidelines

Guidelines have been issued by USFWS to assist in developing measures to mitigate adverse effects on VELB if complete avoidance is not possible. Surveys are valid for a period of two years. Elderberry plants are to be transplanted if they cannot be avoided. However, at the discretion of the USFWS, a plant that would be extremely difficult to move because of access problems may be exempted from transplantation (USFWS 1996). Planting of additional seedling or cuttings may be required under the mitigation guidelines, depending upon the absence or percentage of elderberry plants with emergence holes found in the project area. Elderberry plants with no beetle exit holes are planted at a ratio of 2:1. Elderberry plants with beetle holes in 50 percent or fewer of the plants are planted at a ratio of 3:1. And elderberry plants with beetle holes in more than 50 percent of the plants are planted in the ratio of 5:1. In addition, a mix of native plants (cottonwood, willow, etc.) associated with the elderberry shrubs at the project site are to be planted at a ratio of at least one specimen of native tree and shrub species for every elderberry plant (seedling or cutting).

Discussion

Off-site mitigation for elderberry plant impacts will be required for any of the proposed reservoirs. This mitigation will include acquisition of suitable land, transplantation of existing elderberry bushes, and planting of cuttings of both elderberries and associated native plants. The USFWS requires the mitigation area provide at least 1,800 square feet for each transplanted elderberry shrub, with as many as five elderberry cuttings or seedlings and up to five associated natives. This planting density is primarily for riparian forest habitats. If the mitigation site is an open habitat, as is the case for the proposed Sites, Colusa, and Newville Reservoirs, more area may be needed. Watering basins will also be needed at each site. The mitigation area should be protected in perpetuity as habitat for the valley elderberry longhorn beetle, which would require continuing funding, management, protection, and monitoring.

The proposed Colusa Project area had the least number of individual elderberry plants and less suitable elderberry habitat, thus mitigation would be minimal for this site. Sites, Newville, and Red Bank reservoir sites would require extensive replanting of elderberry plants as well as planting of seedlings and cuttings of both elderberries and associated species such as cottonwood and willow. Many of the plants within the Sites and Newville reservoir areas are accessible and could be transplanted. However, because of the steepness of the terrain within the Red Bank project area, transplantation of the elderberry shrubs would be more difficult.

The elderberry plants within the proposed Newville and Red Bank project areas tend to be healthier and less stressed than the plants at the Sites Reservoir area. The associated riparian forest is also best developed within the proposed Red Bank Reservoir area. The condition of the riparian vegetation and elderberry plants within the proposed Sites Reservoir was generally worse than that at Newville Reservoir.

The numbers of elderberry plants within the proposed Sites and Newville project areas is similar, thus the mitigation area required would be approximately the same. However, although the Red Bank Project area is much smaller than the Sites or Newville areas, there were almost twice as many elderberry stems. This in turn would double the off-site mitigation area required for the Red Bank Project.

Surveys are valid for a two-year period according to USFWS guidelines because of the potential for the adult female beetles to lay their eggs in different elderberry plants from which they emerged. Field surveys will need to be conducted again before a final report is produced. In addition, areas not surveyed prior to this report, such as areas with restricted access, conveyance routes, road relocations, recreation, etc. will need to be surveyed. Analyses will also be needed to predict how possible changes in water regimes within the channels and associated savannas downstream of potential reservoir areas will affect elderberry survival and distribution.

Mitigation requirements for each of the proposed reservoir sites will need to be discussed with the USFWS. Contact with appropriate USFWS personnel has already been initiated by telephone. Survey methodologies have been discussed and approved.

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State of California
The Resources Agency
Department of Water Resources
Division of Planning and Local Assistance

DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

Appendix D: Fish Survey Summary

September 2000

Integrated
Storage
Investigations

CALFED
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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix D: Fish Survey Summary

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Introduction

In late 1997, the Department of Water Resources began a two-year reconnaissance level study of North of the Delta Offstream Storage authorized by Proposition 204—the Safe, Clean, Reliable Water Supply Act approved by voters in 1996. In early 1999, CALFED consolidated all storage investigations under a comprehensive program called Integrated Storage Investigations. The North of the Delta Offstream Storage Investigation was incorporated into one of seven ISI program elements.

The North of the Delta Offstream Storage Investigation continues engineering, economic, and environmental impact analyses to determine the feasibility of four north of the Delta storage projects. The four potential alternatives are Sites Reservoir, Colusa Project, Thomes-Newville Project, and Red Bank Project (Figure 1). Phase I, currently underway, includes preliminary field surveys of environmental resources and extensive field surveys of cultural resources, geological, seismic and foundation studies, and an engineering feasibility evaluation. Phase II will start when CALFED's Record of Decision and Certification for the Programmatic EIR/EIS is completed and if north of Delta offstream storage is consistent with CALFED's preferred program alternative. Phase II will include completion of necessary fish and wildlife surveys, evaluations of potential mitigation sites, preparation of project-specific environmental documentation, final project feasibility reports, and the acquisition of permits necessary for implementation.

Under Phase I, the Department of Fish and Game conducted studies of fish and wildlife resources in each project area. This appendix summarizes studies of fish in the tributaries that flow through each of the four proposed project areas. The information gathered will be used to describe impacts on fish resources during the planning process. Fishery studies conducted for the Sacramento River will be summarized in a separate report.

Contract with DFG

DFG initiated fish studies in 1997. Studies were conducted to develop data adequate to meet the needs of the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and DFG consultations as required by endangered species legislation. Past studies were also reviewed and evaluated as part of this effort.

Report Organization and Content

Results and discussions of findings in past fishery studies and recently conducted surveys of fishery resources in the four proposed project areas are included in this appendix. The general procedure for commonly used fish surveys are outlined, with specific sampling data and results discussed in respective sections for each proposed project area.

Methodology

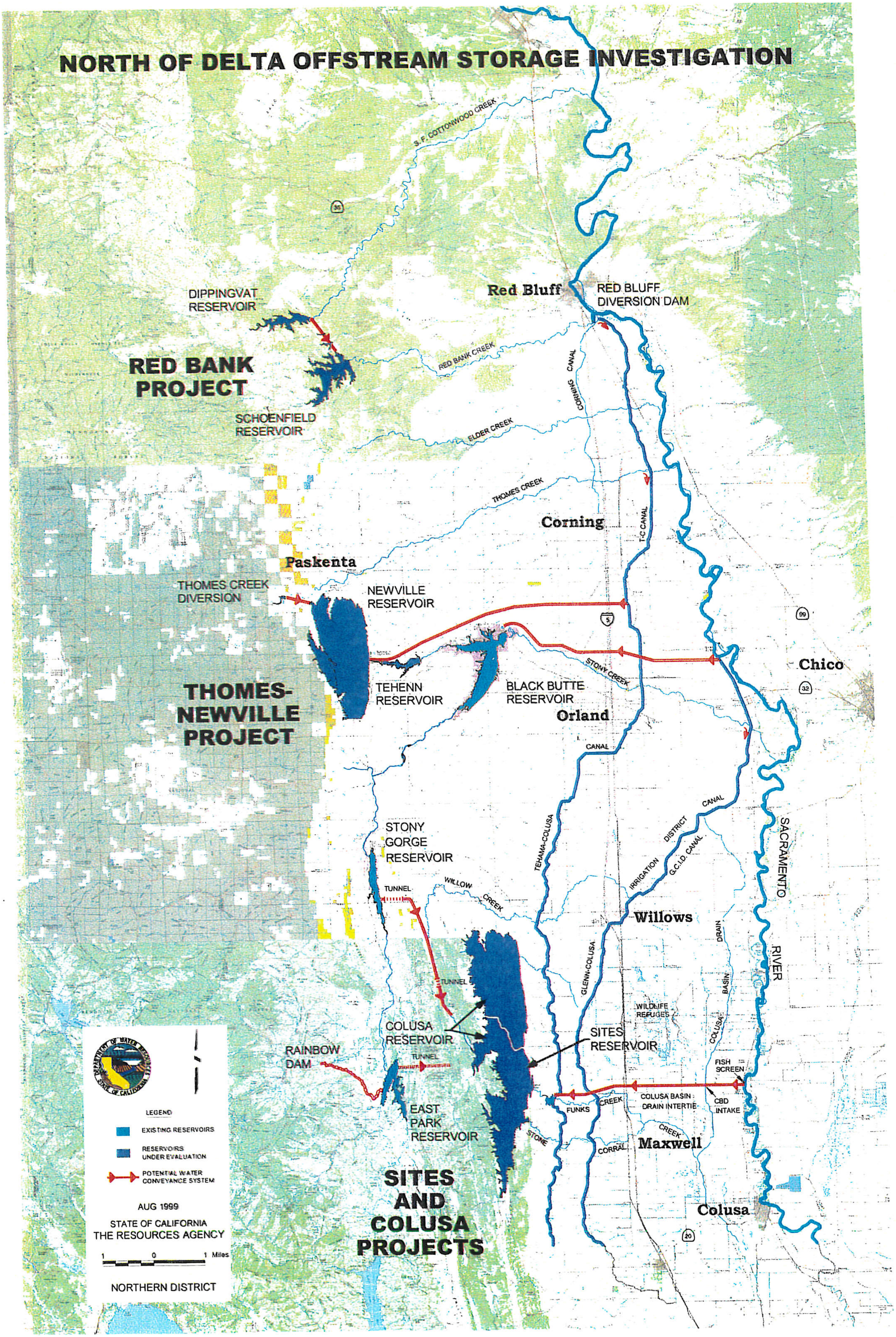
At the proposed project sites, fish surveys were conducted by diving, seining, fyke netting, and/or electrofishing. These methods were used to collect data on occurrence and relative abundance of species of fish. This section discusses general procedures for these methods. Details of surveys and results for each site are discussed in the respective sections.

Diving

Fish were observed in deep pools by divers wearing faceplates. Fish species were identified and numbers of each species observed were recorded. Diving was used as a sampling technique when pools were too big or deep for other sampling methods.

Seining

A seine is used to collect fish for sampling data. Three different seines varying in size were used depending on the size of the pool. The largest seine was 60 feet long, 5 feet high, with a mesh size of one-quarter inch and a 7-foot-by -7-foot pocket. A medium sized seine was 29 feet long, 6 feet high, with a mesh size of one-quarter inch and a pocket size of 7 feet by 5 feet. The third seine, used only for small pools and ponds, was 12 feet long, 4 feet high, with a mesh size of one-quarter inch and a 7-foot-by-5-foot pocket. A seine was brought around from one edge of the pool to the other. To prevent fish from escaping, a barrier net was stretched across the creek upstream and downstream from the pool to be seined. Captured specimens were stored in a bucket of water until they could be examined. Specimens were identified and the first 20 of each species were measured for fork length to the nearest millimeter and then released downstream. The seine was pulled a total of three times at each site. Representative specimens were either preserved or photographed for positive identification.


NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION
RED BANK PROJECT
DIPPINGVAT RESERVOIR
SCHOENFIELD RESERVOIR
S. F. COTTONWOOD CREEK
RED BANK CREEK
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Fyke Nets

Fish captured in fyke nets were measured for fork length to the nearest millimeter and weighed by water displacement to the nearest gram. No estimates of abundance were done for fish caught in fyke nets. Therefore, these fish were not included in the relative abundance tables.

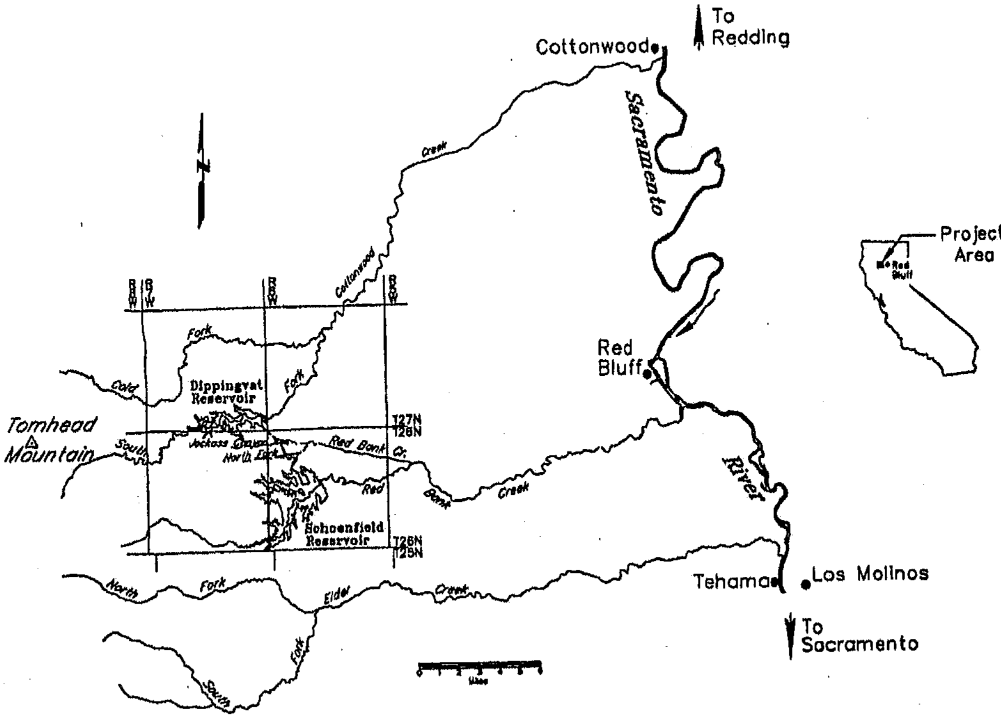
Electrofishing

Electrofishing was done with a Smith-Root Type VII electroshocker. Sections of creek varying from 33 to 138 feet were netted off, upstream and downstream. With a backpack electroshocker, DFG biologists waded into the stream starting from the upstream net and moved downstream. The anode of the electrofisher was inserted into likely fish habitat. The stunned fish were then collected into buckets, measured for fork length to the nearest millimeter for the first 20 of each species, and then a plus count was taken. Fish were weighed using water displacement to the nearest gram. The surface area of each station was calculated in square feet and then converted to square millimeters for fish density analysis. The resulting relative abundance was converted to and reported in fish per square yard.

Red Bank Project Fish Studies

This section describes the results of current and past fish studies conducted on Red Bank, South Fork Cottonwood, and Cottonwood Creeks, the major tributaries of the Red Bank Project area (Figure 2). Past studies date to 1969 and contain the reconnaissance-level fish and wildlife evaluation of Sacramento Valley alternative west side conveyance routes prepared by DFG (Smith and Van Woert 1969). Other studies reviewed include reports prepared by DFG and DWR in 1972, 1975, 1985, and 1987 (Haley and Van Woert 1972, Bill et al. 1975, Brown et al. 1985, Smith 1987).

Figure 2. Cottonwood Creek System and the Red Bank Project



Red Bank Creek Fish Resources

DFG Biologists sampled fish in Red Bank Creek within the footprint of the Schoenfield Reservoir in 1998. Data were collected at 28 stations. In summer 1998, seining was done at 16 stations dispersed on Red Bank Creek and its tributaries, Dry and Grizzly Creeks. Twelve stations were sampled on Red Bank Creek by electrofishing in October and November 1998.

Nongame Fish

Four species of nongame fish were observed (Table 1). The most common species of nongame fish found were California roach (0.588 fish/yd^2) and Sacramento pike minnow (0.158 fish/yd^2) (Table 2).

Resident Game Fish

In 1998, DFG biologists observed four species of resident game fish in Red Bank Creek (Table 3). The most common resident game fish were largemouth bass (0.009 fish/yd^2) and bluegill (0.001 fish/yd^2) (Table 4).

Steelhead

Also in 1998, DFG biologists found juvenile steelhead in the footprint of the proposed Schoenfield Reservoir in Red Bank by electrofishing and estimated density to be 0.002 fish/yd^2. Steelhead were found in two of 28 stations sampled.

Table 1. Nongame Fish Observed in the Red Bank and Cottonwood Creeks

Common Name	Scientific Name	Cottonwood Creek (1976)	Red Bank Creek (1998)
California roach	*Hesperoleucus symmetricus*	X	X
Carp	*Cyprinus carpio*	X	
Golden shiner	*Notemigonus crysoleucas*	X	
Hardhead	*Mylopharodon conocephalus*	X	
Hitch	*Lavinia exilicauda*	X	
Mosquitofish	*Gambusia affinis*	X	
Pacific lamprey	*Lampetra tridentata*	X	X
Prickly sculpin	*Cottus asper*	X	
Sacramento pike minnow	*Ptychocheilus grandis*	X	X
Sacramento sucker	*Catostomus occidentalis*	X	X
Speckled dace	*Rhinichthys osculus*	X	
Threespine stickleback	*Gasterosteus aculeatus*	X	
Tule perch	*Hysterocarpus traski*	X	

Table 2. Relative Abundance of Nongame Fish (Fish/Yd^2) Caught in Lower Cottonwood Creek, 1976, and in Red Bank Creek, 1998

Species	Cottonwood Creek (1976)	Red Bank Creek (1998)
California roach	0.003	0.588
Carp	0.003	
Hardhead	0.022	
Sacramento pike minnow	0.015	0.158
Sacramento sucker	0.006	0.091

Table 3. Game Fish Observed in Cottonwood Creek, 1976, and in Red Bank Creek, 1998

Common Name	Scientific Name	Cottonwood Creek (1976)	Red Bank Creek (1998)
Black bullhead	*Ictalurus melas*	X	
Bluegill	*Lepomis macrochirus*	X	X
Brown bullhead	*Ictalurus nebulosus*	X	
Brown trout	*Salmo trutta*	X	
Chinook salmon	*Onchorhynchus tshawytscha*	X	
Green sunfish	*Lepomis cyanellus*	X	X
Largemouth bass	*Micropterus salmoides*	X	X
Smallmouth bass	*Micropterus dolomieui*	X	
Steelhead	*Onchorhynchys mykiss*	X	X
White catfish	*Ictalurus catus*	X	

Table 4. Relative Abundance of Resident Game Fish (Fish/ Yd^2) Caught in Lower Cottonwood Creek and in Red Bank Creek

Species	Cottonwood Creek (1976)	Red Bank Creek (1998)
Bluegill	0.022	0.001
Brown bullhead	0.006	
Green sunfish	0.015	0.001
Largemouth bass	0.003	0.009
Smallmouth bass	0.003	

Cottonwood Creek Fish Resources

DFG biologists surveyed Cottonwood Creek from the confluence of the north fork to the mouth of Cottonwood Creek in 1976 (Richardson et al. 1978). Observations were made by diving, seining, fyke netting, and electrofishing. Abundance estimates were made for fish caught by electrofishing. Fish caught in fyke nets or observed by divers were not included in the relative abundance tables, because no estimates of abundance were done for these fish.

Nongame Fish

Thirteen species of nongame fish were observed (Table 1). The most common species of resident nongame fish found were hardhead (0.022 fish/yd^2) and Sacramento pike minnows (0.015 fish/yd^2) (Table 2). Some Sacramento pike minnows and Sacramento suckers also migrate to the Sacramento-San Joaquin estuary to rear and return to Cottonwood Creek as adults to spawn (Richardson et al. 1978). Life history information is valuable in planning instream flow studies, HEP evaluations, and determining project impacts.

Resident Game Fish

Ten species of resident game fish were observed in the Cottonwood Creek system in 1976 (Richardson et al. 1978) (Table 3). The most common resident game fish were bluegill (0.022 fish/yd^2) and green sunfish (0.015 fish/yd^2) (Table 4). Green sunfish and bluegill were common in the lower reaches surveyed (Richardson et al. 1978).

Steelhead

DFG biologists found juvenile steelhead in South Fork Cottonwood Creek in the Yolla Bolly Wilderness in the summer of 1976. No estimates of numbers of juvenile steelhead were made. The Yolla Bolly Wilderness is well above the site of the proposed Dippingvat Dam. Adult steelhead were seined from the mouth of Cottonwood Creek in November 1976 (Brown, et al., 1985). DFG estimates that Cottonwood Creek supports an average annual migration of 1,000 steelhead based on the best estimates of biologists who were most familiar with Cottonwood Creek (DFG 1966).

Chinook Salmon

Fall Run. Fall-run chinook salmon ascend Cottonwood Creek and spawn in late October through November (Richardson et al. 1978). They spawn in

Cottonwood Creek from the mouth to the confluence of North Fork Cottonwood Creek. About 53 percent of fall-run chinook salmon spawn from the mouth of Cottonwood Creek to the Interstate-5 highway bridge, 23 percent spawn from the Interstate-5 highway bridge to the confluence of Cottonwood Creek and South Fork Cottonwood Creek, and 24 percent spawn in Cottonwood Creek between the confluence of the south and north forks. Their young begin migrating after they incubate in January (Richardson 1978). They migrate downstream from January through May. DFG estimates that an average of 3,600 fall-run chinook salmon spawn in Cottonwood Creek (Table 5) (Elwell 1962; Fry 1961; Fry and Petrovich 1970; Hoopaugh 1978; Hoopaugh and Knudson 1979; Kano et al. 1996; Kano 1998a, 1998b; Knutson 1980; Mahoney 1962; Menchen 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970; Puckett et al. 1979; Reavis 1983, 1984, 1986).

Table 5. Estimates of Chinook Salmon Spawning in the Cottonwood Creek System, 1952-98 (DFG Spawning Stock Reports)

Year	Fall Run	Spring Run		
		Beegum Gulch	North Fork	South Fork
1952	-	-	-	-
1953	3,000	-	-	-
1954	1,000	-	-	-
1955	800	-	-	-
1956	660	-	-	-
1957	358	-	-	-
1958	600	-	-	-
1959	3,300	-	-	-
1960	350	-	-	-
1961	1,500	-	-	-
1962	6,000	-	-	0
1963	3,500	-	-	-
1964	3,450	-	-	-
1965	900	-	-	-
1966	2,900	-	-	-
1967	600	-	-	-
1968	8,540	-	-	-
1969	4,967	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	0
1973	-	0	-	-
1974	-	3	-	-
1975	-	3	-	1
1976	2,427	-	-	-
1977	1,512	-	-	-
1978	1,120	-	-	0
1979	-	-	-	-
1980	-	-	-	-
1981	3,356	-	-	-
1982	700	0	-	-
1983	1,000	-	-	-
1984	500	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	0	-	-
1990	-	-	-	-

Table 5. Estimates of Chinook Salmon Spawning in the Cottonwood Creek System, 1952-98 (DFG Spawning Stock Reports) continued

Year	Fall Run	Spring Run		
		Beegum Gulch	North Fork	South Fork
1991	676	-	-	-
1992	1,585	-	-	-
1993	-	1	-	-
1994	-	-	-	-
1995	-	8	-	-
1996	-	6	-	-
1997	-	-	-	-
1998	-	477	-	0

Late Fall-Run. Late fall-run chinook salmon migrate up Cottonwood Creek and spawn in January. DFG Biologists observed them spawning at the mouth of North Fork Cottonwood Creek in January 1976 (Richardson et al. 1978). Their young migrate downstream in May and June as much smaller fry than fall-run at that time of year. Young late fall-run chinook salmon were caught in fyke nets near the mouth of Cottonwood Creek in May and June 1976 (Richardson 1978). DFG estimates that an average of 300 late fall-run chinook salmon migrate up Cottonwood Creek (Smith and Van Woert 1969). DFG biologists surveying Cottonwood Creek in 1977 observed late fall-run chinook salmon spawning, but no estimates of run size were made.

Spring-Run. Spring-run chinook salmon migrate up Cottonwood Creek in April and spend the summer in deep pools in South Fork Cottonwood Creek, Beegum Gulch, and North Fork Cottonwood Creek. Most are found in Beegum Gulch. Young spring-run chinook salmon migrate downstream from January through May. DFG estimates that an average of 500 spring-run chinook salmon migrate up Cottonwood Creek (DFG 1966). DFG biologists surveyed Beegum Gulch in 1998 and found about 500 spring-run chinook salmon. Some young spring-run salmon from the Sacramento River use the lower reach of Cottonwood Creek from Interstate-5 to the mouth for rearing during the summer and fall (Richardson et al. 1978).

Spawning Habitat. DFG biologists took gravel samples in summer 1977 to measure quantity and quality of salmon spawning habitat in Cottonwood Creek. Approximately 392,000 square feet of gravel suitable for chinook salmon spawning was identified in the Cottonwood Creek system (Richardson and Brown 1978). About 40,000 square feet of that total was in south fork. Other investigations have produced estimates ranging from 285,000 square feet (Hansen et al. 1940) to 2,000,000 square feet (Leach and Van Woert 1968) of gravel in the system. A female chinook salmon requires about 100 square feet of gravel for spawning (Leach and Van Woert 1968). Most of the gravel was found in Cottonwood Creek below its confluence with North Fork Cottonwood Creek. Little suitable gravel was found in North Fork Cottonwood Creek.

Instream Flow. An instream flow study was conducted in 1976 and 1977 to measure the amount of chinook salmon spawning and rearing habitat in Cottonwood Creek and South Fork Cottonwood Creek. Optimum spawning flow was about 180 cfs and optimum rearing flow was 200 cfs from the mouth of Cottonwood Creek to the confluence of Cottonwood Creek and South Fork Cottonwood Creek. Optimum spawning flow was about 80 cfs and optimum rearing flow was 100 cfs in the lower seven miles of South Fork (Brown 1979). Natural monthly stream flow averages 295 cfs during fall-run chinook spawning in November near the mouth of Cottonwood Creek (Table 6). Average monthly flows range from 604 to 2,174 cfs when salmon rear from January through May.

Table 6. Average Monthly Stream Flow in Cottonwood Creek at the Cottonwood Gage

Month	Average Monthly Flow (cfs)
January	1,744
February	2,174
March	1,590
April	1,205
May	604
June	283
July	112
August	66
September	66
October	108
November	295
December	955

Thomes-Newville Project Fish Studies

DFG initiated studies of the impacts on fish and wildlife of a Thomes-Newville Project in 1979 as part of DWR's Thomes-Newville Reservoir planning studies. However, the planning studies were halted in 1982. DFG completed a report of its abbreviated studies in 1983 (Brown et al. 1983). In 1998, DFG initiated studies of fish and wildlife resources of a Thomes-Newville Project as part of the North of Delta Offstream Storage Program. A brief survey of spring-run chinook salmon was conducted during the recent investigations. This section discusses recent findings and recapitulates the effort and results of the 1982 study (Brown et al. 1983).

Methodology

Juvenile Salmon

Seining for juvenile chinook salmon in Stony and Thomes Creeks was done over a period of three years, 1980 to 1982. Ten sample stations were selected on Thomes and Stony Creeks. Each station was seined weekly from February to June, with 50-foot delta mesh seines (Brown et al. 1983).

Fyke nets were used to sample for juvenile salmonids during the 1981 and 1982 seasons on Thomes Creek only. Irregular and frequent floodflow releases from Black Butte Reservoir made it impractical to fyke net in Stony Creek. Two fyke nets were used in Thomes Creek. One was placed in the mainstem and another near the confluence to the discharge channel from the Tehama-Colusa Canal. The nets were fished continuously from Monday to Friday and were removed during weekends or during high water. Each net in the mainstem was fished from February through March. Captured fish were measured for fork length to the nearest millimeter and weighed by water displacement to the nearest gram (Brown et al. 1983).

Adult Salmon and Steelhead

Adult chinook salmon carcasses were counted to estimate the number of salmon in Stony and Thomes Creeks. Stony Creek was surveyed for carcasses between the Sacramento River confluence and the North Diversion Dam. Thomes Creek was surveyed between the Sacramento River confluence and Paskenta and in a channel from the discharge point of the Tehama-Colusa Canal to its confluence with Thomes Creek. Counts were taken once per week from November through January in 1980-81 and 1981-82 on Thomes Creek and from December through February in 1981-82 on Stony Creek. Each carcass was tagged by fastening a number 3 hog ring to its mandible. Tick marks were notched into the hog rings with wire cutters to identify the appropriate week of tagging. The sex and fork length of each carcass was noted. The date and location of where each carcass was found was recorded; each carcass was then returned to the same area where it was tagged. On successive surveys, tagged fish that were recovered were cut in half to avoid recounting in subsequent surveys. The 1980-81 spawning escapement estimate for Thomes Creek was calculated with the Schaefer method (Ricker 1975), while the 1981-82 estimates for both Stony and Thomes Creeks were estimated with the Peterson method (Ricker 1975) (Brown et al. 1983).

On June 13, 1979; August 18, 1980; and August 12, 1998, Thomes Creek was surveyed to enumerate adult spring-run chinook salmon and summer-steelhead. The area surveyed was from the gorge to the fjord at Hatch Flat near Paskenta. Each pool was examined by snorkel diving. All fish were identified and their size range and relative abundance estimated. No habitat suitable for spring-run salmon and summer steelhead exists in Stony Creek; therefore, no survey was conducted (Brown et al. 1983). Historical estimates for fall-run chinook salmon for both Stony and Thomes Creeks were compiled from DFG salmon-spawning stock reports.

Resident Fish and Migratory Nongame Fish

A fyke net consisting of 0.03 inch oval mesh netting mounted on a 0.01 inch x 0.02 inch metal tubing frame was placed in the creek near the mouth of Thomes Creek. The purpose of the net was to capture juveniles, larval Sacramento suckers, and Sacramento pike minnows migrating to the Sacramento River. A perforated aluminum box—1.6 feet x 1.6 feet x 3.3 feet—was attached to the cod end of the net to receive captured fish. The net was fished 24 hours per day during weekdays from January to June 1981 (Brown et al. 1983).

To estimate the population of spawning Sacramento suckers and Sacramento pike minnows, adult fish were captured in Thomes Creek and its tributary, Mill Creek. From December 1980 through June 1981, 17 samples were taken at 10-day intervals via electrofishing. A 12-foot Avon rubber raft was retrofitted with a Smith-Root Type VII electroshocker. The battery and electroshocking unit were placed inside an ice chest and secured to the raft's rowing frame. Prove arrays were constructed of 0.08-inch stainless steel cable, attached to the bow of the raft, and fished at a depth of 4.9 feet. (Brown et al. 1983).

Captured fish were weighed to the nearest 0.3 ounce and fork lengths were measured to the nearest millimeter. Each fish was marked with a floy spaghetti tag and released. The tag was inserted under the dorsal fin and tied in a loop. The Jolly-Seber method was used to determine the population estimate for Sacramento suckers while the Schaefer method (Ricker 1975) was used to estimate the population of Sacramento pike minnows (Brown et al. 1983).

Electrofishing was done in streams in the footprint of proposed Newville Reservoir in 1981 and 1982. Seven sections were sampled in streams within the project area. These include North Fork Stony, Salt, and Heifer Camp Creeks. Ten sections in Stony Creek and 15 in Thomes Creek were sampled. Fish were captured by backpack electrofishing. Population number and biomass estimates for each species for the Thomes-Newville data were developed using the two-pass method of Seber and LeCren (1967) (Brown et al. 1983).

Thomes Creek Fish Resources

Juvenile Chinook Salmon

1980 Emigration. Thirteen juvenile chinook salmon were captured by seining during the 1980 sample period (Table 7). These fish were caught in the lowermost stations of Thomes Creek from March 20 to May 24, 1980.

1981 Emigration. Six juvenile chinook salmon were captured by seining during the 1981 sample period (Table 7). One of these fish was from Coleman National Fish Hatchery.

In 1981, 206 juvenile chinook salmon were captured by fyke netting in Thomes Creek, 20 from the mainstem and 186 from the discharge canal (Tables 8 and 9).

Table 7. Juvenile Chinook Salmon Seined from Thomes Creek in 1980 and 1981 [1]

Sample Period	Number of Weekly Seinings	Number of Fish	Average Length of Fish (inches)
1980			
March	4	5	2.8
April	5	8	2.8
Total	**9**	**13**	
1981			
March	2	5	4.1
April	1	1	2.3
Total	**3**	**6**	

[1] Brown et al. 1983

Table 8. Fyke Net Catches of Juvenile Chinook Salmon from Mainstem of Thomes Creek in 1981 [1]

Sample Period	Hours Fished	Number of Salmon	Average Length of Fish (inches)
February	672	0	0
March	744	9	2.7
April	648	10	3.1
May	336	1	2.7
Total	**2,400**	**20**	

[1] Brown et al. 1983

Table 9. Fyke Net Catches of Juvenile Chinook Salmon from the Tehama-Colusa Canal Discharge Channel in Thomes Creek in 1981 and 1982 [1]

Sample Period	Number of Fish	Average Length of Fish (inches)
1981		
January	1	1.4
February	126	1.3
March	59	1.3
Total	**186**	
1982		
January	2	1.4
February	45	1.4
March	337	1.5
Total	**384**	

[1] Brown et al. 1983

The catches from the mainstem occurred over a nine-week period beginnning the first week of March and ending the first week of May. Salmon from these catches ranged in size from 2.7 to 3.1 inches fork length (Table 8). Except for the time when the migration occurred, no real descriptive trends can be derived from these data. These fish, however, appear to be much larger than expected for fall-run fish spawned in Thomes Creek. Some fish may have spawned earlier in the mainstem Sacramento River and moved upstream into Thomes Creek. It is common for juvenile salmonids from the Sacramento River to swim upstream into tributaries (Richard Hallock, DFG, personal communication).

Juveniles captured in the discharge channel spawned there. The presence of live adults, carcasses, and redds in the channel together with the presence of juveniles is strong evidence that successful spawning occurred in the channel.

The migration of juvenile chinook salmon from the discharge channel occurred from late February through the third week of March. At this time the discharge was terminated by the U.S. Bureau of Reclamation and no water flowed to indicate newly hatched fish. These fish were of the fall-run spawn. Although the migration was halted by lack of flow, it could have continued if discharge had been extended. In response to the lack of flow, DFG regional personnel rescued in excess of 3,000 juvenile salmon.

1982 Emigration – No juvenile chinook salmon were captured by seining or fyke netting in the mainstem of Thomes Creek during the 1982 sample period. High flows and other duties limited efforts.

As indicated in Table 9, 384 juvenile chinook salmon were captured by fyke netting in the discharge channel from the Tehama-Colusa Canal. The first fish was captured during the first week of January, but the bulk of the migration did not occur until the third week of February. The migration continued until March 30, 1982, when the discharge was terminated by USBR.

Juvenile Steelhead

Seven juvenile steelhead were captured by seining in Thomes Creek in 1981. Four of these fish were probably from Coleman National Fish Hatchery. They had rounded fins and deformed dorsal fins, which are a characteristic of hatchery-grown fish. Juvenile salmonids from the Sacramento River commonly ascend tributaries (Richard Hallock, DFG, personal communication).

Adult Chinook Salmon

Review of past reports show little information on historic salmon runs in Thomes Creek. Only seven surveys were documented between 1955 and 1979. In 1957, the fall-run escapement estimate was 25, and in 1975 the estimate was 170 fish (Mahoney 1958, Hoopaugh 1978a). Estimates of fall-run salmon for survey years 1959, 1960, 1964, 1965, and 1976 were zero (Mahoney 1960, 1962; Menchen 1965, 1966; Hoopaugh 1978b).

1980-81 Fall-Run Estimate. Fifty-nine chinook salmon carcasses were tagged during 12 surveys of Thomes Creek. Of these 59, 17 fish (29 percent) were males while 42 fish (71 percent) were females. This represented a male-female ratio of 1:2.5. Twenty-three carcasses were recovered in fall 1980. From these data an estimated 155 salmon spawned in Thomes Creek during the sample period.

Live fish were first observed in the creek November 11, 1980, but no carcass was tagged until nine days later. The last carcass was tagged on January 12, 1981. Fifty-seven (97 percent) of the fish tagged were located in the Tehama-Colusa Canal outlet channel. Only two fish (3 percent) were tagged in the mainstem. Observation of six redds and four live fish indicates there was some spawning activity in areas below Henleyville.

1981-82 Fall-Run Estimates. Thirty-eight chinook salmon carcasses were tagged during 10 surveys of Thomes Creek. Of these 38, 16 fish (42 percent) were males while 22 fish (58 percent) were females. This represents a male-female ratio of 1:1.4. All of the fish tagged were located in the Tehama-Colusa Canal outlet channel. Twenty tagged carcasses were recovered. From these data an estimated 167 salmon spawned in Thomes Creek during the sample period. No live fish or redd was seen in the mainstem.

1979-1980 Spring-Run Estimates. No adult anadromous salmonid was seen during the June 1979 or August 1980 spring-run chinook salmon surveys in Thomes Creek. Numerous juvenile steelhead and brown trout were seen in the area of the survey which may indicate that habitat for spring-run chinook salmon or summer steelhead may exist. Although surface water temperatures generally approach 77°F in these areas, cooler water (59-68°F) can be found near the bottom of larger pools that could support salmonids.

1999 Spring-Run Estimates. One adult spring-run chinook salmon was seen during August 1999 diving surveys in Thomes Creek. As in 1980, numerous juvenile steelhead and brown trout were seen in the area of the survey.

1980 Late Fall-Run. The late spawning characteristics of a few chinook salmon indicate that they were of the late fall-run. Those that spawned in late December and January were salmon of this race.

Resident Fish and Migratory Nongame Fish

Twenty-two species of fish were observed in Thomes Creek (Table 10). DFG staff developed population and biomass estimates for 13 of these species (Table 11). Three species were game fish and 10 were nongame fish. Steelhead were the most abundant fish above the gorge, while Sacramento pike minnow, Sacramento suckers, hardhead, California roach, and speckled dace were the more common fish below the gorge.

Most of the nongame fish caught in the reach below the gorge were juveniles, indicating that this reach serves mainly as a spawning and rearing area. Adult Sacramento suckers, Sacramento pike minnow, California roach, and hardhead annually migrate from the Sacramento River into Thomes Creek and its tributaries to spawn. Juveniles that do not migrate immediately after hatching remain to rear until the following rainy season when water flows to the mouth.

Thomes Creek below Paskenta usually dries up except for a few residual pools scattered along the streambed during the late summer, making it impossible for resident adult fish to live throughout the summer months. Some adult game fish such as largemouth and smallmouth bass, bluegill, and green sunfish ascend the creek from the Sacramento River during late spring and early summer to use these pools as spawning areas.

Table 10. Fish Species Found in Thomes Creek in 1982[1]

Common Name	Scientific name
Bluegill	*Lepomis machrochirus*
Brown bullhead	*Ictalurus nebulosus*
California roach	*Lavinia symmetricus*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Golden shiner	*Notemigomus crysoleucus*
Goldfish	*Carassius auratus*
Green sunfish	*Lepomis cyanellus*
Hardhead	*Mylopharodon conocephalus*
Hitch	*Lavinia exilicauda*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Pacific lamprey	*Lampetra tredentata*
Prickly sculpin	*Cottus asper*
Sacramento pike minnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentatlis*
Smallmouth bass	*Micropterus dolomeiu*
Speckled dace	*Rhinicthys osculus*
Steelhead	*Onchorynchus mykiss*
Threespine stickleback	*Gasterosteus aculeatus*
Tule perch	*Hysterocarpus traski*
White catfish	*Ictalurus catus*

[1] Brown et al. 1983

Table 11. Average Population Estimates and Biomass Estimates for Fish Caught in Sections of Thomes Creek in 1982[1]

Species	Average Population Estimate	Average Biomass (lb/acre)
Bluegill	3	4.5
California roach	41	10.7
Carp	90	64.2
Goldfish	1	19.2
Green sunfish	14	15.2
Hardhead	47	47.3
Hitch	1	0.4
Largemouth bass	5	8
Prickly sculpin	1	1.8
Sacramento pike minnow	337	89.2
Sacramento sucker	143	16.1
Speckled dace	229	16.1
Tule perch	1	0.2

[1] Brown et al. 1983

Stony Creek Fish Resources

Juvenile Chinook Salmon

1980 Emigration. During the 1980 sample period, 181 juvenile chinook salmon were caught by seining (Table 12). Salmon were first caught during the second week of February and the last salmon was caught during the first week of May.

1981 Emigration. During the 1981 sample period, 73 juvenile chinook salmon were captured by seining (Table 12). Fish were first captured during the third week of February and the last fish were captured during the second week of April.

1982 Emigration. During the 1982 sample period, only four juvenile chinook salmon were captured by seining (Table 12). Two fish were captured during January and two were captured during the first week of March.

Adult Salmon Studies

1981-82 Fall-Run Estimates. Thirty-six chinook salmon carcasses were tagged during five surveys. Two of these salmon were recovered. From these data DFG estimates that 393 salmon spawned in Stony Creek during the sample period. Of the 36 tagged, 11 fish (31 percent) were males while 25 fish (69 percent) were females. This represents a male-female ratio of 1:2.3.

Most of the spawning activity was located in lower Stony Creek in the reach between the Interstate-5 bridge and the mouth. At least 35 redds and 29 carcasses were counted in this area.

Table 12. Juvenile Chinook Salmon Seined from Stony Creek in 1980, 1981, and 1982[1]

Sample Period	Number of Fish	Average Length of Fish (in)
1980		
February	64	1.7
March	51	1.8
April	60	2.0
May	6	3.0
Total	**181**	
1981		
February	5	1.5
March	64	2.1
April	4	3.0
Total	**73**	
1982		
January	2	3.3
March	2	1.7
Total	4	

[1] Brown et al. 1983

Resident Fish Surveys

Six species of fish, two game and four nongame, were captured in streams potentially inundated by the Newville Reservoir (Tables 13 and 14). These streams include North Fork Stony Creek, Salt Creek, and Heifer Camp Creek. Rainbow trout were captured in sections of streams above the inundation line where the water is cool and cover is abundant. California roach, Sacramento pike minnow, Sacramento sucker, carp, and green sunfish were captured in sections of streams below the inundation line. California roach, Sacramento pike minnows, and Sacramento suckers were more abundant species, while carp and green sunfish are relatively uncommon (Brown et al. 1983).

Table 13. Population Estimates for Fish Caught in Selected Sections of Streams within the Newville Reservoir Site in 1983[1]

Species	North Fork Stony Creek	Salt Creek	Heifer Camp Creek
California roach	4	546	120
Carp	1		
Green sunfish	-	13	
Rainbow trout	-	24	8
Sacramento pike minnow	12	24	85
Sacramento sucker	> 2	45	6

[1] Brown et al. 1983

Table 14. Average Biomass Estimates (lb/acre) for Fish Caught in Selected Sections of Streams within the Newville Reservoir Site in 1983[1]

Species	North Fork Stony Creek	Salt Creek	Heifer Camp Creek
California roach	0.9	427.3	72.3
Carp	145.4	-	
Green sunfish	-	33.9	
Rainbow trout	-	74.9	18.7
Sacramento pike minnow	8	339.9	775.1
Sacramento sucker	0.09	88.3	

[1] Brown et al. 1983

The sections of stream within the inundation area are used primarily for spawning and rearing by nongame species (mainly the minnow family), although some green sunfish were observed spawning during the late spring in nonflowing areas of the stream. It is likely that, during high water, adult cyprinids ascend these tributaries from Black Butte Reservoir to spawn (Brown et al. 1983).

Upper Salt Creek supports a population of rainbow trout. Nongame fish were not found in this area nor were migratory cyprinids because they cannot ascend the creek due to a waterfall. This waterfall is not in the inundation area.

However, if Newville Reservoir is built, the waterfall could be flooded, which would allow nongame fish to swim upstream. This may reduce the rainbow trout populations because of competiton with nongame fish (Brown et al. 1983).

Twenty-eight species of fish were observed in Stony Creek (Table 15). DFG developed population and biomass estimates for 21 of these species (Table 16). Eight species were game fish and 13 were nongame fish. Largemouth bass and bluegill were the most abundant gamefish below Black Butte Reservoir; channel catfish and white catfish were the most abundant game fish above the Sacramento River. Sacramento pike minnows and suckers were found in all stations throughout Stony Creek, were the most abundant, and had the highest biomass for all species of fish. Prickly sculpin were found in all sections, but made up a very small portion of the total biomass.

Most nongame fish caught in the reach below Black Butte Reservoir were juveniles, indicating that this reach serves mainly as a spawning and rearing area. Adult Sacramento suckers, Sacramento pike minnow, California roach, and hardhead annually migrate from the Sacramento River into Stony Creek to spawn. Juveniles that do not migrate immediately after hatching remain to rear until the following season when water flows to the mouth. Other game fish such as largemouth bass, smallmouth bass, bluegill, and green sunfish were also observed spawning in backwater areas of Stony Creek. These adult fish may have migrated upstream from the Sacramento River, may have washed downstream from Black Butte Reservoir, or may reside throughout the year in the creek.

Table 15. Fish of the Stony Creek Drainage (Excludes Fish within Newville Reservoir Site)[1]

Common Name	Scientific Name
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis melas*
Bluegill	*Lepomis machrochirus*
Brown bullhead	*Ictalurus nebulosus*
California roach	*Lavinia symmetricus*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Golden shiner	*Notemigomus crysoleucus*
Goldfish	*Carassius auratus*
Green sunfish	*Lepomis cyanellus*
Hardhead	*Mylopharodon conocephalus*
Hitch	*Lavinia exilicauda*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Pacific lamprey	*Lampetra tridentata*
Prickly sculpin	*Cottus asper*
Rainbow trout	*Onchorynchus mykiss*
Redear sunfish	*Lepomis microlophus*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento pike minnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentatlis*
Smallmouth bass	*Micropterus dolomeiu*
Speckled dace	*Rhinicthys osculus*
Threadfin shad	*Dorosoma petenense*
Threespine stickleback	*Gasterosteus aculeatus*
Tule perch	*Hysterocarpus traski*
White catfish	*Ictalurus catus*
White crappie	*Pomoxis annularis*

[1] Brown et al. 1983

Table 16. Average Population Estimates and Biomass Estimates for Fish Caught in Selected Sections of Stony Creek in 1982 [1]

Species	Average Population Estimate	Average Biomass (lb/acre)
Black crappie	8	87.4
Bluegill	19	8
California roach	200	54.4
Carp	5	64.2
Channel catfish	57	47.3
Goldfish	8	33.9
Green sunfish	7	2.7
Hardhead	9	24.1
Hitch	32	20.5
Largemouth bass	13	11.6
Mosquitofish	3	0.09
Prickly sculpin	57	11.6
Sacramento pike minnow	146	91
Sacramento sucker	96	256.9
Smallmouth bass	5	16.1
Speckled dace	318	41.9
Threadfin shad	2	0.9
Threespine stickleback	3	0.05
Tule perch	6	5.4
White catfish	30	34.8
White crappie	5	17.8

[1] Brown et al. 1983

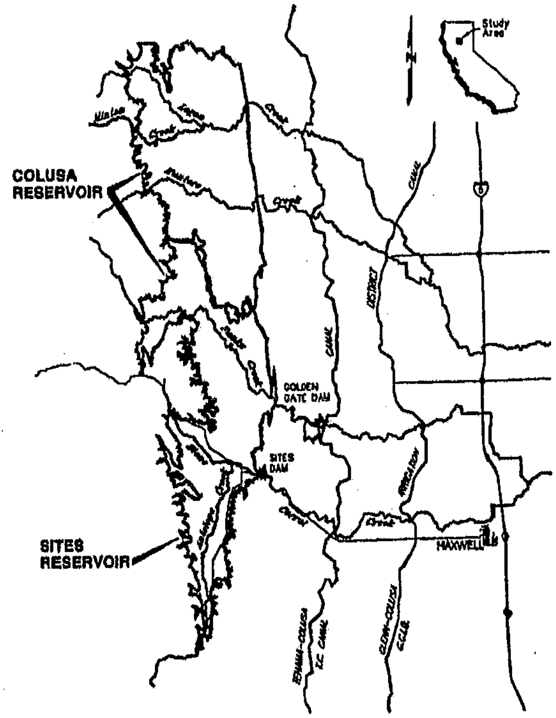
Sites and Colusa Project Fish Studies

Fish studies for the Sites and Colusa Projects included three basic areas of study: fish resources in streams within the proposed reservoirs and in the Colusa Basin Drain, and habitat typing of the dominant streams in the proposed reservoirs.

Sites and Colusa Project Stream Fish Resources

This section summarizes studies of fish in streams that flow through the proposed Sites and Colusa Projects. Studies were conducted in 1998 and 1999. Information gathered in these streams will be used to describe impacts on fish resources during the planning process.

Figure 3. Streams in the Sites-Colusa Project



Methodology

Stone Corral Creek, Funks Creek, Logan Creek, and Hunters Creek and their tributaries originate in oak woodland habitat in western Colusa and Glenn Counties (Figure 3). The creeks flow downstream through annual grassland and cultivated rice fields before flowing into the Colusa Basin Drain. Deeply incised channels characterize these streams with little vegetation on the banks and little cover in streambeds. Streamflow is seasonal with periods of high flow during winter storms, declining flows through spring and early summer, and intermittent flow in late summer. Water quality is poor and high in dissolved minerals. The total dissolved solids in the water are so high that electrofishing as a means of sampling is not possible in the streams.

Pools were seined at specific stations on all creeks surveyed to determine species composition. All sample stations were within the footprint of the Sites-Colusa Project. Thirty-six stations were spread out among Hunter, Minton, Logan, Antelope, and particularly Stone Corral and Funks Creeks. Seven stock ponds in the Sites and Colusa area were also seined for fish.

Twelve species of fish were caught in the Sites and Colusa study area in 1998 and 1999. Five species were game fish and seven species were nongame fish (Table 17). A single spring-run chinook salmon was observed in Antelope Creek, a tributary to Stone Corral Creek in spring 1998. It died a few weeks later and was identified by its carcass.

Table 17. Fish Caught in the Sites Study Area in 1998 and 1999

Common Name	Scientific Name
Bluegill	*Lepomis macrochirus*
California roach	*Hesperoleucus symmetricus*
Chinook salmon	*Oncorhynchus tschawtscha*
Green sunfish	*Lepomis cyanellus*
Hitch	*Lavinia exilicauda*
Largemouth bass	*Micropterus salmoides*
Mosquitofish	*Gambusia affinis*
Redear sunfish	*Lepomis microlophus*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento pike minnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentalis*
Sculpin sp.	*Cottus sp.*

Funks Creek. Fifteen stations were sampled on Funks Creek between July 22, 1998, and January 8, 1999. Stations were evenly spaced between the Golden Gate damsite and the upper limit of flow in Funks Creek. Streamflow was intermittent. Five species of fish were found in Funks Creek, including one type of game fish, largemouth bass (Table 18). The most common fish in Funks Creek was the hitch, with an average density of 3.1 fish/yd^2 (Table 18). Hitch were caught in 11 out of 15 stations seined (Table 18).

Table 18. Species Caught at Each Sample Station and Relative Abundance on Funks Creek

Species	Station Sampled															Fish/yd^2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Hitch			X	X	X	X	X	X	X	X	X	X	X			3.1
Largemouth bass									X			X				0.001
Sacramento pike minnow					X	X			X				X			0.06
Sacramento Sucker					X	X			X	X			X			0.02
Sculpin														X		---

The most diverse sampled sections of Funks Creek were in the lower reaches, stations 5, 6, 9, 10, 12, and 13. The upper reaches of Funks Creek either lacked fish or only one species was found. Hitch densities varied widely throughout the creek, and no one area seemed to maintain a higher population.

Hunters Creek. Three stations on lower Hunters Creek were seined between July 22, 1998, and August 3, 1998. No water was present above these sites. Only two species of fish were found on Hunters Creek, green sunfish and mosquitofish. Both species were found in two of the three stations (Table 19).

Mosquitofish were found in a relative abundance of 3.8 fish/yd^2, but they only occurred in abundance at one station. Green sunfish were found to have an average density of 2.3 fish/yd^2.

Table 19. Relative Abundance of Fish Caught at Hunters Creek

Species	Fish/yd^2
Green sunfish	2.3
Mosquitofish	3.8

Minton Creek. Minton Creek was sampled in two places on August 12, 1998. Samples were taken in lower reaches of the creek because areas of the creek above the sample sites were dry. Hitch were found in only one of those stations, at a density of 0.5 fish/yd^2.

Stone Corral Creek. Eleven stations were sampled on Stone Corral Creek between July 15, 1998, and January 6, 1999. Stations were located from the damsite to about 1 mile above. Flows were less than 1 cfs. Eight species of fish were found in Stone Corral Creek, including two species of game fish, green sunfish and bluegill (Table 20).

The fish most common fish among the stations was the Sacramento pike minnow followed by the hitch (Table 20). Fish density on Stone Corral was relatively low for all species at all stations. Hitch were the dominant species in terms of density 0.8 fish/yd^2.

Table 20. Species Caught at Each Station and Relative Abundance on Stone Corral Creek

Species	Station Sampled											Fish/yd2
	1	2	3	4	5	6	7	8	9	10	11	
Bluegill				X								0.002
California roach		X		X								0.02
Green sunfish			X					X	X	X	X	0.03
Hitch		X	X					X	X	X	X	0.8
Mosquitofish				X								0.002
Sacramento blackfish											X	0.2
Sacramento pike minnow			X	X	X	X		X	X		X	0.2
Sacramento sucker			X	X		X					X	0.02

Most seining stations on Stone Corral Creek were clustered around the same region. Station 1 was far upstream from the others and yielded no fish. The diversity of species caught was highest at stations 4 and 11.

Antelope Creek. Five seining stations were sampled on Antelope Creek between July 14, 1998, and November 25, 1998. Stations were evenly spaced between the mouth of Antelope Creek and the boundary of Sites Reservoir. Streamflow was less than 5 cfs. Three species of fish were captured on Antelope Creek: green sunfish, hitch, and Sacramento pike minnow (Table 21). Hitch were the most abundant fish with an average density of 3.8 fish/yd^2. The Sacramento pike minnow and the green sunfish both had a relative abundance of 0.2 fish/yd^2.

Table 21. Species Caught at Each Station and Relative Abundance on Antelope Creek

Species	Station Sampled					Fish/yd2
	1	2	3	4	5	
Green sunfish		X		X	X	0.2
Hitch	X	X	X	X	X	3.8
Sacramento pike minnow				X	X	0.2

Logan Creek. Four stations were sampled on Logan Creek over two days in August 1998. Stations were located in and near the footprint of the proposed Colusa Reservoir. Streamflow was less than 1 cfs. Hitch were caught in stations 1 and 2. The average density of hitch on Logan Creek was 0.4 fish/yd^2.

Ponds. DFG biologist seined seven stock-watering ponds in the study area. The ponds seined do not dry up during the summer. Three game fish were found in the ponds, red-eared sunfish, bluegill, and largemouth bass. Redear sunfish were found in one pond, bluegill were found in abundance in two ponds, and largemouth bass were found in three ponds. No other fish were found in these ponds.

Discussion

Hitch were found in all the creeks in the Sites and Colusa Project area. Hitch were also present in the greatest numbers. Stone Corral Creek had the greatest diversity of fish throughout the year—eight species—including two species of introduced game fish, bluegill and green sunfish. However fish densities were lower, particularly for hitch in Stone Corral than in other creeks. Funks Creek, the next most diverse creek, had only five species of fish, including one introduced game fish, largemouth bass.

Most fish captured during seining were minnows, members of the Cyprinid family. California roach are the only fish present that are adapted to spending summers in the remaining pools of intermittent streams (Moyle 1976). Very few fish found while seining, including game fish, were above 5.9 inches in lengths, suggesting that juvenile fish only rear in these areas. Adult fish typically ascend seasonal creeks in the study area in winter and spawn there in early spring. Most adults migrate downstream after spawning.

No species of concern or threatened or endangered species were found in this study. The species caught during the study are common in California.

Colusa Basin Drain Fish Studies

This section describes the fish resources of the Colusa Basin Drain. Colusa Basin Drain is a natural channel that historically transported water from west side tributaries such as Willow, Funks, Stone Corral, and Freshwater Creeks to the Sacramento River. It also carried overflowing floodwater from the Sacramento River. With the advent of agriculture in the Sacramento Valley, the Colusa Basin Drain was channelized and dredged to carry agricultural runoff in addition to natural flows.

Streamflow in the CBD peaks in winter months when storms swell the small streams that feed the CBD. Flow also reaches high levels in late summer when rice fields are drained into the CBD. Table 22 shows average monthly streamflow in CBD from 1976 to 1997. Daily and instantaneous flows in the CBD may be much higher.

The CBD provides little bank cover for fish; however, some instream cover is provided by large and small woody debris. Its banks are scoured by periodic high flows and roads often run along the dikes that contain the waters of the CBD. The bottom of the CBD is largely mud. Water in the CBD is turbid and warm in the summer, and turbid and cool during the winter. The proposed diversion from the CBD for Sites and Colusa Reservoirs will be east of the town of Maxwell along the CBD.

Table 22. Average Monthly Streamflow (cfs) in the Colusa Basin Drain at the Highway 20 Crossing

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1976	237	249	160	185	177	371	312	879	239	434	926	904
1977	169	255	138	312	181	256	90	642	121	121	424	388
1978	116	272	254	3121	2133	1429	365	684	469	711	1056	1028
1979	201	312	113	689	940	407	328	802	424	803	1211	1029
1980	200	563	837	1874	2888	1305	326	1048	603	805	1307	1160
1981	275	328	359	1017	840	433	342	1039	446	1057	1464	1182
1982	284	877	1115	1939	472	383	682	743	908	n.r.	1393	1356
1983	467	778	1225	2331	3028	5304	990	n.r.	n.r.	907	1168	1198
1984	315	1302	3623	1523	493	265	547	1190	851	1310	1580	1041
1985	376	1160	683	285	170	196	409	1048	768	1237	1442	1442
1986	316	663	700	754	4214	1833	449	921	834	1052	1338	1338
1987	318	459	235	249	319	508	495	913	707	907	1175	1175
1988	341	668	462	1365	287	431	666	849	515	586	972	972
1989	345	617	354	342	212	404	438	572	587	800	995	995
1990	303	411	181	346	203	n.r.	n.r.	583	439	533	913	913
1991	247	n.r.	n.r.	153	217	916	423	477	353	371	535	535
1992	159	319	291	261	932	670	256	167	250	149	186	186
1993	116	267	347	2900	3049	762	322	279	290	201	489	489
1994	203	419	466	315	740	331	300	191	147	61	418	418
1995	155	565	549	6612	2020	3823	591	551	364	297	416	416
1996	255	368	749	972	2668	1092	493	771	472	249	660	660
1997	229	643	643	3698	1464	357	321	286	152	368	953	953
AVG	**256**	**547**	**642**	**1420**	**1257**	**1023**	**435**	**697**	**473**	**617**	**956**	**956**

Methodology

Two fyke nets were placed in the CBD, one upstream of the proposed diversion point and one downstream. The first net was put in at the confluence of Willow Creek and the CBD. The second was placed just south of Hwy 20 on the CBD. The fyke nets have a 3 foot-by-5 foot opening, and a 12-foot funnel. Galvanized pipe frames support the net opening. Nets of variable size stretched mesh were used: 1 inch, 0.25 inch, and 0.125 inch. The largest sized mesh was at the front of the funnel, and smallest size mesh was at the back. The narrow end of each net is connected to a wooden live box, 2.5 feet by 1.5 feet by 1.6 feet. Holes in the side and back of the box were covered by screening with a mesh size of 0.19 inch. The fyke nets were held in fishing position by rope bridles attached to ropes secured to metal fencing posts and/or a tree or utility pole on the bank. The nets were installed on January 19, 1999, and checked daily Monday through Friday. The nets were removed from the canal during periods of high water. Captured specimens were identified and measured for fork length to the nearest millimeter for the first 20 of each species, after which species were only tallied. Representatives of each species were either photographed or preserved for future positive identification.

Periodic seining using the medium sized—29-feet long, 6-feet high, one-quarter inch mesh; seine, and hook and line sampling were also used to sample the fish of the Colusa Basin Drain at the upper net location. Two hoop nets and a gill net were also placed at the upper fyke net location February 1, 1999. The hoop nets were installed upstream of the fyke net. The hoop nets were 7 feet long with six hoops 2 feet in diameter set 1 foot apart, with a net mesh size of 1 inch. They had two finger funnels each. These nets were secured to a wooden bridge and placed on either side of the channel. The hoop nets were baited with fish carcasses. The gill net spanned the entire distance of the drain downstream of the fyke net. These nets were removed March 10, 1999. One hoop was replaced at the bridge on March 19, 1999.

Results

A total of 9 game fish and 17 nongame fish were caught in the CBD (Tables 23 and 24). The warmouth (*Lepomis gulosus*) and the largemouth bass (*Micropterus salmoides*), which were caught by U.S. Geological Survey in 1996, were not observed in this recent survey.

Table 23. Resident Game Fish of the Colusa Basin Drain

Common Name	Scientific Name
Black bullhead	*Ictalurus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tschawtscha*
Green sunfish	*Lepomis cyanellus*
White catfish	*Ictalurus catus*
White crappie	*Pomoxis annularis*

Table 24. Resident Nongame Fish of the Colusa Basin Drain

Common Name	Scientific Name
Big scale logperch	*Percina macrolepida*
California roach	*Hesperoleucus symmetricus*
Carp	*Cyprinus carpio*
Flathead minnow	*Pimephales promelas*
Goldfish	*Carassius auratus*
Hitch	*Lavinia exilicauda*
Inland silversides	*Menidia beryllina*
Mosquitofish	*Gambusia affinis*
Pacific lamprey	*Lampetra tridentata*
Sacramento blackfish	*Orthodon microlepidotus*
Sacramento pike minnow	*Ptycholcheilus grandis*
Sacramento splittail	*Pogonichthys macrolepidotus*
Sacramento sucker	*Catostomus occidentalis*
Sculpin sp.	*Cottus sp.*
Threadfin shad	*Dorosoma pretenense*
Tui chub	*Gila bicolor*
Tule perch	*Hysterocarpus traski*

One late fall-run chinook salmon carcass was found in the upper fyke net. In October 1998, fall-run chinook salmon were observed migrating up the CBD at the Delevan Wildlife Area. DWR biologists saw spring-run chinook salmon in Walker Creek, a tributary to Willow Creek, in spring 1998. Four splittail were caught in the fyke net located just below Highway 20 in July and August, 1999. All four were young-of-the-year splittail. They averaged 1.4 inches, and ranged from 0.9 to 2.0 inches fork length.

The greatest diversity of fish was caught in the upper fyke net, at the confluence of Willow Creek and the CBD. The gill net and the hoop net caught only a few different species of fish (Table 25). Various tadpoles, mostly bullfrog, (*Rana catesbieana)*, were by far the most numerous animal caught by any method, but particularly the fyke nets. Channel catfish were the most frequently caught fish, the majority of which were juveniles. Mostly juvenile fish were caught in the nets. Rarely did fish exceed 5.9 inches, with the exception of the goldfish. Adult channel catfish, up to 17.7 inches, were caught by hook and line. Carp, up to 20 inches, were also caught with hook and line.

Seining was the most efficient form of sampling in the Colusa Basin Drain, with a catch per hour effort ratio of 21.8. The hoop net was the least efficient method of capture, with a catch per hour effort ratio of 0.01 (Table 26).

Table 25. Number of Species Captured at Each Trapping Station

Species	Gill net	Hoop net	Seine	Hook & line	Fyke nets	Total
Big scale logperch			2		3	5
Black bullhead				1	7	8
Black crappie			1		2	3
Bluegill	1	1	10	1	23	36
Brown bullhead				20	18	38
California roach			15		1	16
Carp				69	2	71
Channel catfish	2	1		28	195	226
Chinook salmon					1	1
Flathead minnow					1	1
Goldfish				16	15	31
Green sunfish			8		48	56
Hitch			40	1	52	93
Inland silversides			1		4	5
Mosquitofish			3		6	9
Pacific lamprey					7	7
Sacramento blackfish			96		23	119
Sacramento pike minnow	1				2	3
Sacramento splittail					4	4
Sacramento sucker	1	1	1		3	6
Sculpin sp.			1		1	2
Threadfin shad					6	6
Tui chub						1
Tule perch		1			4	5
White catfish				7	18	25
White crappie					3	3

Table 26. Catch Per Hour Effort for Each Trapping Method

Trapping Method	Total Effort Hours	Catch per Hour Effort
Gill net	336	0.02
Hoop net	576	0.01
Seine	8	21.8
Hook and line	41	3.5
Fyke net	2500	0.25

Discussion

Four Sacramento splittail were caught. This species were federally listed as threatened in March 1999. Numerous fall-run chinook salmon were observed in the CBD and the carcass of one late fall-run chinook salmon was found. Fall-run chinook salmon and late fall-run chinook salmon are federally proposed for listing as threatened. Spring-run chinook salmon were observed in Walker Creek, a tributary to the CBD. They were listed as a State of California Threatened Species in February 1999. They are also proposed for listing as a federally endangered species.

Willow and Freshwater Creeks are tributaries to the CBD. They flow all year in their upper reaches and have deep pools suitable for steelhead juveniles. Steelhead smolts migrate during high stream flows in the winter. The nets set up in the CBD might not have caught them because larger fish and migrating yearling steelhead avoid fixed fyke nets. Willow and Freshwater Creeks should be sampled during summer to detect rearing steelhead fry.

Sites and Colusa Project Habitat Types

This section summarizes studies of habitat types along the streams in the proposed Sites and Colusa Project areas conducted in 1998 and 1999.

Methodology

An initial channel type survey, including an evaluation of the overall channel morphology, was made at the beginning of the study of each creek. Channel type was subsequently determined when the overall character of the channel changed for over 20 bankfull widths.

Channel type surveys began by first noting if the stream is a threaded or single channel. Then the bankfull width was measured at the prominent scour marks and sedimentation on the bank substrate with a 100-foot vinyl tape. Ten depths were taken at the study section to obtain the average bankfull depth. The substrate type was noted (Table 27).

Table 27. Substrate Type and Size Used[1]

Substrate Type	Size in inches
Boulder	> 10
Large Cobble	5-10
Small Cobble	2.5-5
Gravel	0.08-2.5
Sand	<0.08

[1] Flosi et al. 1998

Habitat type evaluation on Funks Creek began at Golden Gate damsite on January 12, 1999, and proceeded upstream to a point just above the mouth of Grapevine Creek on February 25, 1999. After this point, Funks Creek no longer contained water. Habitat typing continued on Grapevine Creek from the confluence with Funks Creek on February 26, 1999, and concluded at the reservoir inundation line on April 28, 1999. Stone Corral Creek habitat typing began on February 10, 1999, and continued until the channel no longer contained water, just past the confluence of Antelope Creek. Habitat typing concluded for Stone Corral and began on Antelope Creek on February 23, 1999. Habitat typing concluded on Antelope Creek on April 22, 1999, at the reservoir inundation line.

Each habitat unit was described as a pool, flat water, or riffle. All data was recorded on a standardized habitat typing data sheet (Flosi et al. 1998). Side channels were evaluated separately only when they demonstrated a different habitat type due to the small nature of the creek bed and intermittent water flow. Once the habitat unit type was identified it was assigned a unit number. For each unit, a mean length (measured as the thalweg length), width, and depth were taken, as well a maximum depth. All measurements were made and recorded in feet and tenths of feet using standard engineering measuring tapes and stadia rods. For pools, the tail-crest depth, type of pool-tail substrate, and the percent the substrate is embedded were also evaluated.

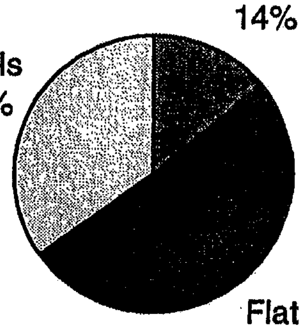
In addition to unit type data, the time surveying began, air and water temperature, date, and surveyors present were all recorded daily. Yellow flags were left at the end of the last habitat unit surveyed each day. The substrate type and percent exposed substrate was recorded. A shelter value for the unit was given based on the quantity and composition of the cover. The total percent cover for the habitat unit was recorded, then broken down into the percentages of the total that each cover element represented.

The bank composition was evaluated and dominant vegetation for right and left banks was recorded. Plant species and bank substrates were entered. The percent of the bank vegetated was evaluated up to bankfull width plus 20 feet. The percent and type, (deciduous or coniferous), of cover by tree canopy at midday was also evaluated. This was done for the entire part of each stream studied.

Results

Funks Creek. Flat water constituted 51 percent of the total creek measured. The average flat water length on Funks Creek was 212 feet. Pools at 35 percent of the total length with an average length of 146 feet, were the second most dominant habitat type. Riffles constituted 14 percent of the creek, with an average unit length of 57 feet (Figure 4).

Figure 4. Relative Occurrence of Habitat Types in Funks Creek



Gravel was the most common substrate (Table 28). Small cobble substrate was the second most common substrate type, occurring at 28 percent of the units surveyed. Silt/clay type substrate was most commonly associated with the gravel substrate, either as the primary or secondary substrate. It also frequently occurred as a layer over bedrock or boulder substrates. Silt/clay was the dominant substrate in the lower reaches of Funks Creek, giving way to gravel as the dominant substrate in the upper reaches of the stream.

Table 28. Summary of Substrates (%) by Habitat Type on Funks Creek

Habitat type	Silt/Clay	Sand	Gravel	Small cobble	Large cobble	Boulder	Bedrock
Riffle	19	0	26	21	10	1	24
Flat water	11	1	33	21	5	8	21
Pool	6	1	41	43	5	2	2
Average	12	1	33	28	7	4	15

The bank composition was overwhelmingly silt/clay. Occasional areas of bedrock bank or cobble bank occurred; where roads passed through or near the creek, boulders dominated the bank. Greater variability of bank composition occurred in the lower reaches of the creek. Most bedrock banks occurred in major blocks where bedrock ridges rose through the valley floor.

Star thistle and grasses dominated both banks. The average percent bank covered by vegetation was 52 percent for the right bank and 53 percent for the left bank. Occasional cottonwoods, willows, oaks, and walnut trees punctuate the bank. Only 18 percent of the habitat units had some degree of canopy. The average canopy cover was 5 percent, or 26 percent when considering only those units that had any canopy cover at all. Trees were concentrated at Golden Gate, where habitat typing began on Funks Creek, and in the upper reaches of the creek.

The average of the total units covered by all cover combined was 27 percent. Aquatic vegetation was the prevalent type of cover, boulders were the most common large cover item. Aquatic vegetation and boulders each comprised an average of 25 percent of the total cover (Table 29). Large woody debris and root masses occurred relatively infrequently. Undercut banks occurred in 17 percent of the habitat units. Pools overall had a large degree and variety of cover, while flat water and riffles had less cover.

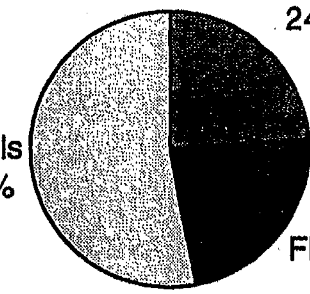
Table 29. Summary of Habitat Cover in Funks Creek

	Percent of each habitat having cover	Percent of Cover Type									
		Undercut banks	Small woody debris	Large woody debris	Root masses	Terrestrial vegetation	Aquatic vegetation	Bubble curtain	Boulders	Bedrock ledges
Riffles	20	-	-	1	-	20	15	30	28	6
Flat water	38	34	1	1	-	1	27	10	25	1
Pools	24	18	3	1	1	1	34	2	21	19
Average	27	17	1	1	-	7	25	14	25	9

Grapevine Creek. Riffles made up 24 percent of the total creek measured (Figure 5). The average riffle length on Grapevine Creek was 72 feet. Flat water made up 23 percent of the total length with an average length of 143 feet, and was the least dominant habitat type. Pools made up just over half, 53 percent, of the total length of Grapevine Creek within the reservoir footprint.

Small cobble was the most common substrate in Grapevine Creek. Gravel was also common, occurring as the substrate in 30 percent of the habitat units. Large cobble was the dominant substrate in 13 percent of the units surveyed. Small cobble substrate was spread throughout the creek system; however, there were no distinct pockets of this or any other substrate.

Figure 5. Relative Occurrence of Habitat Types in Grapevine Creek



Thirty-two percent of the pools on Grapevine Creek were dominated by small cobble substrate. Gravel was dominant in 22 percent of these. Flat water was dominated by gravel and small cobbles (Table 30).

Table 30. Summary of Substrates on Grapevine Creek

	Silt/Clay	Sand	Gravel	Small cobble	Large cobble	Boulder	Bedrock
Riffle	5		32	24	11	1	27
Flat water	12	1	35	41	7	2	2
Pool	6		22	32	21	5	14
Average	8		30	32	13	3	14

Bank composition was overwhelmingly silt/clay. Frequent patches of gravel/cobble banks occurred throughout the creek channel surveyed. Most bedrock banks occurred in major blocks where bedrock ridges rise through the valley floor.

Grasses and star thistle dominated both banks. The average percent bank covered by vegetation was 56 percent for the right bank and 54 percent for the left bank. Occasional oaks, willows, cottonwoods, walnuts, and gray pines punctuate the bank. Thirty-nine percent of the habitat units examined on Grapevine Creek had some degree of canopy—38 percent from deciduous trees and shrubs, and 1 percent from pines. The average canopy cover was 12 percent. Trees were more concentrated at the upstream end where Grapevine Creek starts to climb in elevation toward the edge of the reservoir footprint.

The average of the total unit covered by all cover combined was 29 percent. Aquatic vegetation was the most prevalent type of cover, occurring in 72 percent of the flat water units surveyed. Aquatic vegetation comprised an average 53 percent of the total unit cover (Table 31).

Pools had the largest mean total coverage at 32 percent. Aquatic vegetation comprised 46 percent of the cover in pools. Riffles had a mean total cover 28 percent, 40 percent of which was aquatic vegetation. Terrestrial vegetation, boulders, and bubble curtains also provided cover in riffles—14 percent, 17 percent, and 7 percent, respectively. Flat water averaged 26 percent total coverage, of this 72 percent of the cover was aquatic vegetation.

Aquatic vegetation was the most common large cover item, occurring in 53 percent of the units surveyed. Root masses were another large cover item that occurred with some frequency at 7 percent. Terrestrial vegetation occurred in 9 percent of the habitat units, and bedrock ledges in 4 percent of the units. Riffles and pools contained all of the major types of cover (Table 31).

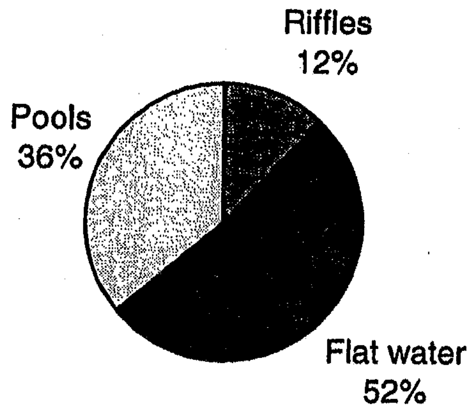
Table 31. Summary of Habitat Cover in Grapevine Creek

	Percent of each habitat having cover	Percent of Cover Type								
		Undercut banks	Small woody debris	Large woody debris	Root masses	Terrestrial vegetation	Aquatic vegetation	Bubble curtain	Boulders	Bedrock ledges
Riffles	28	1	3	3	13	14	40	7	17	2
Flat water	26	5	3	-	4	8	72	4	4	-
Pools	32	7	3	12	4	4	46	4	9	11
Average	29	4	3	5	7	9	53	5	10	4

Stone Corral Creek. Flat water made up the majority of habitat type measured, comprising 52 percent of the total creek. The average flat water length on Stone Corral Creek was 213 feet. Pools, making up 36 percent of the total length and with an average length of 145 feet, were the second most dominant habitat type in terms of total footage. Riffles made up 12 percent of the creek's total length, with an average unit length of 48 feet (Figure 6).

Bedrock was the most common substrate, occurring as the primary substrate in 31 percent of the total units surveyed on Stone Corral Creek. Gravel substrate was the second most common substrate type, occurring in 24 percent of units surveyed. Silt/clay type substrate was commonly associated with bedrock or gravel, occurring as a layer over the other substrates. The lower reach of Stone Corral Creek was heavily dominated by bedrock, giving way to a more gravel base near the confluence with Antelope Creek. Silt/clay substrate is spread consistently throughout the creek system.

Figure 6. Relative Occurrence of Habitat Types in Stone Corral Creek



Thirty-three percent of pools had silt/clay as the dominant substrate (Table 32). Fifty-two percent of flat water had gravel as the dominant substrate. Riffles had 56 percent bedrock dominant and 17 percent silt/clay dominant substrate. The most common occurring pool tail substrate was bedrock.

Table 32. Summary of Substrates on Stone Corral Creek

	Silt/Clay	Sand	Gravel	Small cobble	Large cobble	Boulder	Bedrock
Riffle	17		9	1		17	56
Flat water	20		52		14	14	
Pool	33	5	12	2		12	36
Average	23	2	24	1	5	14	31

The bank composition was overwhelmingly silt/clay. Occasional areas of bedrock bank or cobble bank occurred; where roads passed through or near the creek, boulders dominated the bank. Greater variability of bank composition then occurred in the lower reaches of the creek, where cobbled banks frequently occurred. Most bedrock banks occurred in major blocks where bedrock ridges rise through the valley floor.

Bank vegetation included grasses and star thistle, which dominated both banks. The average percent bank covered by vegetation was 62 percent for the right bank and 63 percent for the left bank. Occasional oaks, willows, cottonwoods, and walnut trees punctuate the bank. Only 11 percent of the habitat units surveyed had some degree of canopy. The average canopy cover was 4 percent, all deciduous trees and shrubs. Trees were more concentrated at the lower end where habitat typing began on Stone Corral Creek.

The average of the total unit covered by all cover types combined was 33 percent. Aquatic vegetation was the most prevalent type of cover, comprising an average of 56 percent of the total unit coverage.

Riffles had a mean total cover of 39 percent, 49 percent of which was aquatic vegetation. An average of 7 percent of the cover in riffles was comprised of boulders. Flat water averaged 34 percent total coverage, of this 61 percent of the cover was aquatic vegetation. Pools had a mean percent total coverage of 26 percent.

Aquatic vegetation was the most common large cover item, occurring in 56 percent of the units surveyed. Boulders and terrestrial vegetation were the next most common cover items at 16 percent and 12 percent, respectively. Undercut banks occurred in 6 percent of the habitat units, and bedrock ledges in 4 percent of the units. No habitat unit types contained all major types of cover (Table 33).

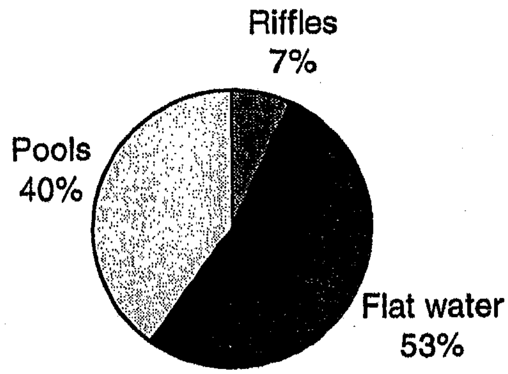
Table 33. Summary of Habitat Cover in Stone Corral Creek

	Percent of each habitat having cover	Percent of Cover Type								
		Undercut banks	Small woody debris	Large woody debris	Root masses	Terrestrial vegetation	Aquatic vegetation	Bubble curtain	Boulders	Bedrock ledges
Riffles	39	-	-	-	-	25	49	18	7	2
Flat water	34	5	5	-	-	6	61	-	21	3
Pools	26	12	-	-	1	4	57	-	19	7
Average	33	6	2	-	-	12	56	6	16	4

Antelope Creek. Flat water made up the majority of the total footage measured, comprising 53 percent of the total creek measured. The average flat water length on Antelope Creek was 135 feet. Riffles made up 7 percent of the creek's total length, with an average unit length of 18 feet. Pools comprised 40 percent of the total length measured with an average length of 103 feet (Figure 7).

Silt/clay was the most common substrate, occurring as the primary substrate in 24 percent of Antelope Creek. Gravel and small cobble were also common substrates at 22 percent each. Silt/clay type substrate was commonly associated with gravel. Small cobble increased in frequency of occurrence in the upper reaches of Antelope Creek. Gravel substrate occurred uniformly throughout Antelope Creek (Table 34).

Figure 7. Relative Occurrence of Habitat Types in Antelope Creek



Silt/clay dominated the majority of pools. Twenty-nine percent of flat water units had silt/clay as the dominant substrate. Gravel and small cobbles at 23 percent and 22 percent respectively (Table 34) dominated riffles.

Table 34. Summary of Substrates on Antelope Creek

	Silt/Clay	Sand	Gravel	Small cobble	Large cobble	Boulder	Bedrock
Riffle	7	2	23	22	7	9	30
Flat water	29	3	25	27	7	2	7
Pool	35	3	18	16	10	14	4
Average	24	3	22	22	8	8	14

Bank composition was largely silt/clay. Occasional areas of bedrock bank or cobble bank occurred; where roads passed through or near the creek, boulders dominated the bank. The diversity of bank substrate increased, particularly gravel and cobble, in the upper reaches of Antelope Creek.

Grasses and star thistle dominated both banks. The average percent bank covered by vegetation was 80 percent for the right bank and 80 percent for the left bank. Oaks, willows, cottonwoods, walnut trees, and gray pines punctuate and occasionally line the bank. Forty-seven percent of the habitat units surveyed had some degree of canopy. The average canopy cover was 20 percent. Trees were more concentrated at the middle to upper reaches.

The average of the total stream habitat covered was 31 percent (Table 35). Aquatic vegetation was the most prevalent type of cover, occurring in 65 percent of the units surveyed. Aquatic vegetation comprised an average of 46 percent of the total unit cover.

Riffles had an average total cover of 34 percent, with 43 percent aquatic vegetation. Flat water averaged 30 percent total coverage—58 percent aquatic vegetation. The primary cover for all units was aquatic vegetation. Some units indicated a higher percentage of cover, but these occur on an infrequent basis in this creek.

Aquatic vegetation and terrestrial vegetation were the most common large cover items, occurring in 46 percent and 17 percent respectively of the units surveyed. Most units surveyed had small amounts of a variety of cover types.

Table 35. Summary of Cover in Antelope Creek

Habitat type	Percent of each habitat having cover	Percent of each habitat type								
		Undercut banks	Small woody debris	Large woody debris	Root masses	Terrestrial vegetation	Aquatic vegetation	Bubble curtain	Boulders	Bedrock ledges
Riffles	34	4	5	4	15	16	43	1	12	-
Flat water	30	4	3	1	8	19	58	1	5	1
Pools	29	18	7	1	7	15	37	1	13	1
Average	31	9	5	2	10	17	46	1	10	1

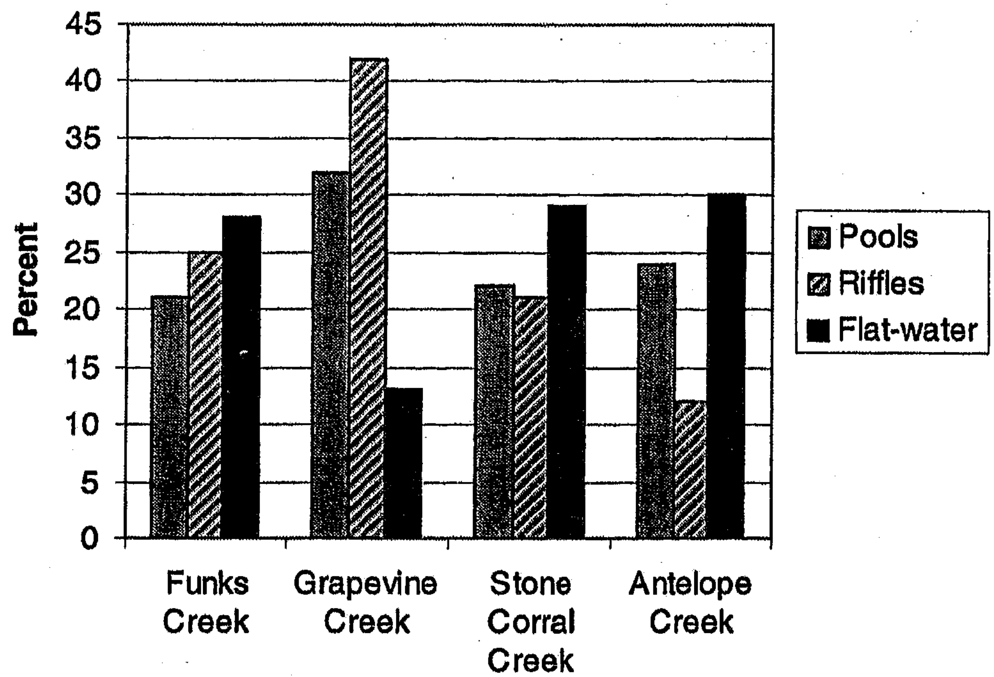
Discussion

Habitat typing was done to quantify physical aquatic habitat to provide information for the NEPA and CEQA process. This quantification will determine habitat lost by inundation and will form the basis for mitigation. Grapevine Creek had more pools and riffles. Grapevine Creek also had the least amount of flat water. Funks Creek and Stone Corral Creek had similar amounts of pools, flat water, and riffles. Antelope Creek was more like Stone Corral and Funks Creeks than Grapevine Creek. Grapevine Creek flows from springs in hills to the west of Sites-Colusa and is steeper than the other creeks. That causes Grapevine Creek to have less flat water than the other creeks (Table 36 and Figure 8).

Table 36. Comparison of Relative Occurrence of Pools, Flat Water, and Riffles in Creeks in the Sites-Colusa Project Area

	Funks	Grapevine	Stone Corral	Antelope
Pools	21	32	22	24
Riffles	25	42	21	12
Flat water	28	13	29	30

Figure 8. Relative Occurrence of Habitat Types in Sites-Colusa



Stone Corral Creek had a high abundance of larger substrates. Grapevine Creek had the lowest percentage of silt. Grapevine Creek also had the most gravel, small cobble, and large cobble substrate. Fine materials are abundant in Stone Corral and Antelope Creeks. The relatively steep nature of Grapevine Creek washes fine materials away and leaves coarser materials behind (Table 37).

Table 37. Summary of Substrates (%) by Habitat Type on Creeks in the Sites-Colusa Study Area

Creek	Habitat type						
	Silt/Clay	Sand	Gravel	Small cobble	Large cobble	Boulder	Bedrock
Funks	12	3	32	28	7	3	15
Grapevine	8	1	30	32	13	3	13
Stone Corral	23	2	24	1	5	14	31
Antelope	24	3	22	22	8	8	13

The occurrence of cover types followed the same trends for all four creeks surveyed. Aquatic vegetation was the dominant cover type in each creek. Stone Corral Creek showed a higher percent occurrence of boulders—nearly twice as many as Antelope Creek and nearly five times as many as Funks and Grapevine Creeks.

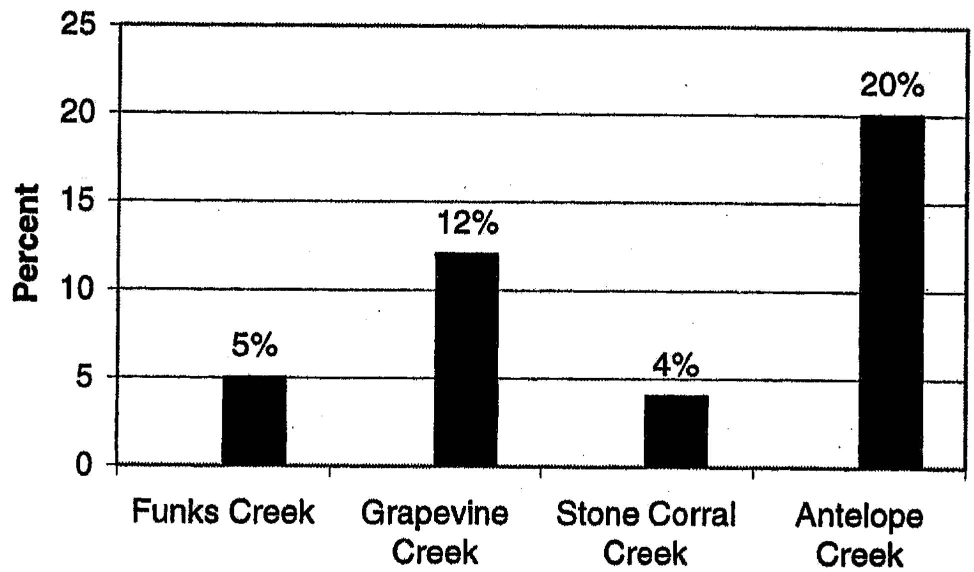
Bubble curtains were more common in Funks Creek. Antelope Creek had more cover provided by root masses than the other creeks (Table 38).

Table 38. Summary of Cover (percent of each habitat type) on Creeks in the Sites-Colusa Study Area

Creek	Percent of each habitat having cover	Percent of Habitat Cover								
		Undercut banks	Small woody debris	Large woody debris	Root masses	Terrestrial vegetation	Aquatic vegetation	Bubble curtain	Boulders	Bedrock ledges
Funks	27	17	1	1	1	7	25	14	25	9
Grapevine	29	4	3	4	7	10	53	6	10	4
Stone Corral	33	6	1	-	1	10	54	6	16	4
Antelope	31	9	5	2	10	17	46	1	9	1

The pools of all four creeks had similar degrees of cover for all habitats, which were spread very closely to 30 percent coverage. Notable spikes in percent unit covered occurred in unit types that have a very low frequency of occurrence. Grapevine and Antelope Creeks show an increase in the occurrence of canopy (Figure 9).

Figure 9. Percent of Canopy Over Creeks Measured at Sites-Colusa Project Area



Creek flows varied widely with lack of rainfall, forcing activity to be suspended on some areas of Funks, Stone Corral, and Antelope Creeks until further rain revived the stream flow. This suggests that streams on the floor of the Antelope Valley are intermittent and only flow during the summers of particularly wet years. Antelope Creek, and particularly Grapevine Creek, could flow year round. The majority of the fish found in this area were juvenile fish that would probably use the creeks only as rearing areas. The high concentration of sediments and aquatic vegetation would also raise the biological oxygen demand in the creeks during the summer months in any remaining deeper pools, making them uninhabitable to most fish, with the exception of the California roach, *Lavinia exilicauda* (Moyle 1976).

Both Grapevine and Antelope Creeks are the continuations of the main creek channels of those systems. Both creeks also show an increase in canopy and larger substrates. When viewed as just two creek systems, Funks-Grapevine and Stone Corral-Antelope both show a trend toward more canopy and larger substrates. The increased canopy and decreased sedimentation in the upper reaches of Antelope Creek and Grapevine Creek may provide sufficient cooling factors for year-long fish inhabitants. Eight-to-10 inch largemouth bass, *Micropterus salmoides*, were seen in the upper reaches of Grapevine Creek, which suggests a year-round flow capable of supporting larger fish. The larger substrate size also provides cover for the minnow fry that occupy the creeks in the spring.

Very little riparian vegetation, such as rushes, essential cover for aquatic amphibians and reptiles, exists on the banks of any of the creeks in the Sites-Colusa Project area, with the exceptions of the upper reaches of Antelope and Grapevine Creeks.

Summary of Fish Studies for Proposed Projects

Thomes Creek has runs of fall-run, late fall-run, and limited numbers of spring-run chinook salmon. Steelhead also spawn in Thomes Creek. Large runs of Sacramento suckers and Sacramento pike minnows migrate up Thomes Creek. Fall-run salmon, Sacramento suckers, and Sacramento pike minnow also migrate up Stony Creek. Cottonwood Creek has larger runs of fall-run, late fall-run, and spring-run chinook salmon. Cottonwood Creek has a run of steelhead, as well as annual migrations of Sacramento suckers and Sacramento pike minnows. Stone Corral Creek and Funks Creek have no established runs of chinook salmon but have small runs of Sacramento suckers and Sacramento pike minnows.

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North of the Delta
Offstream Storage Investigation

Progress Report Appendix E:

Amphibian and Reptile Survey Summary

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Introduction

In late 1997, the Department of Water Resources began a two-year reconnaissance level study of North of the Delta Offstream Storage, authorized by Proposition 204—the Safe, Clean, Reliable Water Supply Act approved by voters in 1996. In early 1999, CALFED consolidated all storage investigations under a comprehensive program called Integrated Storage Investigations. The North of the Delta Offstream Storage Investigation was incorporated into one of seven ISI program elements.

The North of the Delta Offstream Storage Investigation analyzes engineering, economic, and environmental impact to determine the feasibility of four north-of-the-Delta storage projects. The four potential alternatives are Sites Reservoir, Colusa Project, Thomes-Newville Project, and Red Bank Project (Figure 1). Phase I, currently underway, includes preliminary field surveys of environmental resources and extensive field surveys of cultural resources, geological, seismic, and foundation studies, and engineering feasibility evaluation. Phase II will start when CALFED's Record of Decision and Certification for the Programmatic EIR/EIS is completed and if North of Delta Offstream Storage is consistent with CALFED's preferred program alternative. Phase II will include completion of necessary fish and wildlife surveys, evaluations of potential mitigation sites, preparation of project-specific environmental documentation, final project feasibility reports, and the acquisition of permits necessary to implement the project.

Under Phase I, the Department of Fish and Game conducted studies of fish and wildlife resources in each project area. This appendix summarizes surveys of amphibians and reptiles in the four proposed project areas. The information gathered will be used to describe impacts on fish and wildlife resources during the planning process.

Contract with DFG

Amphibian and reptile studies were initiated in 1997 for Red Bank, Sites, and Colusa Projects. DFG collected data on occurrence, distribution, and relative abundance of amphibians and reptiles at the proposed reservoir inundation areas for these projects. DFG also reviewed past amphibian and reptile studies for Red Bank and Thomes-Newville Projects.

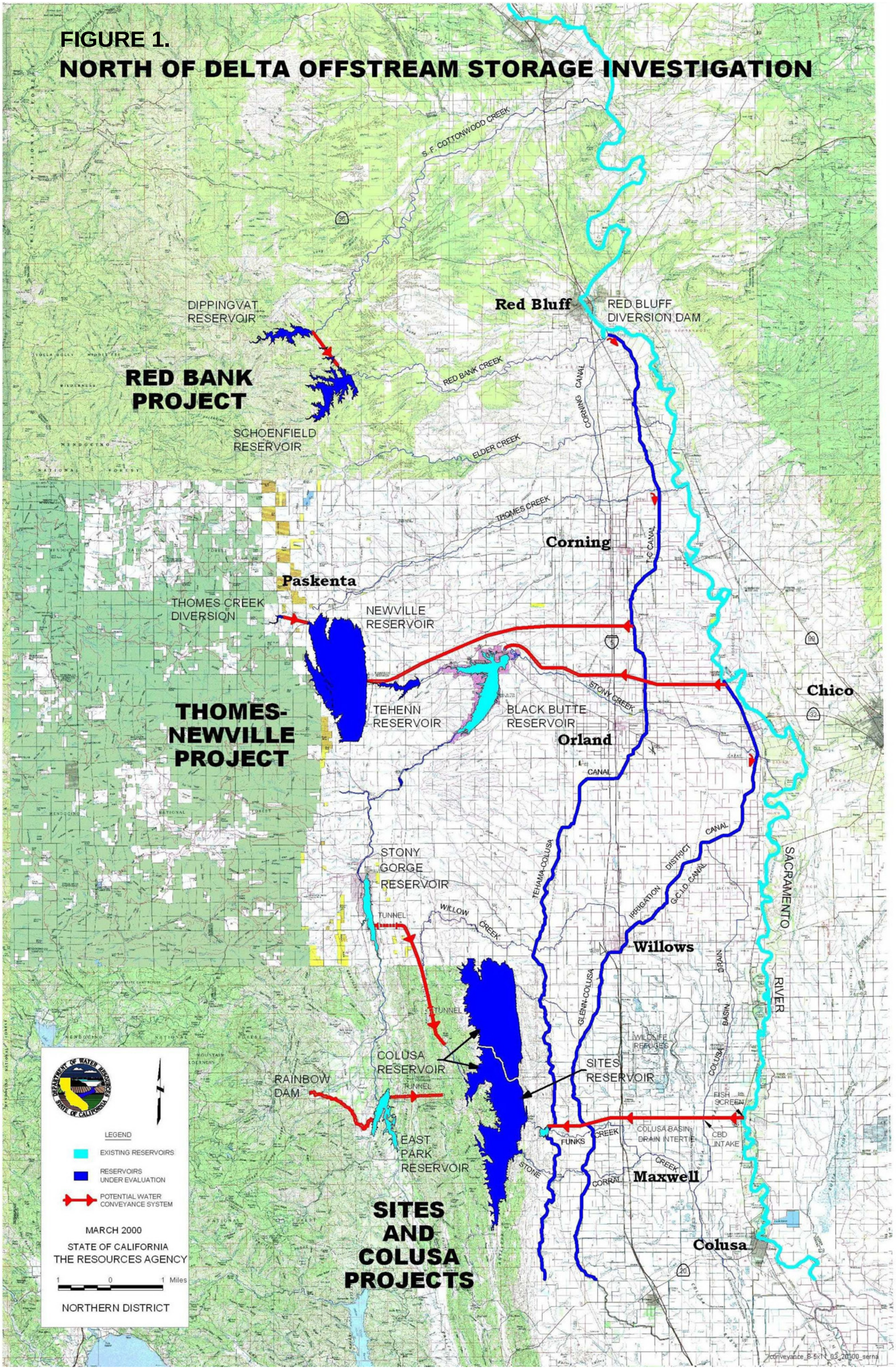

FIGURE 1.
NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION

Report Organization and Content

Results and findings of past studies and recently conducted surveys of amphibians and reptiles in the proposed project areas are discussed in this appendix. The general survey procedures used in the recent surveys at Sites, Colusa, and Red Bank Project areas are discussed below. The specific sampling data and results of these surveys and past studies are discussed in respective sections for each proposed project area. Findings of species with special status are summarized at the end of this appendix.

Methodology

DFG staff conducted surveys for amphibians and reptiles from August 1997 through spring 1999 in Sites, Colusa, and Red Bank Project areas. The surveys included threatened or endangered species, Species of Concern, and common species of amphibians and reptiles.

The Stebbins field guide (1985) was used to determine historic ranges of the species. DFG staff also used physical observation of the present habitat, historic records, and DFG's Natural Diversity Data Base to establish the list of potential species that could occur in the project areas (Table 1). The major focus of field surveys was to locate the special species listed in Table 1 that could potentially occur in the project area. Survey techniques used included night driving, dip netting, seining, and day and night ground searches in all weather conditions and seasons to find species of common amphibians and reptiles.

Table 1. Special Species of Amphibians and Reptiles in Project Areas

		Project Area		
Species	**Status**	**Sites and Colusa**	**Red Bank**	**Thomes-Newville[1]**
Amphibians				
California red-legged frog	Federally threatened	X	X	X
California tiger salamander	Candidate for federal listing; State Species of Concern	X		X
Foothill yellow-legged frog	Federal and State Species of Concern	X	X	X
Western spadefoot toads	Federal and State Species of Concern	X	X	X
Reptiles				
California horned lizard	Federal and State Species of Concern	X		
Western pond turtle	Federal and State Species of Concern	X	X	X

[1] Results from surveys of Thomes-Newville Project area conducted in 1981-82

All habitats at the selected survey sections were identified and categorized as to type of water body (e.g., pond, farm impoundment, vernal pool, or creeks). All ponds were measured for length, width, and depth during the initial assessment in fall 1997. Aquatic vegetation, root-wads, water turbidity, and characterization of the surrounding terrain (e.g., degree of degradation, canopy, embankment, and soil type) were recorded during the initial assessment period and on all subsequent surveys. Staff visually inspected ponds at the time of the preliminary assessment to determine the presence of, and the ability to support, amphibians, reptiles, and fish. Once the ponds were located and assessed, they were assigned an identification code. Vernal pools were surveyed during spring 1998 and assigned an identification code. All ponds and vernal pools were marked on a topographical quad map by their appropriate code.

Creeks were divided into a maximum of three regions, depending on the length of each habitat type contained in the reservoir footprint. A total of eight transects were established to encompass vernal pools and support California tiger salamander surveys at the Sites and Colusa Project areas. California tiger salamander transects were assigned an identification code and marked on a topographic map. Other transects were established throughout the potential Sites, Colusa, and Red Bank Reservoir areas to encompass a variety of habitat types for general herpetology surveys. Photocopies of topographical maps were made of the specific areas to be surveyed for workers to take out into the field. Staff obtained permission to survey on private property from the property owners at least a week in advance of all surveys.

Survey data were collected in a standard 5 to 7 inch "write in the rain" notebook. At the end of the day, data for the California red-legged frog, California tiger salamander, and general herpetology surveys were transferred to a standardized data sheet from *A Standardized Protocol for Surveying Aquatic Amphibians, Technical Report NPS/WRUC/NRTRP-95-01.* All other data was photocopied and inserted into the appropriate binder. For general herpetology surveys, data was also transferred onto a CALFED Herpetology Investigation Field Observation Report. All data was transferred to a computer spreadsheet program. A photocopy of the topographical map with the area surveyed was highlighted and the location of any Species of Concern found marked on it was stapled to the data sheet. The surveyors present, the time of survey, environmental, and weather conditions were all recorded. The condition and type of the habitat were noted, including emergent and aquatic vegetation, turbidity of water, condition and predominant type of surrounding vegetation, and substrate. Land use or alteration was noted as well.

California Red-legged Frog

Surveys for the California red-legged frog (*Rana aurora draytonii*), a federally threatened species, were conducted from August 1997 to January 1998 and from May through October 1998 in Sites, Colusa, and Red Bank Project areas. Surveys were not conducted during the breeding or rearing period of red-legged frogs to avoid disturbing breeding frogs, eggs, or larvae. All ponds and creeks in the study area were surveyed a minimum of four times during the five-month period in 1998. Day surveys were performed on clear, sunny days with minimal wind. Night surveys were conducted on warm, still nights from an hour past sunset until midnight (U.S. Fish and Wildlife 1997).

Crews of two to nine people conducted surveys. The surveyors would often break up into teams or work as individuals to either walk the perimeter of the ponds or the length of the stream for both day and night surveys. Taking care not to disturb habitat, the shoreline of each pond or creek section was thoroughly inspected, with particular care to examine overhangs, root-wads, emergent vegetation, or other structures that are used as shelter by red-legged frogs. Two surveyors would walk in opposite directions at the water's edge, while two other surveyors would walk opposite directions at a distance of 17 to 33 feet from the water's edge. During night surveys, 6-volt battery lamps were used to scan the water surface for eye-shine (U.S. Fish and Wildlife 1997). Day surveyors used binoculars to scan ahead up to 50 feet to spot frogs before they jumped into the water. The survey team also used auditory identification of frog calls during day and night surveys. A single lens reflex camera was used to photograph any species of interest for future identification verification. Photographs were also taken of the environment in which animals were found, to confirm field notes and to document the state of the habitat when it was surveyed (Bury and Corn 1991).

California Tiger Salamander

California tiger salamanders (*Ambystoma californiense*) are candidate species for federal listing, currently DFG Species of Concern, and are fully protected. The historic range of California tiger salamanders in the Sites and Colusa Project areas was determined using Stebbins field guide (1985). As in the California red-legged frog survey, a preliminary survey of the study area was done to assess the potential of California tiger salamander habitat. Grasslands, vernal pools, and farm pond impoundments that contained water for only part of the year were all examined as potential California tiger salamander habitat sites. All ponds, vernal pools, and the surrounding territory were examined for burrows, log debris, and type of terrestrial vegetation. Each pond was then seined. Transects were laid out within potential breeding habitat and grassland terrain (Brode 1993). Eight transects averaging about 0.62 by 0.31 miles were established.

Transect and visual pond inspections were conducted at night, during storms that continued from the day into the night, or when the air temperature was between 45-50° F or warmer between the months of November and March for both the 1997-98 and 1998-99 seasons.

For transects, the team members formed a line, keeping a distance of at least 17 feet between them. Six-volt flashlights were used to scan the terrain. All mammal burrows, cracks, logs, and debris in the transect were inspected for California tiger salamanders. A camera was brought to photograph adult specimens for future identification verification and to photograph the area in which they were found.

Visual pond surveys were performed by biologists who walked concentric circles around the pond starting with an inner circle at the water's edge, with walkers spanning out about 33 feet. Surveyors would walk in opposite directions around the pond, utilizing 6-volt flashlights to scan back and forth for animals. Any surrounding burrows or logs were inspected.

Dip netting and seining aquatic surveys were done twice a year for each vernal pool and intermittent pond, at least 15 days apart. The first survey was done between March 15 and April 15, and the second between April 15 and May 15. Only ponds that would hold water for at least 10 weeks during the survey time interval were inspected.

Initial samples were made using a 12-inch dip net with a 1/8-inch mesh. Each pond was divided so that the dip net sweeps would sample 50 percent of the surface area. Seining was done using one of three seines depending on the size of the pond, the largest seine being 60 feet long, 5 feet high, with a 1/4-inch mesh, and a 7 foot by 7 foot pocket. A medium sized seine was 29 feet long, 6 feet high, with a 1/4-inch mesh, and a pocket size of 7 feet by 5 feet. The third seine, used only for small ponds, was 12 feet long, 4 feet high, with a 1/4-inch mesh, and a 7 feet by 5 feet pocket. When possible, the seine would be pulled through the pond, arcing from one point around and back again, sweeping the whole pond at once. Large ponds had to be seined in sections.

Western Pond Turtle

DFG biologists looked for western pond turtles (*Clemmys marmorata*), a federal and State Species of Concern, when seining or during daytime visual surveys in the project areas. Carapaces (shells) of dead turtles were also noted and measured. During periods of warm weather, biologists watched the creek when possible while traveling to and from work stations, which yielded positive results in locating western pond turtles. A general lookout for western pond turtles was established while driving or walking near creeks.

General Amphibian and Reptile

General herpetology surveys were done by ground, searching ponds and transects, by seining, or by night driving studies in the Sites, Colusa, and Red Bank Project areas. Ground searches were done both day and night. Seining was done during the day. Driving surveys were only done at night. General amphibian and reptile surveys were conducted year-round throughout these project areas, when the weather was appropriate for amphibian and reptile activity.

Transects were walked by team members in a line, 17 feet apart. All logs, trees, burrows, rocks, and crevices were inspected for animals. Transect areas included riparian, grasslands, and oak woodlands. Binoculars were used to scan ahead for animals such as turtles and frogs (Bury and Corn 1991). Night transects were walked in the same manner, using 6-volt flashlights for illumination. During the warmer seasons, biologist going to and from transects kept a general watch for reptiles and amphibians.

Ponds were inspected by both ground searches and seining. Teams of two to nine members spread out from the pond's edge to 33 feet away to conduct ground searches. Frog calls were noted as an auditory identification of species. A fine mesh minnow seine was pulled from one bank to the other to seine ponds. Trapped animals were identified by species and tallied. Hand-held dip nets were used to capture animals near the shore.

Night-driving surveys were conducted from a motor vehicle traveling at speeds between 15-25 mph (Brown et al 1987). Specimens found on the shoulder were identified and counted. Night drive routes included roads both within and surrounding the project area. These roads were traveled in both directions. During the warmer seasons, a general watch was made on the roadsides whenever surveyors were driving in the study area. A camera was used to photograph specimens for species verification and to maintain a general record of the find. Roads interior to the reservoir sites and immediately surrounding the project areas were driven a total of eight times in 1997 in the Sites and Colusa Project areas.

Sites and Colusa Projects

Surveys for reptiles and amphibians were conducted by DFG employees from August 1997 through spring 1999 in the Sites and Colusa Project areas. The major objectives of these surveys were to search for California red-legged frogs, federally threatened; California tiger salamanders, candidate for federal listing and State Species of Concern; and to conduct general herpetology surveys. Four species listed as federal and California State Species of Concern that could potentially occur in the Sites and Colusa Project areas—foothill yellow-legged frogs, western pond turtles, western spadefoot toads, and California horned lizard—were also looked for during the course of this survey (DFG 1998).

Results

A total of 2,400 hours were spent in the Sites and Colusa Project areas looking for reptiles and amphibians. A total of 19 species, 5 amphibians and 14 reptiles, were found during this survey (Table 2). Only one special species listed in Table 1 was found, the western pond turtle. These turtles are listed by the Natural Diversity Data Base as occurring in Colusa County. California red-legged frogs and California tiger salamanders were not found.

The most prevalent species found was the bullfrog. Bullfrogs, Pacific tree frogs, and western toads were the most commonly observed amphibians (Table 4). Western fence lizards were the most prevalent reptiles, with a catch per hour effort ratio of 0.17 (Table 4).

Table 2. Amphibian and Reptile Species Observed in the Sites and Colusa Project Areas

Common Name	Scientific Name
Amphibians	
Bullfrog	*Rana catasbieana*
California newt	*Taricha torosa*
California slender salamander	*Batrachoseps attenuatus*
Pacific treefrog	*Hylla regilla*
Western toad	*Bufo boreas*
Reptiles	
Aquatic garter snake	*Thamnophis couchii*
Common garter snake	*Thamnophis sirtalis*
Common king snake	*Lampropeltus getula*
Gopher snake	*Pituohpis catenifer*
Ring neck snake	*Diadophis punctatus*
Sharp tailed snake	*Contia tenuis*
Southern alligator lizard	*Elgaria muliticoranata*
Western fence lizard	*Sceloporus occidentalis*
Western pond turtle[1]	*Clemmys marmorata*
Western racer	*Coluber constrictor*
Western rattlesnake	*Crotalus viridus*
Western sagebrush lizard	*Sceloporus graciosus gracilis*
Western skink	*Eumeces skiltonianus*
Western terrestrial garter snake	*Thamnophis elegans*

Seven-hundred-and-fifty hours were spent searching riparian habitat, which yielded the greatest diversity of species. Fourteen of the nineteen total species of reptiles and amphibians, all three frog species, and all but three reptile species were found in this type of habitat (Table 3). Bullfrogs and western toad larvae were also found in pools of the riparian zone.

Fourteen species of reptiles and amphibians were also found in the oak woodland habitat. Adults of all five species of amphibians and all but five species of reptiles were found in the oak woodlands.

A total of 2,060 hours was spent in ground searches. Ground searching was the most productive method of locating a variety of reptiles and amphibians, with an overall catch per hour effort ratio of 8.1 (Table 4). Representatives of all species found during the study were located via ground searches. Dip netting and seining were particularly effective in capturing semi-aquatic reptiles and amphibians, especially larval amphibians (Table 4).

[1] State and federal Species of Concern

During the winter and early spring of 1999, the vernal pools of the Sites and Colusa Project areas either remained dry or only held water for a week's time. The protocol for dip netting vernal pools for California tiger salamanders could not be met as a result.

Table 3. Species Found in Each Habitat Type

Common Name	Riparian	Oak Woodland	Grassland	Farm Pond	Vernal Pool	Roads
Amphibians						
Bullfrog	X	X	X	X		
Bullfrog larvae	X	X		X		
California newt		X		X		
California slender salamander		X		X		
Pacific treefrog	X	X	X	X	X	
Pacific treefrog larvae				X	X	
Western toad	X	X	X	X		
Western toad larvae	X			X	X	
Reptiles						
Aquatic garter snake	X				X	
Common garter snake	X	X	X	X	X	
Common king snake	X		X	X		
Gopher snake	X	X	X	X	X	
Ring neck snake					X	
Sharp tailed snake	X					
Southern alligator lizard	X	X	X	X		
Western fence lizard	X	X	X	X	X	
Western pond turtle[1]	X					
Western racer	X	X				
Western rattlesnake	X	X	X	X		X
Western sagebrush lizard		X				
Western skink		X				
Western terrestrial garter snake	X	X		X		

[1] State and federal Species of Concern

Table 4. Catch Per Hour Effort for Each Survey Method

Common Name	Ground Searching	Dip Netting	Seining	Night Driving
Amphibians				
Bullfrog	4.8	0.7	1	0
Bullfrog larvae	1.1	0	2.9	0
California newt	0.003	0	0	0
California slender salamander	0.009	0	0.3	0
Pacific tree frog	1.2	3.8	0.6	0
Pacific tree frog larvae	0	27.6	0	0
Western toad	0.5	0.02	0.04	0
Western toad larvae	0.2	13.4	7.1	0
Reptile				
Aquatic garter snake	0.0005	0.009	0	0
Common garter snake	0.02	0.04	0.02	0
Common king snake	0.003	0	0	0
Common racer	0.0002	0	0	0
Gopher snake	0.007	0.009	0	0
Ring neck snake	0.0005	0	0	0
Sharp tailed snake	0.0005	0	0	0
Southern alligator lizard	0.005	0	0	0
Western fence lizard	0.17	0	0	0
Western pond turtle[1]	0.0009	0	0	0
Western rattlesnake	0.02	0.009	0.06	0.2
Western sagebrush lizard	0.0005	0	0	0
Western skink	0.006	0	0	0
Western terrestrial garter snake	0.05	0	0.02	0
Totals	**8.1**	**45.6**	**12.1**	**0.2**

Discussion

The foothill yellow-legged frog, which occurs in both Glenn and Colusa counties and is listed by the DFG as a Species of Concern, was not observed in the project area. These frogs prefer the running waters of mid-sized streams.

Several reptile and amphibian species whose historic range may include the Sites and Colusa Project areas that were not observed include the Oregon salamander (*Ensatina escholtzii oregonense)*, the black salamander (*Aneides flavipunctatus)*, and the mountain king snake (*Lampropeltis zonata)*. These species tend to prefer shaded oak woodlands of the arroyos to the west side of the project area.

Western spadefoot toad, rubber boas (*Charina bottea bottae)*, and the California night snake (*Hypsiglena torquata nuchalata)* were expected to be found in the grasslands of the Antelope Valley, but were not.

Western pond turtles were found in the project area, as well as outside the reservoir footprint, both upstream and downstream. California red-legged frogs, which generally have a similar habitat preference as western pond turtles and are frequently found occupying the same areas (Jennings, Hayes, and Holland 1985), were not, however, found during these surveys. Further surveys of the streams and pools surrounding the reservoir inundation area will be conducted.

Red Bank Project

DFG initiated studies of amphibians and reptiles in the Red Bank Project area in 1997. DFG also reviewed past studies as part of the Red Bank Investigations (Bill et al 1975, Smith 1987, Brown et al 1987). This summary briefly describes the results of current and past studies of amphibians and reptiles conducted on Cottonwood Creek and Red Bank Creek.

DFG staff conducted surveys for reptiles and amphibians from August 1997 through spring 1999 in the Red Bank Project area. The major objectives of these surveys were to search for California red-legged frogs (federally listed as threatened) and to conduct general herpetology surveys. Three species listed as federal and State Species of Concern that could potentially occur in the Red Bank Project area—foothill yellow legged frogs, western pond turtles, and western spadefoot toads)—were also looked for during the course of these surveys (DFG 1998).

Results

Cottonwood Creek

DFG conducted one-year reconnaissance-level studies of the Red Bank Project in 1986 (Brown et al 1987). Biologists spent about 25 hours searching the banks of Cottonwood Creek in the study area in 1986 and 125 hours searching in 1998. Two species listed as Species of Concern were found, foothill yellow-legged frogs and western pond turtles (Table 5). These two species were distributed throughout the study area.

During these studies, fourteen species of amphibians and reptiles were found. The most common species of amphibians observed in the Cottonwood Creek study area were foothill yellow-legged frogs (14.80/hr) and western toads (13.10/hr) (Table 6). The most common species of reptiles observed were common garter snakes (0.39/hr) and western pond turtles (0.17/hr) (Table 6).

Table 5. Amphibians and Reptiles Observed in the Red Bank Project Area

Common Name	Scientific Name	Cottonwood Creek	Red Bank Creek
Amphibians			
Bullfrog	*Rana catesbeiana*	X	X
California red-legged frog[1]	*Rana aurora draytonni*		X
Foothill yellow-legged frog[2]	*Rana bolei*	X	X
Pacific tree frog	*Hyla regilla*	X	X
Western toad	*Bufo boreas*	X	X
Reptiles			
Common garter snake	*Thamnophis sirtalis*	X	X
Common kingsnake	*Lampropeltis getulus*	X	X
Gopher snake	*Pituophis malanoleucus*	X	
Southern alligator lizard	*Elgaria multicarinata*	X	X
Western fence lizard	*Sceloperus occidentalis*	X	X
Western pond turtle[2]	*Clemmys marmorata*	X	X
Western racer	*Coluber constrictor*		X
Western rattlesnake	*Crotalus viridis*	X	X
Western sagebrush lizard	*Sceloperus graciousus gracilis*	X	X
Western skink	*Eumeces skiltonianus*	X	X
Western terrestrial garter snake	*Thamnophis elegans*	X	X

Red Bank Creek

Biologists spent 75 hours searching Red Bank Creek and surrounding areas in 1986 and 300 hours in 1998. Biologists found two species listed as Species of Concern, the foothill yellow-legged frog and the western pond turtle (Table 5). These two species were distributed throughout the Red Bank Project study area. Biologists also observed a threatened species, the California red-legged frog, in 1986 and 1998 at Sunflower Gulch, a tributary to Red Bank Creek. Biologists found sixteen species of amphibians and reptiles (Table 5).

Discussion

The most common species of amphibians observed in the Red Bank study area were western toads (5.65/hr.) and foothill yellow-legged frogs (3.91/hr.) (Table 6). The most common species of reptiles observed were western terrestrial garter snakes (0.13/hr.) and western pond turtles (0.09/hr.) (Table 6).

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[1] Listed as federally threatened species
[2] State and federal Species of Concern

Table 6. Relative Abundance of Amphibians and Reptiles Observed in the Red Bank Project Area

Species	Catch per hour: Cottonwood Creek	Catch per hour: Red Bank Creek
Amphibians		
Bullfrog	0.02	1.06
California red-legged frog[1]		<0.01
Foothill yellow-legged frog[2]	14.8	3.91
Pacific tree frog	0.01	1.58
Western toad	13.1	5.65
Reptiles		
Common garter snake	0.39	0.03
Common king snake	0.01	0.01
Gopher snake	0.05	0.01
Southern alligator lizard	0.02	0.01
Western fence lizard	0.14	0.08
Western pond turtle[2]	0.17	0.09
Western racer		0.01
Western rattlesnake	0.12	0.01
Western sagebrush lizard	0.02	0.01
Western terrestrial garter snake	0.15	0.13

The most significant finding in the current investigation is the confirmation of the presence of a California red-legged frog in Sunflower Gulch. One was observed in the same location in 1986 (Brown et al 1987). Extensive searches failed to find other red-legged frogs in the study area. It is probable that the population of red-legged frogs is very small at the site of the proposed Red Bank Project.

Two Species of Concern are plentiful throughout the Red Bank Project study area: the foothill yellow-legged frog and the western pond turtle. They were found in both Red Bank Creek and the South Fork of Cottonwood Creek.

Thomes-Newville Project

DFG initiated studies of the impacts on fish and wildlife of a Thomes-Newville Project in 1979 as part of DWR's Thomes-Newville Reservoir planning studies. However, the planning studies were halted in 1982. DFG completed a report of its abbreviated studies in 1983 (Brown et al 1983). This section recapitulates the effort and results of DFG's 1981-82 field studies. No new studies of amphibians or reptiles at the Thomes-Newville Project area were undertaken during the recent investigations of offstream storage.

[1] Listed as federally threatened species
[2] State and federal Species of Concern

Methods

Surveys for amphibians and reptiles in the Thomes-Newville Project area were conducted from April 1981 through May 1982. Before surveying began, it was necessary to determine the historic range and available suitable habitat of the threatened California red-legged frog and Species of Concern that might be present in the project area, such as the California tiger salamander, western pond turtle, foothill yellow-legged frog, and western spadefoot toad. This evaluation was made by physically observing the present habitat in conjunction with historic records, reviewing previous field data, and consulting professional and amateur organizations such as the Natural Diversity Database, the DFG Natural Heritage Division, and others involved in consulting or amateur herpetology in the study area. Biologists and herpetologists from State and federal agencies and environmental groups, as well as university and museum personnel, were also consulted on possible indigenous reptiles and amphibians in the study area.

Pitfall trapping was done in the Thomes-Newville Project area surveys. Square plywood roofs supported by wooden legs approximately 4.3 inches above the soil surface covered plastic 5.0 gallon buckets or 3 pound coffee cans that were buried so their open top was level with the soil surface. Animals seeking shelter would run under the roofs, fall into the can or bucket, and be trapped. The roofs prevented livestock and people from stepping into the traps.

Buckets measured 10.8 inches on the inside diameter and varied from 12.0 inches to 14.0 inches in depth. Their plywood roofs had 16.0-inch sides. Coffee cans measured 6.1 inches on the inside diameter and were 6.9-inches deep. Coffee can traps were constructed by burying one can with both lids removed above another with its bottom lid intact. This resulted in doubling the trap depth to 13.8 inches. The plywood roofs for these traps had 12.0-inch sides.

Two-hundred-and-nine traps were installed during the course of the survey, including 79 bucket traps and 130 can traps. The trapping effort included placing traps within each of the major habitat types found within the project site and surrounding areas. Grassland, oak savannah, pine-oak woodland, chaparral, and riparian areas comprised the major habitat types selected for pitfall trap installation.

Pitfall traps were checked four times per week from spring through early fall. During late fall and winter, traps were checked at least once per week. The increased frequency of trap checking during the warmer seasons coincided with increased terrestrial activity of many amphibian and reptile species. Captured amphibians and lizards were marked by clipping their toes in a predetermined sequence to obtain population estimates based on recaptures of marked individuals. These species regenerate their lost limbs.

Team members walked 16 feet apart in a line to search for amphibians and reptiles. All logs, trees, burrows, rocks, and crevices were inspected for animals. Areas searched included riparian, grasslands, and oak woodlands. Binoculars were used to scan ahead for animals such as turtles and frogs. This method was most effective for snakes, lizards, toads, slender salamanders, and tree frogs. Night searches were walked in the same manner, using 6-volt flashlights for illumination. During the warmer seasons, a general watch for reptiles and amphibians was made by staff going to and from transects.

Searches of aquatic habitat in the Thomes-Newville area included visual observations of animals on shore or in shallow water. Hand-held dip nets were used to capture animals near the shore. The study also included seining stock ponds and ephemeral pools in the project area, using a 50-foot beach seine.

Night drives occurred an average of six times per month in the Thomes-Newville area. Night drives followed roads both within and surrounding the project boundaries. These roads were traveled in both directions. Night surveys were very successful in locating snakes, lizards, and toads. During the warmer seasons, a general watch was made on the roadsides whenever surveyors were driving in the study area. A camera was used to photograph specimens for species verification and to maintain a general record of the find.

Results

This 1981-82 survey produced observations of 22 amphibian and reptile species that occur within the habitats in the project area and surrounding areas (Table 7). No estimate of population sizes was possible because of the small number of recaptures that occurred during the pitfall trapping.

Table 7. Amphibians and Reptiles Observed in the Thomes-Newville Project Area in 1982[1]

Common Name	Scientific Name
Amphibians	
Black salamander	*Aneides flavipunctatus*
Bullfrog	*Rana catesbeiana*
California slender salamander	*Batrachoseps attenuatus*
Foothill yellow-legged frog[2]	*Rana boylei*
Pacific tree frog	*Hyla regilla*
Western spadefoot toad[2]	*Spea hammondi*
Western toad	*Bufo boreas*
Reptiles	
Common garter snake	*Thamnophis sirtalis*
Common king snake	*Lampropeltis getulus*
Gopher snake	*Pituophis malanoleucus*
Sagebrush lizard	*Sceloperus graciosus*
Sharp-tailed snake	*Contia tenuis*
Southern alligator lizard	*Elgaria multicarinata*
Striped racer	*Masticophis lateralis*
Western aquatic garter snake	*Thamnophis couchi*
Western fence lizard	*Sceloperus occidentalis*
Western pond turtle[2]	*Clemmys marmorata*
Western racer	*Coluber constrictor*
Western rattlesnake	*Crotalus viridis*
Western skink	*Eumeces skiltonianus*
Western terrestrial garter snake	*Thamnophis elegans*
Western whiptail	*Cnemidophorus tigris*

Western toads, Pacific tree frogs, and western fence lizards were found in all habitat types. Gopher snakes and western rattlesnakes were also found in most habitat types. Some species such as black salamanders and western sagebrush lizards were much more limited in their distribution (Table 8).

[1] Scientific names are taken from Collins 1997
[2] State and federal Species of Concern

Table 8. Amphibian and Reptile Species Found in the Thomes-Newville Project Area in 1982

Species	Grassland	Chaparral	Oak Savannah	Oak Woodland	Riparian	Stream	Standing Water
Amphibians							
Black salamander				X			
Bullfrog					X	X	X
California slender salamander	X	X	X	X			
Foothill yellow-legged frog[1]					X	X	X
Pacific tree frog	X	X	X	X	X	X	X
Western spadefoot toad[1]	X		X				
Western toad	X	X	X	X	X	X	X
Reptiles							
Common garter snake	X				X	X	X
Common king snake	X	X	X	X			
Gopher snake	X	X	X	X	X		
Sagebrush lizard		X					
Sharp-tailed snake	X	X					
Southern alligator lizard	X	X	X	X	X		
Striped racer	X	X					
Western aquatic garter snake					X	X	
Western fence lizard	X	X	X	X	X	X	X
Western pond turtle[1]					X	X	X
Western racer	X	X	X		X		
Western rattlesnake	X	X	X	X	X		
Western skink	X	X	X				
Western terrestrial garter snake	X		X		X	X	X
Western whiptail		X	X	X			
Total number of species observed	**15**	**14**	**13**	**10**	**13**	**8**	**8**

Ground searching proved to be the most successful method of observation in terms of the number of species it produced. This method accounted for 90.9 percent of all species found. Night driving yielded 63.6 percent, followed by pitfall trapping and searches of aquatic habitats, each of which produced 40.9 percent of all species found.

Pitfall traps tended to trap amphibians, lizards, and smaller snakes, such as the sharp-tailed snake (*Contia tenuis*). Larger snakes, because of their length, could easily avoid falling into the traps. This trapping method failed to provide any amphibian or reptile species not found by at least one other collection method.

[1] State and federal Species of Concern

Time limitations and lack of access prevented use of the beach seine except on one occasion in April 1982. A stock pond with a surface area of approximately 0.1 acre, located adjacent to Newville Road and about 0.25 mile south of the bridge near the Tehama-Glenn County line, was seined in April 1982. One seine haul yielded 13,761 Pacific tree frog tadpoles and two western spadefoot toad tadpoles. Several adult bullfrogs (*Rana catesbeiana*) were observed, but no adult or larval salamanders were found (Table 9).

Table 9. Observation and Capture Methods for Amphibian and Reptile Species in the Thomes-Newville Project Area in 1982

	Observation or Capture Method			
Species	**Pitfall Trapping**	**Night Driving**	**Ground Searching**	**Aquatic Surveys**
Amphibians				
Black salamander			X	
Bullfrog		X		X
California slender salamander	X		X	
Foothill yellow-legged frog[1]		X	X	X
Pacific tree frog	X	X	X	X
Western spadefoot toad[1]	X	X	X	X
Western toad		X		X
Reptiles				
Common garter snake		X	X	X
Common king snake		X	X	
Gopher snake		X	X	
Sagebrush lizard			X	
Sharp-tailed snake	X		X	
Southern alligator lizard	X	X	X	
Striped racer		X	X	
Western aquatic garter snake			X	X
Western fence lizard	X	X	X	
Western pond turtle[1]			X	X
Western racer		X	X	
Western rattlesnake		X	X	
Western skink	X		X	
Western terrestrial garter snake	X	X	X	X
Western whiptail	X		X	
Total number of species observed	**9**	**14**	**20**	**9**

Although no amphibian or reptile species listed as rare or endangered occurred in the project area, three species considered of special concern to the State of California because of habitat losses complete their reproductive cycle in

[1] State and federal Species of Concern

both temporary and permanent ponds found throughout the inundation area. western spadefoot toads, foothill yellow-legged frogs, and western pond turtles occur in the streams coursing through the reservoir site.

Discussion

DFG believe this survey found most, if not all, of the different amphibian and reptile species occurring within the reservoir site and surrounding areas. Two notable exceptions, the ringneck snake (*Diadophis punctatus)* and the night snake (*Hypsiglena torquata)*, may occur here, based on habitat descriptions and range maps presented in Stebbins (1966). The survey failed to find either of these species.

The combination of survey methods proved adequate for their purpose. These methods seem well suited for a short-term survey such as this, since they allow a great deal of territory to be covered in a brief period of time. Although accurate estimates of amphibian and reptile species are difficult or impossible to make using these methods, they do appear to provide reliable qualitative inventory of which species are present.

The pitfall trapping method required a relatively large amount of preparation time compared to the results it produced. Approximately three person-months were spent obtaining materials and installing traps. Had the survey continued through summer 1982 and spring 1983, enough recaptures of marked individuals may have occurred to allow population estimates to be made. In general, it appears that studies of this sort, faced with uncertain funding, should concentrate on finding species present using methods that require less preparation time.

Summary of Special Species Findings

Table 10 summarizes the observations of species with special status in each project area. The findings for Sites, Colusa, and Red Bank Project areas are a result of recent surveys, while those of Thomes-Newville Project area are the result of past surveys.

Western pond turtles, a federal and State Species of Concern, was found in the Sites and Colusa Project area. No other Species of Concern were found in the potential project area during these surveys. However, California red-legged frogs, a federally threatened species, generally have a similar habitat preference as western pond turtles and are frequently found occupying the same areas. Further surveys of the area surrounding the proposed inundation area will be conducted.

In comparison, a California red-legged frog and several Species of Concern were found at the proposed Red Bank Project area. Foothill yellow-legged frogs and western pond turtles were found in both Red Bank and Cottonwood Creeks.

A number of Species of Concern were also found at the Thomes-Newville project area in earlier surveys. Foothill yellow-legged frogs, western spadefoot toads, and western pond turtles were all found in 1981-82 field studies.

Table 10. Special Species of Amphibians and Reptiles Observed in Project Areas

		Project Area		
Species	**Status**	**Sites and Colusa**	**Red Bank**	**Thomes-Newville[1]**
Amphibians				
California red-legged frog	Federally threatened		X	
California tiger salamander	Candidate for federal listing; State Species of Concern			
Foothill yellow-legged frog	Federal and State Species of Concern		X	X
Western spadefoot toads	Federal and State Species of Concern			X
Reptiles				
California horned lizard	Federal and State Species of Concern			
Western pond turtle	Federal and State Species of Concern	X	X	X

[1] Results from surveys of Thomes-Newville Project area conducted in 1981-82

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DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

Appendix F: Sacramento River Diversion and Its Potential Impacts

June 2000

Integrated
Storage
Investigations

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North of the Delta
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Progress Report

Appendix F: Sacramento River Diversion and Its Potential Impacts

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California Department of Water Resources

June 2000

Integrated
Storage
Investigations

CALFED
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PROGRAM

Executive Summary

The Environmental Services Office, Fish Facilities Section, recommends that, for a new diversion to offstream storage in the Sacramento Valley, the Department of Water Resources should pursue an on-river inclined flat-plate screen, at the appropriate diversion size and site. This preferred alternative is technically feasible, protects fish, reduces long-term operations and maintenance relative to other conceptual design alternatives, and meets all National Marine Fisheries Service and Department of Fish and Game criteria for fish screening. The interagency Central Valley Fish Facilities Review Team has also favorably reviewed this alternative, and the design is also consistent with those recently selected for the new, larger, fish facilities in the Sacramento Valley (e.g., Glenn-Colusa Irrigation District, Reclamation District 1004, Reclamation District 108, Princeton-Codora-Glenn Irrigation District/Provident Irrigation District). However, during the OSI design process, current research on a number of critical fish facility issues (e.g., fish exposure time to screens) may change agency fish screening criteria and thinking, which could, in turn, significantly change our facility design. Needless to say, concepts and truths (if any) about effective fish screen design, operations, and maintenance are moving targets and constantly evolving. Further, we note that a 5,000 cfs diversion, if selected, will encounter substantial siting and regulatory obstacles, which DWR should carefully consider before proceeding with construction of such a relatively large fish facility.

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Introduction

The Environmental Services Office's offstream storage investigations related to fish screening began in January 1998. The purpose of our work was to assist Northern District and Central District with fish facility design alternatives and evaluations of the fish impacts from the alternatives. To do so, ESO evaluated alternatives of proposed diversion locations and, based on the location and diversion size, developed conceptual fish screen designs that should be considered in choosing a preferred diversion scenario. Additionally, the alternative designs received informal review from regulating agencies for guidance in identifying possible design flaws or other issues that would eliminate some alternatives. We also compared the conceptual alternative designs with information available from existing fish facilities of similar design and function for fishery impacts, operations and maintenance issues, sediment deposition, facility complexity, and estimated construction costs.

This report primarily provides the information gathered to date on the fish screen alternatives for a new diversion location on the upper Sacramento River. First, we generally discuss fish screen design criteria, current screening issues, and biological impacts of screens to fish. Next, we present our analysis of conceptual design alternatives and diversion sites (originally presented to Northern District in our October 1998 report). We then summarize agency comments on our conceptual design alternatives. Finally, based upon the information gathered from field site visits to existing fish screen diversion facilities, studies of fish screen designs, and agency comments, ESO recommends and develops, with the assistance of the Division of Engineering, a preferred alternative fish screen design to a pre-feasibility level.

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Fish Screen Design Criteria

Legal, Regulatory, Policy

In California, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the California Department of Fish and Game, regulate fish screens in order to reduce fish loss, especially of threatened and endangered species. Both NMFS and DFG have adopted fish screening criteria, on February 24, 1997, and April 14, 1997, respectively. NMFS criteria specifically govern anadromous salmonids, while DFG criteria cover all fish species. The third agency, USFWS, has adopted only one specific criterion.[1]

NMFS implements its criteria under authority granted to it by the federal Endangered Species Act, the Federal Power Act, and the federal Fish and Wildlife Coordination Act. DFG screen criteria have their own independent statutory authority (found in the California Fish and Game Code), which is also often combined with DFG authority under the California Endangered Species Act, California Environmental Quality Act, and Fish and Wildlife Coordination Act. DFG may also require fish screens as part of Federal Energy Regulatory Commission, Army Corps of Engineers, State Water Resources Control Board, and Regional Water Quality Control Board permits. USFWS authority for requiring screens and establishing the criteria the screens must meet is granted by the federal Endangered Species Act, Fish and Wildlife Coordination Act, and Central Valley Project Improvement Act.

Except for screen approach and sweeping velocities, NMFS and DFG criteria are general in nature. Further, implementation of both NMFS and DFG criteria is flexible, in that, on a project-by-project basis, the agencies may permit modifications, waivers, or variances from the standing criteria if the project or site conditions justify. Alternatively, the agencies can also make criteria more stringent on a project-by-project basis. For example, site specific conditions, such as flooding, sediment and debris load, and quality of fish populations, may necessitate that a project meet more restrictive fish screening criteria. However, once established for a particular project, fish screen criteria become legal requirements (for example, as part of a Biological Opinion or a license from the Federal Energy Regulatory Commission).

While fish screen criteria include numeric values for screen approach and sweeping velocities and screen mesh sizes, both NMFS and DFG criteria address a much broader range of fish facility design and operation, including placement of civil works, screen materials, and cleaning and other operations and maintenance issues. The following discussion of NMFS and DFG criteria applies only to streams and rivers in the northern Sacramento Valley. Fish screens located in canals, lakes, reservoirs, and tidal areas (for example, the San Francisco

[1] That is the 0.2 foot per second (fps) screen approach velocity for protection of delta smelt, which is referenced and incorporated into both the DFG and NMFS criteria.

Bay and Sacramento - San Joaquin Delta) are governed by slightly different criteria. In addition, diversions of 40 cubic feet per second or less anywhere are also guided by different criteria.

Velocity

Approach velocity is the vector component of water velocity perpendicular to the screen face and, per NMFS, is measured approximately three inches in front of the screen. For self-cleaning or automatically cleaned screens in streams and rivers, DFG and NMFS call for a uniform approach velocity for fry (less than 60 mm in length) of 0.33 feet per second or less. DFG requires that design be flexible enough to allow for subsequent screen adjustment to achieve uniform velocity. NMFS recommends "adjustable porosity control" downstream of the screens (for example, baffles) for the same reason.

NMFS calls for the sweeping velocity, the velocity parallel to the screen face, to simply be greater than the approach velocity, while DFG calls for a sweeping velocity of at least two times the approach velocity. For sweeping velocity, then, the DFG criterion overrides the NMFS criterion.

Screen Materials

Pursuant to NMFS criteria for fry-sized salmonids, screen openings may not exceed 2.38 mm (3/32 inches) for perforated plate and woven wire screen materials, and 1.75 mm for profile bar (or other slotted openings), with a minimum open area of 27 percent. These same dimensions hold in the DFG criteria for streams and rivers with steelhead rainbow trout. Both NMFS and DFG recommend that screen materials be corrosion and foul resistant.

Civil Works Placement

To cause the least impacts to fish, the diversion location process must first consider all possible elevations and temperature effects in the river. Both NMFS and DFG prefer to keep fish in the river environment, so on-river screens are favored over off-river.[2] In addition, for large (i.e., long) diversions, on-river screens that incorporate resting spots are preferred over those that involve bypasses. The screens should be aligned with the streambank and roughly parallel to flow, with a smooth transition between screen and streambank. Such structural conditions are desirable because they will minimize eddies and stagnant flow that can provide habitat for predators. In general, a design should eliminate any hydraulic condition that could lead to fish delay or injury and/or provide predator habitat. Furthermore, the fish screen structure must be protected from debris or other damage.

NMFS and DFG both require that fish screens have a preventative maintenance program, including cleaning "as frequently as necessary" to ensure

[2] For the offstream storage project specifically, NMFS and DFG have already indicated their preference for an on-river screen

the proper operation of the facility. NMFS adds that the cleaning system must be automatic.

Other Requirements

For NMFS and DFG, designs for fish screens that fall under their jurisdiction (for NMFS, an ESA consultation or a FERC relicensing) must be submitted for approval. Both agencies also require that fish screen design include an operations and maintenance plan. Both DFG and NMFS may require a post-construction facility evaluation, monitoring, and reporting, including ongoing hydraulic monitoring at large facilities (per NMFS).

Both agencies entertain variance requests from their respective criteria.

Current Screening Issues

Before DWR builds any new diversion facility, we will need to address many fish screening issues. The following is a list of current screening issues that relate to the fish facility portion of the North of Delta Offstream Storage Investigation.

Fish Bypasses

For off-river fish facilities, the fish screens end in a fish bypass, which returns the fish to the river, downstream of the diversion intake. Long on-river screens may also require intermediate fish bypasses to prevent excessive fish exposure time to the screen. The regulating agencies (DFG, NMFS) discourage fish bypasses in fish screen designs, because they prefer that fish be kept in the river if possible. Thus, on-river fish screens without bypasses need to be evaluated first. If it is determined that on-river screens are not feasible, then off-river screens with bypasses can be investigated.

Exposure Time

The amount of exposure time that a fish endures when passing a fish screen is equal to the length of the screen divided by the water velocity. For example, if the water velocity is 2 ft/sec and the screen is 120 feet long, then the exposure time is 60 seconds, assuming the fish move at the water velocity. For in-canal (off-river) screens, the regulating agencies prefer an exposure time of 60 seconds or less. For screens built on riverbanks with no bypasses and satisfactory river conditions, exceptions can be made. Also, if multiple, on-river, flat-plate screens are used, the distance between the screens should be at least twice the length of one screen so that fish have time to recover before encountering the next screen.

Fish Lifts

Fish lifts are used to lift fish and water from the river or in a fish bypass system. Fish lifts could be used at the entrance to the Tehama-Colusa Canal in Red Bluff to lift fish and water from the river into the drum screen forebay, which would allow the use of existing screens and fish bypasses. In a bypass system, the fish lifts elevate the fish so they can return by gravity to the river below the diversion intake. Consequently, velocities in the bypass lines will be greater than if the bypass flowed by gravity only. The NMFS requires bypass velocities to be greater than 2.0 fps.

Baffles

Adjustable flow control baffles are placed behind the screen to control and better distribute the flow, thereby helping to provide consistent approach velocities across the screen face. If baffles are not used, high velocity "hot" spots can occur, possibly impinging fish on the screen face. Baffles should be placed close enough behind the screen to affect a small portion of the screen panel. If baffles are too far away from the back of the screen face, they will tend to affect the entire screen panel, not just a small portion of the panel. Also, baffle controls should be readily accessible above the water surface and individually controllable.

Flow Control

As opposed to velocity control with baffles, the regulatory agencies also need assurance that actual diversion flow will be at or less than the screen design flow. Consequently, every diversion facility should incorporate flow control, whether it is gates, weirs, valves, or pumps. If flow cannot be controlled, then regulatory screening criteria may be exceeded, possibly impinging fish on the screen.

Screen Cleaning

Screen cleaning, whether brush, airburst, or waterburst, is one of the most important components of a fish facility. Regulatory criteria state that screens must be cleaned as frequently as necessary to prevent flow impedance. A cleaning cycle once every five minutes meets this standard. When a fish screen collects debris, the total available screen area is reduced, increasing the approach velocity above the accepted criteria and possibly impinging fish. If debris loading without cleaning continues, screen damage could occur if the water surface differential between the front and the back of the screen becomes too large.

Sediment

In Northern California, sediment is a major problem due to high river velocities. High velocities in the river suspend sediment, which is deposited throughout a fish facility, especially in front of and just behind the screen. If not removed, sediment can accumulate and reduce available screen area. Therefore, all fish screening facilities should be designed and built with provisions for sediment removal.

Trash Boom and Trash Racks

Large floating objects, such as trees, can damage a fish screen and its cleaning system. Therefore, trash booms and racks must be considered. Where applicable, a floating trash boom or piles should be placed in the water in front of the facility to deflect any large floating objects away from the facility. A trash rack should be placed across the intake to stop any objects that avoid the trash boom or piles (the last line of defense for a fish screen).

Structural Integrity and Flood Protection

The facility structure should be built to withstand high flows and debris loads. As mentioned earlier, if screen cleaning fails and debris collects on the fish screen, a water surface elevation differential between the front and back of the screen will develop. An alarm system should be in place to warn of such an emergency, but if the alarm fails also, the structure needs to be strong enough to handle this increase in load. Blowout panels above the screen or in a non-screened bay can be installed to open, or a switch can turn off the pump, if the load gets too great.

Undesirable Hydraulic Effects

NMFS criteria state that the civil works design shall attempt to eliminate undesirable hydraulic effects, such as eddies or stagnant flow zones, that may delay or injure fish or provide predator opportunities. The criteria add that upstream training walls or other structures shall be used to control hydraulic conditions and define the angle of flow to the screen face. Large facilities may require hydraulic monitoring to identify and correct areas of concern.

Isolated Bays

To increase reliability and facilitate maintenance, fish screening facilities should have isolated bays. For instance, a 1,000 cfs diversion could have five bays at 200 cfs each, so that if a tree damages a screen panel or a pump fails, that bay can be taken out of service and the other bays can continue to operate. This applies to both on-river and off-river diversions.

Access

All fish facility components should be readily accessible for maintenance or repair.

Maintenance

Maintenance is the single most critical aspect of an installed fish facility. Screen cleaners, pumps, valves, and gates are all mechanical systems that need care to function properly. Screen removal and cleaning, trash boom and rack cleaning, and sediment removal must be performed on a regular basis. Brush screen cleaners need to be checked for wear and proper orientation and contact pressure to the screen. The nozzles used in water backwash screen cleaners must be monitored for erosion. Air and water backwash systems need to be checked for leaks that lower pressure and, therefore, cleaning ability. Trash booms and racks need to be inspected for debris loads. Most importantly, each facility must have and follow an operations and maintenance plan.

Corrosion and Fouling

DFG criteria recommend that stainless steel or other corrosion-resistant material be used for screens to reduce clogging due to corrosion. Active and passive corrosion protection systems can also be considered. In addition, strong consideration should be given to the use of anti-fouling materials to reduce biological growth. Initial costs for corrosion and anti-fouling materials could save many future maintenance dollars.

River Flows and Stages

An adequate area of screen must be submerged to meet regulatory screening criteria. Historical flows and stages must be studied so that the fish screen is placed at the proper elevation. Improper placement of the fish screen could result in not enough submerged screen available and approach velocity criteria exceedence.

New Diversion Location

Finding a good place on the river is a key component to building a functional fish facility. If a bad location is chosen, sweeping velocities may not be adequate, sediment deposition may occur, or the river may change course and leave the facility in the dry. A good location for a fish facility is one that is in the non-meandering portion of the river, has deep, fast water, and is not an area in which fish congregate.

Biological Impacts of Fish Screen Alternatives

Potential Impacts of Screened Diversion Facilities on Fish

Protection Criteria

As stated previously, fish protection from water diversion facilities falls under the jurisdiction and regulation of the California Department of Fish and Game and the National Marine Fisheries Service and in some instances U.S. Fish and Wildlife Service. NMFS fish screen criteria identify that the three main causes of delay, injury, and loss of fish at water diversion intakes are entrainment, impingement, and predation. Entrainment occurs when a fish swims or is drawn into a diversion. Impingement is defined as a fish contacting a screen, a trashrack, or debris at the intake of the diversion with their entire body for more than five minutes (Kavvas et al. 1998). Predation losses are related to facility designs that create predator holding areas or hydraulic conditions that are stressful to bypassed juvenile fish, thus increasing their exposure or susceptibility to predators.

The swimming ability of fish is a primary consideration in designing a fish screen facility and depends upon multiple factors, including species, physiology, environmental conditions, and biological interactions. Factors influencing a specific fish's swimming ability include the following: genetics, physiological development (life stage, growth), behavioral characteristics, physical condition (health, reproductive maturity, injuries), endurance, water quality, temperature, light levels, and water velocities. Because the swimming ability of any fish species is variable and influenced by complex interactions with its environment, screen criteria are applied conservatively.

Screens

Injuries

Contact of fish with diversion structures can cause bruising, descaling, and other injuries. Impingement is perceived as the greatest source of potential physical damage to fish. Impingement, if prolonged, repeated, or caused by high intake (approach) velocities, can cause direct mortality for some species and life stages.

Swimming Fatigue and Exposure Times

Injuries to fish can occur if exposure times to an intake screen are extended in combination with conditions requiring constant swimming at or near a fish's maximum ability. As exposure time to diversion facilities increases, the chances also increase for injuries or mortality, as well as fatigue. When fish become fatigued, thier loss of swimming ability increases the chance for contacts with screens or other facility structures, leading to possible injuries and impingement. As swimming ability is impaired, the fish's ability to escape predators is also compromised.

Predation

Fish near diversion intakes may have a greater susceptibility to predation. Fish screen structures can provide hiding places for larger predators to prey on smaller fish either passing a screen or entering or exiting bypasses. Small or juvenile fish may be more susceptible to predation when they are disoriented from turbulent flow near the bypass exit or fatigued from swimming at the limits of their ability for long periods. If juvenile fish are injured from screen or bypass contacts, they will also be susceptible to predation.

Entrainment

Entrainment of fish through a screened diversion (built to meet current screen criteria) is unlikely for most juvenile fish larger than 20 mm total length (depending on body morphology). For screened diversions located where steelhead fry are present, current criteria for screen mesh size is set at 1.75 mm. This protects very small fish from entrainment through the screen. However, entrainment potential increases if the screens are not sealed well against the structure or if there are holes that a fish can pass through. To eliminate or reduce the chance of entrainment, all screens must be inspected for complete seals and gaps larger than the screen mesh size.

Bypass Systems

NMFS criteria define bypass systems as channels that transport juvenile fish from the face of a screen to a relatively safe location in the main migratory route of the river or stream. Juvenile bypass systems are necessary for screens located in canals because anadromous fish must be returned to their main migratory route. Depending on the screen configuration and location, NMFS may not require bypasses if other configurations provide higher degrees of fish protection (NMFS 1997). DFG criteria are not specific to bypass design; however, the agency reserves the right to include supplemental criteria and to grant variances that are at least as protective of fish as existing criteria.

Screens and bypasses are required to work in unison hydraulically to move fish to the bypass outfall with minimum injury or delay. Flows should gradually increase leading into the bypass entrance. Flow in the conduit needs to be at atmospheric pressures, at least 2.0 fps velocity or greater (with no free falls or hydraulic jumps), and have a minimum depth of 9 inches. Bypass pipes should have smooth interior surfaces and be no less than 24 inches in diameter without valves, extreme bends, or pumps. Bypass outfalls should enter ambient river velocities of greater than 4.0 fps, with sufficient depths depending on flows and velocity of river and bypass, to avoid injuring fish. Bypass exit impact velocities should not exceed 25 fps, and the discharges should not create adult salmon attraction or jumping injuries (NMFS 1997).

Injuries

Injuries to fish entering and exiting bypass systems include descaling, fin erosion, bruising, eye hemorrhaging, or internal injuries. Bypass systems that are not internally smooth or that create adverse hydraulic conditions for fish passage have the potential for delaying or injuring fish due to disorientation, startling, and fatigue, resulting in increased contact with structures.

Swimming Fatigue and Exposure Time

Fish that have passed into bypass systems have either entered on their own or been carried there by currents that are beyond the fish's swimming ability. If a fish has to work at maximum effort to try to maintain itself in strong currents, it will experience fatigue more quickly than in slower, calmer water. High velocities in a bypass help to pass a fish away from screens and diversions quickly; however, the bypass needs to be fairly short to reduce the efforts of the fish and its exposure to stressful flow conditions. Stressed or fatigued fish are more susceptible to predation and can show latent effects of stress in reduced health, reduced growth rates, and overall reduced survival.

Predation

Entrainment of fish into bypasses may subject fish to predators either near the intake or near the outfall of bypass conduits. Hydraulic conditions at the bypass entrance and outfall determine how well juvenile fish can maintain their orientation, the amount of effort expended through the bypass, and the amount of energy left to avoid predators, seek refuge, and continue downstream passage. Proper bypass design reduces predator accumulation at entrances or outfalls; however, predators will take advantage of structure or flow conditions that favor their ability to hold in higher velocities and provide opportunity for feeding.

Impact Evaluations

Monitoring Requirements

Under NMFS criteria, new fish screen facility construction will be required to have biological and hydraulic evaluations to verify that design and protection objectives are met. Monitoring requirements are discretionary in DFG screen criteria. For any variance to current agency screen criteria, evaluation and monitoring may be required to ensure the variance still meets protection objectives. For many current fish screen projects, NMFS, DFG, and USFWS are requiring project proponents to develop and implement evaluation and monitoring plans for fish screens. The agencies require proponents to establish the success of the facility at meeting screen criteria and protection levels. The information gathered also enables agencies and proponents to determine if any modifications are required to meet criteria and protection goals. In addition, agencies are requiring operations and maintenance plans and their implementation. This requirement ensures the screen and appurtenant facilities are operated and maintained at optimum operational conditions for the life of the facility.

Monitoring Programs at Existing Screens

Monitoring and evaluation programs are currently being implemented at many new or retrofitted diversion points along the Sacramento River. These programs will be or are collecting hydraulic and biological measurements to determine the ability of the facility to meet criteria under expected operation conditions.

GCID Fish Screen Improvement Project

The Glenn-Colusa Irrigation District has expanded its screening facility to meet diversion and fish protection needs. The facility is designed to divert nearly 3,000 cfs under maximum diversion demands. Evaluation plans for the facility are detailed in a *Guidance Manual for the GCID Fish Screen Improvement Program* (Montgomery Watson 1998).

Hydraulic Measurements

The purpose of hydraulic testing is to calibrate and adjust the flow control mechanisms to optimize hydraulic operation of the facility and to record the optimum hydraulic performance of the facility and compare it to model data and design criteria. For the fish screen, measurements will include intake channel velocities, screen approach and sweeping velocities, and evaluation of screen cleaning performance. Internal fish screen bypasses, the water control structure that regulates flow in the bypass channel, and the bypass channel hydraulics will also be checked for design criteria velocities and operation during diversion pumping.

Biological Tests

Testing the fish screen for biological impacts will include evaluating fish entrainment, overall fish survival, fish survival in front of screens, survival through the water control structure and in the downstream bypass channel, and fish survival in the internal screen bypass conduits.

These tests, when completed, will provide valuable information regarding impacts to fish of large flat-plate screen diversion facilities with bypasses. The information will provide guidance to design considerations for other large diversions (3,000+ cfs) that might be considered on the Sacramento River.

Screen Impacts Research and Evaluation for Alternative Screen Designs for Offstream Storage

Off-River "V" Screen Designs

The "V" or wedge screen design is a popular fish screen design for larger diversion facilities. The design includes a pair of vertical flat-plate screens angling towards an apex entrance to bypass conduits that return entrained fish below the diversion facility. This style of fish screen is common in the Pacific Northwest.

For example, the White River Project, a fish screen facility constructed by Puget Sound Power and Light Company, consists of angled flat-plate screens. Each flat-plate screen (each side on the "V" configuration) is approximately 160 feet long by 17 feet high. The entrance of the bypass at the apex of the screens has secondary vertical plate screens (4 feet high, 9 feet long), that further reduce the volume of water and help guide fish into the bypass. The screen design flow is between 2,000 cfs and 20 cfs, with 0.4 fps approach velocity and 2.0 fps sweeping flow past 2 mm wedge wire screen. These design criteria was based on protecting pink salmon fry.

Similar facilities have been installed at a variety of other sites in the Pacific Northwest, but many of these facilities have not been subjected to biological evaluations (or evaluation data are unavailable). Most of the screen facilities have been designed to meet the resources agencies' criteria protective of juvenile salmonids, targeting an effective protection goal of 100 percent survival.

On-River Modular Inclined Screen (MIS)

High-velocity screening systems, with water velocities ranging from 5 to 10 fps, are beginning to gain acceptance from regulators on the East Coast and in the Pacific Northwest. The primary advantage of high-velocity systems is their small size (they require only 10-20 percent of the screen area of low-velocity systems), which helps reduce their cost to about half that of low-velocity systems. Also, because the water is flowing more swiftly, passing fish are not as vulnerable to predators as they can be in low-velocity screening systems. High-velocity screens are typically installed on an incline, with a pivot supporting the center (as in a seesaw). The fish are guided over the screen and into a bypass system (EPRI 1994). Accumulated debris can be washed away by simply pivoting the screen so that the debris is forced toward the downstream side.

One high-velocity screen that has been successfully demonstrated (the Eicher penstock screen) is designed for installation inside a penstock of an on-river power generating facility. Electric Power Research Institute sponsored studies over the past decade that have contributed to the refinement of the Eicher screen, and efficiencies for fish diversion now typically surpass 99 percent. For instance, a power company in Canada has employed the Eicher penstock screen with great success, saving $4.4 million over the cost of a low-velocity screening system. Regulatory agencies in Canada and the United States have accepted the technology for certain hydro plants (Amaral 1998). Biological evaluations of the Puntledge Eicher Screen facility in British Columbia in 1993 and 1994 showed a bypass efficiency of 99 percent for coho and chinook salmon smolts. Bypass efficiencies for steelhead, sockeye, and chum salmon fry were 100 percent, 96 percent, and 96 percent, respectively. The screens have also proven to be very reliable, requiring little maintenance (Amaral 1998).

A variation in design and application of an angled, high velocity screen, called the Modular Inclined Screen has been developed and tested by EPRI and others (EPRI 1994, 1996; ARL and SWEC 1996). The design is a shallowly angled (10 to 20 degrees), tilting screen completely encased as an individual unit or "module." The MIS screen's modularity enables it to be used at any type of water intake. It is designed to operate at relatively high sweeping water velocities across the screen ranging from 2 to 10 fps. Biological tests in laboratory settings conducted on a number of different species, including chinook and coho salmon, American shad, and rainbow trout, showed exceptional passage rates of 99 percent at velocities up to 8 fps. Latent mortality of these fish following testing was 0 percent to 5 percent. Field application of a full scale MIS was conducted at Green Island Hydroelectric Project on the Hudson River in New York and had similar results to the lab studies. Rainbow trout showed diversion and survival rates of 100 percent under most test conditions (Amaral 1998). Improvements to the system's hydraulics have provided a more uniform flow over the entire screen surface than with other screens, such as the Eicher, which reduces the likelihood of fish injuries due to screen contact.

On-River Archimedes and Centrifugal-helical Lift Pumps

The Red Bluff Research Pumping Plant, completed in 1995, is evaluating the use of Archimedes lift and centrifugal-helical lift pumps for diverting water and passing fish into screen facilities and returning them to the river via a bypass. Initial trials with both lift-pumps showed promising fish survival for multiple species including juvenile chinook salmon. A total of 2,281 fish of 20 species entrained from the Sacramento River during 1995 and 1996 evaluations of the pumps (29, 24-hour trials) showed 96.2 percent survival (47.9 percent of test fish were chinook salmon juveniles). Survival of juvenile chinook salmon subjected to the Archimedes pump, screens, and bypass facilities was very high. Experimental trials (n = 119) with 3,805 hatchery-reared salmon had >99 percent survival of recovered fish and very low injury rates from the pumps or bypasses (Liston et al. 1997).

Bypass Systems

Tehama-Colusa Canal Rotary Drum Screen Bypass Research

The Tehama-Colusa Canal facility was constructed in 1964 with louver fish screens and bypasses. Studies of the facility conducted in 1982 (Vogel et al. 1988; Vogel 1989) resulted in the replacement of ineffective fish louvers and bypass at the Tehama-Colusa Canal with rotary fish screens and a new bypass facility in 1990. Testing of the fish bypass system in 1994 included 58 groups of juvenile chinook salmon distributed between four bypass conduits to assess injury rates and survival associated with individual bypass conduits (USFWS 1997). No direct mortality occurred in recaptured treatment (n = 5,253) fish released directly into the bypass entrances and control (n = 6,080) fish released and recaptured at the bypass outfall. Survival was high three days after treatment (99.4 percent, n = 5,244), with no significant difference in survival between treatment and control groups. After seven days, survival was greater than 90 percent for control (91.8 percent) and treatment fish (92.8 percent). Injury rates (descaling, frayed fins, hemorrhaging) were also low with no significant difference in injury levels between control and treatment groups (P > 0.05). In comparison, the previous bypass design had an associated mortality rate to juvenile chinook salmon estimated at 1.6 percent to 4.1 percent mortality (Vogel et al. 1988).

In all, the Tehama-Colusa evaluations showed that bypasses up to 500 m (1,500 feet) long can pass juvenile fish with negligible losses and injuries. However, regulatory agencies in California still prefer facilities that do not create a need to separate fish from diverted water and send them through bypasses.

Current Screen Impacts Research

UC Davis Fish Treadmill Investigations (Kavvas et al. 1998; Cech et al. 1999)

Excerpted from *Advances in Fish Passage Technology*, edited by Mufeed Odeh, PhD., P.E. (in progress)

Collaborative research by the University of California, Davis, the California Department of Water Resources, and the California Department of Fish and Game using the Fish Treadmill is in its second year. The Fish Treadmill is a unique and versatile annular flume designed to simulate a large, positive barrier, screened diversion and to allow detailed, quantitative observations of fish behavior exposed to controlled, realistic, two-vector flows near a fish screen for prolonged periods. The Fish Treadmill project was designed to produce results applicable to determine optimal approach velocities for fish protection and water diversion, optimal sweeping velocities that maximize fish protection and screen passage, screen passage velocities and maximum allowable screen exposure durations, and the effects of season (i.e., temperature, fish size) and time of day (i.e., day vs. night) on fish performance and behavior near fish screens to develop adaptive management strategies for screened water diversions.

As of May 1999, more than 250 experiments with juvenile and adult delta smelt (*Hypomesus transpacificus*, a federally and state listed species under the ESA), young-of-the-year splittail (*Pogonichthys macrolepidotus*, a federally listed species under the ESA), and hatchery source fall-run chinook salmon (*Oncorhynchus tshawytscha,* California Central Valley winter-run state and federally listed endangered, spring-run state listed threatened) parr and smolts have been completed. For each of these species, experiments have been conducted at ten different approach and sweeping flow combinations, two seasonal temperatures (12° C in winter and spring, and 19° C in summer and fall), and under lighted (day) conditions and dark (night) conditions. We observed and videotaped fish using infrared sensitive equipment in all experiments, including night/dark; a comprehensive suite of biological responses were measured during and after the exposure period.

Preliminary analyses of data already demonstrate the effectiveness and potential of this experimental approach for providing information useful to develop and refine screen design, flow, and operational criteria. There are clear differences in the performance and responses of the different species and, within species, significant effects of life history stage and environmental conditions (temperature and light level). This suggests that a single criterion (for example, a specific approach and sweeping flow requirement) probably will not benefit all species equally nor be equally protective during different seasons or times of day.

At least for these California fish, adaptive management of screened water diversions based on species presence and environmental conditions may be required to meet protection goals.

Some of these preliminary results have been published in technical reports to the California Department of Water Resources and presented at several technical and scientific meetings (including the International Congress on the Biology of Fishes in 1998, and the annual meetings of the California-Nevada Chapter of the American Fisheries Society and the AAAS, in 1999). Several journal articles are being prepared. Some examples of preliminary results are outlined below.

For all species tested so far, there were dramatic differences in performance and behavior between the day and night experiments. At night, screen contact rates (temporary contact with the fish screen) were often ten times higher than during the day at the same flow. During the day, most fish exhibited rheotaxis, swimming either upstream or downstream relative to the sweeping flow. Thus, contrary to common assumption, screen passage velocities were not equal to sweeping velocity but instead were dependent on fish swimming behavior (rheotaxis and swimming velocity). At night, rheotactic behavior and swimming velocities were reduced and screen passage velocities were similar to the sweeping velocity.

For most species, injury rates (for example, scale loss, fin and eye damage) were positively related either to screen contact rates or flow velocities (particularly sweeping velocity) or both.

Potential Impacts Analysis of Alternatives

Analysis Approach

If an offstream storage design proceeds further, analysis of the potential impacts of each proposed alternative screen design could be based on modeling data of alternative diversion operations, including daily, seasonal, and annual diversion periods, volume of diversion, water year type, and expected or predicted environmental conditions. Seasonal migration timing of juvenile fish of concern (fall-, late fall-, winter-, and spring-run chinook salmon, steelhead trout, American shad, splittail, striped bass, sturgeon), and run size estimates in the vicinity of proposed diversions should also be compared against the possible diversion operation scenarios. Research results on screen impact evaluations could then be used to estimate or predict the possible impacts (losses) to fish species for which there are comparable data. Biological impact evaluations data, from screen facilities similar in design to the proposed screen alternatives, provide a measure of possible fish losses at proposed screen diversion facilities on the Sacramento River.

Fish Screen Conceptual Design Alternatives

Off-River Design

Folded "V" Screens

The folded "V" screen option (Attachment B, Figures 2 and 3) is similar to an alternative considered in 1995 as part of the GCID fish screen improvement project. Cost estimates for this design option are based on the GCID folded "V" estimates.

Issues to be addressed for off-river diversion facilities designs include the following: length of bypass; gravity run or pump-assisted bypasses; bypass outfall, design, and location; debris handling facilities; screen cleaning; water level or stage control structures; flood protection; sedimentation rates and sediment removal facilities; and other specifics that may develop based on site conditions.

General conceptual design features include the following:

- Individual "V" bays with a capacity of 1,000 cfs each
- Fish screen with dimensions of approximately 125 feet long x 12 feet high per side of each "V" bay
- Fish bypass pipes return downstream
- Fish bypass lifts or pumps
- Gated structure at intake to protect facility from floodflows
- Floating debris boom at intake
- Trash rack with cleaner
- Brush fish screen cleaning system
- Sediment removal system

General conceptual design attributes include the following:

- Bays individually isolated for dewatering capability (repairs and maintenance).

Advantages: The fish screens are off the river, which reduces the chance of damage to the screens by debris during high river flows and isolates the facility from the river during floodflows. The screens are arranged compactly; therefore the intake uses only a small area of the riverbank. There is operational flexibility with multiple bays. Sediment deposition can occur before it reaches the screens.

Disadvantages: The fish are removed from the river, requiring fish bypass or handling facilities, which increase the biological impacts and costs associated with these facilities. Bypass and handling stress on fish may increase susceptibility to predation; also, the associated structures of the bypass outfall and screen abutment bays provide potential predator cover. The facility has no water surface elevation control; therefore, the screen structure and levees would have to be built to handle very high water surface elevations.

On-River Designs

The options that are being evaluated for installation on-river include the following.

Inclined Flat-plate Screens

The inclined flat-plate screen option (Attachment B, Figures 4 and 5) incorporates individual 1,000 cfs units that can be combined to yield from 2,000 to 5,000 cfs. Examples of this design are currently being constructed at Princeton-Codora-Glenn Irrigation District/Provident Irrigation District and Reclamation District 1004 (RD1004).

General conceptual design features per 1,000 cfs unit include the following:

- Fish screen with dimensions of 135 feet long x 30 feet high
- Five separate bays of 200 cfs each
- Airburst cleaning system
- Sediment removal system
- Gated flow control behind screens
- Two 100 cfs pumps at the terminus of each bay
- Common sediment settling basin

General conceptual design attributes include the following:

- Minimum spacing between 1,000 cfs screen intakes of no less than twice the screen length (approximately 275 feet) as a rough guideline from regulating agencies (NMFS, CDFG)
- Individually isolated screens and pumps to facilitate regular maintenance
- The screen is always submerged; pump-controlled hydraulics at screens under all flows

Advantages: The inclined flat-plate screen eliminates the need for fish bypass or handling facilities, thereby lowering fishery impacts and long-term operation and maintenance costs. It has operational flexibility due to the individual 1,000 cfs units. Debris handling is minimized and possible fish screen damage from debris is reduced by having the entire screen submerged. Gated flow control behind the screens can be closed to protect the facility from river floodflows. The pump wet well can handle all ranges of flows; therefore, the facility can operate at high and low flow river conditions. Facility capital costs could be lower due to the elimination of structures associated with fish bypasses. The on-river inclined flat-plate screen design is already accepted by regulating agencies and is under construction at major Sacramento River diversions.

Disadvantages: Under a low flow condition, sweeping velocities along the screen surface could be dramatically reduced. The facility, divided into 1,000 cfs units, uses a relatively long section of the riverbank. Sediment deposition in front of and behind the screen could also be a problem, especially during high river flow conditions (an automated sediment removal system would be beneficial).

Archimedes Screw Lifts or Internal Helical Pumps with Folded "V" Screens Downstream of Lifts/Pumps

Conceptual design plans for this option (Attachment B, Figures 6 and 7) are based upon the U.S. Bureau of Reclamation's ongoing work at the Red Bluff Research Pumping Plant. These studies and evaluations of large (100 cfs) Archimedes screw lifts and internal helical pumps will determine feasibility and long-term costs and impacts to fish related to these pumps and their associated handling and bypass facilities.

General conceptual design features include the following:

- 100 cfs capacity Archimedes screw lifts (10 feet diameter x 38 feet long) or 100 cfs internal helical pumps
- Trash rack with cleaner
- Gate at intake to protect facility from flood flows
- One fish screen bay per 1,000 cfs
- Fish screens with dimensions of approximately 125 feet long x 12 feet high per side of each bay
- Brush fish screen cleaning system
- Fish bypass pipes return downstream
- Sediment removal system

General conceptual design attributes include the following:

- Lift or pump and fish screen bays can be individually isolated for dewatering capability (repairs and maintenance).

Advantages: The facility can be isolated from the river during flood-flows by isolation gates. The fish screens are not directly on the river, which reduces the chance of damage to the screens from debris during high river flows. There is operational flexibility due to the individual 100 cfs units. The existing 3,000 cfs capacity drum fish screens at the Tehama-Colusa Canal intake can be used, resulting in a cost savings.

Disadvantages: The fish are removed from the river, requiring fish bypass or handling facilities, which increase the biological impacts and costs associated with these facilities. The large size of the Archimedes screw lifts and internal helical pumps could result in more mechanical problems compared to pumps that do not have to pass fish. There may be problems associated with pump structures, bypass system, and outfall structures creating predator holding areas. *Fish lifts and pumps are not currently accepted by the regulating agencies.*

Modular Inclined Screens

Modular inclined screens (Attachment B, Figures 8 and 9) are patterned after Eicher penstock screens that are used at hydroelectric facilities in the United States. The MIS is a more recent concept design that was studied using models and scaled prototypes. A one-half scale prototype was investigated at Niagara Mohawk's Green Island Hydroelectric Project on the Hudson River in New York. EPRI studies on fish impacts of the MIS showed promising results from tests. For example, all fish that passed through the MIS facility showed low mortality and injury rates for bypassed juveniles and adults of a variety of species. However, the MIS is a unique screen design that was tested with greater approach velocities than current DFG and NMFS California screen criteria approach velocities; both NMFS and DFG consider the MIS an experimental technology.

General conceptual design features include the following:

- Bays with a capacity of 100 cfs
- Fish screen with dimensions of approximately 12 feet wide x 30 feet long at 0.33 fps approach velocity
- Fish bypass pipes return downstream
- Fish bypass lifts or pumps
- Sediment removal system
- Trash rack with cleaner
- Gates before and after screen

General conceptual design attributes include the following:

- Always submerged and hydraulically controllable under all river flows by pumps
- Bays individually isolated for dewatering (repairs and maintenance)
- No structure necessary at intake to control water surface elevation in front of the screens

Advantages: The facility can be isolated from the river during floodflows by gates. The fish screens are not directly on the river, which reduces the chance of debris damaging the screens during high river flows. Individual 100 cfs units provide operational flexibility. The MIS can be operated at higher approach and sweeping velocities with little or no survival impact to fish based on lab and field evaluations.

Disadvantages: The fish are removed from the river, requiring fish bypass or handling facilities, which increase the costs associated with these facilities. Sediment deposition could also be a problem, especially during high river flow conditions (an automated sediment removal system would be beneficial). As with other screen facilities that require bypasses, the associated structures could create predator holding areas and may increase potential predation losses of bypassed fish. *The MIS design is not currently accepted by the regulating agencies.*

Additional information on construction and size requirements of an MIS screen facility is still required to refine the design and narrow cost estimates. Questions remain on the size of individual screen modules: can multiple screen modules be operated by one pump or does each module require its own pump for best operation and flow control? Also, if more than one screen module can be operated by one pump, what number of screen modules per pump unit is optimal, and is flow control adequate through multiple modules when operated by a single pump?

As stated earlier, fishery impact analysis of the MIS facility option is based on the studies conducted by EPRI and additional information gathered from communications with researchers involved with those studies. Results of the EPRI studies showed high survival (99 percent) of juvenile fish species in lab and field tests and low injury rates for fish up to 50 mm (chinook, coho, and Atlantic salmon, rainbow trout, brown trout, herring, catfish, bluegill, walleye, and shiners). EPRI concluded that the MIS could be the lowest cost screen for fish protection because the increased approach velocities, if accepted by the regulatory agencies, result in a smaller screen area per volume of water.

Conclusions

Conceptually, the MIS, Archimedes screw lifts, and internal helical pumps are feasible. The Red Bluff Research Pumping Plant has conducted ongoing studies and evaluations of the large (100 cfs) Archimedes screw lifts and internal helical pumps to determine feasibility and long-term costs and impacts to fish related to handling and bypass facilities. EPRI has studied the MIS with scale models, computer models, and in half-scale, full operation at a hydroplant facility on the East Coast. For both the fish lifts and pumps, and the MIS, results were very good for fish handling impacts with low to no injuries or mortalities, depending on operating configurations and flows. However, the MIS has not yet been tested on the West Coast and would require additional investigations to determine feasibility and gain acceptance by regulating agencies.

The folded "V" screens and inclined flat plate screens are better known alternatives and are currently accepted by regulating agencies. However, folded "V" screens require extensive fish bypass and handling facilities and, thereby, have greater impacts on fish drawn into the diversion. Inclined flat-plate screens minimize fisheries impacts because no fish bypass and handling facilities are necessary. The inclined flat-plate design is being applied currently at larger Sacramento River diversions.

Attachment B, Table 1 provides a comparison of each of the alternatives based on information available and relative estimated costs from actual construction costs or bid information gathered for similar screen facilities. Attachment B, Figure 1 is a cost estimation curve for existing or evaluated fish facilities in the Central Valley.

Diversion Site Alternatives

Four locations are being investigated as diversion points for offstream storage: existing diversions at the Tehama-Colusa Canal intake near the Red Bluff Diversion Dam and the GCID intake near Hamilton City, and new diversion locations at Monroeville and Compton Landing (Attachment A).

Red Bluff Diversion Dam / Tehama-Colusa Canal Intake

Sacramento River water currently cannot be taken by gravity flow from September 15 through May 15 because the RBDD gates are required to be open to facilitate fish passage. DWR has discussed with the Tehama-Colusa Canal Authority possible alternatives for a new pumped diversion at RBDD that would meet current water demand as well as that for offstream storage.

Design alternatives being developed are listed below:

1. 2,100 cfs Pumped Diversion Capacity (Existing Canal Capacity at Funks Reservoir)

a. Two 1,050 cfs on-river inclined flat-plate screens (Attachment B, Figure 10)

Conceptual design plans have been developed for current capacity needs. Cost estimates are based on bids for installation of the PCGID/PID fish screens currently under construction on the Sacramento River.

b. 20 to 30 Archimedes screw lifts or internal helical pumps using existing drum screens

Conceptual design plans for this option have been developed. Cost estimates are based on information from USBR's 1992 *Summary of Appraisal Study for Red Bluff Diversion Dam Fish Passage Program*.

c. Modular inclined screens 21 x 100 cfs units, for a total 2,100 cfs diversion (Attachment B, Figures 8 and 9)

Current design sizes screens for operation within existing DFG and NMFS screen criteria. Site-specific topography data is required to determine fish bypass operational design criteria and location of bypass pipes or flumes.

2. 5,000 cfs pumped diversion capacity; increasing deliverable capacity by 2,900 cfs

a. Set of five on-river inclined flat-plate screens; 1,000 cfs per screen

Same issues as stated above in 1a.

b. 50 to 60 Archimedes screw lifts or internal helical pumps using existing drum screens and new "V" screens (Attachment B, Figure 7)

Sixty percent (3,000 cfs) of the Archimedes screw lifts or internal helical pumps would deliver water into a canal that would connect with the existing drum screens. New "V" screens would be built to handle the remaining 2,000 cfs.

c. Modular inclined screens 50 x 100 cfs units

This option has the same issues as stated above in 1c.

GCID Intake Screen Expansion

Construction is currently underway on the extension of the flat-plate screen to increase GCID screen capacity to 3,000 cfs. The project will provide current costs for a flat-plate screen facility in comparison to other diversion concepts under consideration for offstream storage at other locations.

1. Using expanded screen to divert up to 3,000 cfs during higher winter river flows

The existing and new screen are not designed to take water when the flow is above 60,000 cfs in the Sacramento River. To do so, the support structure for the screens would have to strengthened. Screen cleaning may also have to be modified to handle increased debris loads. At high river flows, pumping is not needed, but a gate structure would be needed to protect the canal from the river. In addition, during these high flows, water would have to be diverted around the pump station.

2. Adding new screens above existing screens to divert up to 5,000 cfs; modifying new screen facility to divert higher winter flows, operation at or above 60,000 cfs

   Expansion of the new facility to increase diversion capacity to 5,000 cfs and to take water under high flow conditions could be achieved by replacing the barrier panels above the existing screens with new screen panels, thereby increasing the height of the existing screens. Modifications as specified in the 3,000 cfs option would also be required.

New Sacramento River Diversion (Alternatives at Monroeville and Compton Landing)

Our conceptual designs have been developed primarily for new diversion fish facilities that could be sited at Monroeville or Compton Landing across from Moulton Weir. Feasibility cost estimates are based on actual costs, when available, from newer existing screened diversion facilities or facilities under construction on the Sacramento River.

Design alternatives being developed are listed below:

1. 2,100 cfs diversion at Monroeville
   a. Two 1,050 cfs on-river inclined flat-plate screens

      Cost estimates for our conceptual design are based on the 605 cfs PCGID/PID fish screen facility currently under construction on the Sacramento River.
   b. Modular inclined screens 21 x 100 cfs units, for a total 2,100 cfs diversion

      Current design option sizes screens for operation within existing DFG and NMFS fish screen criteria. Additional information, including site specific topography data is required to determine fish bypass operational design criteria and locate bypass pipes or flumes for this experimental screen.
2. 2,900 cfs diversion at Compton Landing
   a. Three 1,000 cfs on-river inclined flat-plate screens

      This option has the same issues as stated above in 1a.
   b. Modular inclined screens 29 x 100 cfs units, for a total 2,900 cfs diversion

      This option has the same issues as stated above in 1b.
3. 5,000 cfs diversion at Monroeville or Compton Landing
   a. Folded “V” screens with five 1,000 cfs bays (Attachment B, Figures 2 and 3)

Cost estimates for this design option are based on the GCID folded "V" estimates from 1996.

b. Set of five on-river inclined flat-plate screens; 1,000 cfs per screen bay (Attachment B, Figures 4 and 5)
   This alternative requires a relatively large increase in right-of-way aquisition along the Sacramento River.

c. Modular inclined screens 50 x 100 cfs units
   This option has the same issues as stated above in 1b.

Colusa Basin Drain

Colusa Basin Drain is a potential source of water for offstream storage. Based on communications with regulating agency personnel, the presence of fish species of concern in the basin requires a screen on any diversion from the drain. Based on this information, a diversion screen facility design will need to be developed. Further studies of fish species distribution and seasonal abundance may provide alternatives to diversion operations or facility designs, which will need to be discussed with regulating agency personnel as information is developed.

A proposed fish exclusion facility discussion paper (Attachment E) describes options to exclude adult salmon from the CBD and provide return access to the Sacramento River. The option described would still maintain access to the floodplains of the CBD for other migratory native fish. This option was presented as one possible solution to reducing potential impacts to migrating adult salmon attracted into the drain by diverted Sacramento River water used for irrigation and collected in the drain. Other options may be available and would need further investigation. Specific fisheries sampling will be necessary to evaluate habitat conditions and use by fish species of concern to fully evaluate all alternatives.

Agency Review and Comments on the Conceptual Design Alternatives

On January 6, 1999, the ESO Fish Facilities Section presented its conceptual design report to the Central Valley Fish Facilities Review Team. The team, composed of representatives from DFG, NMFS, USFWS, Natural Resource Conservation Service, U.S. Bureau of Reclamation, CALFED, and DWR, meets monthly to review fish facility matters under the auspices of the Interagency Ecological Program.

Despite two requests for comments, of the six agencies on the team only DFG and NMFS provided informal or formal feedback (verbal or written). In particular, USFWS was asked twice to provide comments.

DFG and NMFS provided remarkably similar feedback. For example, both agencies objected to the large size (5,000 cfs) of a new diversion from the Sacramento River. Depending upon Sacramento River flow, they believe that the impacts to the river and fishery could simply be unacceptable. Furthermore, from a facility perspective, such a large diversion would require the largest screen ever constructed on the Sacramento River, one that would probably have to incorporate bypasses or lengthy resting spots for fish. Further, NMFS would require multi-level assurances, both physical and contractual, to guarantee that water is not inappropriately diverted from the Sacramento River through a 5,000 cfs facility.

Regarding bypasses, both agencies prefer to keep the fish in the river; thus, DFG and NMFS did not support an off-river (or in-canal) fish facility, unless DWR demonstrated that an on-river facility was not technologically feasible. An on-river facility is consistent with how new facilities are being constructed on the Sacramento River, including Reclamation District 108, RD1004, GCID, and PCGID/PID. DFG also noted that the MIS would be considered an experimental technology, and should be tested first in California prior to proceeding any further with design.

Based upon these comments from DFG and NMFS, we narrowed the scope of our pre-feasibility design to an on-river, inclined flat-plate screen, at 2,000, 3,000, and 5,000 cfs. The 5,000 cfs capacity diversion facility, notwithstanding the regulatory advice, was maintained as an alternative at the request of Northern and Central Districts.

Preferred Pre-Feasibility Level Design Alternatives

Discussion: Selection of a Preferred Alternative

Based on the results of the regulatory and conceptual design review, the preferred pre-feasibility level design alternative for a new diversion site is the on-river inclined flat-plate screen.

The design is accepted by the regulatory agencies and is currently being used (albeit a smaller scale) on the Sacramento River. It is readily accepted because it eliminates the need for fish bypass or handling facilities and keeps the fish in the river, thereby lowering fishery impacts. Also, NMFS and DFG criteria state that for streams and rivers, where physically practical, the screen shall be constructed at the diversion entrance. The screen face should be generally parallel to river flow and aligned parallel with the adjacent bank. This design can readily handle a large range of flows in the Sacramento River, from floodflows to low flows. Further, having the entire screen submerged minimizes floating debris problems. It has built-in reliability due to the incorporation of five 200 cfs bays into each 1,000 cfs unit.

Conversely, submerged, neutrally-buoyant debris could damage screen panels. Sited on the river, the area in front of and just behind the screen cannot be dewatered. This specific area is also difficult to access, such that inspection and maintenance of screens, cleaners, and baffles would be difficult and have to be performed underwater. Also, sediment deposition in front of and behind the screen will be more of a problem for this design when compared with an off-river facility. Nonetheless, all of these issues are addressed to the extent practicable in our design.

The inclined flat-plate screen design will be divided into three different diversion capacities for study: 2,000; 3,000; and 5,000 cfs. Detailed design and cost estimates are presented only for the 3,000 and 5,000 cfs facilities.

Design and Cost Estimates of On-River Inclined Flat-plate Screen

1. **2,000 cfs Diversion**
   This design will incorporate two 1,000 cfs inclined flat-plate screen modules into one 2,000 cfs diversion facility. The distance between each module will be 275 feet, and it will use approximately 600 linear feet of the riverbank.
2. **3,000 cfs Diversion**
   This design will incorporate three 1,000 cfs inclined flat-plate screen modules into one 3,000 cfs diversion facility. The distance between each module will be 275 feet, and it will use approximately 1,000 linear feet of the riverbank. DWR's Division of Engineering total project cost estimate for this design is $30.1 million dollars. See Attachment C for pre-feasibility designs and cost estimates.
3. **5,000 cfs Diversion**
   This design will incorporate five 1,000 cfs inclined flat-plate screen modules into one 5,000 cfs diversion facility. The distance between each module will be 275 feet, and it will use approximately 1,900 linear feet of the riverbank. DWR's Division of Engineering total project cost estimate for this design is $50.8 million dollars. See Attachment C for pre-feasibility designs and cost estimates.

   Note: The 5,000 cfs diversion facility has a large footprint and consumes almost 2,000 feet of riverbank. Thus, the facility would enter into an area where the river meanders away from the levee, which may not be a good location. If the 5,000 cfs diversion facility continues to be examined, we recommend finding a location other than Compton Landing, one better able to handle a large facility. In contrast, the 2,000 and 3,000 cfs facilities should work well at the Compton Landing site.

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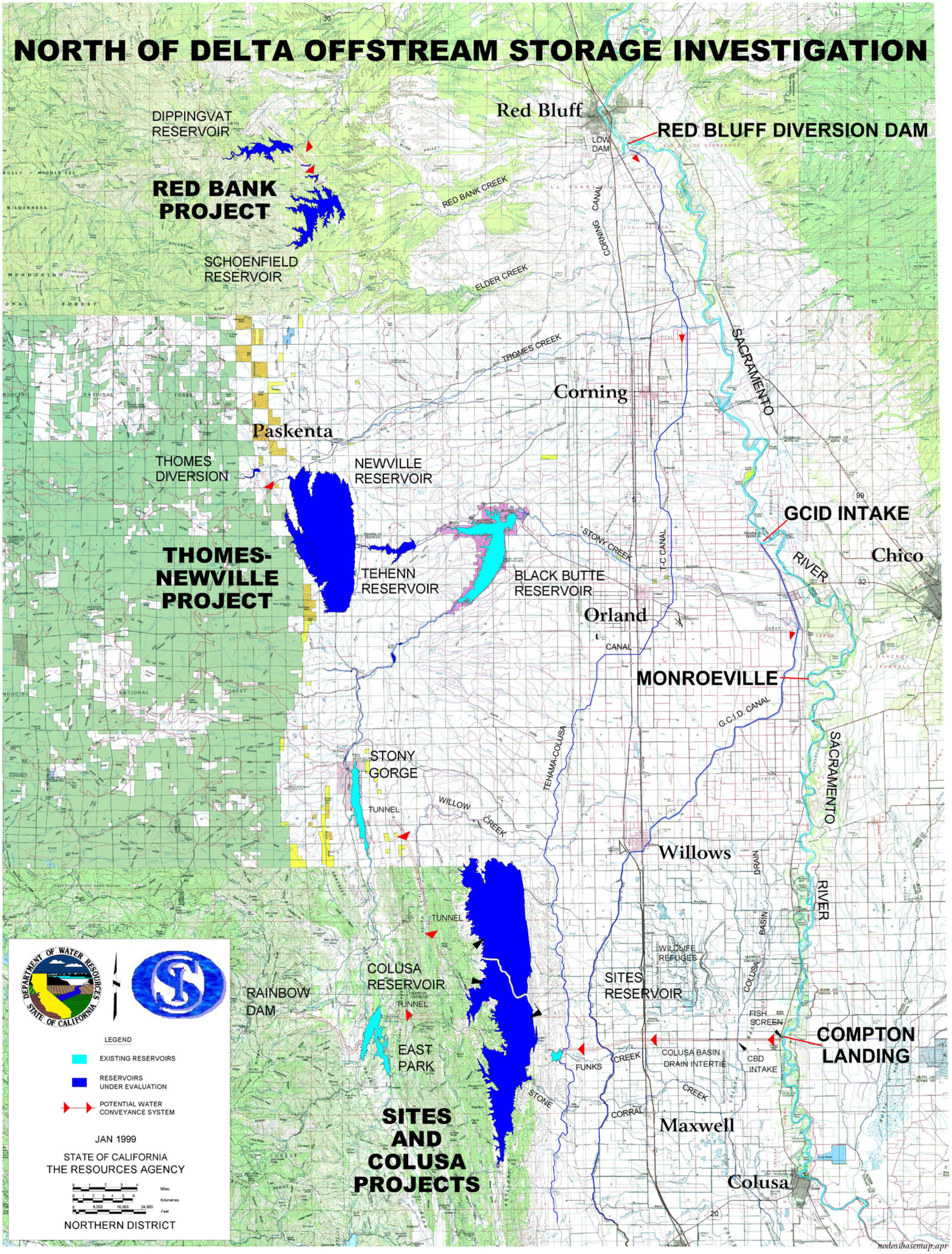
Attachment A: Diversion Location Map



NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION
Red Bluff
RED BLUFF DIVERSION DAM
LOW DAM
DIPPINGVAT RESERVOIR
RED BANK PROJECT
SCHOENFIELD RESERVOIR
RED BANK CREEK
CORNING CANAL
ELDER CREEK
THOMES CREEK
SACRAMENTO
Corning
Paskenta
THOMES DIVERSION
NEWVILLE RESERVOIR
THOMES-NEWVILLE PROJECT
TEHENN RESERVOIR
BLACK BUTTE RESERVOIR
STONY CREEK
T-C CANAL
GCID INTAKE
RIVER
Chico
Orland
CANAL
MONROEVILLE
G.C.I.D. CANAL
TEHAMA-COLUSA
STONY GORGE
TUNNEL
WILLOW CREEK
SACRAMENTO
Willows
DRAIN
BASIN
RIVER
TUNNEL
WILDLIFE REFUGES
COLUSA RESERVOIR
SITES RESERVOIR
RAINBOW DAM
TUNNEL
COLUSA
FISH SCREEN
COMPTON LANDING
EAST PARK
FUNKS
CREEK
COLUSA BASIN DRAIN INTERTIE
CBD INTAKE
CREEK
STONE
CORRAL
SITES AND COLUSA PROJECTS
Maxwell
Colusa
DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
POTENTIAL WATER CONVEYANCE SYSTEM
JAN 1999
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT
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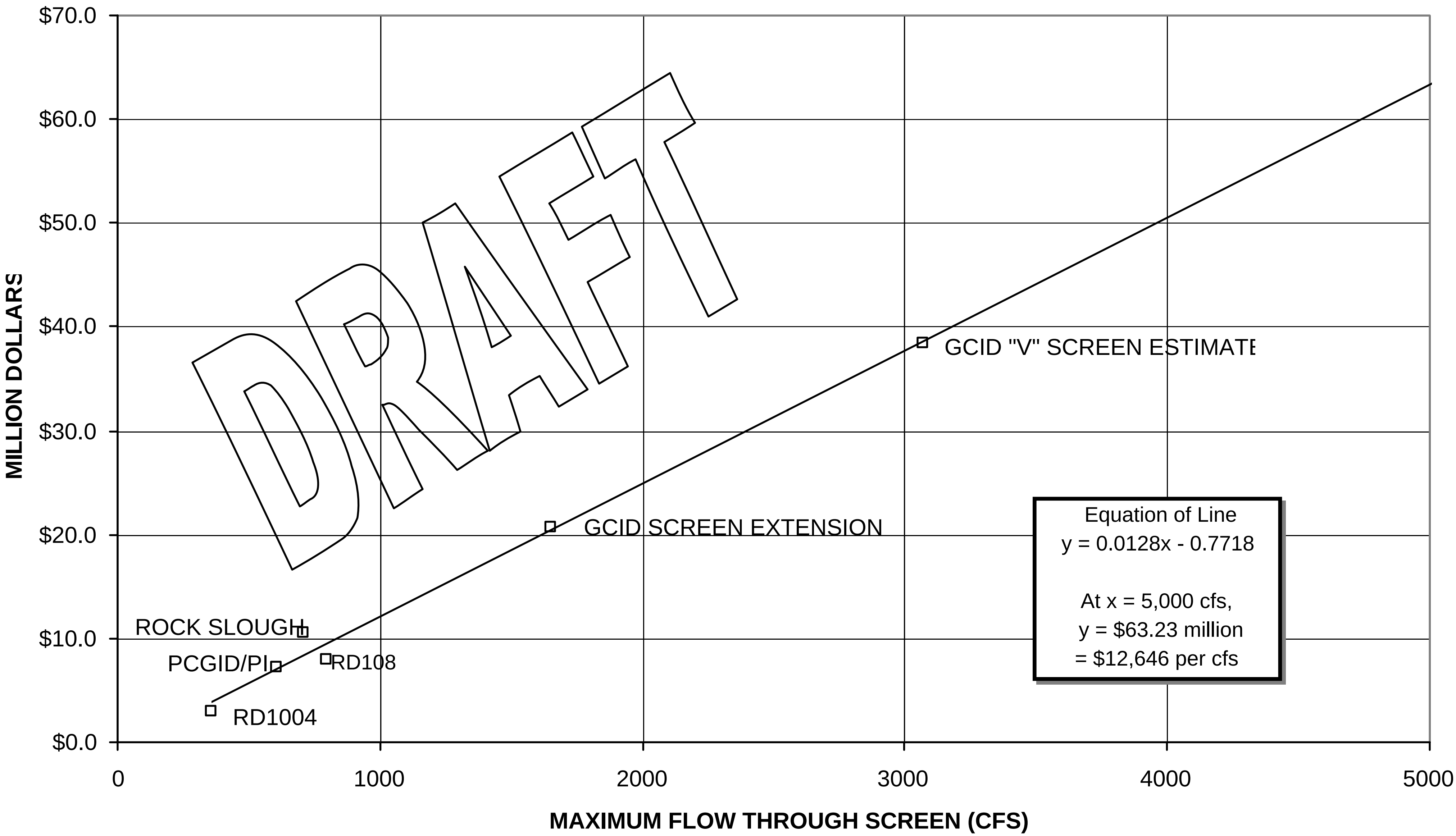
Attachment B: Conceptual Designs and Costs

Figure 1. Northern California Offstream Storage Diversion Intake Construction Cost Estimation



DWR-ESO-FISH FACILITIES

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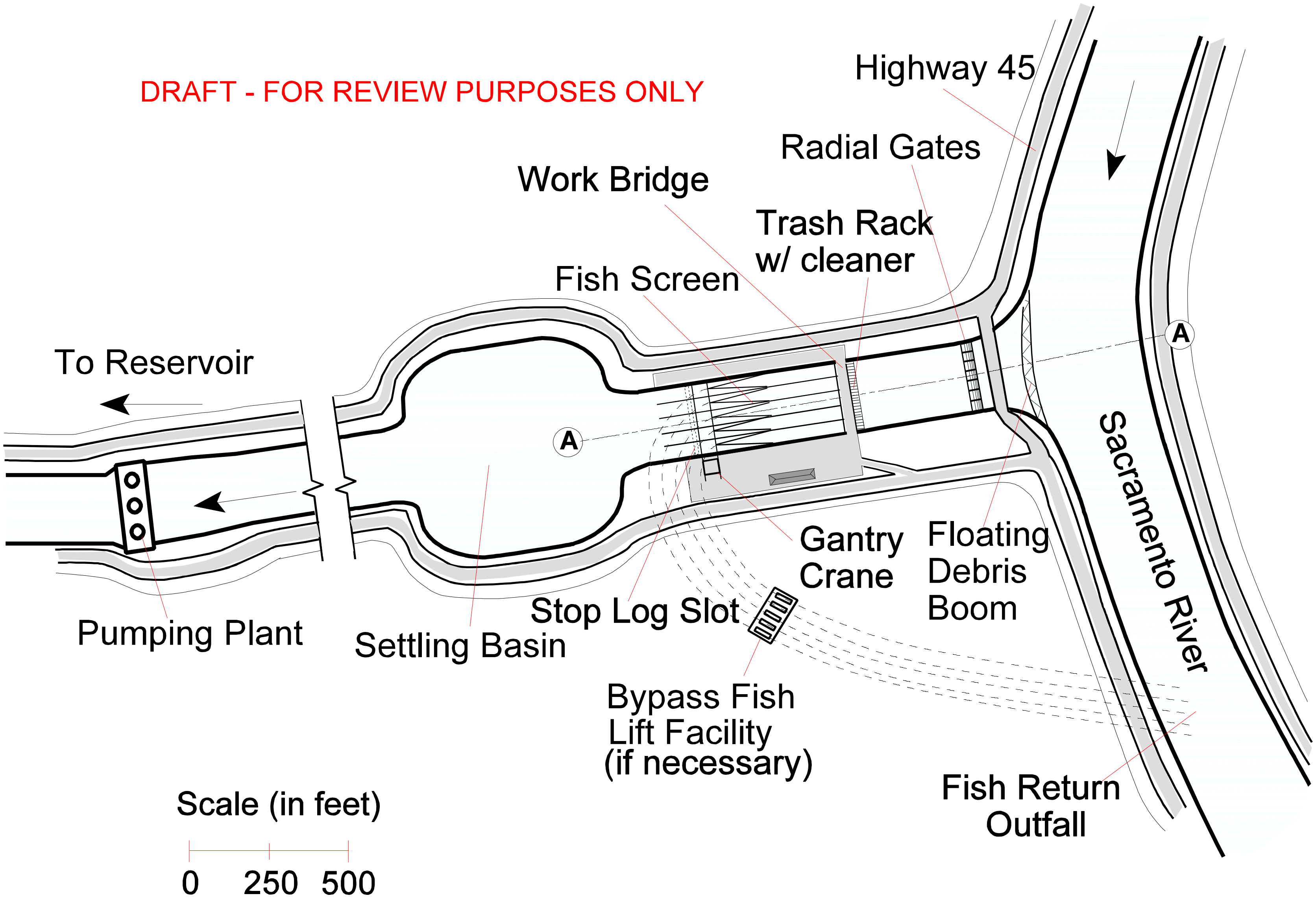

Figure 2. Folded "V" Screens. Off-River Diversion Facility

DWR-ESO-FISH FACILITIES

DWR-ESO-FISH FACILITIES

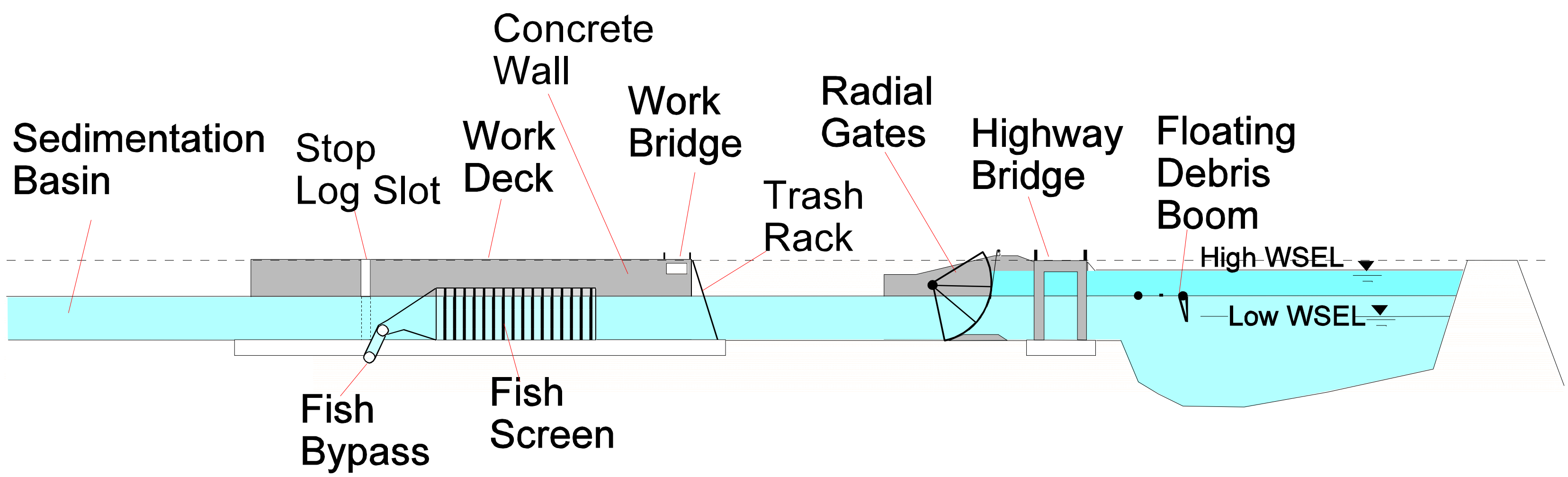

Figure 3. Section A - A Folded "V" Screens

DWR-ESO-FISH FACILITIES

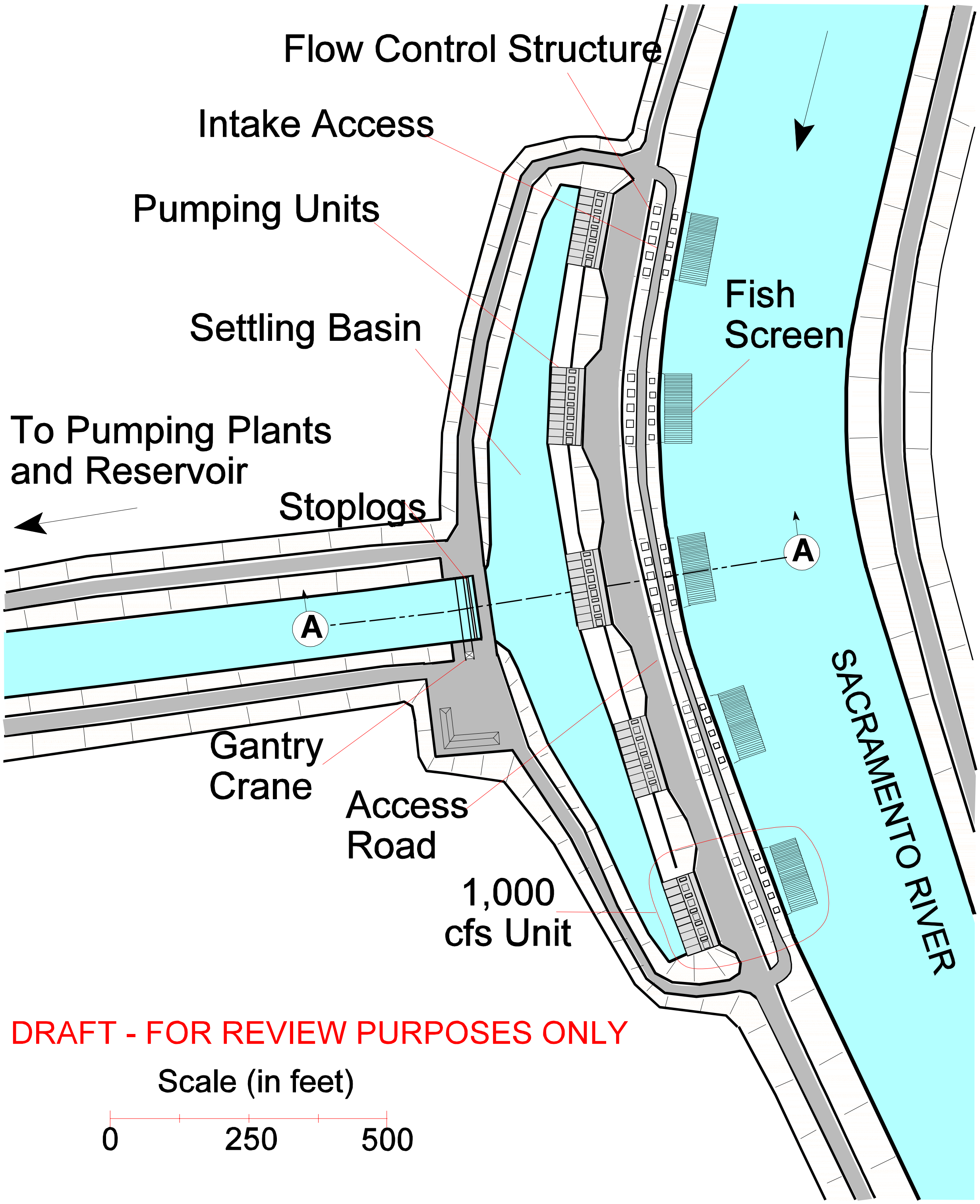

Figure 4. Inclined Flat-Plate Screens. 5,000 cfs On-River Diversion.

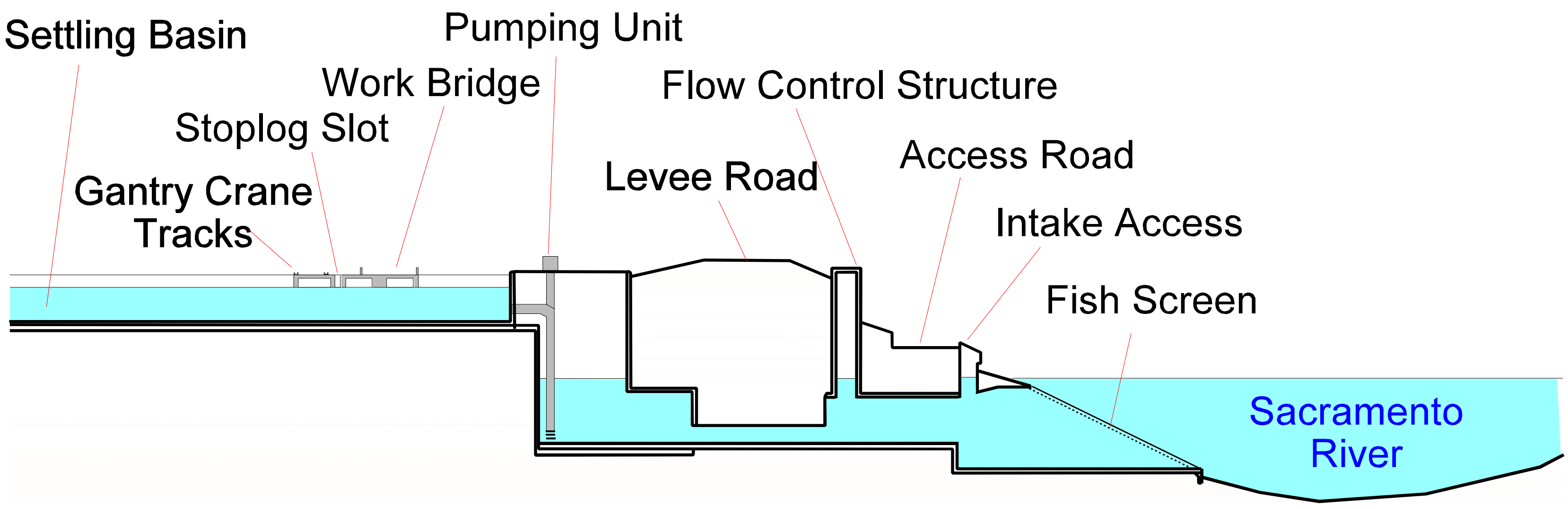

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Figure 5. Section A-A Elevation View of On-River Inclined Flat-Plate Fish Screen

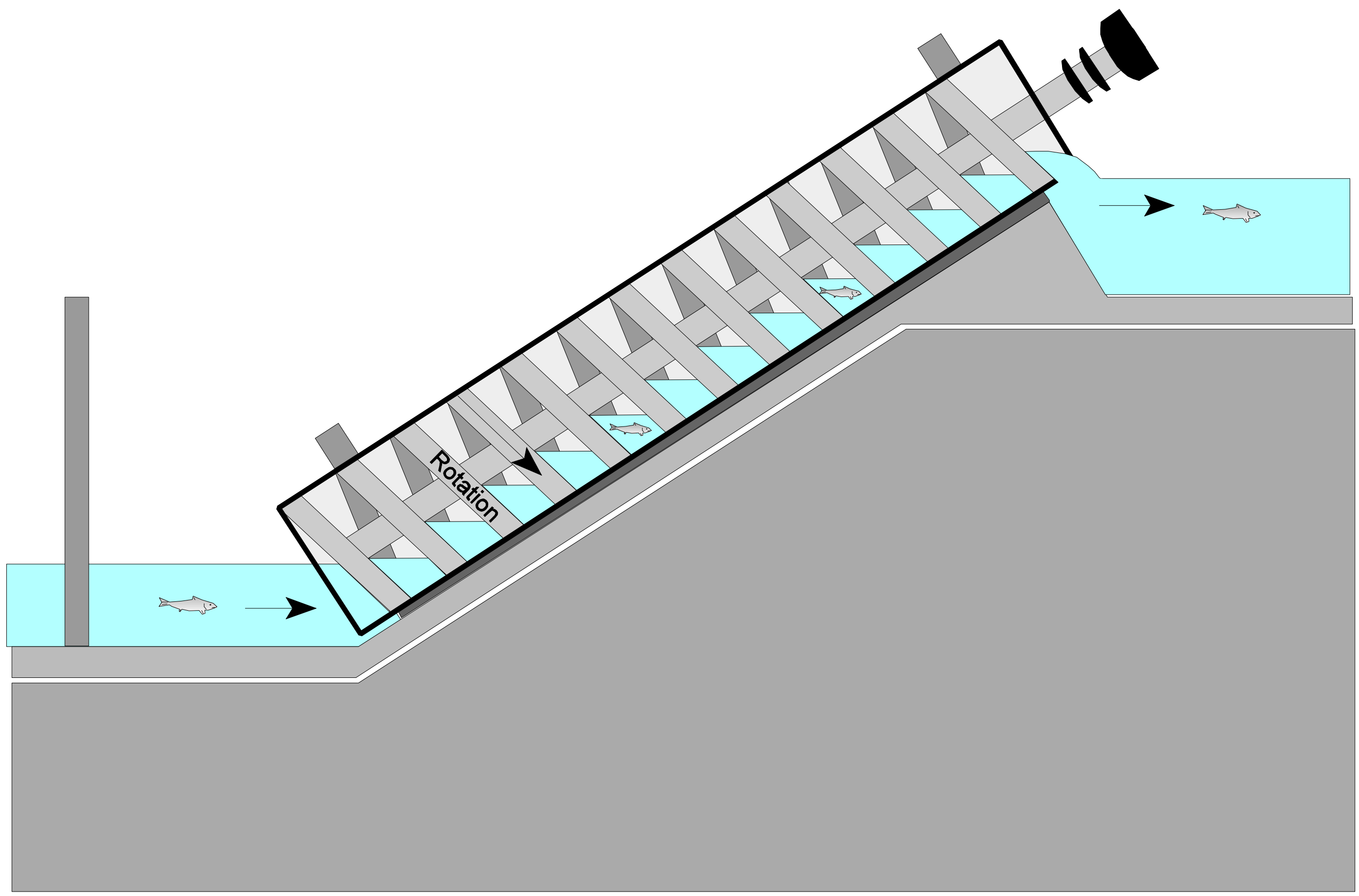


Figure 6. Archimedes Screw Fish Lift

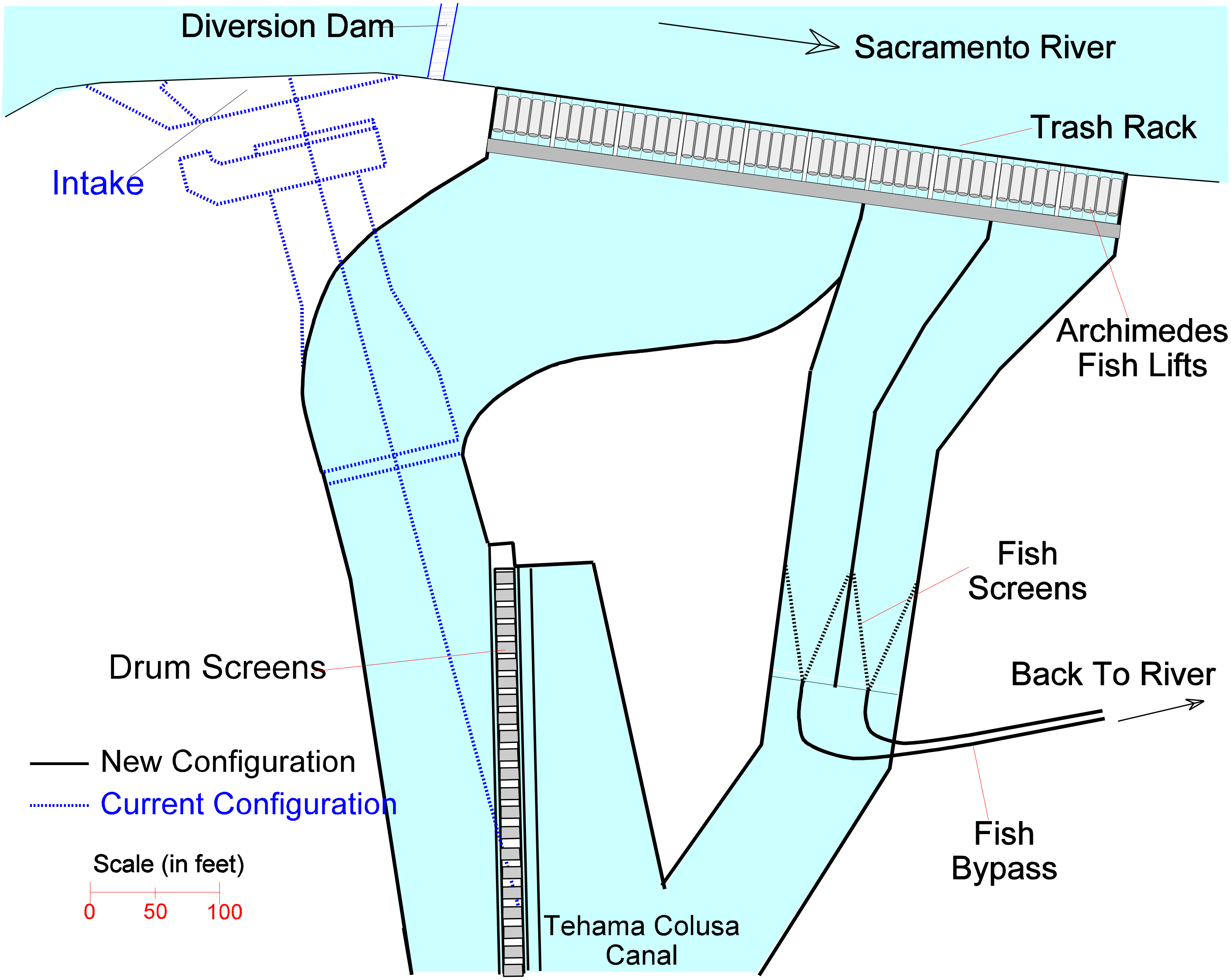
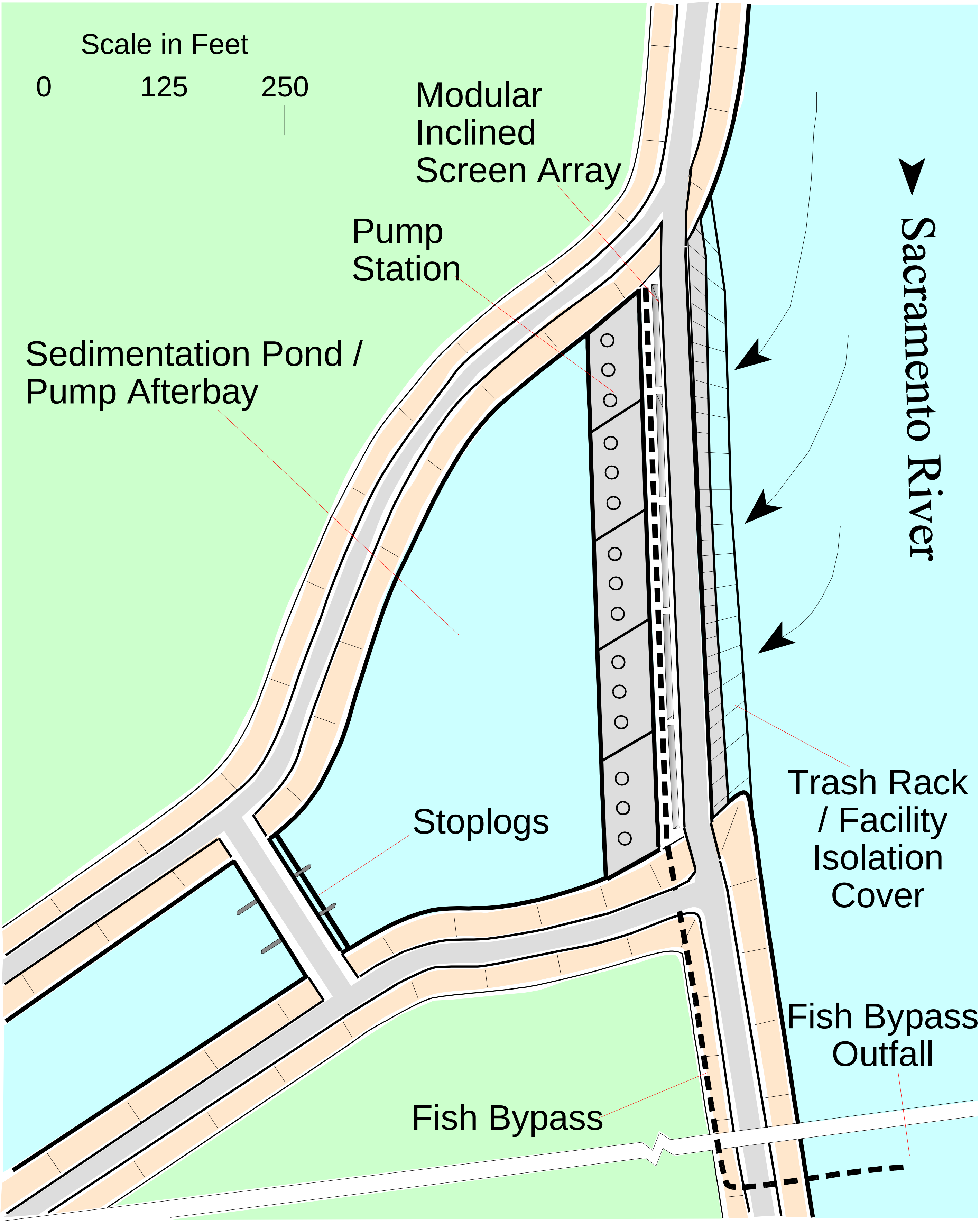


Figure 7. 5,000 cfs Diversion at Red Bluff using Archimedes Fish Lifts



DWR-ESO-FISH FACILITIES

Figure 8. Modular Inclined Screen Plan View

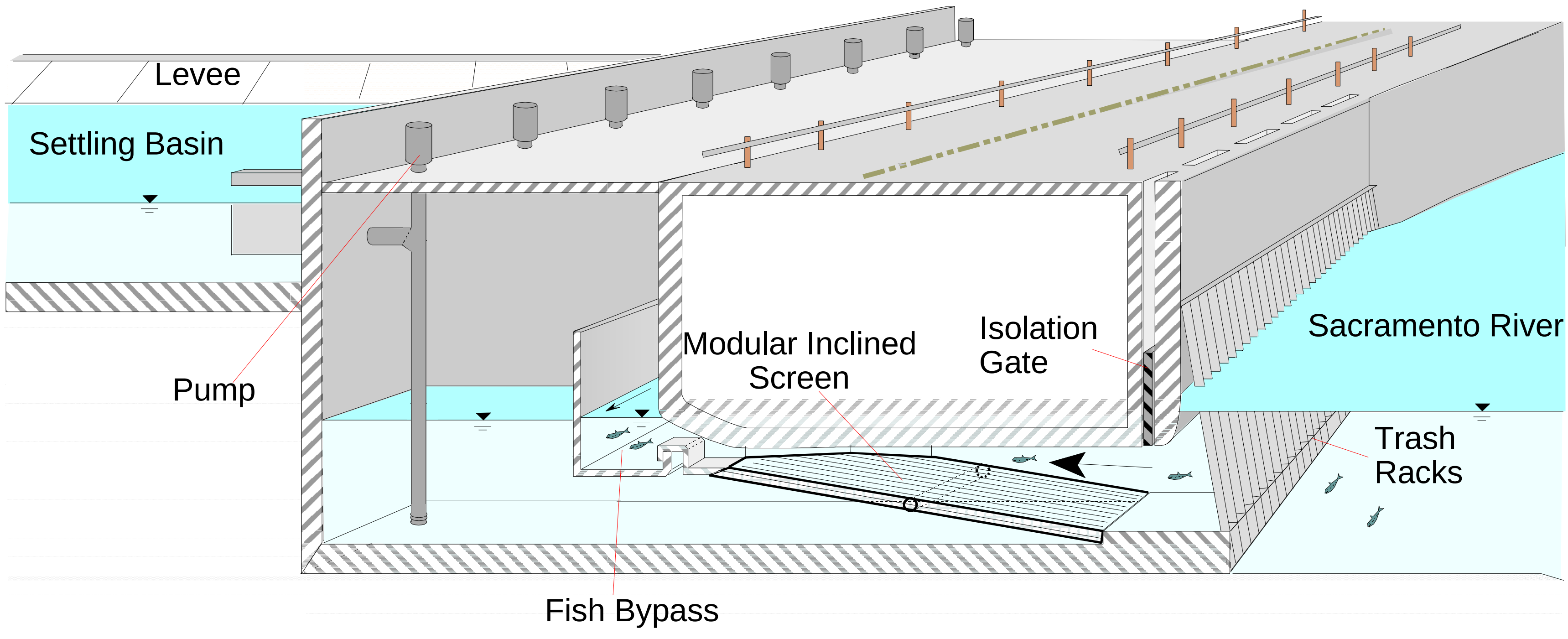


Figure 9. Elevation View Modular Inclined Screen

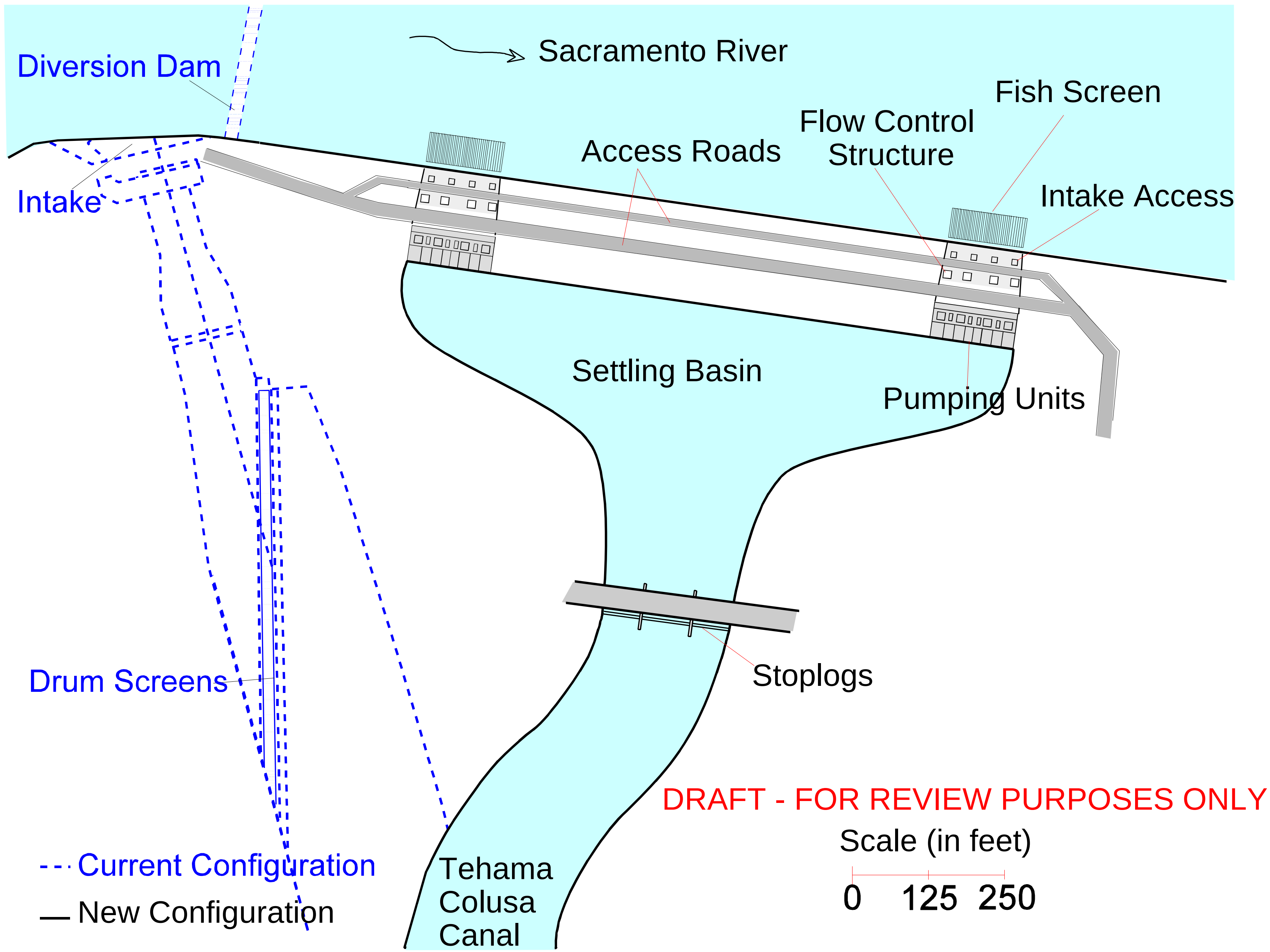


Figure 10. 2,100 cfs On-River Diversion at Red Bluff using Two 1,050 cfs Inclined Flat-Plate Units

DWR-ESO-FISH FACILITIES

Attachment C: Pre-Feasibility Costs

Project: Sites Diversion Structures - 3000 cfs
Feature: Cost Estimate - Flat Screens

Item No.	ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST $
1	Mob/Demob and Site Preparation	LS	1	75,000.00	$ 75,000.00
2	Foundation Dewatering	LS	1	35,573.00	$ 35,573.00
3	Aggregate Base	TON	1,855	26.00	$ 48,230.00
4	Excavation	CY	115,267	4.00	$ 461,068.00
5	Backfill	CY	95,089	5.00	$ 475,445.00
6	Sheet Pile Wall (Steel)	SF	54,965	24.00	$ 1,319,160.00
7	6' Dia. Steel Pipe	LF	1,365	680.00	$ 928,200.00
8	Miscellaneous Metals	LB	72,000	2.00	$ 144,000.00
9	Steel Grating (Walkway System)	LB	50,160	3.00	$ 150,480.00
10	12'x30' Flat Screens (S.S.)	SF	10,800	10.00	$ 108,000.00
11	Screen Frame System (S.S.)	EA	3	15,069.00	$ 45,207.00
12	Structural Conc.(Intake, Radial Gate, Bridge)	CY	19,690	287.00	$ 5,651,030.00
13	Steel Reinforcement	LB	3,938,000	0.50	$ 1,969,000.00
14	Flap Gates	EA	30	21,973.00	$ 659,190.00
15	Sluice Gates	EA	15	121,955.00	$ 1,829,325.00
16	Radial Gates - Steel	LB	50,744	6.00	$ 304,464.00
17	Airburst Screen Cleaning System	LS	1	259,523.00	$ 259,523.00
18	Sediment Removal System	LS	1	215,126.00	$ 215,126.00
19	Electrical Conduit, Fittings & Wire	LS	1	75,000.00	$ 75,000.00
20	Power supply, Electronic Contain. Struct.	LS	1	60,000.00	$ 60,000.00
21	Stone Protection	TON	11,500	40.00	$ 460,000.00
22	Filter Fabric	SF	102,000	1.00	$ 102,000.00
23	Sand Bedding	TON	3,580	18.00	$ 64,440.00
24	Hand Rail	LF	2,120	19.00	$ 40,280.00
25	Equipment Fasteners	LB	10,000	5.00	$ 50,000.00
26	Flow Meters	EA	15	34,125.00	$ 511,875.00
27	Misc. Concrete - Float Anchor, Main. Pad	CY	214	209.00	$ 44,726.00
28	Furnish and Install Barrier Floats	EA	208	293.00	$ 60,944.00
29	Regulatory Floats	EA	7	1,628.00	$ 11,396.00
30	Baffles (Galv. Steel)	LB	106,600	4.00	$ 426,400.00
31	100 cfs Pumps	EA	30	65,520.00	$ 1,965,600.00
32	6' Chain Link Fence	LF	210	34.00	$ 7,140.00

Subtotal	$	18,557,822.00
35% Contingency	$	6,495,237.70
Direct Pay	$	25,053,059.70
Design&Administrative(10%)	$	2,505,305.97
Construction Supervision(10%)	$	2,505,305.97
Total Project Cost =	$	30,063,671.64

Project: Sites Diversion Structures - 5000 cfs
Feature: Cost Estimate - Flat Screens

Item No.	ITEM	UNIT	QUANTITY	UNIT COST		ITEM COST $
1	Mob/Demob and Site Preparation	LS	1	100,000.00	$	100,000.00
2	Foundation Dewatering	LS	1	35,573.00	$	35,573.00
3	Aggregate Base	TON	3,750	26.00	$	97,500.00
4	Excavation	CY	159,933	4.00	$	639,732.00
5	Backfill	CY	179,745	6.00	$	1,078,470.00
6	Sheet Pile Wall (Steel)	SF	83,915	24.00	$	2,013,960.00
7	6" Dia. Steel Pipe	LF	3,000	681.00	$	2,043,000.00
8	Miscellaneous Metals	LB	120,000	2.00	$	240,000.00
9	Steel Grating (Walkway System)	LB	83,640	3.00	$	250,920.00
10	12'x30' Flat Screens (S.S.)	SF	18,000	10.00	$	180,000.00
11	Screen Frame System (S.S.)	EA	5	15,069.00	$	75,345.00
12	Structural Conc.(Intake, Radial Gate, Bridge)	CY	32,370	287.00	$	9,290,190.00
13	Steel Reinforcement	LB	6,474,000	0.50	$	3,237,000.00
14	Flap Gates	EA	50	21,973.00	$	1,098,650.00
15	Sluice Gates	EA	25	121,955.00	$	3,048,875.00
16	Radial Gates - Steel	LB	50,744	6.00	$	304,464.00
17	Airburst Screen Cleaning System	LS	1	431,143.00	$	431,143.00
18	Sediment Removal System	LS	1	344,614.00	$	344,614.00
19	Electrical Conduit, Fittings & Wire	LS	1	150,000.00	$	150,000.00
20	Power supply, Electronic Contain. Struct.	LS	1	100,000.00	$	100,000.00
21	Stone Protection	TON	26,220	40.00	$	1,048,800.00
22	Filter Fabric	SF	233,000	1.00	$	233,000.00
23	Sand Bedding	TON	8,160	18.00	$	146,880.00
24	Hand Rail	LF	3,550	19.00	$	67,450.00
25	Equipment Fasteners	LB	16,000	5.00	$	80,000.00
26	Flow Meters	EA	25	34,125.00	$	853,125.00
27	Misc. Concrete - Float Anchor, Main. Pad	CY	356	209.00	$	74,404.00
28	Furnish and Install Barrier Floats	EA	329	293.00	$	96,397.00
29	Regulatory Floats	EA	11	1,628.00	$	17,908.00
30	Baffles (Galv. Steel)	LB	178,000	4.00	$	712,000.00
31	100 cfs Pumps	EA	50	65,520.00	$	3,276,000.00
32	6' Chain Link Fence	LF	210	34.00	$	7,140.00

Subtotal	$	31,372,540.00
35% Contingency	$	10,980,389.00
Direct Pay	$	42,352,929.00
Design&Administrative(10%)	$	4,235,292.90
Construction Supervision(10%)	$	4,235,292.90
Total Project Cost =	$	50,823,514.80

Attachment D: Field Visits

Table 1. Field Visits

Date	Site	Purpose
June 12, 1998	Colusa Basin Drain	Tour of lower portion of the drain
June 19, 1998	Colusa Basin Drain	Tour of upper portion of the drain
July 1, 1998	Colusa Basin Drain	Tour of drainages that empty into the drain
November 4, 1998	Rd108 Intake On The Sacramento River	Investigate vertical flat-plate fish screen
November 1998	Rancho Esquon Intake (Adams Dam) On Butte Creek	Investigate inclined flat-plate fish screen
November 1998	Rd1004 Intake On The Sacramento River	Investigate inclined flat-plate fish screen
November 1998	Durham Mutual Intake On Butte Creek	Investigate inclined flat-plate fish screen
November 30, 1998	Gcid Intake On The Sacramento River	Investigate vertical flat-plate fish screen
November 30, 1998	Stony Creek	Investigate siphon under stony creek
November 30, 1998	Pcgid/Pid Intake On The Sacramento River	Investigate inclined flat-plate fish screen
January 19, 1999	Los Vaqueros Intake On Old River	Investigate flat-plate fish screen
May 4 And 5, 1999	Gorrill Ranch Intake On Butte Creek	Hydraulic investigation of vertical flat-plate fish screen

Attachment E: Colusa Basin Drain Discussion Paper

State of California The Resources Agency

DEPARTMENT OF WATER RESOURCES

OFFICE MEMO

TO: Naser Bateni

DATE: August 4, 1998

SUBJECT: Colusa-Basin Drain diversion

FROM: Leslie Millett, (916) 227-1076
Ted Frink, (916) 227-0177
Environmental Services Office

This memo contains information that we have gathered about the Colusa-Basin Drain (CBD), sensitive fish species that may use the area, and an option for diverting water from the CBD. In previous discussions, the question was raised as to whether it would be necessary to screen a diversion on the CBD for juvenile chinook salmon, steelhead and splittail. There are three ways that salmonids and splittail could enter the CBD.

The first way these species could enter the drain is through the Yolo Bypass. At the southern end, the Yolo Bypass (Bypass) begins at Prospect Slough at Little Holland Tract. The Yolo Bypass Toe Drain (Toe Drain) flows directly into Prospect Slough. Prospect Slough is an off shoot of Cache Slough which connects to the Sacramento River at southern tip of Ryer Island. The Toe Drain contains water year round and runs the entire length of the Bypass. The Knights Landing Ridge Cut connects the Bypass to the CBD. An employee of Rosemount Farms informed us that water from the CBD flows year round through the Knights Landing Ridge Cut and into the Toe Drain. However, DFG (1982) reported that flow in the Knights Landing Ridge Cut was less than 1 cfs in the summer of 1980. Therefore, the connection between the CBD, the Yolo Bypass, and the Sacramento River is unobstructed and may allow for year round continuity in some years.

DWR staff began monitoring for splittail and salmon in the Yolo Bypass in 1997. They have seen adult chinook salmon, possibly spring-run, within the Bypass and have heard consistent reports of fall-run chinook salmon migrating up the Toe Drain in autumn (Sommer, personal communication). Juvenile chinook salmon and adult and juvenile splittail are captured within the Bypass from January through June. Juvenile salmon have been shown to migrate 12 kilometers upstream for rearing in tributaries to the Sacramento River (Maslin *et al.* 1997). Salmon and splittail could move from the Bypass and into the CBD. Additional sampling would be necessary to determine the upstream extent of any movement by both adults and juveniles.

The second place fish species may enter the CBD is through the Knights Landing Outfall Gates (Outfall Gates). The purpose of the Outfall Gates is to let CBD water into the Sacramento River. The Outfall Gates are operated electronically and triggered by stage levels in the CBD and in the Sacramento River. The Outfall Gates are opened when stage levels in the CBD are higher than levels in the Sacramento River, and closed when the reverse occurs.

The third way fish species may enter the CBD is through reclamation district diversions off the Sacramento River. There are 140 unscreened diversions on the west side of the Sacramento River from Knights Landing to Red Bluff Diversion Dam. Many of these fall within the CBD's 75 mile alignment. Within the Colusa-Basin drainage area, Provident Irrigation District and Princeton-Cordura-Glenn Irrigation District divert Sacramento River water year round (Boyd, personal communication). The Sacramento River water is used first on agricultural fields and then put into the CBD. Because water temperatures may not be lethal to salmon in the winter months, we can not rule out the possibility of salmon surviving within distribution ditches and being transferred into the CBD. Department of Fish and Game staff reported that there are numerous unscreened diversions along the CBD that entrain young salmon (Odenweller, personal communication). More work would need to be done to determine the number of unscreened Sacramento River diversions along the drain, the path of Sacramento River water through agricultural fields and ditches to the CBD, and sampling for juvenile salmon.

The sources of water in the CBD are the Glenn-Colusa Canal, which contains Sacramento River water, return flows from agriculture, diversions off the Sacramento River which use the CBD for conveyance (e.g. Maxwell Irrigation District), treatment plant effluent, and west side tributaries. The importance of the origins of the waters in the CBD leads to whether the adult salmonids migrating upstream are doing so as strays from the Sacramento River or whether they are returning to natal streams in the tributary streams.

The main question is whether or not there is a sustainable population of salmonids. There may not be a sustainable population of steelhead in the west side tributaries because the summer rearing habitat is probably not adequate. However, surveys of the tributaries should be done to definitely determine this. At this time, critical habitat for steelhead within California has not been proposed by National Marine Fisheries Service (NMFS) and information on steelhead use in the Colusa-Basin drainage is not available from Department of Fish and Game. Critical habitat has been proposed for Chinook salmon by NMFS. One critical habitat area for fall-run Chinook salmon includes Salt Creek and Stone-Corral Creek, both tributaries to the Colusa-Basin Drain. These creeks may not be included in the final critical habitat decision but are currently included in the proposed areas.

Anecdotal observations are plentiful that chinook salmon migrate up the CBD beginning in mid-August, specifically in the vicinity of the Delevan National Wildlife Refuge. Documentation is not available. In 1988 or 1989, a fish passage facility was installed at Maxwell Irrigation District's Delevan weir. The fish passage facility provides salmon access to the CBD and tributaries upstream from the weir. An employee at the Delevan National Wildlife Refuge has seen adult salmon trapped in the fields that were flooded with water from the Glenn-Colusa canal. In addition, a resident who lives on Walker Creek, tributary to Willow Creek, has often seen adult salmon in the creek. The resident said the creek is spring-fed, although the local warden has seen it dry in September.

Future investigations should document whether there is successful reproduction in the tributaries to the CBD. The most likely run that could be sustained would be the fall-run simply because low flows and high temperatures during much of the year would not support other salmon runs or steelhead. The question remains whether the substrate of the stream channels is sufficiently free of fines, whether flows remain at suitable levels, and whether water temperatures remain low enough to allow successful incubation of salmon eggs. Future surveys and sampling would be necessary to resolve these questions.

If reproduction of salmon within the tributaries to the Colusa-Basin Drain can be ruled out, it may be preferable to prevent adult salmonids from moving into the CBD. One possible option would be to block access into the CBD at a location where the fish could have access back into the Sacramento River. An adult salmon exclusion/guidance and passage facility could be constructed at the junction of the CBD and the Knights Landing Ridge Cut near the Outfall Gates. The facility would consist of two parts: 1) A guidance/exclusion structure which could be either a bar trash rack with 3 - 4 inch spacing, or a louver screen similar to those used at the State and Federal pumps and fish facilities in the south Delta; and 2) a fish ladder constructed at the Outfall Gates to allow salmon passage back into the Sacramento River. In combination, these facilities could guide adult salmon away from the channels leading into the upper CBD and allow them passage back into the Sacramento River.

The trashrack-louver guidance structure placement would be at the junction of CBD and the Knights Landing Ridge Cut (T. 11 N., R. 2 E., Sect. 15). The structure design could be an upstream pointed "V", of narrow spaced trashrack bars or a series of angled louver panels within the CBD just upstream of the confluence with the Knights Landing Ridge Cut. A second possible design could have the trashrack or louvers angle (approximately SW to NE) across the confluence of the CBD at the Knights Landing Ridge Cut to direct adult salmon around the corner toward the Outfall Gates. Either of these design options would have to be removable, require sizing to have some ability to function well under high flow conditions, and be able to withstand debris loads or have cleaning facilities designed for them.

The benefits of the trashrack/louver system is that it will have narrow spacing of the bars or louvers so that adult salmon would not be able to pass through the barrier. However, other native species that are smaller than salmon as adults would still be able to move into the CBD or tributaries. DFG staff indicated that if juvenile salmon use the Colusa-Basin Drain for rearing similar to their use of upper Sacramento River tributaries (Maslin *et al.* 1997), it would not be desirable to block juvenile salmon movement into and out of the CBD (McKee, personal communication).

The adult salmon guided away from the CBD toward the Knights Landing Outfall Gates would then need an opportunity to access the Sacramento River to continue their upstream migration. The Outfall Gates are a barrier to fish passage currently, since they are closed most of the time. When the Outfall Gates are open, it is only to allow floodwater to spill into the Sacramento River from the CBD. The gates themselves are only gated pipes, which would not provide adequate passage opportunities for adult salmon. A relatively straightforward solution to provide passage would be to construct a fish ladder that could provide continuous access over the Outfall Gates to the Sacramento River. A ladder would also provide attraction flow to help guide the salmon to the ladder entrance.

Currently, some water leaks from the Outfall Gates. Additional water drawn through a ladder and put into the lower portion of the CBD would provide some additional attraction to adult salmon, however the ladder would allow salmon to pass back into the Sacramento directly. The amount of water contributed by a ladder would not have a significant effect on flood levels downstream from the dam.

There are many designs of fish ladders that could possibly be constructed at the Outfall Gates. Additional surveys and site specific information would be necessary to select an appropriate ladder design. The ladder design would need to take into account flood water levels and the water surface level fluctuations, and debris loads that occur on the Sacramento and within the CBD. From this information, a ladder could be designed to operate under the flow variations at the site and over a range of seasons. The goal is to maximize the operational flow range of a ladder and provide the most continuous time period that adult salmon could functionally pass through the ladder.

Additional work would also be required to research possible designs of the trashrack/louver system. Once designs were drafted out then estimates of construction costs could be made for any feasible options. This option to exclude salmon from traveling up the

CBD would rely on additional information and data gathered on numbers of adult salmon and spawning locations, if any. Additional data is critical, especially on the reproductive success of adult salmon that enter the CBD and travel into the upper drainage. Also, additional information regarding the use of the CBD by native fishes would need to be considered in any facility that aims to selectively exclude fish based on size, and in the design of a fish ladder that could pass many species.

If flow is diverted from the CBD, additional evaluations should be done to determine how much water the CBD contributes to the Yolo Bypass. The impact of reducing flows from the CBD to the Bypass should be assessed since the Bypass is an important spawning and rearing area for splittail and chinook salmon (Sommer 1998).

Unless data are gathered that indicates otherwise, staff from NMFS and DFG recommend we plan for a screen on the diversion within the CBD (McKee and Mobley, personal communications). ESO staff recommend that if a Colusa Basin Drain diversion is considered and depending on results of investigations mentioned above, the feasibility analysis should include a screening facility on the diversion structure to screen out juvenile salmonids and splittail and/or a screening facility to keep adult salmonids out of the CBD. If there is a continued interest to divert from the drain, then staff recommend that a sampling program be developed to evaluate the nature of salmonid and splittail use of the CBD.

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State of California
The Resources Agency
Department of Water Resources
Division of Planning and Local Assistance

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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix P: Sites and Colusa Reservoir Projects, Construction Materials Sampling and Testing

August 2000

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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix P: Sites and Colusa Reservoir Projects, Construction Materials Sampling and Testing

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Northern District
California Department of Water Resources

August 2000

Integrated
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Investigations

CALFED
BAY-DELTA
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Contents

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Introduction

This report presents the results of ongoing and previous investigations of construction materials for the proposed Sites Dam, Golden Gate Dam, and associated saddle dams for Sites Reservoir, and to a lesser extent the proposed Hunters Dam and Logan Dam for Colusa Reservoir. This investigation is part of the analysis of several alternative dam/reservoir sites being proposed for offstream storage as part of the North of the Delta Offstream Storage Investigation. The investigation focused on the materials required for earthfill and rockfill structures. Issues addressed include the geology of the site vicinity; occurrence of impervious materials in terrace deposits; suitability of sandstone for random fill, aggregate, and riprap; and occurrence of appropriate aggregate sources within a reasonable haul distance.

The proposed Sites Dam and Golden Gate Dam would impound a reservoir (Sites Reservoir) with a capacity of 1.8 million acre-feet and the addition of Hunters Dam and Logan Dam would result in a reservoir (Colusa Reservoir) with a capacity of 3.0 million acre-feet. The location of the proposed reservoirs is shown on Figure 1.

Previous Work

Sites and Golden Gate dam sites were previously investigated by the United States Bureau of Reclamation in 1969 and 1980. The Hunters and Logan dam sites have only had reconnaissance-level work performed by the Department of Water Resources. Several studies have investigated the availability and suitability of construction materials for these dam sites.

A report entitled *Engineering Geology Appendix-Part II* (USBR, Project Development Division, Geology Branch, 1969) provides geologic data for USBR's use in preparing cost estimates for proposed canals, dams, and a pumping-generating plant. That report includes: 1) descriptions of the sandstone units and terrace deposits proposed for use as aggregate, riprap, random fill, and impervious material; 2) maps of the units and locations of trench and auger sites; 3) results of laboratory testing; and 4) estimates of the volume of construction materials located near each proposed dam site. The USBR investigation included mapping proposed impervious materials from terrace deposits in the valley upstream from each site and delineating proposed rock quarrying at the old Sites Quarry and on the southeast ridge at Golden Gate. Summary results of the USBR testing and analysis, and volume estimates are presented in Table 1 and areas investigated are shown on Figure 2.

USBR conducted additional studies on saddle dams and rock testing and published a report *Construction Materials Report for Sites Dam, Golden Gate Dam, and Dike Sites* (USBR, Mid-Pacific Region Geology Branch) in 1980. The results of this testing are presented in Table 2. DWR reviewed data from previous work and submitted a Memorandum Report entitled "Colusa Reservoir Complex" in 1978. This report gives preliminary cost estimates for dam and spillway construction for the proposed Colusa Reservoir.

Table 1. Construction Materials Summary from USBR (1969)

Designation (Figure 1)	Stripping Depth (ft)	Avg. Thickness (ft)	Depth to Water (ft)	Oversize	Volume of Material (cu. yd.)	Lithology	Source	Liquid Limits	Plasticity Indices	Compacted Density lb/ft^3
					IMPERVIOUS SOURCES					
Area 1	0.5-1	10.5	8.0-15.7	0-5% 5"max.	9,800,000	Lean clay (CL), minor clayey gravelly sand (SC)	Quaternary Terrace Deposits	35.8-36.3	16.4-17.5	106.4-107.8
Area 1a		9	9.0-11.7	None encountered	2,800,000	Lean clay (CL)	Quaternary Terrace Deposits			
Area 2	0.5-1	9	5.5-30	None encountered	13,700,000	Lean clay (CL), minor Sandy Clay (CL-ML) and silty Sand (SM-GM)	Quaternary Terrace Deposits and Alluvium	30.2-34.9	10.9-16,2	105.7-110.0
Area 2a		10.7	6.5-30	None encountered	4,400,000	Same	Same			
Area 3	0.5	8	Not in Alluvium	None encountered	2,400,000	Lean Clay (CL)	Quaternary Alluvium	35.5-40.7	15.7-21.6	106.8
Area 4	0.5	7.5	7.5-10.5	Trace 5" max.	2,900,000	Lean Clay (CL), minor Clayey Gravelley Sand (SC)	Quaternary Terrace Deposits	NA	NA	NA
					RIPRAP - ROCKFILL, BEDDING					
Area 5	5.0-10	250	Not in quarry area	NA	15,000,000	Lightly weathered to fresh cemented sandstone	Venado Formation			
					2,000,000	Slopewash, moderatedly weathered sandstone, siltstone, claystone, thin bedded sandstone				
Area 6	5.0-10	250		NA	6,000,000	Lightly weathered to fresh cemented sandstone	Venado Formation			
					800,000	Slopewash, moderatedly weathered sandstone, siltstone, claystone, thin bedded sandstone				
Area 7	5.0-10	250	Not in quarry area	NA	11,900,000	Lightly weathered to fresh cemented sandstone	Venado Formation			
					1,800,000	Slopewash, moderatedly weathered sandstone, siltstone, claystone, thin bedded sandstone				

DRAFT

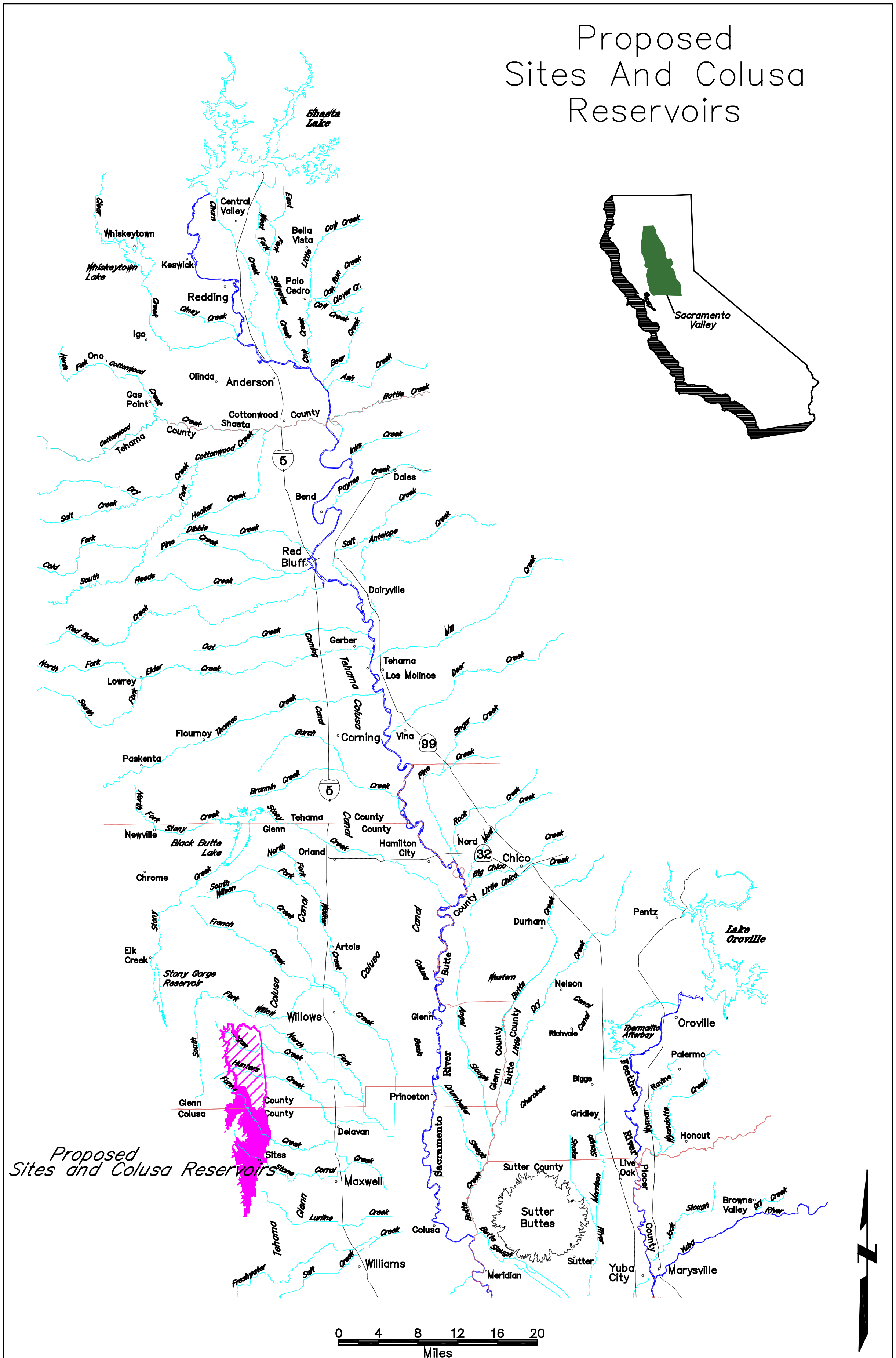

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Figure 1. Sites and Colusa Reservoirs Regional Location Map

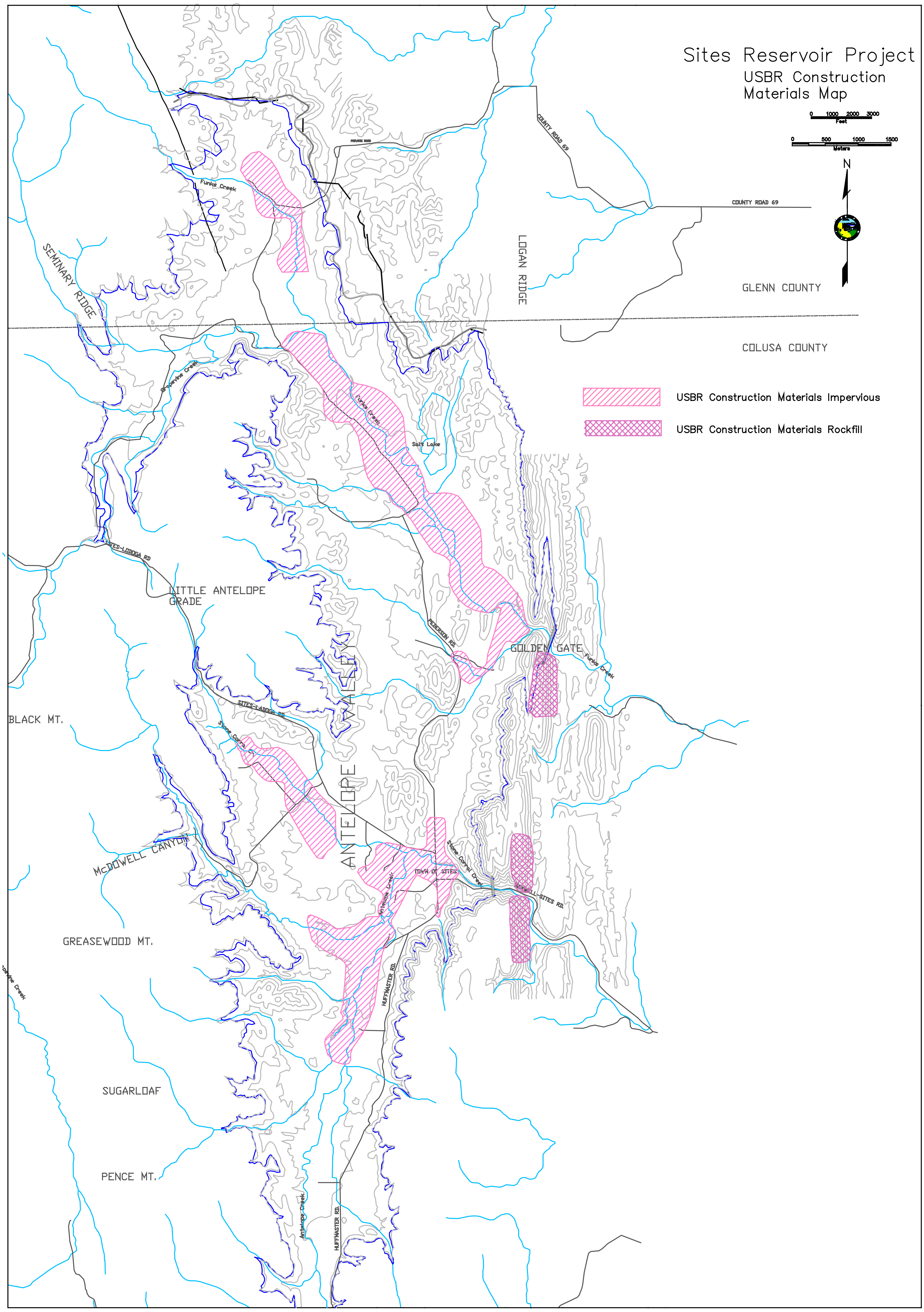


Figure 2. USBR Construction Materials Source Areas

Table 2. Historic Rock Test Data from USBR, 1969 and 1980

Date of Sampling	Sample	Specific Gravity S.S.D.	Absorption	Abrasion (L.A. Rattler)	Soundness (Mg SO4)	Wetting and Drying	Notes
1962	#1 Weathered Sandstone	2.44	3.4%	45% loss	Relatively High Loss	"after 15 cycles in fresh & salt water a noticeable softening and loosening of surface grains is evident"	Samples from old Sites Quarry tested by the U.S. Army Corps of Engineers for use as riprap on Sacramento River levees.
	#2 Fresh Sandstone	2.58	3.3%	39.1% loss	92.50%	"Slight surface sloughing"	
	#3 Fresh Sandstone	2.5	3.5%	34.1% loss	15% loss	Not Reported	
1972	Poorer of The Brown #1	2.42	6.1%				Sample of 500 pounds of rock from Sites Quarry 1 mile east of Sites, California. Samples analyzed by USACE
	#2	2.37	7.0%				
	#3	2.41	6.3%				
	Better of The Brown #1	2.44	4.8%	39%		"Better of the Brown" specimens flaked during the entire test.	
	#2	2.44	4.8%				
	#3	2.41	4.1%				
	Blue #1	2.43	4.1%	26%		"blue" rock parted along joints during the twelfth cycle. Minor flaking occurred to all "Blue" specimens throughout the test	
	#2	2.5	2.9%				
	#3	2.45	3.1%				
1974	1.5"-.75"	2.47	4.4%	18.9%/100			Sample of quarry rock from Sites Quarry South tested by Bureau of Reclamation Denver, CO. Sample from lower in quarry
	.75"-.375"	2.47	5.1%	52.6%/500			
	.375"-#4	2.45	6.0%				

Scope of Study

This study assessed the availability of adequate construction materials for the proposed earthfill dams. This was accomplished by reviewing the available data, performing field investigations, sampling, laboratory testing, and compiling the data into this report. The types of construction materials required for dam construction include impervious materials, rock and random fill, filter and drain material, and concrete aggregate. The geologic materials investigated include terrace deposits, sandstone, and commercial or developable sand and gravel deposits.

This study concentrated on refining the volume estimates and boundaries of the terrace and sandstone deposits previously investigated, performing additional laboratory testing of the materials to ensure conformance to the necessary standards, and evaluating additional rock sources for Golden Gate Dam.

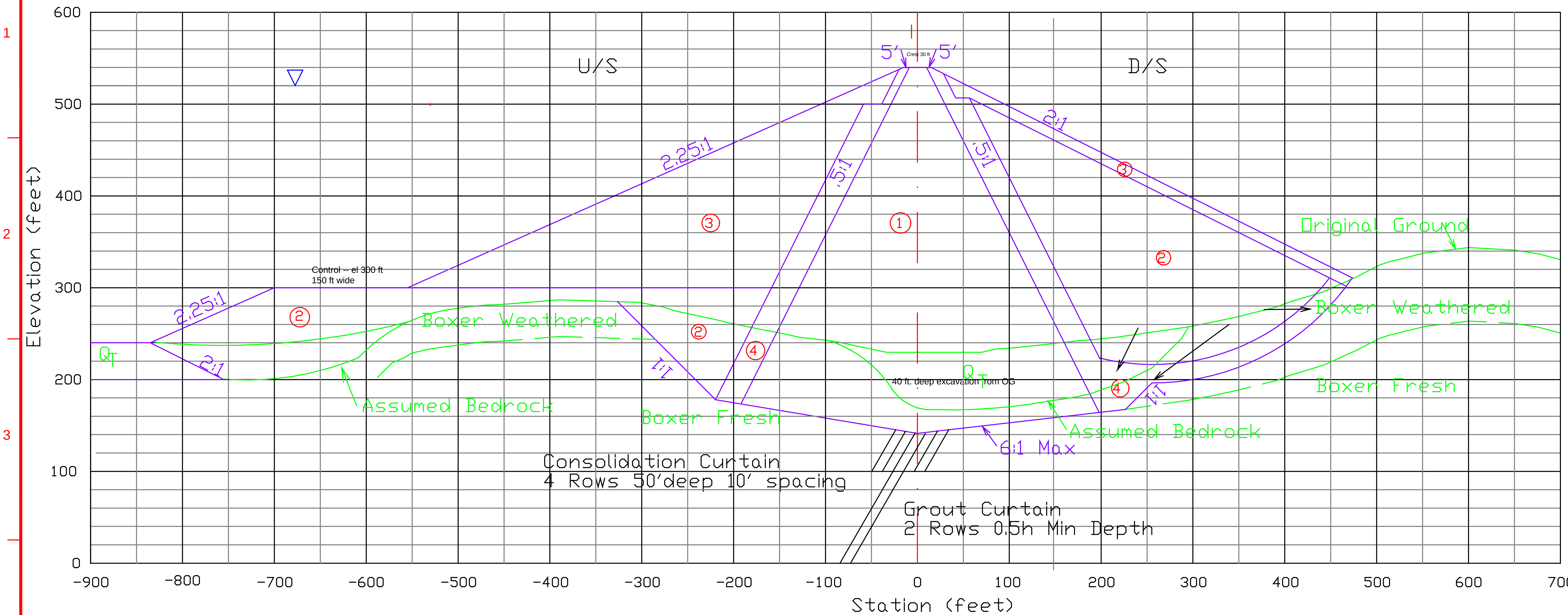
Previous investigations for the Logan and Hunter dam sites were limited, so this study provides preliminary mapping of source areas, field reconnaissance, and limited laboratory testing to confirm the suitability of the material.

Aggregate studies were done because it was questionable that available on-site materials were of satisfactory quality. These studies included an assessment of gravel mining operations currently operating, historic operations, and other potential sources.

Field investigations for impervious materials included measuring the thicknesses of terrace deposits exposed in stream channels, confirming terrace deposit boundaries, confirming depths and soil types using test pits, and sampling test pits for materials testing. The field investigation of rock sources included mapping sandstone units, measuring the thickness of sandstone and mudstone interbeds, and assessing the amount of weathering.

Material Requirements

Based on preliminary studies, each of the earthfill structures contains four zones of material. Current design studies for the Golden Gate Dam and Sites Dam (see Offstream Storage Investigation Progress Report) calls for impervious core, random rock, shell zone, and filter and drain (see Figure 3). The most recent design for Hunters Dam, Logan Dam, and the saddle dams (Northern District 1999) includes impervious core, random fill, filter, and drain. The estimated volume requirements of these materials for each dam are presented in Tables 3, 4 (Northern District), and 5 (DOE). Recommended laboratory tests and preferred material properties of each construction material zone are presented in Tables 6 and 7.



Zone 1 Core
Zone 2 Random
Zone 3 Shell and Rockfill
Zone 4 Filter and Drain

Source: DOE June 1999

GOLDEN GATE DAM
CROSS-SECTIONS
CURVED ALIGNMENT
DOWNSTREAM LOCATION
6/10/99

REV.	DATE	DESCRIPTION	DRAWING SCALES	GEOLOGY REPORT No. / CONSTRUCTION SPEC. No. / GEOLOGY DRAWING No.	GEOLOGIC MAPPING AND/OR LOGGING BY: / DRAWING PREPARED BY: DATE: 06/30/99	STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES DIVISION OF PLANNING & LOCAL ASSISTANCE NORTHERN DISTRICT GEOLOGY SECTION	Figure 3 Typical Golden Gate Dam Cross-section (Looking Northerly)	RELEASE DATE: / SHEET No. / PLATE

Plot Time: Jun 09, 2000 - 10:04am Filename:N: \geo\EMPLOYEES\ber\Cmreport\FINALFIGURES\Figure3actual.dwg

Table 3. Sites Reservoir Required Construction Materials Quantities (in cubic yards)

	Sites Dam	Golden Gate Dam	Saddle Dam 1	Saddle Dam 2	Saddle Dam 3	Saddle Dam 4
Excavation	**731,941**	**1,556,621**	**72,267**	**146,240**	**1,398,431**	**33,208**
Stripping:	641,211	1,337,940	61,139	124,033	1,189,128	28,180
Cutoff Trench:	90,730	218,682	11,128	22,206	209,302	5,028
Fill	**4,745,177**	**11,276,180**	**130,854**	**208,429**	**4,665,816**	**39,607**
Zone 1 - Impervious Core:	970,723	2,551,828	42,514	67,472	1,199,498	39,607
Zone 2 - Random:	3,217,399	7,374,246	43,586	57,352	2,586,890	
Drains:	289,090	700,653	21,908	40,927	430,503	
Transition:	267,965	649,453	22,846	42,678	448,925	

	Saddle Dam 5	Saddle Dam 6	Saddle Dam 7	Saddle Dam 8	Saddle Dam 9	Sites Reservoir Total
Excavation	**615,743**	**123,126**	**45,835**	**901,482**	**56,051**	**5,700,000**
Stripping:	508,002	102,697	37,415	761,967	45,640	4,800,000
Cutoff Trench:	107,741	20,429	8,420	139,514	10,411	800,000
Fill	**1,843,907**	**248,596**	**62,992**	**2,118,213**	**78,578**	**25,400,000**
Zone 1 - Impervious Core:	533,357	78,421	26,800	606,304	31,816	6,100,000
Zone 2 - Random:	863,684	88,732	4,131	939,140	6,454	15,200,000
Drains:	218,752	39,869	15,695	280,385	19,732	2,100,000
Transition:	228,113	41,575	16,366	292,383	20,576	2,000,000

Sites Reservoir Summary--Earthfill Dam with a crest of 540 feet

Water Surface Elevation=520 feet

Capacity=1,800 taf

Source: DWR Northern District, 1999

Table 4. Colusa Reservoir Required Construction Material Quantities (in cubic yards)

	Sites Dam	Golden Gate Dam	Colusa Saddle Dam 1	Prohibition Dam	Owens Dam	Hunters Dam	Colusa Saddle Dam 2
Excavation	**731,941**	**1,556,621**	**104,753**	**2,549,068**	**2,856,598**	**5,247,086**	**727,234**
Stripping:	641,211	1,337,940	92,262	2,349,513	2,672,818	4,841,493	687,076
Cutoff Trench:	90,730	218,682	12,491	199,556	183,780	405,593	40,158
Fill	**4,745,177**	**11,276,180**	**214,004**	**11,333,934**	**11,679,831**	**24,766,228**	**2,283,531**
Zone 1 - Impervious Core:	970,723	2,551,828	51,152	1,630,785	1,577,253	3,341,283	173,205
Zone 2 - Random:	3,217,399	7,374,246	113,600	8,494,550	8,991,069	18,965,043	1,949,320
Drains:	289,090	700,653	24,110	627,216	576,830	1,276,594	78,817
Transition:	267,965	649,453	25,142	581,383	534,679	1,183,308	82,189

	Logan Dam	Colusa Saddle Dam 3	Colusa Saddle Dam 4	Colusa Saddle Dam 5	Colusa Saddle Dam 6	Colusa Saddle Dam 7	Colusa Reservoir Total
Excavation	**5,345,029**	**490,790**	**145,981**	**378,760**	**21,859**	**604,022**	**20,800,000**
Stripping:	4,736,104	409,376	120,798	319,774	17,989	502,162	18,700,000
Cutoff Trench:	608,925	81,414	25,182	58,986	3,870	101,860	2,000,000
Fill	**30,573,933**	**1,579,686**	**351,868**	**1,306,592**	**26,760**	**1,575,250**	**101,700,000**
Zone 1 - Impervious Core:	5,043,213	423,807	109,428	334,297	26,760	469,192	16,700,000
Zone 2 - Random:	21,808,058	815,237	139,572	723,316	0	687,248	73,300,000
Drains:	1,931,918	166,753	50,357	121,882	0	205,018	6,000,000
Transition:	1,790,744	173,888	52,511	127,097	0	213,791	5,700,000

Colusa Reservoir Summary-Earthfill Crest--540 feet

Water Surface Elevation=520 feet capacity=3,100 taf

Table 5. Updated Dam Volumes for the Revised Section for Sites and Golden Gate Dams (in cubic yards)

	Sites Dam	Golden Gate Dam*	Description
Core (Zone 1)	1,068,600	3,459,600	Impervious core from reservoir site deposits consisting predominately of lean clay (CL), with some sandy clay and clayey sand (SC)
Random (Zone 2)	1,085,400	2,796,900	Random rock consisting of moderately to slightly weathered rock up to 30-inch maximum particle size, with fines not to exceed 35% minus No. 4.
Total Shell (Zone 3)	1,180,500	2,866,300	Shell zone of fresh rock up to 30-inch maximum particle size, with fines not to exceed 20% minus No. 4.
Filter/Drain (Zone 4)	501,400	1,467,300	Filter and drain consisting of fresh rock processed to various sizes, generally 1-1/2-inch maximum particle size (3% limit on minus No. 200 sieve material).
	3,835,900	10,590,100	

*Volumes for Golden Gate Dam are for the downstream curved alignment.

Source: DWR, DOE, 1999 (refer to Figure 3)

Table 6. Construction Materials Tests and Preferred Properties

	Atterberg Limits		**Gradation**	**Organic Content**	**Compaction**	**Permeability**	**Triaxial Shear**	**Specific Gravity**	**Classification**
	Liquid Limit	**Plastic Limit**							
ASTM	D 4318	D 4318	D 422	D 2974	D 1557	D 5084	D 4767	D 854	D 422
Impervious Core (Zone 1)	36%	17%	Less than 15-35% sand		107pcf@18 %moisture	1 X 10-6cm/sec	F30		Predominately lean clay (CL), with some sandy clay and clayey sand (SC).
	Unconfined Compression	Wet Dry test	Abrasion-L.A. Rattler	Soundness	Specific Gravity and Absorption	Bulk Density	Splitting Tensile Strength	Bulk Density	Classification
ASTM	D 3148	D 5313	C 131/535	C 88	C 127/128	C 29	C 496	C 29	C 136
Random Rock Zone 2	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified	138	Not Specified	Not Specified	Moderately to slightly weathered rock up to 30-inch maximum particle size, with fines not to exceed 35% minus No. 4.
Shell and Rockfill Zone 3	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified	145	Not Specified	Not Specified	Fresh rock up to 30-inch maximum particle size, with fines not to exceed 20% minus No. 4.
Filter and transition Zone 4	Not Specified	Not Specified	Not Specified	Not Specified	Not Specified	125	Not Specified	Not Specified	Fresh rock processed to various sizes, generally 1 1/2-inch maximum particle size (3% limit on minus No. 200 sieve material).

Table 7. Preferred Embankment Material Properties and Description

Material	Shear Strength Parameters				Dens			Description
	Effective		Total		Dry	Moist	Saturated	
	F'	c" (psf)	F	c (psf)				
Impervious Core (Zone 1)	34	0	16	800	107	111	131	Predominately lean clay (CL), with some sandy clay and clayey sand (SC).
Random Rock (Zone 2)	39	0	Not Specified	Not Specified	138	Not Specified	Not Specified	Moderately to slightly weathered rock up to 30-inch maximum particle size, with fines not to exceed 35% minus No. 4.
Shell and Rockfill (Zone 3)	42	0	Not Specified	Not Specified	145	Not Specified	Not Specified	Fresh rock up to 30-inch maximum particle size, with fines not to exceed 20% minus No. 4.
Filter and Drain (Zone 4)	42	0	Not Specified	Not Specified	125	Not Specified	Not Specified	Fresh rock processed to various sizes, generally 1-1/2-inch maximum particle size (3% limit on minus No. 200 sieve material).

Source: Bill Verigin Memo, February 1999

Geology

The following discussion of geology is adapted USBR (1969). The Sites Reservoir is on the west side of the Sacramento Valley in the foothills of the Coast Ranges. The area is underlain by Lower and Upper Cretaceous sedimentary rocks of the Great Valley Sequence folded along northerly trending axes and cut by north- and northeast-striking faults. The regional geology is shown in Figure 4.

The major structural features in the region include the Sites anticline, a major anticlinal flexure on the west side of the Sacramento Valley that passes through the long axis of the reservoir and is paralleled to the west by a broad shallow syncline, called the Fruto syncline. The Salt Lake fault parallels the axis of the anticline near the center of Antelope Valley. The Sites anticline is interpreted by Phipps and Unruh (1992), as a major, west-vergent thrust (Salt Lake fault) juxtaposing moderately to steeply east-dipping rocks in its hanging wall against the west-dipping east limb of the Fruto syncline, which plunges to the north. The Salt Lake fault is known from south of Cache Creek to west of Willows and is a bedding plane fault in its hanging wall. The fault is steeply cross cutting in its foot wall near Sites and approaches bedding plane geometry towards the south (Leesville grade to Cache Creek canyon).

Great Valley Sequence

The Sites and Golden Gate dam sites are on the eastern flank of the Sites anticline near the contact between the Venado sandstone member of the Cretaceous Cortina Formation and the underlying siltstone/mudstone of the Boxer Formation. The contact between the Boxer and the Cortina is generally taken to be the lowest major sandstone unit.

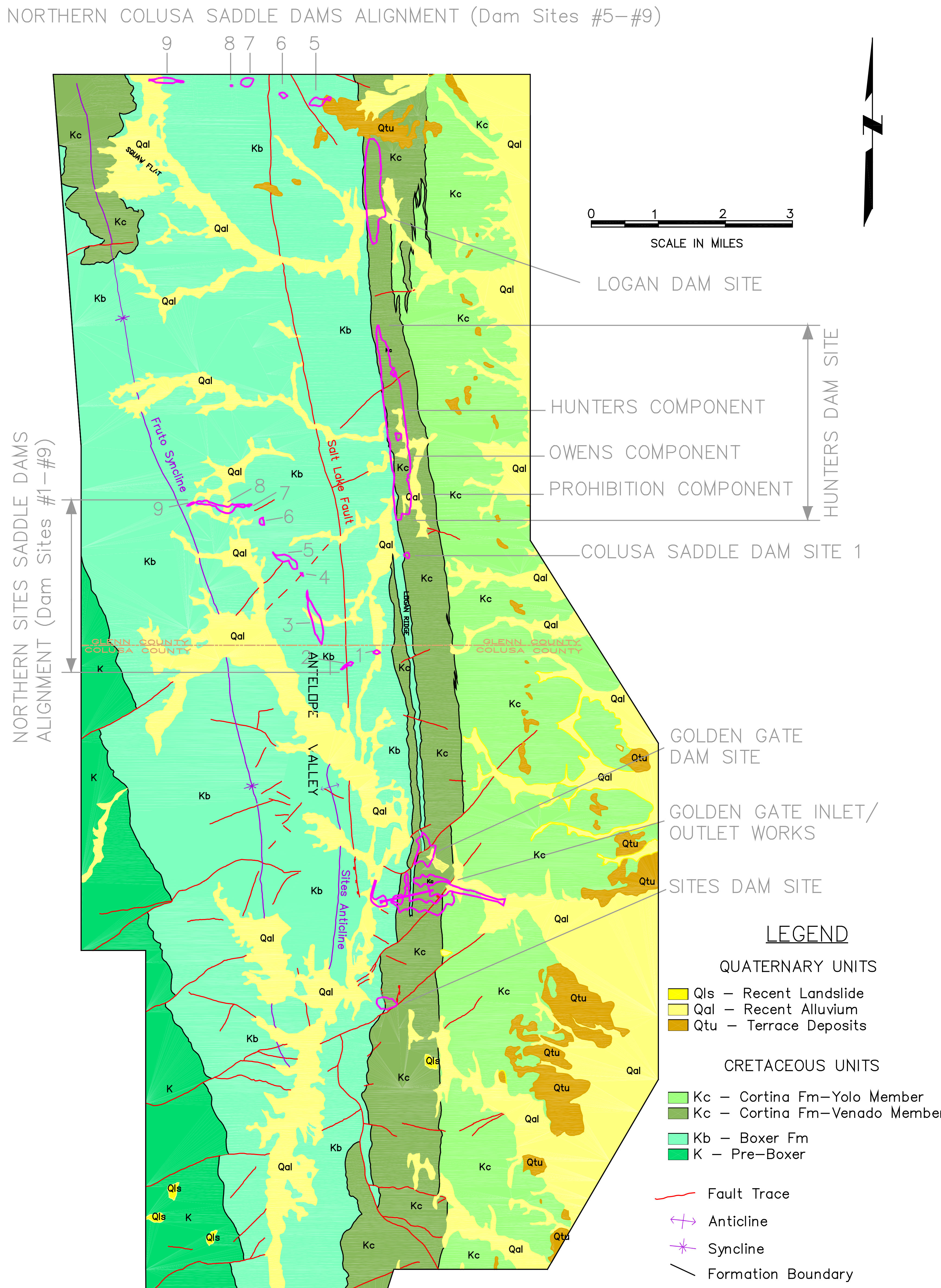
The Boxer Formation consists of thin bedded mudstone with scattered thin to medium sandstone interbeds representative of basin-plain deposits of distal turbidites. The base of the Boxer Formation includes the Salt Creek conglomerate member but it is not exposed in this area (Ingersoll 1981). The Boxer Formation is less resistant to weathering and erosion, underlies the valley east of the sandstone ridges of the Venado, and makes up the core of the Sites anticline.

The Cortina Formation includes three mapped members, the Venado sandstone, the Yolo shale, and the Sites sandstone. The basal unit of the Venado sandstone is primarily fine- to medium-grained, hard, and occurs chiefly in 1- to 10-foot-thick beds. Petrographic studies indicate that the rock is cemented by carbonates and by a silica-clay matrix. The Venado includes a lesser amount of well indurated, crudely fissile mudstone that occurs as 1/8 to 6-inch beds. Mudstone constitutes about five percent of the basal Venado.

Above the basal unit, mudstone beds increase to nearly 50 percent of the section. Further up the section, the Venado consists of repetitive intervals of medium to thick bedded sandstone and thinner bedded sandstone with subordinate mudstone (USBR 1969).

These bedded sandstones form the eastern ridge that is the current proposed location of Golden Gate Dam.

FIGURE 4



NOTES: Sources of geological data include geologic map interpretation, Brown and Rich (1961), U.S. Geological Survey (1972) and USBR (1963).

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

LOCATION AND GEOLOGIC MAP
OF THE
SITES AND COLUSA
RESERVOIR PROJECTS

Figure2_03-15-00_wb

The mudstones of the Yolo shale member are laminated to thin-bedded, range from 800- to 1,000-feet thick, and occupy the strike valleys between the Venado and Sites sandstone members east of the dam sites.

Exposures of the Sites sandstone are located within 15 miles south of the reservoir area and consist of 1,500 to 2,000 feet of interbedded sandstone and siltstone. This sandstone member wedges out into a thick mudstone sequence about 8 miles south of the southern edge of the reservoir boundary.

Cenozoic Deposits

The rocks of the Great Valley sequence have been eroded and, along the valleys and streams, have been partially covered with alluvial deposits and terraces of recent to middle Pleistocene age. These deposits were mapped in the project area by Helley and Harwood, (1985) and include recent stream channel deposits, Holocene alluvium and basin deposits, terraces of the Upper and Lower Modesto Formation, and Upper and Lower Riverbank Formation. The unit descriptions used by Helley and Harwood are summarized below. Stream channel deposits are active deposits of sand and gravel along streams and are without permanent vegetation. The Holocene alluvium consists of gravel, sand, and silt deposited by streams, and occurs outside of the stream channel deposits, but inside of the lowest terrace deposits. Basin deposits are fine-grained silt and clay derived from the same sources as the alluvium. The dark gray to black deposits are the distal facies of the alluvium.

The Upper and Lower Modesto Formation are the lowest distinct alluvial terraces lying topographically above the Holocene stream deposits. The Modesto includes tan and light gray gravelly sand, silt, and clay. The upper member is unconsolidated and unweathered, and it forms the topographically lowest terraces only a few meters thick. The surface preserves the original fluvial morphology with relief of 1-2 meters. The soils on the upper member have A/C horizons but lack an argillic B horizon. The lower member can be slightly weathered and forms terraces that are topographically higher than the upper member. The surface morphology is smooth and it is more extensive than the upper member. The soils on the lower member contain an argillic B horizon with an increase in clay content and red color.

The Riverbank Formation consists of weathered reddish gravel, sand, and silt. The Riverbank is differentiated from the younger Modesto by its terraces being topographically higher and by its more highly developed soil profile. The upper riverbank member is unconsolidated but compact dark brown to red alluvium, and forms the lower of the Riverbank terrace levels about 3 meters to 5 meters above the lower Modesto terrace. The lower member consists of red semi-consolidated gravel, sand, and silt. Its surface is higher and much more dissected than the upper member and has much stronger soil profiles.

Construction Materials

Construction materials needed for the proposed embankment dams include impervious fill for the core, random fill, rockfill, riprap, filter and drain material, and aggregate for concrete structures. The terrace deposits upstream of the dam sites are the proposed source of the impervious material. Earlier reports by USBR was estimated that 4.4 million cubic yards of impervious material were available within 1 mile of the Golden Gate Dam site and 2.8 mcy of impervious material were available within 1 mile of the Sites Dam site. This material would be from terrace deposits within the footprint of the reservoir.

Random or rockfill for Sites Dam was proposed to come from the existing Sites quarry in the Venado sandstone downstream of the dam site. Random fill for Golden Gate Dam was proposed to come from the ridge to the southeast of the originally proposed dam site. The current design uses this ridge as the abutment for the dam. Therefore, we are proposing using the northwest ridge of Venado sandstone for the rock quarry to supplement the materials excavated for the spillway and outlet works. This is within the footprint of the reservoir and would not result in additional environmental effects.

Testing of the Sites quarry materials indicate they are of relatively low strength, and have been identified by previous studies to lack wet-dry durability. The Sites quarry material has sufficient strength characteristics for use as rockfill, but may not be suitable for use as riprap without periodic maintenance. Wet-dry testing by the USBR found the material to have poor durability. DWR is presently conducting a wet-dry test to verify the USBR findings.

Preliminary indications are that the crushed quarried rock would probably not be suitable for the filter and drain material. During the spring of 1998, ten 3-inch cube samples of the quarry rock were collected for analysis. The results are summarized in Tables 8 and 9. During March 1999, approximately 5 yd^3 each of the weathered and unweathered sandstone were crushed to 1.5-inch minus and taken to the Bryte Laboratory for further testing. During May 1999, ten rock cores each of the weathered and unweathered sandstone were collected from the Sites quarry. Further testing is being performed to assess the properties of the quarry rock. If it is not suitable, then filter and drain material would have to be brought from another source. Channel gravels associated with the active streams within the reservoir are too discontinuous to provide an adequate supply of gravel. The alternative source would include paleochannels of the Stony Creek fan that are being mined commercially. These operations are in Willows and Orland. Previously there was a commercial aggregate operation on Cortina Creek south of Williams.

Crushed quarried sandstone is not suitable for use as concrete aggregate. Concrete aggregate sources include the Stony Creek fan deposits described above.

Table 8. Results for Terrace Samples Collected Spring 1998

IMPERVIOUS MATERIALS						
SAMPLE LOCATION	Liquid Limits	TEST				Sample Description
		Plasticity Index	Specific Gravity	Organic Content	Soil Classification	
SC-1	38-45	23-27	2.78-2.79	3.6-4.7	Lean Clay to Sandy Lean Clay (CL)	Dark brown clayey silt, clay rich at 2 ft.; Clay sticky with small round pebbles at 6 ft. (Lower Modesto)
SC-2	34-48	17-31	N/A	3.7-4.4	Lean Clay to Sandy Lean Clay (CL)	Dark clay, homogeneous at 4 ft.; weathered bedrock at 8ft
SC-3	51-53	34-35	N/A	4.9-5.0	Fat Clay to Fat Clay with Sand (CH)	Dark brown silty clay, sticky at 2.5 ft.; weathered bedrock clayey, sticky yellowish gray at 6.5 ft.
LC-1	33-44	17-25	2.77-2.83	3.7-3.8	Lean Clay to Sandy Lean Clay (CL)	Dark brown silty clay (Modesto) at 4.6 ft.; thick clay orange/brown rolls, in balls, possibly weathered bedrock, no chips at 8.0 ft.
LC-2	34-44	17-29	N/A	3.1-4.4	Lean Clay to Lean Clay with Sand (CL)	dark brown organic loam at 1.5 ft.; clayey orange-brownish tan with scattered rounded gravel at 6.0 ft.
GG-1	32-44	16-29	2.78-2.80	4-5.1	Lean Clay with Sand (CL)	Light brown silty clay gravel layers (slight) caliche layer chunks (CaCO3) at 3.5 ft.; medium brown silty clay, caliche with small scattering of pebbles at 13.8 ft.; orangish brown clay layer, no pebbles, water flowing at 17.2 ft.
GG-2	30-59	13-43	N/A	3.8-7.2	Sandy Lean Clay to Fat Clay (CL_CH)	Reddish brown silty clay scattered pebbles at 5.5 ft.; reddish weathered silty clay (Riverbank) at 11 ft.; gray to dark brown weathered clay with white mineralized CaCO3 or salts leaching out from groundwater at 15 ft.; blue clay in channel at 18 ft.

Table 9. Results for Quarry Samples Collected Spring 1998

QUARRY ROCK 3" CUBE SAMPLES			
Sample Number	Compressive Strength (psi)	Specific Gravity	Percent Absorption
SSQ-1	9,960 - 11,130	2.48-2.50	2.6-2.8
SSQ-2	11,690 - 12,370	2.49-2.50	2.5-2.6
SSQ-3	No Sample		
SSQ-4	11,630 - 11,830	2.5	2.4-2.5
SSQ-5	10,160 - 10,820	2.45-2.46	2.8-3.0
SSQ-6	9,910 - 10,990	2.45	2.9-2.9
SSQ-7	10,320 - 11,220	2.50-2.52	2.3-2.7
SSQ-8	12,060 - 12,690	2.48-2.49	2.3-2.5
SSQ-9	11,040 - 11,360	2.48-2.49	2.6-2.8
SSQ-10	10,979 - 11,490	2.45-2.46	2.7-2.8

Crushed Sandstone	
L.A. Rattler 1.5"x.375"	11.4% loss/100 rev.
	43.4% loss/500 rev.
Specific Gravity	2.48
Absorption	4.20%
Durability Index 0.75"x#4	Dc=42
Specific Gravity	2.5
Absorption	4.10%

The aggregate testing indicates that both the fresh and weathered sandstone from Sites Quarry are poor quality materials for use as concrete aggregates. The average loss for both sandstones by the Los Angeles Rattler Test was greater that the 45 percent maximum allowable for concrete mix designs. USBR’s poor soundness, and wet-dry results, further indicate the low quality as a concrete aggregate.

The investigation of sources for impervious material was performed by a detailed analysis of the aerial photographs taken May 12, 1997. Terrace boundaries were mapped for the three different geomorphic expressions that were recognized in the aerial photographs. The aerial photo interpretations were field checked, the terrace deposits along the incised stream channels in the project area were described, and the exposed thickness was measured. As a result of field checking, one additional terrace type was recognized.

The four terraces recognized for this investigation include from youngest to oldest:

> A low terrace that occurs as small isolated remnants along the stream courses of Stone Coral, Antelope, and Funks Creeks between the bottom of the channel and the surface that occupies the valley floors. This terrace is generally 4 to 6 feet thick with weak soil development and consists of clayey

silt with some minor gravel. The color is generally very dark grayish brown (10YR3/2) to dark yellowish brown (10YR4/4). Gravel clasts are sub-angular sandstone displaying the original bedding planes. This terrace is tentatively correlated with the younger (upper) Modesto terrace of Helley and Harwood. This terrace was not extensive enough to show on Figures 5, 6, and 7.

The next terrace occurs as a broad, flat surface with very little relief occupying the floor of the valleys. This terrace is widespread in its lateral extent and is generally 12 to 20 feet thick although locally it is more than 30 feet thick. Soil development is greater than on the lower terrace but is still weak. The upper part of this terrace is clayey silt with increasing clay downward. Some gravel lenses were observed along the sides of the incised stream channels and in places there was a clay bed at the base of the observable deposit. The upper 2 to 3 feet is very dark grayish brown (10YR3/2 or 3), becoming lighter downward, brown or dark yellowish brown (10YR4/3 or 4). This terrace is tentatively correlated with the older (lower) Modesto terrace of Helley and Harwood. The map symbol for this terrace is Qlft (Quaternary low flat terrace).

The third terrace has very little surface relief but slopes gently up the tributary drainages. This terrace is generally thinner with observed thicknesses of 8 to 12 feet but the deposits resemble those of the Qlft surface. The upper 2 to 3 feet are dark clayey silts that grade downward to lighter silty clays. Colors are in the very dark grayish brown to brown range (10YR3 to 4), with weak soil development. This terrace is probably also Modesto in age. The map symbol for this surface is Qiss (Quaternary intermediate sloped surface).

The fourth terrace is found sporadically throughout the reservoir area generally above the valley floor. It usually has a sloped surface with some local relief. Observed thicknesses were generally 8 to 10 feet, but were as great as 25 feet along the western front of Logan Ridge and as little as 3 to 4 feet overlying the Boxer mudstone in some areas. Composition of this unit was generally clay to gravelly clay with the clasts subrounded to rounded, including red and black chert and igneous rocks. The color of this unit was usually brown to light brown (7.5 YR4 to 6). In several places this terrace is overlain by the Qlft surface, or the Qlft surface is cut into this surface. This terrace is tentatively correlated with the Riverbank terrace of Helley and Harwood. The map symbol for this terrace is Quss (Quaternary upper sloped surface).

Another surface was observed in the project area that consisted of horizontal, flat-lying ridge tops and notches. This surface was generally erosional on the Boxer Formation, contains no construction material, and was therefore disregarded for this report.

In spring 1998, terrace samples were collected at seven streambank exposures in Funks and Stone Corral Creeks. These samples were analyzed for Atterberg Limits, plasticity, specific gravity, and classification. Summary results are presented in Table 8.

Fifteen test pits were dug into the various terrace deposits in the Sites Reservoir area during the second week of June 1999. Generally three samples were collected from each test pit for future laboratory analysis. Test pit logs are shown in Attachment A. Summary field descriptions of the samples are shown in Table 10. The results of the materials testing for these samples are included in Attachment D.

Sites Dam

Impervious Materials

The terrace deposits mapped in the Antelope Creek and Stone Corral Creek drainages within 5 miles of Sites Dam site are shown in Figure 5. The mapped area of the valley floor occupied by the Qlft terrace is 1,070 acres. With a conservative estimate of the thickness of the terrace of 10 feet, the volume of material in this terrace deposit is 17 million yd^3. The field classification of this material is silty clay to clayey silt with a slight amount of gravel in the stream channel, and it appears to be suitable for the impervious fill zone. The volume of impervious material required for the Sites Dam is about 1 million cubic yards, which is 60 acres at 10 feet thick. This volume of material is available within 1 mile of the dam site.

Seven test pits were placed in the terrace deposits upstream from Sites Dam as shown in Figure 5. Four of the test pits encountered groundwater at depths of 10 to 16 feet and were terminated, two reached 16 feet with no groundwater, and one encountered bedrock at 12 feet. Generally there was a lack of stratification in the test pits with the material grading downward from clayey silt to silty clay. A clayey gravel was found in test pits SC-10 and SC-6 at 14 feet. There was no lithologic distinction observed between test pits in the Qlft surface and the Quss surface.

Soil classification tests and Atterberg limits were run on each of the test pit samples. The results are included in Attachment B. Generally the samples were classified as lean clay or lean clay with sand, USCS symbol CL. Six samples were classified as fat clay having liquid limits above 50.

Random Fill and Rockfill

The source of random fill and rockfill for Sites Dam is the Venado sandstone north of the existing Sites Quarry. Discounting the effects of swell and waste, a wedge of material in a parallelogram shape 300 feet wide by 300 feet high and 1,000 feet long at minimum would be needed to provide the 3.2 mcy random fill required. A quarry in the Venado sandstone was judged by DOE to produce both shell and random rockfill. By selective loading or processing with crushing and screening, it was estimated that the fresh sandstone would produce shell rockfill and the weathered sandstone, siltstone, and claystone would produce random rockfill. This quarry area is outside the footprint of the proposed reservoir area.

Filter and Drain

Filter and drain material will probably require aggregate from a source outside the vicinity of the reservoir area.

Table 10. Field Descriptions of Test Pit Samples[1]

SAMPLE #	DESCRIPTION	USCS[2]	COLOR (MUNSELL)
SC4-1	SILT, clayey, slightly moist.	ML	10YR3/3
SC4-2	CLAY, silty.	CL	10YR3/6
SC4-3	CLAY, minor silt, slightly plastic, moist.	CL	10YR3/2
SC5-1	CLAY, minor silt.	CL	10YR3/1
SC5-2	CLAY, very minor silt, medium plastic, wet below ten feet.	CL	10YR3/3
SC6-1	CLAY, minor silt and gravel.	CL	10YR 3/2
SC6-2	CLAY, minor gravel.	CL	10YR4/4
SC6-3	CLAY, clayey gravel with minor sand, gravels are subrounded black chert & red sandstone.	CL	7.5YR5/4
SC7-1	CLAY, silty, few sand grains.	CL	10/YR4/2
SC7-2	CLAY, minor silt, scattered fine gravel clasts, gastropod shell.	CL	10YR6/6
SC8-1	SILT, clayey, minor gravel, gravel lens in side wall.	ML	10YR3/3
SC8-2	CLAY, silty, with sand and gravel, angular.	SC	7.5YR5/4
SC8-3	CLAY, gravelly, rounded clast up to cobble in size.	GC	7.5YR5/8
SC9-1	CLAY, minor silt, slightly moist, calcareous streaking.	CL	2.5YR4/3
SC9-2	CLAY, moist, plastic, some black mottling.	CL	2.5YR4/2
SC10-1	SILT, clayey.	ML	10YR3/4
SC10-2	CLAY, silty.	CL	10YR4/6
SC10-3	GRAVEL, clayey.	GC	10YR4/4
GG1-1	SILT, clayey, slightly moist.	ML	10YR3/3
GG1-2	CLAY, silty, moist, slightly plastic, some mottling.	CL	10YR4/4
GG1-3	CLAY, minor silt.	CL	10YR4/4
GG2-1	SILT, clayey, slightly moist.	ML	10YR4/2
GG2-2	CLAY, silty, moist, slightly plastic.	CL	10YR4/4
GG2-3	CLAY, silty, moist, slightly plastic.	CL	10YR4/4
GG3-1	SILT, clayey, slightly moist, crumbly.	ML	10YR3/3
GG3-2	SILT, clayey.	ML	10YR4/4
GG3-3	CLAY, silty, moist, slightly plastic.	CL	10YR4/4
GG4-1	CLAY, silty, moist.	CL	10YR4/2
GG4-2	CLAY, silty, very moist to wet.	CL	10YR3/4
GG5-1	CLAY, silty, slightly moist, stiff.	CL	10YR3/3
GG5-2	CLAY, silty, moist, slightly plastic, some mottling.	CL	10YR4/4
GG6-1	CLAY, silty, slightly moist, tough.	CL	10YR3/2
GG7-1	SILT, clayey, slightly moist, crumbly.	ML	10YR3/2
GG7-2	SILT, clayey.	ML	10YR4/4
GG7-3	CLAY, silty, moist, slightly plastic.	CL	10YR4/4
GG8-1	CLAY, silty, gravel clasts - fine to medium.	CL	10YR4/2
GG8-2	Weathered bedrock - mudstone, crumbly.	bedrock	-

[1] Sample locations are shown on Figures 5, 6, and 7.

[2] Unified Soil Classification System

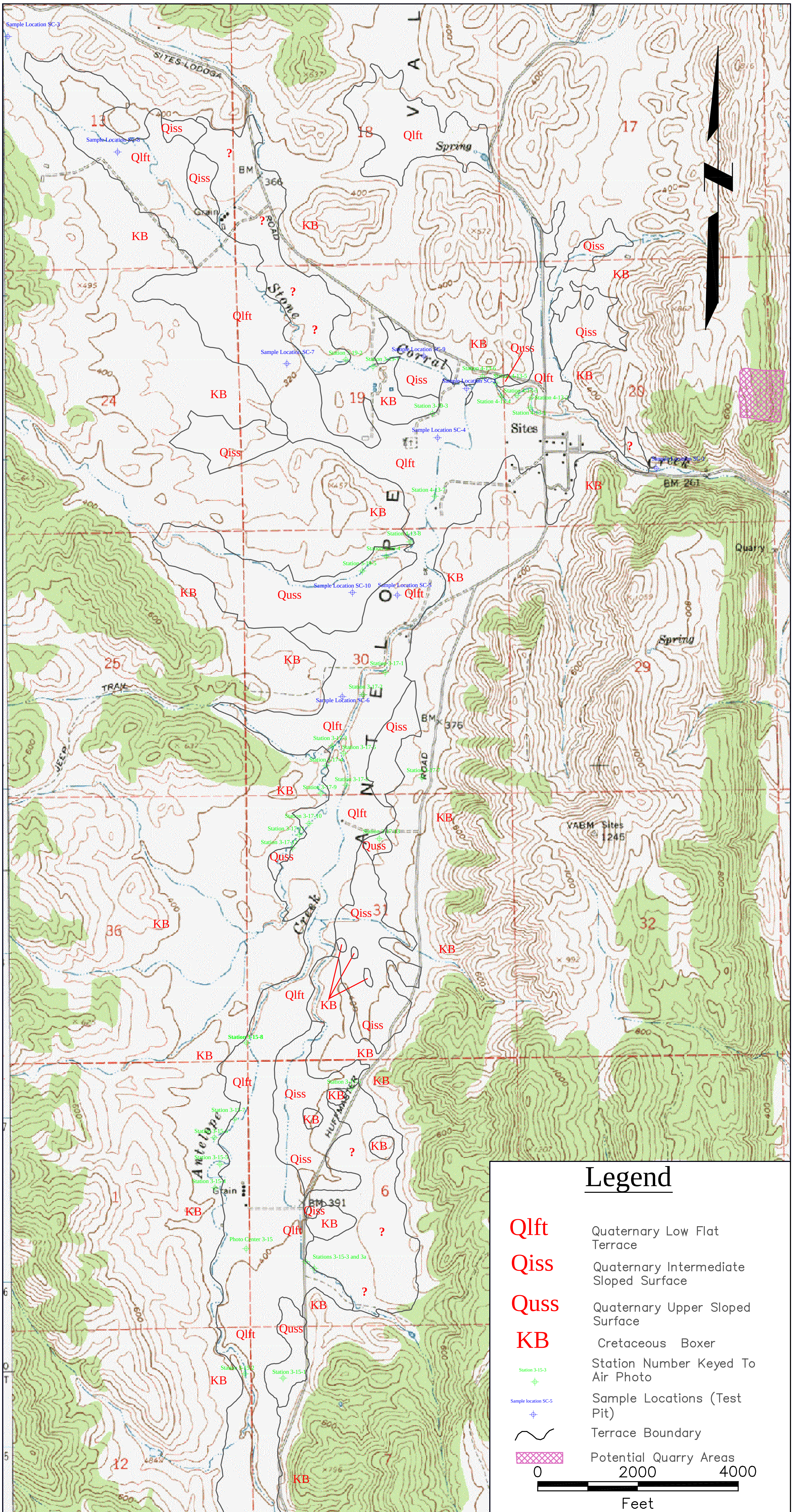


Figure 5. Terrace Deposits, Antelope and Stone Corral Creeks

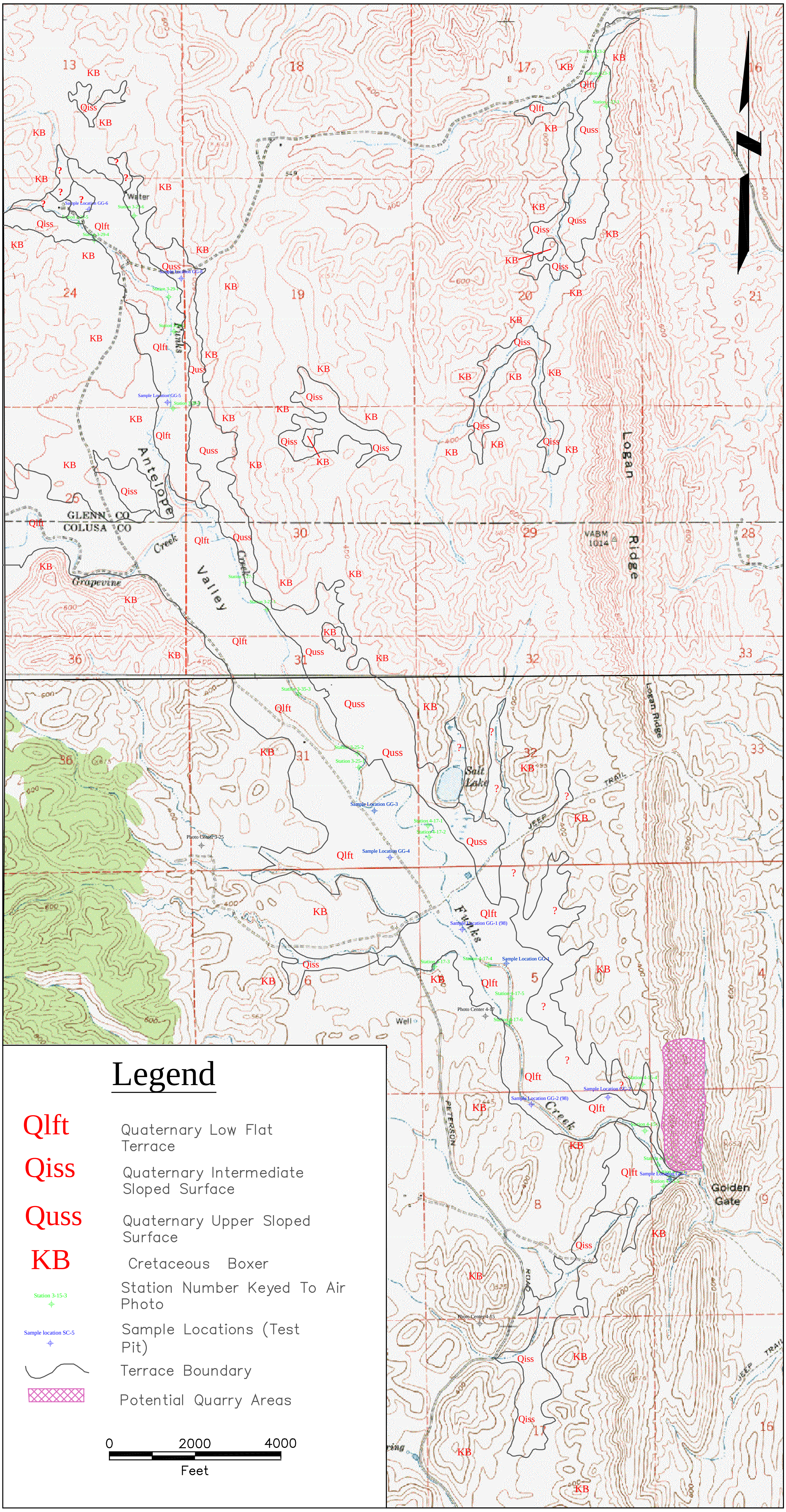


Figure 6. Terrace deposits, Funks and Grapevine Creeks

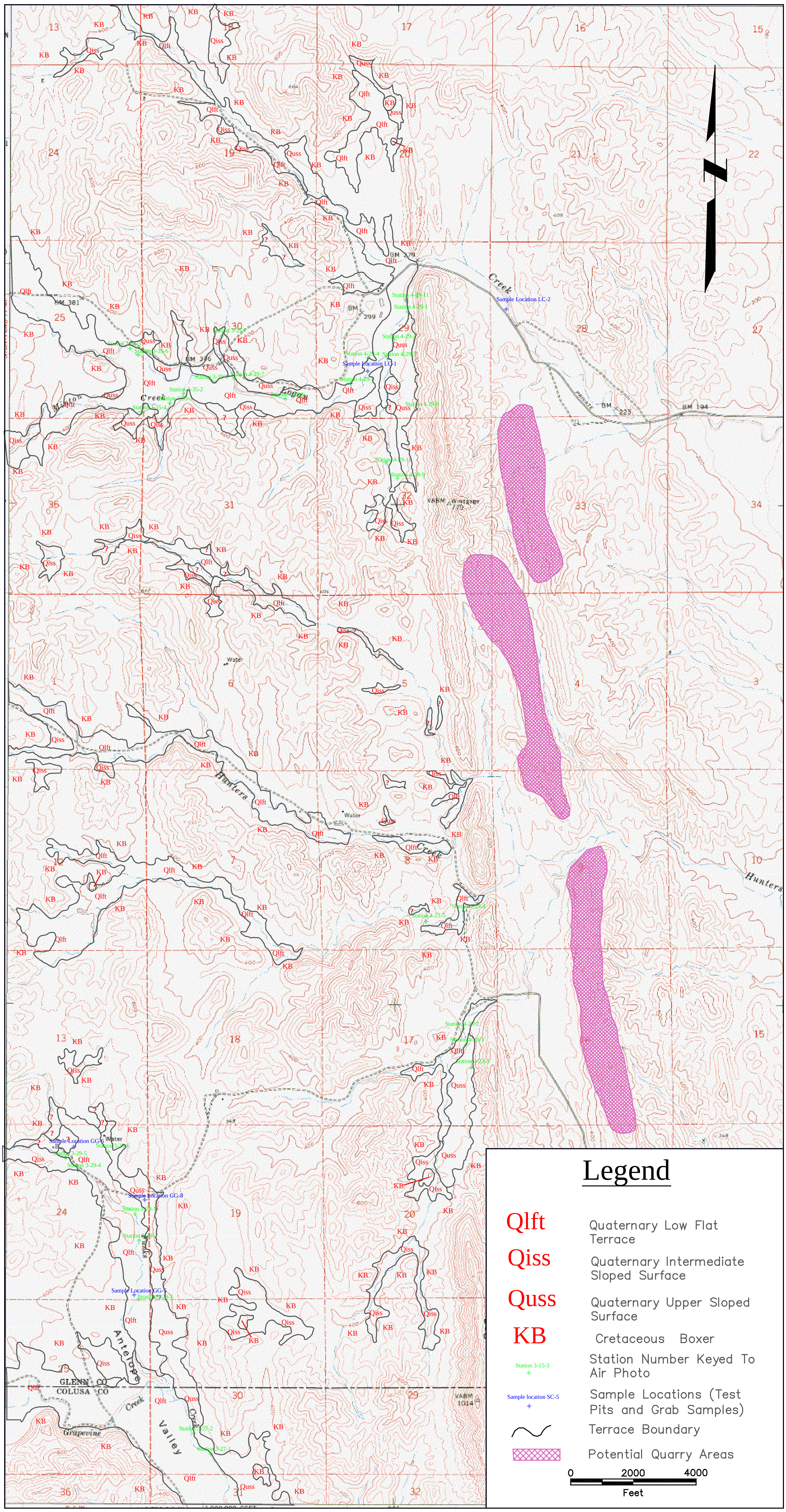


Figure 7. Terrace Deposits Hunters and Logan Creeks

Golden Gate Dam

Impervious Materials

Terrace deposits mapped in the Funks Creek drainage within 3 miles of the dam site are shown in Figure 6. The mapped area of the valley floor occupied by the Qlft terrace is 628 acres. With a conservative estimate of 10 feet for the terrace thickness, the volume of material in this terrace deposit is 10 million yd^3. The field classification of this material is silty clay to clayey silt with some gravel in the stream channel, and it appears to be suitable for the impervious fill zone. The material along Funks Creek appears to have more silt content in the upper 10 feet than the Stone Corral/Antelope Creek material. The volume required for the Golden Gate Dam is about 2,552,000 yd^3, which is 158 acres at 10 feet thick (3.5 mcy for the downstream curved alignment, 220 acres). This volume of material is available within 1 mile of the dam site.

Five test pits were placed along Funks Creek within 2 miles of the Golden Gate Dam site. Two test pits encountered groundwater at 8 to 14 feet and were terminated, two reached 18 feet and one reached 20 feet. The lithologies were mostly clayey silt with increasing clay content downward. Samples from GG-4 were clay rich. All test pits were placed in the Qlft surface.

Soil classification tests and Atterberg limits were run on each test pit sample. The results are included in Attachment B. All the samples were classified as lean clay or lean clay with sand, Unified Soil Classification System symbol CL.

Random Fill

The proposed source of the random fill for Golden Gate Dam is the Venado sandstone to the northwest of the downstream alignment. Discounting the effects of swell and waste, a wedge of material in a parallelogram shape, 300 feet wide by 300 feet high and 2,400 feet long at a minimum, would be required to provide the 8 million yd^3 of random fill required. No testing has been performed on this quarry site but its properties should be similar to the Sites Quarry. A quarry in the Venado sandstone was judged by DOE to produce both shell and random rockfill. By selective loading or processing with crushing and screening, it was estimated that the fresh sandstone would produce shell rockfill and the weathered sandstone, siltstone, and claystone would produce random rockfill. This quarry is inside the reservoir footprint.

Filter and Drain

Filter and drain material will probably require aggregate from a source outside the vicinity of the dam site.

Concrete Aggregate

Sample results indicate that crushed Venado sandstone will not be suitable for use as concrete aggregate. The nearest commercial sources of aggregate are on the Stony Creek fan between Willows and Artois and near Orland. Stony Creek aggregate has been found suitable for use with high-alkali cement and has been used in the construction of East Park Dam, Stony Gorge Dam, and Black Butte

Dam. Currently permitted reserves of Stony Creek aggregate are 61 million tons with a total estimated reserve of 1,031 million tons (Glenn County ARMP 1997).

In addition to commercial sources on the Stony Creek fan, it is estimated that 41 million tons of sand and gravel are impounded behind Black Butte Dam. These deposits probably contain a higher amount of silt and clay and would need to be cleaned before use. Extraction of these deposits would result in an increase in capacity of Black Butte Reservoir. Similar conditions exist on East Park Reservoir 20 miles west of Sites.

There was a commercial gravel operation on Cortina Creek south of Williams that has closed. The quantity and quality of aggregate that may be available along Cortina Creek is unknown.

Saddle Dams

Impervious Materials

The terrace deposits mapped in the middle Funks Creek and Grapevine Creek drainages are shown in Figure 6. The mapped area of the valley floor occupied by the Qlft terrace is 461 acres. With a conservative estimate of the thickness of the terrace of 10 feet, the volume of material in this terrace deposit is 7,437,500 yd^3. The field classification of this material is silty clay to clayey silt with some gravel in the stream channel, and it appears to be suitable for the impervious fill zone. The volume required for the saddle dams is about 2,626,000 yd^3, which is 162 acres at 10 feet thick. This volume of material is available along Funks Creek generally within 1 mile of the saddle dam alignment.

Three test pits were placed toward the northern end of Funks Creek near the saddle dam alignment. Bedrock was encountered at 6 feet in GG-6 and 9 feet in GG-8, and groundwater was encountered at 10 feet in GG-5. The lithology of the terrace deposits was silty clay. Test pits GG-6 and GG-8 were placed in the Quss surface and GG-5 in the Qlft surface.

Soil classification tests and Atterberg limits were run on each test pit sample. The results are included in Attachment B. One sample from each test pit was classified as fat clay, USCS symbol CH.

Random Fill

The proposed source of random fill for saddle dams is the Venado sandstone ridge northwest of the proposed Golden Gate Dam. A wedge of material in a parallelogram shape 300 feet wide by 300 feet high and 1,400 feet long would be required to provide 4.6 mcy of fill. No testing has been performed on this quarry site but its properties should be similar to the Sites quarry.

This quarry is inside the reservoir footprint and is the same quarry that would provide random fill material for Golden Gate Dam. Haul distance to the major saddle dams would be 1 to 3 miles.

Drain and Transition

There is a possibility that the transition material can be supplied by crushed Venado sandstone. Drain material will probably require aggregate from a source outside the vicinity of the dam site.

Colusa Reservoir Dams

Impervious Materials

The terrace deposits mapped in the Hunters, Logan, and Minton Creeks and other unnamed drainages are shown on Figure 7. The mapped area of the valley floors occupied by the Qlft terrace is 964 acres. Assuming the terrace thickness is 10 feet, the volume of material in these terrace deposits is about 15 million yd^3. The terrace deposits along the drainages in the Colusa Reservoir area are not as extensive as those along Funks, Stone Corral, and Antelope Creeks. The field classification of the terrace material exposed in the incised stream channels is silty clay to clayey silt with some gravel.

The volume of impervious fill required for the Hunters and Logan Dams and the Colusa saddle dams is 13,200,000 yd^3, which is 818 acres at 10 feet thick. Haul distances of 3 or more miles will be required to transport this material to the dam sites. Nearly all of the Qlft terrace deposits inside the reservoir footprint will be required. Another potential source of impervious fill material is the deposits of weathered Boxer Formation mudstones that occur in the area. Some of these deposits have been observed with thicknesses of 12 or more feet.

No test pits have been placed in the Colusa Reservoir footprint for material testing and classification.

Random Fill

A source for the random fill for the dams for the Colusa complex has not yet been identified. The required volume of material is approximately 60,000,000 yd^3. This volume of Venado sandstone is not available within the reservoir footprint. There are some Boxer sandstones mapped along the western margin of the reservoir, but these are also outside the footprint. The ridges of Venado sandstone upon which the Hunters Dam and Logan Dam are based are single ridges, not double ridges like the Golden Gate Dam and Sites Dam sites. Using the analogy of a ridge quarry of 300 by 300 feet, a ridge over 3 miles long would be required to supply the required volume of material. There is a 250-foot-high ridge about 1/2 to 3/4 mile east of Hunters Dam site that apparently consists of sandstone beds that could provide a source for the random fill. This ridge has not been mapped or sampled for an evaluation of its properties. It would also require an environmental study as it is outside the reservoir footprint.

Drain and Transition

There is a possibility that the transition material can be supplied by crushed Venado sandstone. Drain material will probably require aggregate from a source outside the vicinity of the dam site.

Conclusions

Construction materials in the vicinity were investigated for the Sites Project. Materials required include impervious core, random fill, shell and rockfill, and filter and drain. The geologic materials investigated include terrace deposits, sandstone beds, and sand and gravel deposits. For Sites Dam, Golden Gate Dam, and the saddle dams, there is an adequate reserve of terrace deposits with the appropriate properties to supply the material for the impervious core. There is an adequate quantity of quarry sandstone either within or just outside of the reservoir to supply the random rock. The sandstone may be of marginal quality to provide the shell zone, and it is undergoing further testing. Degradation of the shell by weathering of the exposed rock should be expected during the life of the structure and may require selective replacement. If the sandstone will not meet properties needed for pervious shell material, the preliminary zoned rockfill design will have to be revised or, another source would be required. Sources of stronger rock have not yet been investigated. Filter and drain and concrete aggregate would need to be provided from sand and gravel deposits outside the reservoir area. Adequate reserves of developable sand and gravel exist on the Stony Creek fan in the vicinity of Willows and Orland.

A reconnaissance-level investigation was performed for construction materials for the Colusa Reservoir dams. Required materials include impervious core, random fill, rockfill, filter, and drain. For Hunters Dam and Logan Dam, the volume of nearby terrace deposits for the impervious core equal the volume required. Terrace deposits have not been sampled. The source of the random fill has not been identified. Sandstone beds of the Cortina Formation do not exist within the reservoir footprint in the Colusa Cell of the reservoir and the ridge occupied by the dam is a single ridge. There is a ridge about 1/2 mile east of Hunters Dam but it has not been mapped or sampled. Filter and drain, and concrete aggregate would need to be provided from sand and gravel deposits outside the reservoir area. Adequate reserves of developable sand and gravel exist on the Stony Creek fan in the vicinity of Willows and Orland.

Recommendations

Sites Dam

- Detailed geologic mapping of sandstone quarry area to estimate sandstone versus mudstone volume. May include limited drilling.
- Sample and test weathered and unweathered mudstone to determine physical properties to establish whether it can be used as random or rock fill.
- Perform further tests on the sandstone to establish whether it can be used as the dam's upstream shell.

Golden Gate Dam

- Detailed geologic mapping of sandstone quarry area (may be spillway alignment) to estimate sandstone versus mudstone volume. May include limited drilling.
- Sample and test weathered and unweathered mudstone to determine physical properties to establish whether it can be used as random or rock fill.
- Perform further tests on the sandstone to establish whether it can be used as the dam's upstream shell.
- Sample sandstone to confirm properties are consistent with those of rock from Sites quarry area.

Hunters and Logan Dams

- Test pit, sample and analyze terrace deposits.
- Map areas of thick soil development on the Boxer Formation.
- Test pit, sample and analyze thick soils.
- Obtain right of entry to Logan Land and Cattle Co. property east of Hunters Dam, and map sandstone ridge that is potential source of random fill.
- Sample and test sandstone and mudstone from ridge.
- If sandstone is suitable for random fill, then perform full environmental analysis of ridge (botanical, biological, cultural, etc.).

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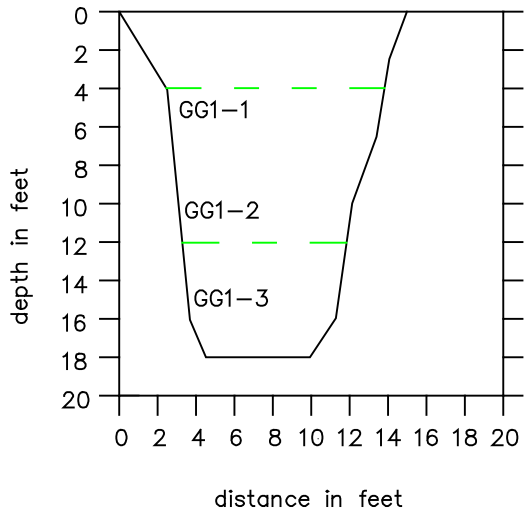
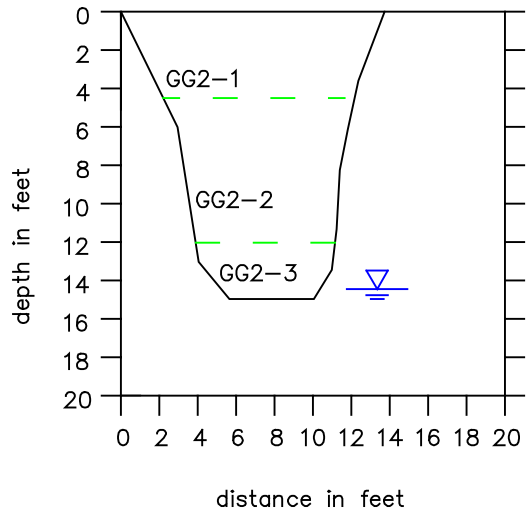
Attachment A. Test Pit Logs

GG1



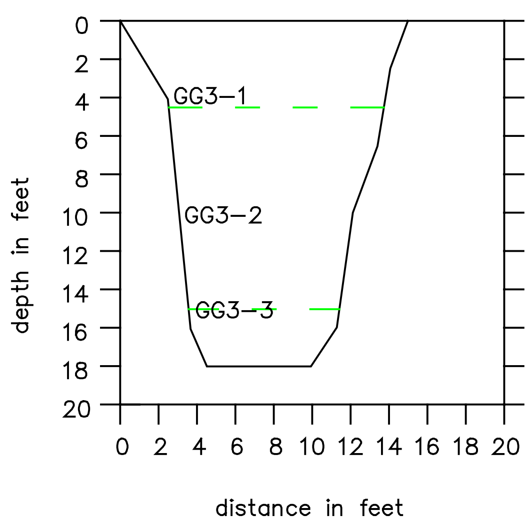
GG1-1	ML	SILT, clayey, slightly moist, Munsell color 10YR3/3, dark brown.
GG1-2	CL	CLAY, silty, moist, slightly plastic, some mottling, Munsell color 10YR4/4, dark yellowish brown.
GG1-3	CL	CLAY, minor silt, Munsell color 10YR4/4, dark yellowish brown.

GG2



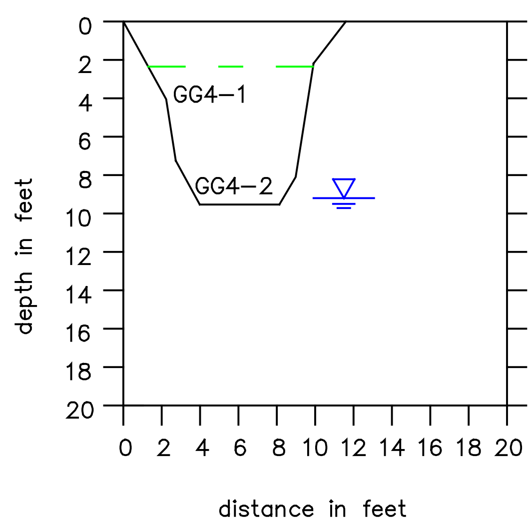
GG2-1	ML	SILT, clayey, slightly moist, Munsell color 10YR4/2, dark grayish brown.
GG2-2	CL	CLAY, silty, moist, slightly plastic, Munsell color 10YR4/4, dark yellowish brown.
GG2-3	CL	CLAY, silty, moist, slightly plastic, Munsell color 10YR4/4, dark yellowish brown.

GG3



GG3-1	ML	SILT, clayey, slightly moist, crumbly, Munsell color 10YR3/3, dark brown.
GG3-2	ML	SILT, clayey, Munsell color 10YR4/4, dark yellowish brown.
GG3-3	CL	CLAY, silty, moist, slightly plastic, Munsell color 10YR4/4, dark yellowish brown.

GG4



GG4-1	CL	CLAY, silty, moist, Munsell color 10YR4/2, dark grayish brown.
GG4-2	CL	CLAY, silty, very moist to wet Munsell color 10YR3/4, dark yellowish brown.

LEGEND

CL — Soil symbols used are from the "Unified Soil Classification System"

GG1-1 — Soil and/or bedrock sample number. Sample number is located at depth taken in cross section.

— — Contact between different materials within same geologic unit.

Water table.

NOTES: Trench locations shown on Figure 6

All trenches were dug using a Mitsubishi hydraulic excavator.

STATE OF CALIFORNIA
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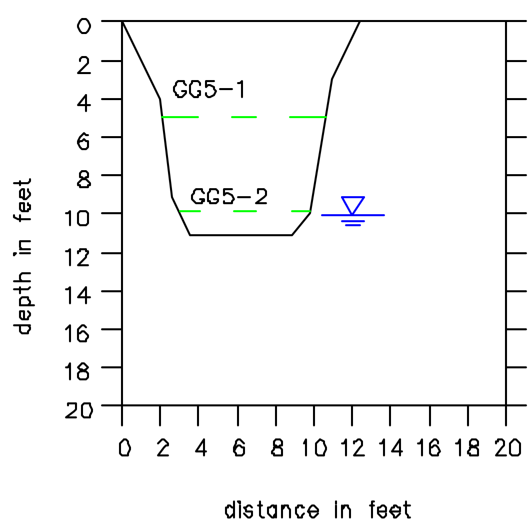
NORTHERN DISTRICT

THE SITES AND COLUSA PROJECTS
CONSTRUCTION MATERIALS

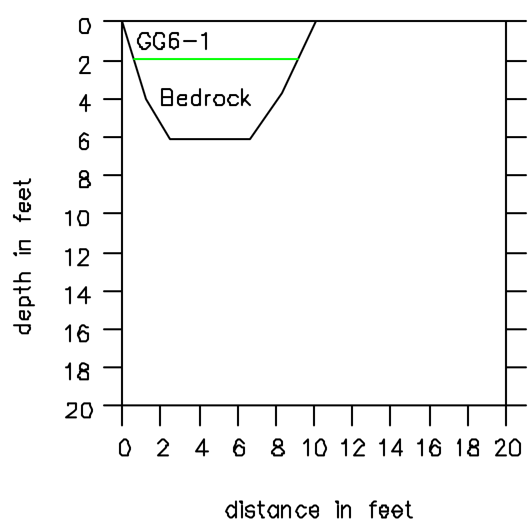
TEST PIT LOGS

GG5



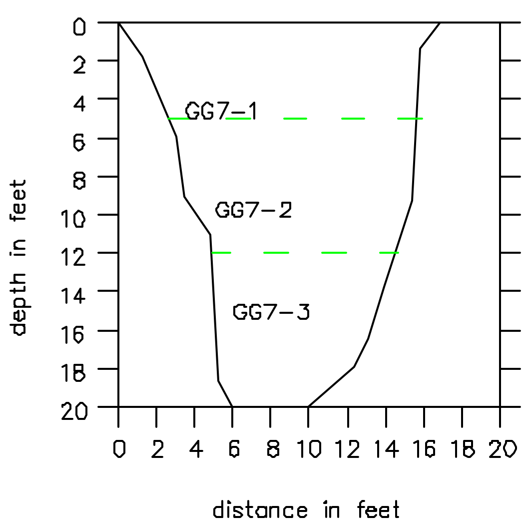
GG5-1	CL	CLAY, silty, slightly moist, stiff, Munsell color 10YR3/3, very dark brown.
GG5-2	CL	CLAY, silty, moist, slightly plastic, some mottling, Munsell color 10YR4/4, dark yellowish brown.

GG6



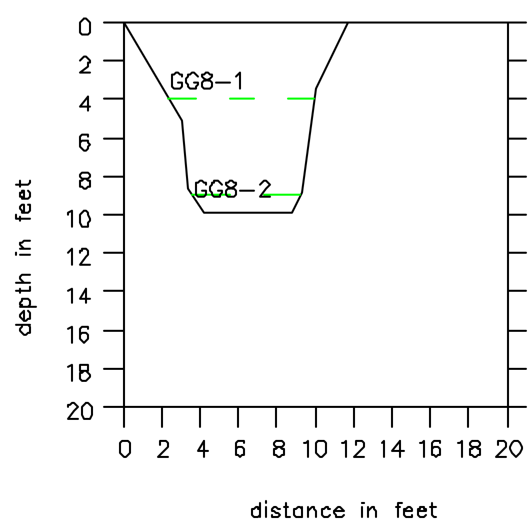
GG6-1	CL	CLAY, silty, slightly moist, tough, Munsell color 10YR3/2, very dark grayish brown.

GG7



GG7-1	ML	SILT, clayey, slightly moist, crumbly, Munsell color 10YR3/2, very dark grayish brown.
GG7-2	ML	SILT, clayey, Munsell color 10YR4/4, dark yellowish brown.
GG7-3	CL	CLAY, silty, moist, slightly plastic, Munsell color 10YR4/4, dark yellowish brown.

GG8



GG8-1	CL	CLAY, silty, gravel clasts – fine to medium, Munsell color 10YR4/2, dark grayish brown.
GG8-2		Weathered bedrock – mudstone, crumbly.

LEGEND

CL	Soil symbols used are from the "unified Soil Classification system"
GG5-1	Soil and/or bedrock sample number. Sample number is located at depth taken in cross section.
— —	Contact between different materials within same geologic unit.
——	Contact between different geologic units.
▽	Water table.

NOTES: Trench locations shown on Figure 6

All trenches were dug using a Mitsubishi hydraulic excavator.

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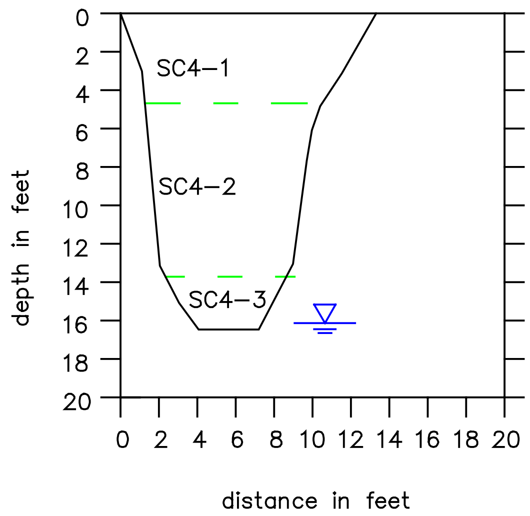
THE SITES AND COLUSA PROJECTS
CONSTRUCTION MATERIALS

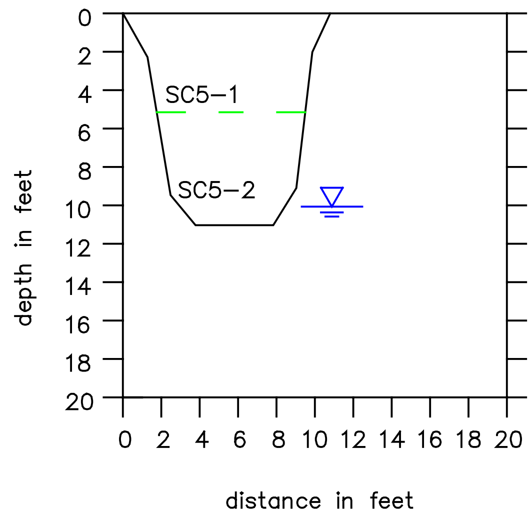
TEST PIT LOGS

SC4



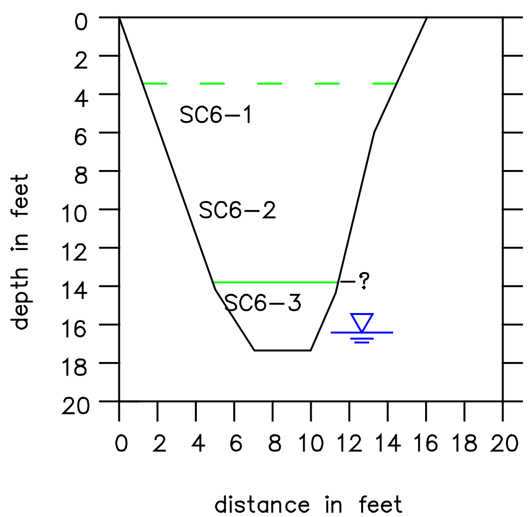
SC4–1	ML	SILT, clayey, slightly moist, Munsell color 10YR3/3, very dark brown.
SC4–2	CL	CLAY, silty, Munsell color 10YR3/6, dark yellowish brown.
SC4–3	CL	CLAY, minor silt, slightly plastic, moist, Munsell color 10YR3/2, very dark grayish brown.

SC5



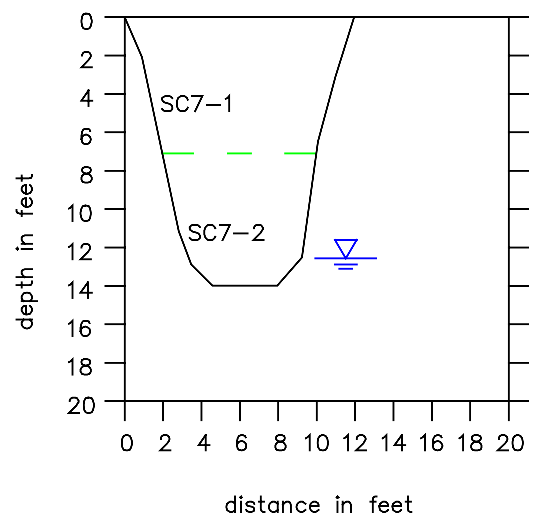
SC5–1	CL	CLAY, minor silt, Munsell color 10YR3/1, very dark gray.
SC5–2	CL	CLAY, very minor silt, medium plastic, wet below ten feet, Munsell color 10YR3/3, dark brown.

SC6



SC6–1	CL	CLAY, minor silt and gravel, Munsell color 10YR3/2, very dark grayish brown.
SC6–2	CL	CLAY, minor gravel, Munsell color 10YR4/4, dark yellowish brown.
SC6–3	CL	CLAY, clayey gravel with minor sand, gravels are subrounded black chert and red sandstone, Munsell color 7.5YR5/4, brown.

SC7



SC7–1	CL	CLAY, silty, few sand grains, Munsell color 10YR4/2, dark grayish brown.
SC7–2	CL	CLAY, minor silt, scattered fine gravel clasts, gastropod shell, Munsell color 10YR6/6, bownish yellow.

LEGEND

CL	Soil symbols used are from the "Unified Soil Classification System"
SC4–1	Soil and/or bedrock sample number. Sample number is located at depth taken in cross section.
— —	Contact between different materials within same geologic unit.
——	Contact between different geologic units.
▽	Water table.

NOTES: Trench locations shown on Figure 5

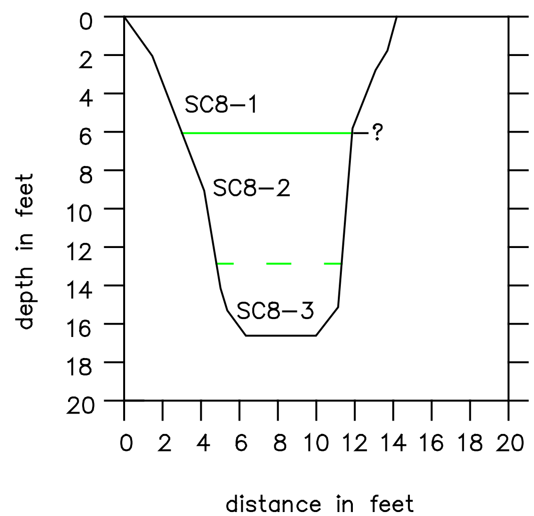
All trenches were dug using a Mitsubishi hydraulic excavator.

STATE OF CALIFORNIA
THE RESOURCE AGENCY
DEPARTMENT OF WATER RESOUCES
NORTHERN DISTRICT

THE SITES AND COLUSA PROJECTS
CONSTRUCTION MATERIALS

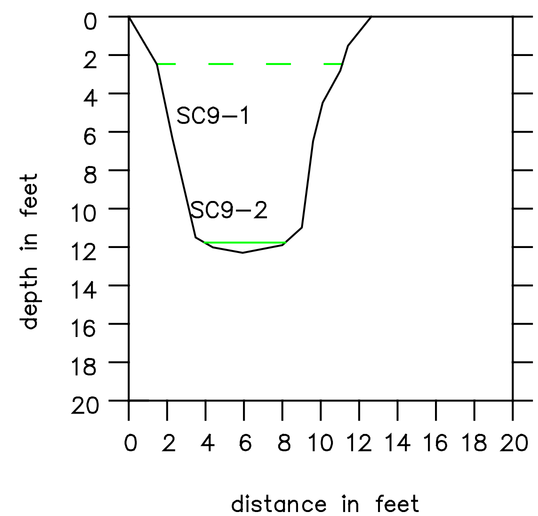
TEST PIT LOGS

SC8



SC8–1	ML	SILT, clayey, minor gravel, gravel lens in side wall, Munsell color 10YR3/3, very dark brown.
SC8–2	SM	CLAY, silty, with sand and gravel –angular, Munsell color 7.5YR5/4, brown.
SC8–3	CL	CLAY, gravelly, rounded clasts up to cobble in size, Munsell color 10YR5/8 to 7.5YR5/8, yellowish brown to strong brown.

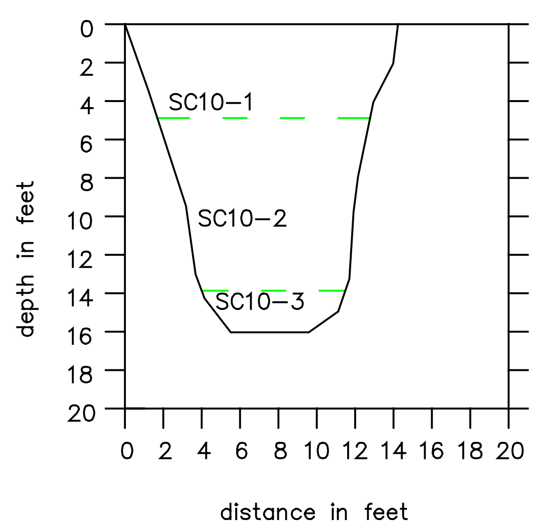
SC9



SC9–1	CL	CLAY, minor silt, slightly moist. calcareous streaking, Munsell color 2.5YR4/3, reddish brown.
SC9–2	CL	CLAY, moist, plastic some black mottling, Munsell color 2.5YR4/2, weak red.

Possible bedrock at 12 feet?

SC10



SC10–1	CL	SILT, clayey, Munsell color 10YR3/4, dark yellowish brown.
SC10–2	CL	CLAY, silty, Munsell color 10YR4/6, dark yellowish brown.
SC10–3	GC	GRAVEL, clayey, Munsell color 10YR4/4, dark yellowish brown.

LEGEND

CL	Soil symbols used are from the "Unified Soil Classification System"
SC9–1	Soil and/or bedrock sample number. Sample number is located at depth taken in cross section.
— —	Contact between different materials within same geologic unit.
——	Contact between different geologic units.
▽	Water table.

NOTES: Trench locations shown on Figure 5

All trenches were dug using a Mitsubishi hydraulic excavator.

STATE OF CALIFORNIA
THE RESOURCE AGENCY
DEPARTMENT OF WATER RESOUCES
NORTHERN DISTRICT

THE SITES AND COLUSA PROJECTS
CONSTRUCTION MATERIALS

TEST PIT LOGS

Attachment B. Laboratory Results

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE: Proposed Geologic Exploration for Borrow Material

LAB. NO	HOLE NO.	F.S. NO	PERCENT FINER – MECHANICAL ANALYSIS – GRAVEL 6"	3"	1½"	¾"	⅜"	4	SAND 8	16	30	50	100	200	HYDROMETER – SILT & CLAY 5M	2M	1M	ATTERBERG LIMITS L.L.	P.I.	SPEC. GRAV. -#4	ORG %	CLASSIFICATION GROUP SYMBOL	GROUP NAME
97-157	SC-1	1										100	98	93				45	27	2.78	4.7	CL	Lean clay
97-158	•	2				100	99	99	97	96	95	91	81	70				38	23	2.79	3.6	CL	Sandy lean clay
97-159	SC-2	1								100	99	97	80	61				34	17	–	3.7	CL	Sandy lean clay
97-160	•	2						100	96	93	92	91	90	87				48	31	–	4.4	CL	Lean clay
97-161	SC-3	1						100	99	97	94	92	90	86				51	35	–	4.9	CH	Fat clay
97-162	•	2						100	94	89	86	83	81	79				53	34	–	5.0	CH	Fat clay with sand
97-163	LC-1	1							100	99	98	91	75	61				33	17	2.77	3.7	CL	Sandy lean clay
97-164	•	2							100	99	99	98	96	92				44	25	2.83	3.8	CL	Lean clay
97-165	LC-2	1									100	99	95	88				44	29	–	4.4	CL	Lean clay
97-166	•	2							100	99	97	92	84	75				34	17	–	3.1	CL	Lean clay with sand
97-167	GG-1	1									100	99	93	74				32	16	2.78	4	CL	Lean clay with sand
97-168	•	2						100	98	96	94	92	88	81				44	29	2.80	5.1	CL	Lean clay with sand
97-169	•	3							100	99	99	97	94	85				41	25	–	5	CL	Lean clay with sand
97-170	GG-2	1						100	99	99	98	96	87	67				30	13	–	3.8	CL	Sandy lean clay
97-171	•	2						100	98	97	96	94	86	68				36	18	–	4	CL	Sandy lean clay
97-172	•	3				100	99	99	99	98	97	95	91	86				59	43	–	7.2	CH	Fat clay
97-173	•	4						100	99	96	93	88	84	76				45	30	–	6.1	CL	Lean clay with sand

DATE: 6/3/98
INITIAL: RGJ
REQUEST NO.: 98-18

REMARKS:

Sheet 1 of 1

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE Sandstone Quality for Rip-Rap and RCC Aggregate

LAB. NO.	HOLE NO.	F.S. NO.	PERCENT FINER MECHANICAL ANALYSIS GRAVEL 3"	1 1/2"	3/4"	3/8"	4	SAND 8	16	30	50	100	200	3-inch CUBE SAMPLES compressive strength (psi)	specific gravity (ssd)	percent absorption %	CLASSIFICATION GROUP SYMBOL	GROUP NAME
98-174	SSQ-1	A												11130	2.50	2.6		
•	•	B												9960	2.48	2.6		
•	•	C												10830	2.48	2.8		
98-175	SSQ-2	A												11840	2.50	2.5		
•	•	B												11690	2.50	2.5		
•	•	C												12370	2.49	2.6		
98-176	SSQ-3	A												*	*	*		
•	•	B												*	*	*		
•	•	C												*	*	*		
98-177	SSQ-4	A												11830	2.50	2.4		
•	•	B												11630	2.50	2.5		
•	•	C												**	**	**		
98-178	SSQ-5	A												10160	2.46	3		
•	•	B												10200	2.45	2.8		
•	•	C												10820	2.45	2.8		
98-179	SSQ-6	A												9940	2.45	2.8		
•	•	B												9910	2.45	2.9		
•	•	C												10990	2.45	2.9		
98-180	SSQ-7	A												11220	2.52	2.5		
•	•	B												10320	2.51	2.3		
•	•	C												10740	2.50	2.7		
98-181	SSQ-8	A												12690	2.48	2.3		
•	•	B												12130	2.49	2.5		
•	•	C												12060	2.49	2.4		

DATE 5/25/1998
INITIAL RGJ
REQUEST NO 98-18

REMARKS: * Unable to obtain cube sample. One side of slab is fractured and uneven.
** can only secure two cube specimens from slab.

Sheet 1 of 2

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE Sandstone Quality for Rip-Rap and RCC Aggregate

LAB. NO.	HOLE NO.	F.S. NO.	PERCENT FINER MECHANICAL ANALYSIS GRAVEL 3"	1 1/2"	3/4"	3/8"	4	SAND 8	16	30	50	100	200	3-inch CUBE SAMPLES compressive strength (psi)	specific gravity (ssd)	percent absorption %	CLASSIFICATION GROUP SYMBOL	GROUP NAME
98-182	SSQ-9	A												11250	2.49	2.8		
•	•	B												11040	2.49	2.6		
•	•	C												11360	2.48	2.6		
98-183	SSQ-10	A												11240	2.45	2.8		
•	•	B												10970	2.46	2.7		
•	•	C												11490	2.46	2.7		

RESULTS OF QUALITY TESTS ON CRUSHED SANDSTONE

1. ASTM C-131 Los Angeles Rattler Test (Grading A = $1^1/_2$ x 3/8 size fraction) :

100 revolutions = 11.4 percent loss

500 revolutions = 43.4 percent loss

Specific Gravity and Absorption tests before performing LART

Spec. Grav. = 2.48

Absorption = 4.2 percent

2. ASTM C— Durabilitly Index (3/4 x #4 size fration)

Durability Index, Dc = 42

Specific Gravity and Absorption tests before performing Coarse Durability Index

Spec. Grav. = 2.50

Absorption = 4.1 percent

DATE 5/25/1998
INITIAL RGJ
REQUEST NO 98-18

REMARKS: In determining the absorption, the strength samples (cubes) were oven dried at 160 °F. The crushed samples were oven dried at 230 °F. All samples were soaked for 24 hours.

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites Dam

FEATURE: ______

LAB NO.	HOLE NO.	F.S. NO.	DEPTH (feet)	PERCENT FINER – MECHANICAL ANALYSIS – GRAVEL 3.0"	1.5"	3/4"	3/8"	4	SAND 8	16	30	50	100	200	HYDROMETER SILT & CLAY 5m	2m	1m	ATTERBERG LIMITS LL	PI	MOISTURE CONTENT %	PERCENT ORGANIC	GROUP SYMBOL	CLASSIFICATION GROUP NAME
99-737	SC-4	1	5									100	97	88				35	20			CL	Lean clay
99-738		2	10					100	96	99	98	96	95	87				39	25			CL	Lean clay
99-739		3	15					100	96	98	98	97	96	84				52	37			CH	Fat clay
99-740	SC-5	1	5						100	99	98	97	96	91				46	31			CL	Lean clay
99-741		2	10					100	99	97	96	94	92	87				57	42			CH	Fat clay
99-742	SC-6	1	5			100	99	99	96	97	96	94	88	80				49	35			CL	Lean clay with sand
99-743		2	10					100	96	97	96	94	89	83				54	38			CH	Fat clay with sand
99-744		3	15			100	98	97	87	82	79	75	68	60				45	30			CL	Sandy lean clay
99-745	SC-7	1	5					100	99	96	94	92	90	88				51	36			CH	Fat clay
99-746		2	10			100	99	99	94	92	87	82	78	73				42	25			CL	Lean clay with sand
99-747	SC-8	1	5		100	99	99	98	96	94	91	87	81	74				43	29			CL	Lean clay with sand
99-748		2	10			100	99	99	96	93	90	85	72	60				41	26			CL	Sandy lean clay
99-749		3	15		100	98	84	91	78	72	68	61	47	36				36	20			CL	Clayey sand
99-750	SC-9	1	5							100	99	99	98	97				72	51			CH	Fat clay
99-751		2	10						100	99	98	98	97	97				68	48			CH	Fat clay
99-752	SC-10	1	5								100	99	95	85				44	24			CL	Lean clay with sand
99-753		2	10					100	99	99	99	98	95	85				41	25			CL	Lean clay with sand
99-754		3	15	100	86	86	80	77	71	67	65	60	53	41				36	21			CL	Clayey sand with gravel
99-755	GG-1	1	5						100	99	99	98	96	87				31	18			CL	Lean clay
99-756		2	10					100	99	98	97	97	96	90				45	20			CL	Lean clay
99-757		3	15					100	97	95	94	93	91	85				41	24			CL	Lean clay
99-758	GG-2	1	5								100	99	96	85				35	19			CL	Lean clay with sand
99-759		2	10							100	99	98	92	77				34	18			CL	Lean clay with sand
99-760		3	15							100	99	98	93	79				35	18			CL	Lean clay with sand
99-761	GG-3	1	5								100	99	95	79				38	18			CL	Lean clay with sand
99-762		2	10					100	94	90	87	81	73	62				32	15			CL	Sandy lean clay
99-763		3	15									100	97	84				39	16			CL	Lean clay with sand
99-764	GG-4	1	4					100	99	98	98	98	96	80				42	25			CL	Lean clay
99-765		2	8									100	99	91				39	22			CL	Lean clay
99-766	GG-5	1	5					100	96	96	95	94	92	89				59	47			CH	Fat clay
99-767		2	15			100	98	99	97	94	89	84	66	55				31	14			CL	Sandy lean clay
99-768	GG-6	1	3					100	99	98	97	97	94	90				52	37			CH	Fat clay
99-769	GG-7	1	5									100	98	88				35	18			CL	Lean clay
99-770		2	10					100	99	99	98	98	95	85				33	16			CL	Lean clay with sand
99-771		3	15					100	99	98	98	98	96	84				30	12			CL	Lean clay with sand
99-772	GG-8	1				100	99	98	98	95	94	93	90	84				54	38			CH	Fat clay with sand
99-773		2	6					100	99	92	91	90	88	87				44	24			CL	Lean clay

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

DATE: 3/17/99
INITIAL:
REQUEST NO: 99-35

REMARKS:

Filename: 9935.XLS

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISON OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites Dam

FEATURE: Composite Samples

LAB NO.	HOLE NO.	F.S. NO.	DEPTH (feet)	PERCENT FINER: MECHANICAL ANALYSIS: GRAVEL 3"	1.5"	3/4"	3/8"	SAND 4	8	16	30	50	100	200	HYDROMETER SILT & CLAY 5µ	2µ	1µ	ATTERBERG LIMITS LL	PI	MOISTURE CONTENT %	PERCENT ORGANICS	GROUP SYMBOL	CLASSIFICATION GROUP NAME
99-1419	GG-Samples							100	99	98	97	97	94	83	41	33	27	38	22		3.9	CL	Lean clay w/sand
99-1420	SC-Samples							100	97	96	95	93	89	81	48	38	33	45	30		4.2	CL	Lean clay w/sand

DATE: 9/28/99

INITIAL: dmt

REQUEST NO.: 99-51

REMARKS: 99-1419 Specific Gravity - 2.74; Max. Dry Density - 111.8pcf; Opt. Moist. - 17.4%
99-1420 Specific Gravity - 2.74; Max. Dry Density - 110.0pcf; Opt. Moist. - 17.0%

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

Attachment C. Terrace Descriptions

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Terrace Descriptions

Station Number	Depth	Description	USCS	Color Munsell
3-15-1	0-2	SILT, clayey, brown	ML	
	2-6	CLAY, silty lighter brown	CL	
	6-7	GRAVEL, clay matrix, clasts rounded chert	GC	
3-15-2	0-4	SILT, clayey	ML	
	4-10	GRAVEL, silty, clasts are subangular sst.	GM	
3-15-3	0-2	SILT, clayey, minor rounded, fine gravel clasts of red and black chert	ML	10YR3/4
	2-4	SILT with clay and sand to granule above silty gravel w/ rnd chert clasts 3-4in.	ML	10YR4/3
3-15-4		Boxer Fm at surface		
3-15-5	0-2	SILT, clayey with gravel clasts to 3 in	ML	10YR4/4
3-15-6	0-4	Thin terrace overlying Boxer		
3-15-7	0-2	CLAY, silty, no gravel	CL	10YR4/2
	9-11	CLAY, plastic	CL	10YR5/4
3-15-8	0-15	Clayey silt and silty clay, some gravel lenses to 4 ft., 2+ft clay at base		
3-17-1	0-4	SILT, clayey	ML	
	8-10	CLAY, plastic	CL	
3-17-2	0-3	SILT, clayey	ML	10YR4/2
	3-9	CLAY, silty	CL	10YR4/4
	9-12	CLAY, plastic	CL	10YR5/4
3-17-3	0-3	SILT, clayey	ML	
	12-15	CLAY, plastic	CL	
3-17-4	0-5	Terrace deposit above Boxer FM.		
3-17-5	0-12	Flat lying clay bed bottom 2ft of terrace		
3-17-6	0-5	SILT, clayey, with gravel, clasts large, subangular sst., no soil structure	ML	7.5YR4/2
3-17-7	0-1.5	CLAY, silty with angular mudstone fragments overlying Boxer Fm.	CL	7.5YR4/4
3-17-8	0-5	SILT, clayey	ML	10YR4/3
	5-10	CLAY. Silty	CL	10YR4/4
	10-20	??		
3-17-9	0-6	Six feet of terrace deposit overlying Boxer Fm.		

Note: Station Number is keyed to the flight line and photo number

Terrace Descriptions (Cont.)

Station Number	Depth	Description	USCS	Color Munsell
3-17-10	0-4	SILT, clayey	ML	
	4-9	GRAVEL, clayey, silty, sandstone clasts	GC	
		Just upstream, reddish silty clay at base under gravel lens (buried soil)		7.5YR4/4
3-17-11	9-11.5	Buried soil under gravel lens, SILT, fine sandy clayey	ML	7.5YR4/6
3-17-12	0-5	Upper sloped surface, 5 ft. thick overlying Boxer Fm.		7.5YR4/3
		Low, flat terrace, blocky prismatic soil structure, no Boxer at base		10YR4/2
3-17-13	0-? Not exposed	Upper sloped surface, CLAY, silty with rounded clasts, fine to medium	CL	7.5YR4/4
3-19-1	0-2.5	Thin soil overlying Boxer Fm		
3-19-2	0-2.5	Thin soil overlying Boxer Fm, bedding planes juxtaposed		
3-19-3	0	Boxer exposed at surface		
3-19-4	0-6.5	SILT, clayey at surface grading to silty clay	ML	
3-19-5	0-8	CLAY, gravelly, silty, clasts rounded to 4 inches red and black chert	CL	7.5YR4/4
3-15-1	0-2	SILT, clayey, brown	ML	
	2-6	CLAY, silty lighter brown	CL	
	6-7	GRAVEL, clay matrix, clasts rounded chert	GC	
4-13-2	0-3	SILT, clayey, blocky-prismatic structure, crumbles easily	ML	10YR3/3
	3-9	Clay, silty to clayey silt,	CL	10YR4/3
	9-12	CLAY, silty with fine gravel clasts overlying Boxer Fm.	CL	10YR5/4
		Buried soil in opposite bank		7.5YR4/4
4-13-3		Cemented gravel bed overlying Boxer Fm.		
4-13-4	0-4	SILT, minor clay, few fine gravel clasts, inset lower terrace	ML	10YR4/3
	4-6	GRAVEL, clayey, silty matrix, clasts fine to medium	GC	
4-13-5	0-3	CLAY, silty over Boxer Fm.	CL	7.5YR4/4
4-13-6		Possible Tehama Fm. on hillside, clayey silt matrix with scattered clasts		10YR6/4
4-13-7	10-12	Possible buried soil between terrace deposit and Boxer Fm., CLAY with rounded gravel clasts	CL	7.5YR4/3
4-13-8	0-3	Thin soil overlying Boxer Fm,		

Note: Station Number is keyed to the flight line and photo number

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Terrace Descriptions (Cont.)

Station Number	Depth	Description	USCS	Color Munsell
4-15-1	0-15	typical terrace deposit		
	15-25	GRAVEL, sandy loose, unconsolidated, rounded sst. Clasts, rusty staining minor clay	GC	5YR4/6
	25-30	CLAY, silty moist, soft moderately plastic	CL	5Y3/2
4-15-2		lower inset? Terrace with poor soil over buried soil, 7.5YR3/4 with orange mottles		
4-15-3	0-28	terrace deposit with very little structure		10YR3/3
	28-30	Grey clay		
4-15-4	0-1	colluvium overlying terrace deposit		
	1-6	CLAY, silty, hard, blocky, base not exposed	CL	10YR4/2
4-15-5		SILT, clayey, friable	ML	10YR4/4
		CLAY, silty, blocky with orange and grey mottling	CL	10YR5/2
4-17-1	7-10	Flat lying conglomerate bed overlying Boxer, hard, cemented, medium to coarse clasts, rounded sandstone and chert, sandstone matrix	GW	
4-17-2	0-1	SILT, clayey	ML	10YR 3/3
	1-5	CLAY, sandy, silty, with gravel. Buried soil	CL	7.5YR4/6
4-17-3	0-2	SILT, clayey, minor fine gravel	ML	10YR3/2
	2-4	CLAY, silty	CL	10YR4/3
	4-5	CLAY, minor silt	CL	10YR4/2
4-17-4	0-17	Terrace Deposit		
	17-20	CLAY, grey	CH	gley
4-17-5	0-7	Thin terrace over sandstone Boxer		
4-17-6		Terrace varies from 6 to 15 ft thick		
3-25-1	0-12	Channel gravels appear to be plated onto sidewalls		
3-25-2	0-3.5	SILT, clayey with minor fine gravel clasts	ML	10YR3/3
	3.5-7.5	CLAY, gravely, subrounded sst. clasts to 8 inches, overlying Boxer	CL	10YR5/6
3-25-3	0-3.5	SILT, clayey with minor fine gravel clasts	ML	10YR4/3
	3.5-8	CLAY, silty	CL	10YR4/4
	8-11.5	CLAY, minor silt, occaisional gravel clasts	CL	10YR4/3
3-25-4	0-5	SILT, clayey	ML	10YR4/3
	5-7.5	GRAVEL, clay matrix, fine to coarse, subrounded to rounded sst and chert	GC	10YR5/6
	7.5-10	Boxer		

Note: Station Number is keyed to the flight line and photo number

Terrace Descriptions (Cont.)

Station Number	Depth	Description	USCS	Color Munsell
3-27-1	0-2	SILT,very fine sand	ML	10YR5/6
	2-6	Silt with minor fine gravel, rounded chert clasts		
3-27-2	0-1	SILT, clayey		
	1-6	GRAVEL, clay matrix, fine to medium red and black chert, rounded	GC	7.5YR5/6
3-29-1	0-2	SILT, clayey	ML	10YR4/3
	2-7	SILT, clayey, limb at 3.5 ft	ML	10YR3/2
3-29-2	0-1.2	SILT, clayey, with some granule sized clasts	ML	10YR3/2
	1.2-4.7	SILT, with fine to medium gravel clasts, CaCO3, bone fragment	ML	10YR6/3
	4.7-6.5	GRAVEL, silt matrix, medium to coarse, sandstone clasts subangular	GM	10YR4/3
3-29-3	0-6	SILT, clayey	ML	10YR3/3
	6-8	GRAVEL, silty, clayey, two lenses	GM	
	8-11	CLAY, plastic	CL	10YR5/6
3-29-4	0-6	SILT, clayey with gravel lenses, sandstone bedrock at base	ML	
3-29-5	0-2	Clay, silty to clayey silt	CL	7.5YR3/2
	2-3	SILT, crumbly	ML	10YR3/3
	3-4.7	GRAVEL, silty, clasts fine to cobble, CaCO3 coatings	GM	
	4.7-6	CLAY, silty, stiff, Boxer sst and mst exposed in channel	CL	10YR5/6
3-29-6	0-2	CLAY, silty with rounded clasts of red and black chert and sst. Conc.	CL	7.5YR4/4
4-23-1	0-25	SILT, clayey with granule clasts of mudstone and sst, weathered	ML	7.5YR5/4
4-23-2	0-2.5	SILT, clayey	ML	10YR3/2
	2.5-6.5	CLAY, silty with minor clasts of sst. and claystone	CL	10YR4/3
4-23-3	0-4	SILT with minor clay, mudstone bedrock in channel on high fan	ML	7.5YR 5/4
4-23-4	0-3.5	SILT, clayey with granule clasts of weathered sst, Boxer exposed in channel	ML	7.5YR4/3
4-23-5	0-1.5	Colluvium over lying vertical bedded Boxer		
4-29-1	0-6	SILT, clayey with some gravel, increasing downward, shale and sst. Clasts	ML	10YR4/3
	6-9	GRAVEL, clayey sandy matrix, subrounded to rounded red and black chert	GC	10YR4/3
4-29-2	0-4	CLAY, silty,with gravel clasts, upper sloped surface overlying Boxer	CL	7.5YR4/3
4-29-3	0-4	CLAY, silty	CL	10YR3/2
	4-8	CLAY, silty	CL	10YR5/4
	8-9.5	CLAY, buried soil	CL	7.5YR5/3
4-29-4	0-3	Thin terrace overlying Boxer Fm.		

Note: Station Number is keyed to the flight line and photo number

Terrace Descriptions (Cont.)

Station Number	Depth	Description	USCS	Color Munsell
4-29-5	0-5	SILT, clayey	ML	10YR4/3
	5-8	GRAVEL, clayey sandy matrix, subrounded to rounded chert, sst clasts at base	GC	7.5YR4/6
		Up channel Boxer is near surface, down channel Boxer is replaced by clay		10YR5/4
4-29-6	0-12	Terrace 12 ft thick		
4-29-7		Upper sloped surface appears to plunge under the Low flat terrace and pinch out against the underlying Boxer Fm. USS is GRAVEL, clayey	GC	7.5YR4/6
		QLFT is SILT, clayey with blocky prismatic soil structure	ML	10YR3/3
4-29-8	0-2	Colluvium overlying Boxer, sandstone clasts to 1+ ft.		10YR4/6
4-29-9	0-2.5	CLAY, minor silt over weathered Boxer	CL	10YR4/3
4-29-10	0-2.5	CLAY with minor silt	CL	10YR3/3
	2.5-5	Weathered claystone		10YR5/4
4-29-11	0-6	SILT, clayey	ML	10YR3/4
	6-12	CLAY with minor silt	CL	10YR4/3
3-35-1	0-4	SILT, clayey, dark, blocky prismatic structure	ML	
	4-8	GRAVEL, sandy, clayey overlying Boxer Fm.	GC	
3-35-2	0-4	SILT, clayey, dark, blocky prismatic structure	ML	10YR3/3
	4-9	GRAVEL, clayey overlying west dipping Boxer	GC	5YR4/4
3-35-3	0-6	SILT, clayey	ML	10YR3/3
	6-10	CLAY, silty with gravel	CL	7.5YR4/4
3-35-4	0-4	CLAY, silty on surface of upper sloped surface, overlying Boxer Fm.	CL	7.5YR3/4
3-35-5		CLAY, silty with some gravel, upper sloped surface, cemented gravel breccia in channel	CL	7.5YR4/3
3-35-6	0-5	Typical QLFT deposit, overlying possible Tehama Fm.??		

Note: Station Number is keyed to the flight line and photo number

Attachment A

Net Irrigated Acreage Data

Tables A-2 through A-4 show net irrigated acreage by crop and water source (either surface water, groundwater, or a mix of the two) for each purveyor analyzed for the Water Exchange Element of the Offstream Storage Investigation. Net irrigated acreage is calculated by applying a reduction factor to the gross acreage to remove the effects of roads, canals, ditches, etc. within the mapped field boundaries. The data for this study area are based on the following Land Use Surveys by the Department: Colusa County, 1993; Glenn County, 1993; Tehama County, 1994; and Yolo County, 1997. These years represent the most recently available data. Also summarized are lands identified as idle/fallow during the survey (but could be irrigated at any time) and managed wetland habitat (i.e., seasonal marsh, permanent marsh). Altogether, these data represent the total irrigation potential.

The study area was divided into three project regions, the Northern Service Area, Central Service Area, and Southern Service Area (see Figure A-1). The purveyors within each region are identified by their region in Table A-1.

Table A-1. Purveyors by Project Region

Northern Service Area	**Central Service Area**	**Southern Service Area**
Corning WD (T)	Glenn-Colusa ID (north of CD Intertie) (G)(C)	4-M WD (C)
Proberta WD (T)	Glide WD (upper) (G)	Colusa County WD (C)(Y)
Thomes Creek WD (T)	Kirkwood WD (G)	Cortina WD (C)
	Orland-Artois WD (G)	Davis WD (C)
	Princeton-Codora-Glenn ID (G)(C)	Dunnigan WD (Y)
	Provident ID (G)(C)	Glenn-Colusa ID (south of CD Intertie) (C)
		Glenn Valley WD (C)
		Glide WD (lower) (G)
		Holthouse WD (C)
		Kanawha WD (G)
		La Grande WD (C)
		Maxwell ID (C)
		Reclamation District 108 (C)(Y)
		River Garden Farms Co. (Y)
		Westside WD (C)

Note: (C) Colusa County; (G) Glenn County; (T) Tehama County; (Y) Yolo County.

The Northern Service Area represents lands north of Stony Creek that could be served only from the Red Bank Project. The only exception is Kirkwood WD, which lies north of Stony Creek but could be served via reverse upstream gravity flows in the Tehama-Colusa Canal from the Thomes-Newville Project and thus is included in the Central Service Area. The Central Service

Area contains purveyors that could be primarily served by the Thomes-Newville Project, but also by the Red Bank Project. This area lies between Stony Creek in the north and the Colusa Basin Intertie in the south. The exceptions to this area are: the inclusion of Kirkwood WD; the inclusion of only the upper portion of Glenn-Colusa ID above the Colusa Basin Intertie; and the exclusion of Kanawha WD and the lower portion of Glide WD, which could be served from either the Sites or Colusa projects via reverse upstream gravity flows in the Tehama-Colusa Canal. The Southern Service Area represents lands south of the Colusa Basin Intertie that could be served by all four projects. This area includes Kanawha WD and the lower portion of Glide WD that were excluded from the Central Service Area.

Figure A-1
Service Areas

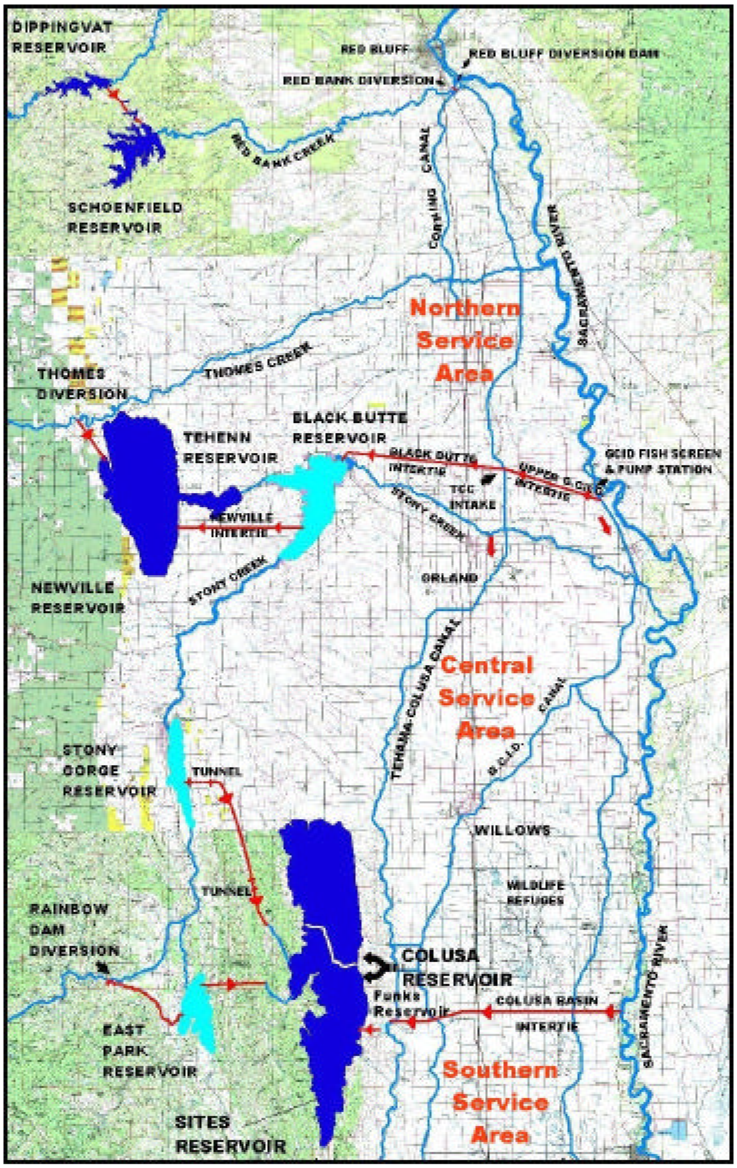

Table A-2

Northern Service Area Net Irrigated Acreage

(acres)

Crop	Corning WD (CC)				Proberta WD (CC)				Thomes Creek WD (CC)				All Lands within the Northern Service Area				Total Purveyor Lands within the Northern Service Area			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	504	57	61	622	0	0	111	111	0	34	117	151	1,478	679	7,703	9,860	504	91	289	884
RICE	456	0	0	456	239	0	122	361	70	84	0	154	856	207	1,509	2,572	765	84	122	971
COTTON																				
SUGAR BEETS													22	0	626	648				
CORN	21	0	10	31	41	0	19	60	0	86	0	86	266	115	1,745	2,126	62	86	29	177
SUNFLOWERS					77	0	75	152					0	0	191	191	77	0	75	152
DRY BEANS													199	0	466	665				
SAFFLOWER													124	91	1,136	1,351				
OTHER FIELD													43	29	436	508				
ALFALFA	95	0	2	97	0	0	110	110	0	384	3	387	776	925	4,227	5,928	95	384	115	594
ALFALFA - X																				
CLOVER SEED									6	0	0	6	57	0	172	229	6	0	0	6
PASTURE	404	132	444	980	195	0	446	641	3	275	60	338	4,984	1,002	15,974	21,960	602	407	950	1,959
PASTURE - X	10	0	0	10									193	0	374	567	10	0	0	10
MEADOW PASTURE	35	0	0	35									124	0	124	248	35	0	0	35
MEADOW PASTURE - X													340	63	0	403				
TOMATOES																				
POTATOES																				
CUCURBITS													0	0	28	28				
ONIONS & CARROTS																				
OTHER TRUCK	5	0	0	5									5	0	135	140	5	0	0	5
ALMONDS	369	248	22	639	65	0	1	66	0	170	28	198	1,136	715	5,773	7,624	434	418	51	903
PISTACHIOS													143	0	284	427				
PRUNES	637	100	7	744	112	0	0	112	0	93	72	165	1,058	820	8,074	9,952	749	193	79	1,021
WALNUTS	49	0	6	55					0	0	4	4	49	1,131	4,719	5,899	49	0	10	59
OTHER DECIDUOUS	135	0	19	154					0	0	8	8	143	0	117	260	135	0	27	162
KIWI													0	11	51	62				
OTHER SUBTROPICAL	1,864	195	508	2,567	0	24	0	24	45	0	3	48	2,551	260	6,956	9,767	1,909	219	511	2,639
GRAPES	20	0	0	20	6	0	3	9					26	0	13	39	26	0	3	29
EUCALYPTUS	523	0	22	545									1,234	35	7,562	8,831	523	0	22	545
Totals	**5,127**	**732**	**1,101**	**6,960**	**735**	**24**	**887**	**1,646**	**124**	**1,126**	**295**	**1,545**	**15,807**	**6,083**	**68,395**	**90,285**	**5,986**	**1,882**	**2,283**	**10,151**
Double Crop Acreage	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**136**	**136**	**0**	**0**	**0**	**0**
Total Irrigated Land Area	**5,127**	**732**	**1,101**	**6,960**	**735**	**24**	**887**	**1,646**	**124**	**1,126**	**295**	**1,545**	**15,807**	**6,083**	**68,259**	**90,149**	**5,986**	**1,882**	**2,283**	**10,151**
FALLOW FIELD	321	48	0	369					0	53	0	53	534	213	1,264	2,011	321	101	0	422
IDLE	860	74	26	960	29	0	509	538	192	129	222	543					1,081	203	757	2,041
RICE FALLOW	239	0	0	239									239	0	170	409	239	0	0	239
SEASONAL DUCK MARSH	15	0	0	15													15	0	0	15
PERMANENT DUCK MARSH																				
PASTURE FALLOW																				
TRUCK FALLOW																				

Table A-3
Central Service Area Net Irrigated Acreage
(acres)

Crop	Glenn-Colusa ID (SR)				Glide WD (TCC) SA#2				Kirkwood WD (TCC)				Orland-Artois WD (TCC)			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	1,663	44	92	1,799	1,037	0	78	1,115	65	29	0	94	2,670	2,066	800	5,536
RICE	42,499	189	2,271	44,959	802	0	0	802					2,661	102	0	2,763
COTTON	7	0	0	7												
SUGAR BEETS	325	0	167	492	147	0	0	147					229	238	276	743
CORN	881	0	70	951	0	0	16	16					638	860	298	1,796
SUNFLOWERS	154	0	0	154												
DRY BEANS	447	0	0	447	49	0	0	49					0	111	167	278
SAFFLOWER	387	0	6	393	239	0	0	239					55	77	0	132
OTHER FIELD	83	0	0	83					0	29	0	29	17	236	1	254
ALFALFA	1,151	90	202	1,443	173	0	0	173	0	65	0	65	971	941	971	2,883
ALFALFA - X																
CLOVER SEED	46	155	4	205									132	374	426	932
PASTURE	2,377	0	26	2,403	3	0	0	3	57	0	98	155	838	1,021	372	2,231
PASTURE - X	19	0	0	19									53	0	0	53
MEADOW PASTURE																
MEADOW PASTURE - X																
TOMATOES																
POTATOES																
CUCURBITS	172	0	0	172												
ONIONS & CARROTS																
OTHER TRUCK													63	0	0	63
ALMONDS	1,124	16	31	1,171	18	0	0	18					1,645	1,729	878	4,252
PISTACHIOS					65	0	0	65					27	13	5	45
PRUNES	223	0	0	223									484	181	309	974
WALNUTS	323	17	141	481									88	0	171	259
OTHER DECIDUOUS	12	0	0	12									42	0	0	42
KIWI	12	0	2	14									2	0	0	2
OTHER SUBTROPICAL	1	0	0	1					8	0	0	8	971	335	164	1,470
GRAPES													34	336	896	1,266
EUCALYPTUS									0	3	0	3	4	10	0	14
Totals	**51,906**	**511**	**3,012**	**55,429**	**2,533**	**0**	**94**	**2,627**	**130**	**126**	**98**	**354**	**11,624**	**8,630**	**5,734**	**25,988**
Double Crop Acreage	**449**	**0**	**41**	**490**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**149**	**206**	**167**	**523**
Total Irrigated Land Area	**51,457**	**511**	**2,971**	**54,939**	**2,533**	**0**	**94**	**2,627**	**130**	**126**	**98**	**354**	**11,475**	**8,424**	**5,567**	**25,466**
FALLOW FIELD	562	0	147	709	17	0	0	17					61	182	390	633
IDLE	1,404	0	15	1,419	116	0	0	116	65	0	25	90	1,186	759	70	2,015
RICE FALLOW	5,073	0	142	5,215	106	0	0	106					322	0	74	396
SEASONAL DUCK MARSH	1,239	5	0	1,244												
PERMANENT DUCK MARSH	7	0	0	7												
PASTURE FALLOW																
TRUCK FALLOW																

Table A-3 (cont.)
Central Service Area Net Irrigated Acreage
(acres)

Crop	Princeton-Codora-Glenn ID (SR)				Provident ID (SR)				Sacramento NWR (SR)				All Lands within the Central Service Area			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	72	10	133	215	52	0	0	52					10,629	3,083	9,110	22,822
RICE	7,430	0	0	7,430	14,177	1	0	14,178					72,416	2,382	2,375	77,173
COTTON													7	0	46	53
SUGAR BEETS	16	0	124	140									870	467	3,234	4,571
CORN	0	35	213	248									2,127	1,473	5,098	8,698
SUNFLOWERS	22	40	98	160									178	40	590	808
DRY BEANS	72	0	53	125									833	181	1,518	2,532
SAFFLOWER	118	0	5	123	23	0	0	23					1,097	206	1,202	2,505
OTHER FIELD									440	0	0	440	663	200	97	960
ALFALFA	53	0	78	131									3,326	1,460	6,831	11,617
ALFALFA - X																
CLOVER SEED	0	0	37	37									179	539	2,195	2,913
PASTURE	80	0	37	117	54	0	2	56					8,743	1,544	3,776	14,063
PASTURE - X													73	0	0	73
MEADOW PASTURE																
MEADOW PASTURE - X																
TOMATOES	34	0	77	111									34	0	404	438
POTATOES																
CUCURBITS	279	0	12	291									611	1	252	864
ONIONS & CARROTS																
OTHER TRUCK													73	16	0	89
ALMONDS					0	8	3	11					4,347	2,838	5,725	12,910
PISTACHIOS	10	116	1	127									160	32	203	395
PRUNES	200	0	16	216									1,745	345	691	2,781
WALNUTS	93	0	296	389	0	0	1	1					754	41	2,030	2,825
OTHER DECIDUOUS	0	17	0	17									177	61	49	287
KIWI													58	38	20	116
OTHER SUBTROPICAL	8	0	0	8									2,989	379	769	4,137
GRAPES													34	336	897	1,267
EUCALYPTUS													10	42	0	52
Totals	**8,487**	**218**	**1,180**	**9,885**	**14,306**	**9**	**6**	**14,321**	**440**	**0**	**0**	**440**	**112,133**	**15,704**	**47,112**	**174,949**
Double Crop Acreage	**72**	**0**	**15**	**87**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1,221**	**224**	**921**	**2,366**
Total Irrigated Land Area	**8,415**	**218**	**1,165**	**9,798**	**14,306**	**9**	**6**	**14,321**	**440**	**0**	**0**	**440**	**110,912**	**15,480**	**46,191**	**172,584**
FALLOW FIELD	50	0	0	50	50	0	0	50					902	215	1,642	2,759
IDLE	132	0	0	132	42	0	0	42					4,872	1,116	3,164	9,152
RICE FALLOW	267	0	2	269	870	0	0	870					6,993	85	267	7,345
SEASONAL DUCK MARSH	41	0	0	41	30	8	0	38	6,317	0	0	6,317	8,569	3,529	0	12,098
PERMANENT DUCK MARSH									1,028	0	0	1,028	1,134	49	0	1,183
PASTURE FALLOW																
TRUCK FALLOW																

Table A-3 (cont.)

Central Service Area Net Irrigated Acreage

(acres)

Crop	TCC Total				Sacramento River Contractor Total				National Wildlife Refuge Totals				Total Purveyor Lands wihtin the Central Service Area			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	3,772	2,095	878	6,745	1,788	53	225	2,066					5,559	2,148	1,103	8,810
RICE	3,463	102	0	3,565	64,106	190	2,271	66,567					67,569	292	2,271	70,132
COTTON					7	0	0	7					7	0	0	7
SUGAR BEETS	376	238	276	890	341	0	291	632					717	238	567	1,522
CORN	638	860	314	1,812	881	35	283	1,199					1,519	895	598	3,012
SUNFLOWERS					176	40	98	314					176	40	98	314
DRY BEANS	49	111	167	327	520	0	53	573					569	111	220	900
SAFFLOWER	295	77	0	372	527	0	10	537					822	77	10	909
OTHER FIELD	17	265	1	283	83	0	0	83	440	0	0	440	540	265	1	806
ALFALFA	1,144	1,006	971	3,121	1,205	90	280	1,575					2,348	1,096	1,251	4,695
ALFALFA - X																
CLOVER SEED	132	374	426	932	46	155	41	242					178	529	466	1,173
PASTURE	898	1,021	470	2,389	2,511	0	65	2,576					3,409	1,021	535	4,965
PASTURE - X	53	0	0	53	19	0	0	19					72	0	0	72
MEADOW PASTURE																
MEADOW PASTURE - X																
TOMATOES					34	0	77	111					34	0	77	111
POTATOES																
CUCURBITS					451	0	12	463					451	0	12	463
ONIONS & CARROTS																
OTHER TRUCK	63	0	0	63									63	0	0	63
ALMONDS	1,663	1,729	878	4,270	1,124	24	34	1,182					2,787	1,753	912	5,452
PISTACHIOS	91	13	5	109	10	116	1	127					102	129	6	237
PRUNES	484	181	309	974	424	0	16	440					907	181	325	1,413
WALNUTS	88	0	171	259	416	17	438	871					504	17	609	1,130
OTHER DECIDUOUS	42	0	0	42	12	17	0	29					54	17	0	71
KIWI	2	0	0	2	12	0	2	14					14	0	2	16
OTHER SUBTROPICAL	979	335	164	1,478	9	0	0	9					987	335	164	1,486
GRAPES	34	336	896	1,266									34	336	896	1,266
EUCALYPTUS	4	13	0	17									4	13	0	17
Totals	**14,287**	**8,756**	**5,926**	**28,969**	**74,702**	**737**	**4,197**	**79,636**	**440**	**0**	**0**	**440**	**89,426**	**9,493**	**10,123**	**109,042**
Double Crop Acreage	**149**	**206**	**167**	**523**	**522**	**0**	**56**	**578**	**0**	**0**	**0**	**0**	**671**	**206**	**223**	**1,100**
Total Irrigated Land Area	**14,138**	**8,550**	**5,759**	**28,447**	**74,180**	**737**	**4,141**	**79,058**	**440**	**0**	**0**	**440**	**88,755**	**9,287**	**9,900**	**107,942**
FALLOW FIELD	78	182	390	650	663	0	147	810					741	182	538	1,461
IDLE	1,366	759	95	2,220	1,578	0	15	1,593					2,944	759	110	3,813
RICE FALLOW	428	0	74	502	6,210	0	143	6,353					6,639	0	218	6,857
SEASONAL DUCK MARSH					1,310	12	0	1,322	6,317	0	0	6,317	7,627	12	0	7,639
PERMANENT DUCK MARSH					7	0	0	7	1,028	0	0	1,028	1,035	0	0	1,035
PASTURE FALLOW																
TRUCK FALLOW																

Table A-4
Southern Service Area Net Irrigated Acreage
(acres)

Crop	4-M WD (TCC)				Colusa County WD (TCC)				Colusa NWR (SR)				Cortina WD (TCC)				Davis WD (TCC)			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	615	0	0	615	5,243	1,079	102	6,424					53	0	0	53	624	0	0	624
RICE	4	0	0	4	878	44	0	922												
COTTON					162	0	0	162												
SUGAR BEETS																				
CORN					128	0	0	128												
SUNFLOWERS					238	10	0	248												
DRY BEANS	98	0	0	98	612	51	6	669												
SAFFLOWER	92	0	0	92	781	148	0	929												
OTHER FIELD					33	0	0	33	217	0	0	217								
ALFALFA	212	0	0	212	851	239	10	1,100					0	56	0	56				
ALFALFA - X																				
CLOVER SEED																				
PASTURE					170	11	1	182												
PASTURE - X																				
MEADOW PASTURE																				
MEADOW PASTURE - X																				
TOMATOES					1,515	975	103	2,593					0	116	0	116	268	0	0	268
POTATOES																				
CUCURBITS	80	0	0	80	1,409	525	11	1,945									329	0	0	329
ONIONS & CARROTS					10	0	0	10												
OTHER TRUCK					23	13	0	36												
ALMONDS					12,964	2,571	86	15,621					200	54	7	261				
PISTACHIOS					15	0	638	653												
PRUNES					52	0	0	52												
WALNUTS					154	64	12	230									6	0	0	6
OTHER DECIDUOUS					87	0	4	91												
KIWI						0														
OTHER SUBTROPICAL					26	88	0	114												
GRAPES					894	218	0	1,112												
EUCALYPTUS					3	0	0	3												
Totals	**1,101**	**0**	**0**	**1,101**	**26,248**	**6,036**	**973**	**33,257**	**217**	**0**	**0**	**217**	**253**	**226**	**7**	**486**	**1,227**	**0**	**0**	**1,227**
Double Crop Acreage	**0**	**0**	**0**	**0**	**427**	**172**	**0**	**599**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**296**	**0**	**0**	**296**
Total Irrigated Land Area	**1,101**	**0**	**0**	**1,101**	**25,821**	**5,864**	**973**	**32,658**	**217**	**0**	**0**	**217**	**253**	**226**	**7**	**486**	**931**	**0**	**0**	**931**
FALLOW FIELD					8	0	0	8					85	0	0	85	130	0	0	130
IDLE	238	4	0	242	2,214	269	24	2,507												
RICE FALLOW					1	0	0	1												
SEASONAL DUCK MARSH									2,599	0	0	2,599								
PERMANENT DUCK MARSH					26	0	0	26	122	0	0	122								
PASTURE FALLOW																				
TRUCK FALLOW																				

Table A-4 (cont.)
Southern Service Area Net Irrigated Acreage
(acres)

Crop	Delevan NWR (SR)				Dunnigan WD (TCC)				Glenn-Colusa ID (SR)				Glenn Valley WD (TCC)				Glide WD (TCC) SA#3			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN					1,373	618	67	2,058	6,299	67	1	6,367	214	0	0	214	1,192	16	37	1,245
RICE					93	0	0	93	47,648	500	0	48,148	67	0	0	67	879			879
COTTON					327	155	0	482	212	0	0	212								
SUGAR BEETS									389	0	2	391	1	0	0	1	175			175
CORN					285	238	0	523	694	0	0	694					151	67	51	269
SUNFLOWERS					39	356	0	395	130	0	0	130								
DRY BEANS					76	0	62	138	556	0	1	557	228	0	0	228	242			242
SAFFLOWER					0	163	0	163	1,498	117	73	1,688					172			172
OTHER FIELD	423	0	0	423	13	0	0	13	323	0	0	323								
ALFALFA					279	304	50	633	1,432	0	0	1,432					138			138
ALFALFA - X									34	0	0	34								
CLOVER SEED																				
PASTURE					29	10	0	39	2,349	0	0	2,349	6	0	0	6	71			71
PASTURE - X									31	0	0	31								
MEADOW PASTURE																				
MEADOW PASTURE - X																				
TOMATOES					564	470	0	1,034	3,061	59	134	3,254								
POTATOES																				
CUCURBITS					329	671	112	1,112	3,711	2	16	3,729	64	0	0	64				
ONIONS & CARROTS																				
OTHER TRUCK					23	0	0	23	60	0	0	60								
ALMONDS					302	606	199	1,107	95	0	0	95					64			64
PISTACHIOS																	13			13
PRUNES					0	32	0	32												
WALNUTS					34	4	0	38	461	0	0	461								
OTHER DECIDUOUS																				
KIWI									95	0	0	95								
OTHER SUBTROPICAL									10	0	0	10								
GRAPES					0	291	0	291	113	0	0	113								
EUCALYPTUS																				
Totals	**423**	**0**	**0**	**423**	**3,766**	**3,918**	**490**	**8,174**	**69,201**	**745**	**227**	**70,173**	**580**	**0**	**0**	**580**	**3,097**	**83**	**88**	**3,268**
Double Crop Acreage	**0**	**0**	**0**	**0**	**76**	**121**	**62**	**259**	**2,313**	**0**	**1**	**2,314**	**0**	**0**	**0**	**0**	**241**	**0**	**0**	**241**
Total Irrigated Land Area	**423**	**0**	**0**	**423**	**3,690**	**3,797**	**428**	**7,915**	**66,888**	**745**	**226**	**67,859**	**580**	**0**	**0**	**580**	**2,856**	**83**	**88**	**3,027**
FALLOW FIELD					362	39	0	401	6	0	2	8					100			100
IDLE					74	39	288	401	7,705	0	0	7,705	40	0	0	40	41			41
RICE FALLOW									48	0	0	48					70			70
SEASONAL DUCK MARSH	3,493	0	0	3,493					567	0	0	567								
PERMANENT DUCK MARSH	512	0	0	512					104	0	0	104								
PASTURE FALLOW					8	0	0	8												
TRUCK FALLOW																				

Table A-4 (cont.)
Southern Service Area Net Irrigated Acreage
(acres)

Crop	Holthouse WD (TCC)				Kanawha WD (TCC)				La Grande WD (TCC)				Maxwell ID (SR)			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	88	0	0	88	4,063	1,268	404	5,735	111	0	0	111	75	0	0	75
RICE					1,536	0	0	1,536	967	0	0	967	4,728	0	0	4,728
COTTON																
SUGAR BEETS					944	295	342	1,581								
CORN					1,099	79	4	1,182								
SUNFLOWERS					634	43	5	682	70	0	0	70				
DRY BEANS	34	0	0	34	341	120	0	461								
SAFFLOWER					637	0	3	640								
OTHER FIELD					7	0	0	7								
ALFALFA	33	0	0	33	616	213	0	829								
ALFALFA - X																
CLOVER SEED																
PASTURE	120	0	0	120	395	0	3	398	98	0	0	98				
PASTURE - X																
MEADOW PASTURE																
MEADOW PASTURE - X																
TOMATOES																
POTATOES																
CUCURBITS	101	0	0	101	64	52	0	116								
ONIONS & CARROTS																
OTHER TRUCK					14	0	0	14								
ALMONDS																
PISTACHIOS																
PRUNES					33	0	0	33								
WALNUTS																
OTHER DECIDUOUS																
KIWI																
OTHER SUBTROPICAL																
GRAPES																
EUCALYPTUS																
Totals	**376**	**0**	**0**	**376**	**10,383**	**2,070**	**761**	**13,214**	**1,246**	**0**	**0**	**1,246**	**4,803**	**0**	**0**	**4,803**
Double Crop Acreage	**0**	**0**	**0**	**0**	**195**	**0**	**0**	**195**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Irrigated Land Area	**376**	**0**	**0**	**376**	**10,188**	**2,070**	**761**	**13,019**	**1,246**	**0**	**0**	**1,246**	**4,803**	**0**	**0**	**4,803**
FALLOW FIELD					70	0	0	70								
IDLE	189	0	0	189	302	19	0	321	114	0	0	114	247	0	0	247
RICE FALLOW					96	0	0	96								
SEASONAL DUCK MARSH													1,175	0	0	1,175
PERMANENT DUCK MARSH													1,262	0	0	1,262
PASTURE FALLOW																
TRUCK FALLOW																

Table A-4 (cont.)
Southern Service Area Net Irrigated Acreage
(acres)

Crop	Reclamation District 108 (SR)				River Garden Farms (SR)				Westside WD (TCC)				All Lands within the Southern Service Area			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	5,018	194	0	5,212					2,754	367	771	3,892	34,070	5,664	20,106	59,840
RICE	23,061	0	0	23,061	1,645	0	0	1,645	784	0	0	784	105,503	7,335	131	112,969
COTTON	106	0	0	106									2,039	155	1,606	3,800
SUGAR BEETS	598	0	0	598					51	0	0	51	3,828	697	2,111	6,636
CORN	2,137	0	0	2,137	534	0	0	534					8,164	1,351	4,218	13,733
SUNFLOWERS	303	0	0	303	430	0	0	430					634	409	919	1,962
DRY BEANS	1,311	0	0	1,311	203	0	0	203	703	0	88	791	5,934	767	3,175	9,876
SAFFLOWER	5,479	121	0	5,600	1,594	0	0	1,594	293	10	0	303	15,701	1,160	3,356	20,217
OTHER FIELD	338	0	0	338					22	0	0	22	1,675	1,269	494	3,438
ALFALFA	1,693	0	0	1,693					47	0	0	47	6,946	1,439	5,216	13,601
ALFALFA - X													34	0	0	34
CLOVER SEED																
PASTURE	197	0	0	197					172	0	0	172	4,332	21	478	4,831
PASTURE - X													58	0	0	58
MEADOW PASTURE													0	0	5	5
MEADOW PASTURE - X																
TOMATOES	7,325	0	0	7,325	1,966	0	0	1,966	3,085	0	2	3,087	21,795	2,614	18,900	43,309
POTATOES																
CUCURBITS	2,173	0	0	2,173	336	0	0	336	1,967	0	142	2,109	15,076	2,390	3,890	21,356
ONIONS & CARROTS													17	0	34	51
OTHER TRUCK	14	0	0	14					79	0	0	79	304	35	466	805
ALMONDS									560	137	741	1,438	15,019	3,535	4,646	23,200
PISTACHIOS													102	0	869	971
PRUNES	37	0	0	37									2,049	276	393	2,718
WALNUTS	438	0	0	438					100	0	0	100	2,790	353	1,883	5,026
OTHER DECIDUOUS	5	0	0	5									281	0	8	289
KIWI													17	0	0	17
OTHER SUBTROPICAL													29	88	4	121
GRAPES													1,416	509	2,085	4,010
EUCALYPTUS													20	0	43	63
Totals	**50,233**	**315**	**0**	**50,548**	**6,708**	**0**	**0**	**6,708**	**10,617**	**514**	**1,744**	**12,875**	**247,833**	**30,067**	**75,036**	**352,936**
Double Crop Acreage	**1,370**	**0**	**0**	**1,370**	**0**	**0**	**0**	**0**	**1,115**	**0**	**205**	**1,320**	**7,636**	**693**	**3,117**	**11,446**
Total Irrigated Land Area	**48,863**	**315**	**0**	**49,178**	**6,708**	**0**	**0**	**6,708**	**9,502**	**514**	**1,539**	**11,555**	**240,197**	**29,374**	**71,919**	**341,490**
FALLOW FIELD	34	0	0	34	14	0	0	14					952	0	634	1,586
IDLE	1,053	0	0	1,053	73	0	0	73	341	0	0	341	16,352	1,782	1,936	20,070
RICE FALLOW													1,876	0	0	1,876
SEASONAL DUCK MARSH	15	0	0	15					14	0	0	14	8,775	107	0	8,882
PERMANENT DUCK MARSH	1	0	0	1									2,141	0	0	2,141
PASTURE FALLOW													0	0	8	8
TRUCK FALLOW	3	0	0	3	4	0	0	4					27	0	42	69

Table A-4 (cont.)
Southern Service Area Net Irrigated Acreage
(acres)

Crop	TCC Total				Sacramento River Contractor Total				National Wildlife Refuge Totals				Total Purveyor Lands within the Southern Service Area			
	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total	Surface	Mixed	Ground	Total
GRAIN	16,331	3,349	1,381	21,061	11,391	261	1	11,653					27,722	3,610	1,382	32,714
RICE	5,208	44	0	5,252	77,083	500	0	77,583					82,291	543	0	82,834
COTTON	489	155	0	644	318	0	0	318					808	155	0	963
SUGAR BEETS	1,171	295	342	1,808	986	0	2	988					2,157	295	344	2,796
CORN	1,663	385	55	2,103	3,364	0	0	3,364					5,027	385	55	5,467
SUNFLOWERS	980	409	5	1,394	864	0	0	864					1,844	409	5	2,258
DRY BEANS	2,334	171	156	2,661	2,070	0	1	2,071					4,404	171	157	4,732
SAFFLOWER	1,975	322	3	2,300	8,571	238	73	8,882					10,546	560	76	11,182
OTHER FIELD	75	0	0	75	661	0	0	661	639	0	0	639	1,376	0	0	1,376
ALFALFA	2,176	812	61	3,049	3,125	0	0	3,125					5,300	812	61	6,173
ALFALFA - X					34	0	0	34					34	0	0	34
CLOVER SEED																
PASTURE	1,061	21	4	1,086	2,546	0	0	2,546					3,607	21	4	3,632
PASTURE - X					31	0	0	31					31	0	0	31
MEADOW PASTURE																
MEADOW PASTURE - X																
TOMATOES	5,432	1,561	105	7,098	12,352	59	134	12,545					17,784	1,620	238	19,642
POTATOES																
CUCURBITS	4,342	1,248	265	5,855	6,220	2	16	6,238					10,561	1,250	281	12,092
ONIONS & CARROTS	10	0	0	10									10	0	0	10
OTHER TRUCK	139	13	0	152	74	0	0	74					213	13	0	226
ALMONDS	14,089	3,368	1,033	18,490	95	0	0	95					14,184	3,368	1,033	18,585
PISTACHIOS	29	0	638	667									29	0	638	667
PRUNES	86	32	0	118	37	0	0	37					123	32	0	155
WALNUTS	294	67	12	373	899	0	0	899					1,192	67	12	1,271
OTHER DECIDUOUS	87	0	4	91	5	0	0	5					92	0	4	96
KIWI					95	0	0	95					95	0	0	95
OTHER SUBTROPICAL	26	88	0	114	10	0	0	10					35	88	0	123
GRAPES	894	508	0	1,402	113	0	0	113					1,007	508	0	1,515
EUCALYPTUS	3	0	0	3									3	0	0	3
Totals	**58,894**	**12,848**	**4,064**	**75,806**	**130,944**	**1,060**	**227**	**132,231**	**639**	**0**	**0**	**639**	**190,475**	**13,907**	**4,290**	**208,672**
Double Crop Acreage	**1,914**	**293**	**267**	**2,474**	**3,683**	**0**	**1**	**3,684**	**0**	**0**	**0**	**0**	**5,597**	**293**	**268**	**6,158**
Total Irrigated Land Area	**56,980**	**12,555**	**3,797**	**73,332**	**127,261**	**1,060**	**226**	**128,547**	**639**	**0**	**0**	**639**	**184,878**	**13,614**	**4,022**	**202,514**
FALLOW FIELD	754	39	0	793	54	0	2	56					808	39	2	849
IDLE	3,552	331	312	4,195	9,077	0	0	9,077					12,629	331	312	13,272
RICE FALLOW	167	0	0	167	48	0	0	48					216	0	0	216
SEASONAL DUCK MARSH	14	0	0	14	1,758	0	0	1,758	6,092	0	0	6,092	7,864	0	0	7,864
PERMANENT DUCK MARSH	26	0	0	26	1,366	0	0	1,366	634	0	0	634	2,025	0	0	2,025
PASTURE FALLOW	8	0	0	8									8	0	0	8
TRUCK FALLOW					7	0	0	7					7	0	0	7

Attachment B

Agricultural Land and Water Use Data

This appendix presents tables showing net irrigated acreage, evapotranspiration of applied water and applied water by crop for each purveyor by region. The regions were identified in Appendix A. The values in these tables represent average year conditions based on the latest available cropping data and values of calculated ETAW and applied water as described in the Applied Water section of this report. For presentation of quantities of applied water in terms of two available sources (i.e., surface water, groundwater), the mixed source acreage was distributed to other categories by using a ratio that represents the estimated percentage of each source applied to an average field condition within the study area.

Table B-1

Average Agricultural Land and Water Use for Corning Water District

Northern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.6	70%	0.9	85%	0.7	533	90	622	320	54	373	479	63	542
RICE	3.2	58%	5.5	63%	5.1	456	0	456	1,459	0	1,459	2,508	0	2,508
COTTON														
SUGAR BEETS														
CORN	1.9	65%	2.9	70%	2.7	21	10	31	40	19	59	61	27	88
SUNFLOWERS														
DRY BEANS														
SAFFLOWER														
OTHER FIELD														
ALFALFA	3.3	70%	4.7	75%	4.4	95	2	97	314	7	320	447	9	455
ALFALFA - X														
CLOVER SEED														
PASTURE	3.4	65%	5.2	75%	4.5	470	510	980	1,598	1,734	3,332	2,444	2,295	4,739
PASTURE - X	2.3	65%	3.5	75%	3.1	10	0	10	23	0	23	35	0	35
MEADOW PASTURE	3.2	65%	4.9	75%	4.3	35	0	35	112	0	112	172	0	172
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS														
ONIONS & CARROTS														
OTHER TRUCK	1.5	70%	2.1	75%	2.0	5	0	5	8	0	8	11	0	11
ALMONDS	2.6	75%	3.5	80%	3.3	493	146	639	1,282	380	1,661	1,726	482	2,207
PISTACHIOS														
PRUNES	2.5	65%	3.8	70%	3.6	687	57	744	1,718	143	1,860	2,611	205	2,816
WALNUTS	2.4	70%	3.4	75%	3.2	49	6	55	118	14	132	167	19	186
OTHER DECIDUOUS	2.6	70%	3.7	75%	3.5	135	19	154	351	49	400	500	67	566
KIWI														
CITRUS - OLIVES	2.1	70%	3.0	75%	2.8	1,962	606	2,567	4,119	1,272	5,391	5,885	1,695	7,580
GRAPES	1.5	75%	2.0	80%	1.9	20	0	20	30	0	30	40	0	40
EUCALYPTUS	2.1	85%	2.5	85%	2.5	523	22	545	1,098	46	1,145	1,308	55	1,363
Totals						**5,493**	**1,467**	**6,960**	**12,588**	**3,717**	**16,305**	**18,390**	**4,917**	**23,307**
Double Crop Acreage						**0**	**0**	**0**						
Total Irrigated Land Area						**5,493**	**1,467**	**6,960**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-2

Average Agricultural Land and Water Use for Proberta Water District

Northern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.6	70%	0.9	85%	0.7	0	111	111	0	67	67	0	78	78
RICE	3.2	58%	5.5	63%	5.1	239	122	361	765	390	1,155	1,315	622	1,937
COTTON														
SUGAR BEETS														
CORN	1.9	65%	2.9	70%	2.7	41	19	60	78	36	114	119	51	170
SUNFLOWERS	1.4	65%	2.2	70%	2.0	77	75	152	108	105	213	169	150	319
DRY BEANS														
SAFFLOWER														
OTHER FIELD														
ALFALFA	3.3	70%	4.7	75%	4.4	0	110	110	0	363	363	0	484	484
ALFALFA - X														
CLOVER SEED														
PASTURE	3.4	65%	5.2	75%	4.5	195	446	641	663	1,516	2,179	1,014	2,007	3,021
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS														
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS	2.6	75%	3.5	80%	3.3	65	1	66	169	3	172	228	3	231
PISTACHIOS														
PRUNES	2.5	65%	3.8	70%	3.6	112	0	112	280	0	280	426	0	426
WALNUTS														
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES	2.1	70%	3.0	75%	2.8	12	12	24	25	25	50	36	34	70
GRAPES	1.5	75%	2.0	80%	1.9	6	3	9	9	5	14	12	6	18
EUCALYPTUS														
Totals						**747**	**899**	**1,646**	**2,097**	**2,510**	**4,607**	**3,318**	**3,435**	**6,753**
Double Crop Acreage						**0**	**0**	**0**						
Total Irrigated Land Area						**747**	**899**	**1,646**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-3

Average Agricultural Land and Water Use for Thomes Creek Water District

Northern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.6	70%	0.9	85%	0.7	20	131	151	12	78	91	18	91	110
RICE	3.2	58%	5.5	63%	5.1	120	34	154	385	108	493	662	171	834
COTTON														
SUGAR BEETS														
CORN	1.9	65%	2.9	70%	2.7	52	34	86	98	65	163	150	93	243
SUNFLOWERS														
DRY BEANS														
SAFFLOWER														
OTHER FIELD														
ALFALFA	3.3	70%	4.7	75%	4.4	230	157	387	760	517	1,277	1,083	689	1,772
ALFALFA - X														
CLOVER SEED	2.4	70%	3.4	75%	3.2	6	0	6	14	0	14	20	0	20
PASTURE	3.4	65%	5.2	75%	4.5	168	170	338	571	578	1,149	874	765	1,639
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS														
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS	2.6	75%	3.5	80%	3.3	102	96	198	265	250	515	357	317	674
PISTACHIOS														
PRUNES	2.5	65%	3.8	70%	3.6	56	109	165	140	273	413	212	393	605
WALNUTS	2.4	70%	3.4	75%	3.2	0	4	4	0	10	10	0	13	13
OTHER DECIDUOUS	2.6	70%	3.7	75%	3.5	0	8	8	0	21	21	0	28	28
KIWI														
CITRUS - OLIVES	2.1	70%	3.0	75%	2.8	45	3	48	95	6	101	135	8	143
GRAPES														
EUCALYPTUS														
Totals						**800**	**745**	**1,545**	**2,341**	**1,905**	**4,246**	**3,511**	**2,569**	**6,080**
Double Crop Acreage						**0**	**0**	**0**						
Total Irrigated Land Area						**800**	**745**	**1,545**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-4

Summary of Average Agricultural Land and Water Use for Northern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.6	70%	0.9	85%	0.7	1,818	8,043	9,860	1,091	4,826	5,916	1,636	5,630	7,266
RICE	3.2	58%	5.5	63%	5.1	960	1,613	2,572	3,070	5,160	8,230	5,277	8,224	13,501
COTTON														
SUGAR BEETS	3.1	65%	4.8	75%	4.1	22	626	648	68	1,941	2,009	106	2,567	2,672
CORN	1.9	65%	2.9	70%	2.7	324	1,803	2,126	615	3,425	4,040	938	4,867	5,805
SUNFLOWERS	1.4	65%	2.2	70%	2.0	0	191	191	0	267	267	0	382	382
DRY BEANS	1.4	70%	2.0	80%	1.8	199	466	665	279	652	931	398	839	1,237
SAFFLOWER	0.0	60%		60%		170	1,182	1,351	0	0	0	0	0	0
OTHER FIELD	1.5	65%	2.3	70%	2.1	58	451	508	86	676	762	132	946	1,078
ALFALFA	3.3	70%	4.7	75%	4.4	1,239	4,690	5,928	4,087	15,475	19,563	5,821	20,634	26,455
ALFALFA - X														
CLOVER SEED	2.4	70%	3.4	75%	3.2	57	172	229	137	413	550	194	550	744
PASTURE	3.4	65%	5.2	75%	4.5	5,485	16,475	21,960	18,649	56,015	74,664	28,522	74,138	102,660
PASTURE - X	2.3	65%	3.5	75%	3.1	193	374	567	444	860	1,304	676	1,159	1,835
MEADOW PASTURE	3.2	65%	4.9	75%	4.3	124	124	248	397	397	794	608	533	1,141
MEADOW PASTURE - X	2.0	65%	3.1	75%	2.7	372	32	403	743	63	806	1,152	85	1,237
TOMATOES														
POTATOES														
CUCURBITS	1.0	75%	1.3	80%	1.3	0	28	28	0	28	28	0	36	36
ONIONS & CARROTS														
OTHER TRUCK	1.5	70%	2.1	75%	2.0	5	135	140	8	203	210	11	270	281
ALMONDS	2.6	75%	3.5	80%	3.3	1,494	6,131	7,624	3,883	15,939	19,822	5,227	20,231	25,458
PISTACHIOS	2.5	75%	3.3	80%	3.1	143	284	427	358	710	1,068	472	880	1,352
PRUNES	2.5	65%	3.8	70%	3.6	1,468	8,484	9,952	3,670	21,210	24,880	5,578	30,542	36,121
WALNUTS	2.4	70%	3.4	75%	3.2	615	5,285	5,899	1,475	12,683	14,158	2,089	16,910	19,000
OTHER DECIDUOUS	2.6	70%	3.7	75%	3.5	143	117	260	372	304	676	529	410	939
KIWI	1.6	75%	2.1	80%	2.0	6	57	62	9	90	99	12	113	125
CITRUS - OLIVES	2.1	70%	3.0	75%	2.8	2,681	7,086	9,767	5,630	14,881	20,511	8,043	19,841	27,884
GRAPES	1.5	75%	2.0	80%	1.9	26	13	39	39	20	59	52	25	77
EUCALYPTUS	2.1	85%	2.5	85%	2.5	1,252	7,580	8,831	2,628	15,917	18,545	3,129	18,949	22,078
Totals						**18,849**	**71,437**	**90,285**	**47,736**	**172,154**	**219,890**	**70,601**	**228,760**	**299,361**
Double Crop Acreage						**0**	**136**	**136**						
Total Irrigated Land Area						**18,849**	**71,301**	**90,149**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-5

Average Agricultural Land and Water Use for (Upper) Glenn-Colusa Irrigation District

Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	1,685	114	1,799	1,180	80	1,259	1,685	91	1,776
RICE	3.2	58%	5.5	63%	5.1	42,594	2,366	44,959	136,299	7,570	143,869	234,264	12,064	246,328
COTTON	2.2	70%	3.1	75%	2.9	7	0	7	15	0	15	22	0	22
SUGAR BEETS	3.2	65%	4.9	75%	4.3	325	167	492	1,040	534	1,574	1,593	718	2,311
CORN	1.9	65%	2.9	70%	2.7	881	70	951	1,674	133	1,807	2,555	189	2,744
SUNFLOWERS	1.5	65%	2.3	70%	2.1	154	0	154	231	0	231	354	0	354
DRY BEANS	1.8	70%	2.6	80%	2.3	447	0	447	805	0	805	1,162	0	1,162
SAFFLOWER	0.1	60%	0.2	60%	0.2	387	6	393	39	1	39	77	1	79
OTHER FIELD	1.6	65%	2.5	70%	2.3	83	0	83	133	0	133	208	0	208
ALFALFA	3.4	70%	4.9	75%	4.5	1,196	247	1,443	4,066	840	4,906	5,860	1,112	6,972
ALFALFA - X														
CLOVER SEED	2.6	70%	3.7	75%	3.5	124	82	205	321	212	533	457	285	742
PASTURE	3.5	65%	5.4	75%	4.7	2,377	26	2,403	8,320	91	8,411	12,836	122	12,958
PASTURE - X	2.4	65%	3.7	75%	3.2	19	0	19	46	0	46	70	0	70
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS	1.0	75%	1.3	80%	1.3	172	0	172	172	0	172	224	0	224
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS	2.7	75%	3.6	80%	3.4	1,132	39	1,171	3,056	105	3,162	4,075	133	4,208
PISTACHIOS														
PRUNES	2.6	65%	4.0	70%	3.7	223	0	223	580	0	580	892	0	892
WALNUTS	2.5	70%	3.6	75%	3.3	332	150	481	829	374	1,203	1,193	493	1,687
OTHER DECIDUOUS	2.7	70%	3.9	75%	3.6	12	0	12	32	0	32	47	0	47
KIWI	1.7	85%	2.0	85%	2.0	12	2	14	20	3	24	24	4	28
CITRUS - OLIVES	2.2	70%	3.1	75%	2.9	1	0	1	2	0	2	3	0	3
GRAPES														
EUCALYPTUS														
Totals						**52,162**	**3,268**	**55,429**	**158,860**	**9,943**	**168,802**	**267,601**	**15,213**	**282,814**
Double Crop Acreage						**449**	**41**	**490**						
Total Irrigated Land Area						**51,712**	**3,227**	**54,939**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-6

Average Agricultural Land and Water Use for (Upper) Glide Water District

Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	1,037	78	1,115	726	55	781
RICE	3.2	58%	5.5	63%	5.1	802	0	802	2,566	0	2,566
COTTON											
SUGAR BEETS	3.2	65%	4.9	75%	4.3	147	0	147	470	0	470
CORN	1.9	65%	2.9	70%	2.7	0	16	16	0	30	30
SUNFLOWERS											
DRY BEANS	1.8	70%	2.6	80%	2.3	49	0	49	88	0	88
SAFFLOWER	0.1	60%	0.2	60%	0.2	239	0	239	24	0	24
OTHER FIELD											
ALFALFA	3.4	70%	4.9	75%	4.5	173	0	173	588	0	588
ALFALFA - X											
CLOVER SEED											
PASTURE	3.5	65%	5.4	75%	4.7	3	0	3	11	0	11
PASTURE - X											
MEADOW PASTURE											
MEADOW PASTURE - X											
TOMATOES											
POTATOES											
CUCURBITS											
ONIONS & CARROTS											
OTHER TRUCK											
ALMONDS	2.7	75%	3.6	80%	3.4	18	0	18	49	0	49
PISTACHIOS	2.6	75%	3.5	80%	3.3	65	0	65	169	0	169
PRUNES											
WALNUTS											

Table B-7

Average Agricultural Land and Water Use for Kirkwood Water District

Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.6	70% 0.9	85% 0.7	82	12	94	49	7	56	74	8	82
RICE												
COTTON												
SUGAR BEETS												
CORN												
SUNFLOWERS												
DRY BEANS												
SAFFLOWER												
OTHER FIELD	1.5	65% 2.3	70% 2.1	17	12	29	26	17	44	40	24	64
ALFALFA	3.3	70% 4.7	75% 4.4	39	26	65	129	86	215	183	114	298
ALFALFA - X												
CLOVER SEED												
PASTURE	3.4	65% 5.2	75% 4.5	57	98	155	194	333	527	296	441	737
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES												
POTATOES												
CUCURBITS												
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS												
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES	2.1	70% 3.0	75% 2.8	8	0	8	17	0	17	24	0	24
GRAPES												
EUCALYPTUS	2.1	85% 2.5	85% 2.5	2	1	3	4	3	6	5	3	8
Totals				**206**	**148**	**354**	**419**	**446**	**865**	**622**	**591**	**1,213**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**206**	**148**	**354**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-8

Average Agricultural Land and Water Use for Orland-Artois Water District

Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	3,910	1,626	5,536	2,737	1,139	3,875	3,910	1,301	5,211
RICE	3.2	58%	5.5	63%	5.1	2,722	41	2,763	8,711	131	8,842	14,972	208	15,180
COTTON														
SUGAR BEETS	3.2	65%	4.9	75%	4.3	372	371	743	1,190	1,188	2,378	1,822	1,596	3,418
CORN	1.9	65%	2.9	70%	2.7	1,154	642	1,796	2,193	1,220	3,412	3,347	1,733	5,080
SUNFLOWERS														
DRY BEANS	1.8	70%	2.6	80%	2.3	67	211	278	120	381	500	173	486	659
SAFFLOWER	0.1	60%	0.2	60%	0.2	101	31	132	10	3	13	20	6	26
OTHER FIELD	1.6	65%	2.5	70%	2.3	159	95	254	254	153	406	397	219	616
ALFALFA	3.4	70%	4.9	75%	4.5	1,536	1,347	2,883	5,221	4,581	9,802	7,524	6,063	13,588
ALFALFA - X														
CLOVER SEED	2.6	70%	3.7	75%	3.5	356	576	932	927	1,497	2,423	1,319	2,015	3,333
PASTURE	3.5	65%	5.4	75%	4.7	1,451	780	2,231	5,077	2,731	7,809	7,833	3,668	11,501
PASTURE - X	2.4	65%	3.7	75%	3.2	53	0	53	127	0	127	196	0	196
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS														
ONIONS & CARROTS														
OTHER TRUCK	1.5	70%	2.1	75%	2.0	63	0	63	95	0	95	132	0	132
ALMONDS	2.7	75%	3.6	80%	3.4	2,682	1,570	4,252	7,243	4,238	11,480	9,657	5,337	14,993
PISTACHIOS	2.6	75%	3.5	80%	3.3	35	10	45	91	27	117	122	34	156
PRUNES	2.6	65%	4.0	70%	3.7	593	381	974	1,541	992	2,532	2,370	1,411	3,782
WALNUTS	2.5	70%	3.6	75%	3.3	88	171	259	220	428	648	317	564	881
OTHER DECIDUOUS	2.7	70%	3.9	75%	3.6	42	0	42	113	0	113	164	0	164
KIWI	1.7	85%	2.0	85%	2.0	2	0	2	3	0	3	4	0	4
CITRUS - OLIVES	2.2	70%	3.1	75%	2.9	1,172	298	1,470	2,578	656	3,234	3,633	864	4,497
GRAPES	1.6	75%	2.1	80%	2.0	236	1,030	1,266	377	1,649	2,026	495	2,061	2,556
EUCALYPTUS	2.2	85%	2.6	85%	2.6	10	4	14	22	9	31	26	10	36
Totals						**16,802**	**9,186**	**25,988**	**38,848**	**21,019**	**59,867**	**58,432**	**27,578**	**86,010**
Double Crop Acreage						**273**	**250**	**523**						
Total Irrigated Land Area						**16,529**	**8,936**	**25,466**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-9

Average Agricultural Land and Water Use for Princeton-Codora-Glenn Irrigation District

Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	78	137	215	55	96	151	78	110	188
RICE	3.2	55%	5.8	60%	5.3	7,430	0	7,430	23,776	0	23,776	43,094	0	43,094
COTTON														
SUGAR BEETS	3.2	65%	4.9	75%	4.3	16	124	140	51	397	448	78	533	612
CORN	1.9	65%	2.9	70%	2.7	21	227	248	40	431	471	61	613	674
SUNFLOWERS	1.5	65%	2.3	70%	2.1	46	114	160	69	171	240	106	239	345
DRY BEANS	1.8	70%	2.6	80%	2.3	72	53	125	130	95	225	187	122	309
SAFFLOWER	0.1	60%	0.2	60%	0.2	118	5	123	12	1	12	24	1	25
OTHER FIELD														
ALFALFA	3.4	70%	4.9	75%	4.5	53	78	131	180	265	445	260	351	611
ALFALFA - X														
CLOVER SEED	2.6	70%	3.7	75%	3.5	0	37	37	0	96	96	0	130	130
PASTURE	3.5	65%	5.4	75%	4.7	80	37	117	280	130	410	432	174	606
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES	1.8	70%	2.6	75%	2.4	34	77	111	61	139	200	88	185	273
POTATOES														
CUCURBITS	1.0	65%	1.5	75%	1.3	279	12	291	279	12	291	419	16	434
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS														
PISTACHIOS	2.6	75%	3.5	80%	3.3	80	47	127	207	123	330	279	156	435
PRUNES	2.6	65%	4.0	70%	3.7	200	16	216	520	42	562	800	59	859
WALNUTS	2.5	70%	3.6	75%	3.3	93	296	389	233	740	973	335	977	1,312
OTHER DECIDUOUS	2.7	70%	3.9	75%	3.6	10	7	17	28	18	46	40	25	64
KIWI														
CITRUS - OLIVES	2.2	70%	3.1	75%	2.9	8	0	8	18	0	18	25	0	25
GRAPES														
EUCALYPTUS														
Totals						**8,618**	**1,267**	**9,885**	**25,937**	**2,756**	**28,693**	**46,305**	**3,690**	**49,994**
Double Crop Acreage						**72**	**15**	**87**						
Total Irrigated Land Area						**8,546**	**1,252**	**9,798**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-10

Average Agricultural Land and Water Use for Provident Irrigation District

Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	52	0	52	36	0	36	52	0	52
RICE	3.2	58%	5.5	63%	5.1	14,178	1	14,178	45,368	2	45,370	77,976	3	77,979
COTTON														
SUGAR BEETS														
CORN														
SUNFLOWERS														
DRY BEANS														
SAFFLOWER	0.1	60%	0.2	60%	0.2	23	0	23	2	0	2	5	0	5
OTHER FIELD														
ALFALFA														
ALFALFA - X														
CLOVER SEED														
PASTURE	3.5	65%	5.4	75%	4.7	54	2	56	189	7	196	292	9	301
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS														
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS	2.7	75%	3.6	80%	3.4	4	7	11	11	19	30	14	24	38
PISTACHIOS														
PRUNES														
WALNUTS	2.5	70%	3.6	75%	3.3	0	1	1	0	3	3	0	3	3
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES														
GRAPES														
EUCALYPTUS														
Totals						**14,311**	**11**	**14,321**	**45,607**	**30**	**45,637**	**78,339**	**39**	**78,378**
Double Crop Acreage						**0**	**0**	**0**						
Total Irrigated Land Area						**14,311**	**11**	**14,321**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-11

Summary of Average Agricultural Land and Water Use for Central Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	12,171	10,652	22,822	8,519	7,456	15,976	12,171	8,521	20,692
RICE	3.2	58%	5.5	63%	5.1	73,607	3,566	77,173	235,542	11,411	246,954	404,839	18,187	423,025
COTTON	2.2	70%	3.1	75%	2.9	7	46	53	15	101	117	22	133	155
SUGAR BEETS	3.2	65%	4.9	75%	4.3	1,104	3,468	4,571	3,531	11,096	14,627	5,407	14,910	20,318
CORN	1.9	65%	2.9	70%	2.7	2,864	5,835	8,698	5,441	11,086	16,526	8,304	15,753	24,057
SUNFLOWERS	1.5	65%	2.3	70%	2.1	198	610	808	297	915	1,212	455	1,281	1,736
DRY BEANS	1.8	70%	2.6	80%	2.3	924	1,609	2,532	1,662	2,895	4,558	2,401	3,700	6,101
SAFFLOWER	0.1	60%	0.2	60%	0.2	1,200	1,305	2,505	120	131	251	240	261	501
OTHER FIELD	1.6	65%	2.5	70%	2.3	763	197	960	1,221	315	1,536	1,908	453	2,361
ALFALFA	3.4	70%	4.9	75%	4.5	4,056	7,561	11,617	13,790	25,707	39,498	19,874	34,025	53,899
ALFALFA - X														
CLOVER SEED	2.6	70%	3.7	75%	3.5	449	2,465	2,913	1,166	6,408	7,574	1,660	8,626	10,285
PASTURE	3.5	65%	5.4	75%	4.7	9,515	4,548	14,063	33,303	15,918	49,221	51,381	21,376	72,757
PASTURE - X	2.4	65%	3.7	75%	3.2	73	0	73	175	0	175	270	0	270
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES	1.8	70%	2.6	75%	2.4	34	404	438	61	727	788	88	970	1,058
POTATOES														
CUCURBITS	1.0	75%	1.3	80%	1.3	612	253	864	612	253	864	795	328	1,123
ONIONS & CARROTS														
OTHER TRUCK	1.5	70%	2.1	75%	2.0	81	8	89	122	12	134	170	16	186
ALMONDS	2.7	75%	3.6	80%	3.4	5,766	7,144	12,910	15,568	19,289	34,857	20,758	24,290	45,047
PISTACHIOS	2.6	75%	3.5	80%	3.3	176	219	395	458	569	1,027	616	723	1,339
PRUNES	2.6	65%	4.0	70%	3.7	1,918	864	2,781	4,986	2,245	7,231	7,670	3,195	10,865
WALNUTS	2.5	70%	3.6	75%	3.3	775	2,051	2,825	1,936	5,126	7,063	2,788	6,767	9,555
OTHER DECIDUOUS	2.7	70%	3.9	75%	3.6	208	80	287	560	215	775	809	286	1,096
KIWI	1.7	85%	2.0	85%	2.0	77	39	116	131	66	197	154	78	232
CITRUS - OLIVES	2.2	70%	3.1	75%	2.9	3,179	959	4,137	6,993	2,109	9,101	9,853	2,780	12,633
GRAPES	1.6	75%	2.1	80%	2.0	202	1,065	1,267	323	1,704	2,027	424	2,130	2,554
EUCALYPTUS	2.2	85%	2.6	85%	2.6	31	21	52	68	46	114	81	55	135
Totals						**119,985**	**54,964**	**174,949**	**336,601**	**125,800**	**462,401**	**553,138**	**168,842**	**721,980**
Double Crop Acreage						**1,333**	**1,033**	**2,366**						
Total Irrigated Land Area						**118,652**	**53,931**	**172,584**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-12

Average Agricultural Land and Water Use for 4 - M Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	615	0	615	431	0	431	615	0	615
RICE	3.2	58%	5.5	63%	5.1	4	0	4	13	0	13	22	0	22
COTTON														
SUGAR BEETS														
CORN														
SUNFLOWERS														
DRY BEANS	1.8	65%	2.8	80%	2.3	98	0	98	176	0	176	274	0	274
SAFFLOWER	0.1	60%	0.2	60%	0.2	92	0	92	9	0	9	18	0	18
OTHER FIELD														
ALFALFA	3.5	65%	5.4	70%	5.0	212	0	212	742	0	742	1,145	0	1,145
ALFALFA - X														
CLOVER SEED														
PASTURE														
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS	1.1	65%	1.7	75%	1.5	80	0	80	88	0	88	136	0	136
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS														
PISTACHIOS														
PRUNES														
WALNUTS														
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES														
GRAPES														
EUCALYPTUS														
Totals						**1,101**	**0**	**1,101**	**1,459**	**0**	**1,459**	**2,211**	**0**	**2,211**
Double Crop Acreage						**0**	**0**	**0**						
Total Irrigated Land Area						**1,101**	**0**	**1,101**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-13

Average Agricultural Land and Water Use for Colusa County Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	5,254	1,170	6,424	3,678	819	4,497	5,254	936	6,190
RICE	3.2	58%	5.5	63%	5.1	878	44	922	2,811	139	2,950	4,831	222	5,054
COTTON	2.3	70%	3.3	75%	3.1	162	0	162	373	0	373	535	0	535
SUGAR BEETS														
CORN	2.0	65%	3.1	70%	2.9	128	0	128	256	0	256	397	0	397
SUNFLOWERS	1.5	65%	2.3	70%	2.1	238	10	248	357	15	372	548	21	568
DRY BEANS	1.8	70%	2.6	80%	2.3	613	56	669	1,103	102	1,204	1,593	130	1,722
SAFFLOWER	0.1	60%	0.2	60%	0.2	782	147	929	78	15	93	157	29	186
OTHER FIELD	1.7	65%	2.6	70%	2.4	33	0	33	56	0	56	86	0	86
ALFALFA	3.5	70%	5.0	75%	4.7	853	247	1,100	2,987	863	3,850	4,267	1,159	5,426
ALFALFA - X														
CLOVER SEED														
PASTURE	3.6	65%	5.5	75%	4.8	170	12	182	612	43	655	936	57	993
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES	1.8	70%	2.6	75%	2.4	1,525	1,068	2,593	2,745	1,923	4,668	3,964	2,564	6,528
POTATOES														
CUCURBITS	1.1	70%	1.6	75%	1.5	1,414	531	1,945	1,556	584	2,140	2,263	796	3,059
ONIONS & CARROTS	2.5	65%	3.8	70%	3.6	10	0	10	25	0	25	38	0	38
OTHER TRUCK	1.6	70%	2.3	75%	2.1	23	13	36	37	21	58	53	27	80
ALMONDS	2.8	80%	3.5	85%	3.3	12,990	2,631	15,621	36,371	7,368	43,739	45,464	8,683	54,147
PISTACHIOS	2.7	80%	3.4	85%	3.2	15	638	653	41	1,723	1,763	51	2,042	2,093
PRUNES	2.6	70%	3.7	75%	3.5	52	0	52	135	0	135	192	0	192
WALNUTS	2.6	75%	3.5	80%	3.3	155	75	230	402	196	598	541	249	790
OTHER DECIDUOUS	2.8	75%	3.7	80%	3.5	87	4	91	244	11	255	322	14	336
KIWI														
CITRUS - OLIVES	2.3	70%	3.3	75%	3.1	27	87	114	62	200	262	89	270	359
GRAPES	1.6	75%	2.1	80%	2.0	896	216	1,112	1,434	345	1,779	1,882	432	2,314
EUCALYPTUS	2.3	85%	2.7	85%	2.7	3	0	3	7	0	7	8	0	8
Totals						**26,308**	**6,949**	**33,257**	**55,368**	**14,366**	**69,734**	**73,469**	**17,631**	**91,100**
Double Crop Acreage						**429**	**170**	**599**						
Total Irrigated Land Area						**25,880**	**6,778**	**32,658**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-14

Average Agricultural Land and Water Use for Cortina Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70% 1.0	85% 0.8	53	0	53	37	0	37	53	0	53
RICE												
COTTON												
SUGAR BEETS												
CORN												
SUNFLOWERS												
DRY BEANS												
SAFFLOWER												
OTHER FIELD												
ALFALFA	3.5	70% 5.0	75% 4.7	50	6	56	176	20	196	252	26	278
ALFALFA - X												
CLOVER SEED												
PASTURE												
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES	1.8	70% 2.6	75% 2.4	104	12	116	188	21	209	271	28	299
POTATOES												
CUCURBITS												
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS	2.8	75% 3.7	80% 3.5	249	12	261	696	35	731	920	43	963
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**456**	**30**	**486**	**1,098**	**75**	**1,173**	**1,496**	**98**	**1,594**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**456**	**30**	**486**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-15

Average Agricultural Land and Water Use for Davis Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	624	0	624	437	0	437	624	0	624
RICE														
COTTON														
SUGAR BEETS														
CORN														
SUNFLOWERS														
DRY BEANS														
SAFFLOWER														
OTHER FIELD														
ALFALFA														
ALFALFA - X														
CLOVER SEED														
PASTURE														
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES	1.8	70%	2.6	75%	2.4	268	0	268	482	0	482	697	0	697
POTATOES														
CUCURBITS	1.1	75%	1.5	80%	1.4	329	0	329	362	0	362	494	0	494
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS														
PISTACHIOS														
PRUNES														
WALNUTS	2.6	70%	3.7	75%	3.5	6	0	6	16	0	16	22	0	22
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES														
GRAPES														
EUCALYPTUS														
Totals						**1,227**	**0**	**1,227**	**1,297**	**0**	**1,297**	**1,837**	**0**	**1,837**
Double Crop Acreage						**296**	**0**	**296**						
Total Irrigated Land Area						**931**	**0**	**931**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-16

AverageAgricultural Land and Water Use for Dunnigan Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	1,806	252	2,058	1,264	177	1,441	1,806	202	2,008
RICE	3.2	58%	5.5	63%	5.1	93	0	93	298	0	298	512	0	512
COTTON	2.3	70%	3.3	75%	3.1	436	47	482	1,002	107	1,109	1,437	144	1,581
SUGAR BEETS														
CORN	2.0	65%	3.1	70%	2.9	452	71	523	903	143	1,046	1,400	207	1,607
SUNFLOWERS	1.5	65%	2.3	70%	2.1	288	107	395	432	160	593	663	224	887
DRY BEANS	1.8	65%	2.8	75%	2.4	76	62	138	137	112	248	213	149	362
SAFFLOWER	0.1	60%	0.2	60%	0.2	114	49	163	11	5	16	23	10	33
OTHER FIELD	1.7	65%	2.6	70%	2.4	13	0	13	22	0	22	34	0	34
ALFALFA	3.5	70%	5.0	75%	4.7	492	141	633	1,721	494	2,216	2,459	664	3,123
ALFALFA - X														
CLOVER SEED														
PASTURE	3.6	65%	5.5	75%	4.8	36	3	39	130	11	140	198	14	212
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES [2]	1.8	70%	2.9	75%	2.7	893	141	1,034	1,607	254	1,861	2,590	381	2,970
POTATOES														
CUCURBITS	1.1	75%	1.5	80%	1.4	799	313	1,112	879	345	1,223	1,198	439	1,637
ONIONS & CARROTS														
OTHER TRUCK	1.6	70%	2.3	75%	2.1	23	0	23	37	0	37	53	0	53
ALMONDS	2.8	75%	3.7	80%	3.5	726	381	1,107	2,033	1,066	3,100	2,687	1,333	4,020
PISTACHIOS														
PRUNES	2.6	65%	4.0	70%	3.7	22	10	32	58	25	83	90	36	125
WALNUTS	2.6	70%	3.7	75%	3.5	37	1	38	96	3	99	136	4	140
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES														
GRAPES	1.6	75%	2.1	80%	2.0	204	87	291	326	140	466	428	175	602
EUCALYPTUS														
Totals						**6,509**	**1,665**	**8,174**	**10,956**	**3,041**	**13,997**	**15,925**	**3,981**	**19,905**
Double Crop Acreage						**161**	**98**	**259**						
Total Irrigated Land Area						**6,348**	**1,567**	**7,915**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

[2] Applied water includes cultural practice.

Table B-17

Average Agricultural Land and Water Use for (Lower) Glenn-Colusa Irrigation District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre) Surface		Ground		Net Irrigated Acreage[1] (acres) Surface	Ground	Total	ET of Applied Water (acre-feet) Surface	Ground	Total	Applied Water (acre-feet) Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	6,333	35	6,367	4,433	24	4,457	6,333	28	6,360
RICE	3.2	58%	5.5	63%	5.1	47,898	250	48,148	153,274	800	154,074	263,439	1,275	264,714
COTTON	2.3	70%	3.3	75%	3.1	212	0	212	488	0	488	700	0	700
SUGAR BEETS	3.3	65%	5.1	75%	4.4	389	2	391	1,284	7	1,290	1,984	9	1,993
CORN	2.0	65%	3.1	70%	2.9	694	0	694	1,388	0	1,388	2,151	0	2,151
SUNFLOWERS	1.5	65%	2.3	70%	2.1	130	0	130	195	0	195	299	0	299
DRY BEANS	1.8	70%	2.6	80%	2.3	556	1	557	1,001	2	1,003	1,446	2	1,448
SAFFLOWER	0.1	60%	0.2	60%	0.2	1,557	132	1,688	156	13	169	311	26	338
OTHER FIELD	1.7	65%	2.6	70%	2.4	323	0	323	549	0	549	840	0	840
ALFALFA	3.5	70%	5.0	75%	4.7	1,432	0	1,432	5,012	0	5,012	7,160	0	7,160
ALFALFA - X	2.4	70%	3.4	75%	3.2	34	0	34	82	0	82	116	0	116
CLOVER SEED														
PASTURE	3.6	65%	5.5	75%	4.8	2,349	0	2,349	8,456	0	8,456	12,920	0	12,920
PASTURE - X	2.5	65%	3.8	75%	3.3	31	0	31	78	0	78	118	0	118
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES	1.8	70%	2.6	75%	2.4	3,091	164	3,254	5,563	294	5,857	8,035	392	8,428
POTATOES														
CUCURBITS	1.1	75%	1.5	80%	1.4	3,712	17	3,729	4,083	19	4,102	5,568	24	5,592
ONIONS & CARROTS														
OTHER TRUCK	1.6	70%	2.3	75%	2.1	60	0	60	96	0	96	138	0	138
ALMONDS	2.8	75%	3.7	80%	3.5	95	0	95	266	0	266	352	0	352
PISTACHIOS														
PRUNES														
WALNUTS	2.6	70%	3.7	75%	3.5	461	0	461	1,199	0	1,199	1,706	0	1,706
OTHER DECIDUOUS														
KIWI	1.8	75%	2.4	80%	2.3	95	0	95	171	0	171	228	0	228
CITRUS - OLIVES	2.3	70%	3.3	75%	3.1	10	0	10	23	0	23	33	0	33
GRAPES	1.6	75%	2.1	80%	2.0	113	0	113	181	0	181	237	0	237
EUCALYPTUS														
Totals						**69,574**	**600**	**70,173**	**187,975**	**1,159**	**189,134**	**314,112**	**1,756**	**315,868**
Double Crop Acreage						**2,313**	**1**	**2,314**						
Total Irrigated Land Area						**67,261**	**599**	**67,859**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-18

Average Agricultural Land and Water Use for Glenn-Valley Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70% 1.0	85% 0.8	214	0	214	150	0	150	214	0	214
RICE	3.2	58% 5.5	63% 5.1	67	0	67	214	0	214	369	0	369
COTTON												
SUGAR BEETS	3.3	65% 5.1	75% 4.4	1	0	1	3	0	3	5	0	5
CORN												
SUNFLOWERS												
DRY BEANS	1.8	70% 2.6	80% 2.3	228	0	228	410	0	410	593	0	593
SAFFLOWER												
OTHER FIELD												
ALFALFA												
ALFALFA - X												
CLOVER SEED												
PASTURE	3.6	65% 5.5	75% 4.8	6	0	6	22	0	22	33	0	33
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES												
POTATOES												
CUCURBITS	1.1	75% 1.5	80% 1.4	64	0	64	70	0	70	96	0	96
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS												
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**580**	**0**	**580**	**870**	**0**	**870**	**1,309**	**0**	**1,309**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**580**	**0**	**580**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-19

Average Agricultural Land and Water Use for (Lower) Glide Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	1,200	45	1,245	840	32	872	1,200	36	1,236
RICE	3.2	58%	5.5	63%	5.1	879	0	879	2,813	0	2,813	4,835	0	4,835
COTTON														
SUGAR BEETS	3.2	65%	4.9	75%	4.3	175	0	175	560	0	560	858	0	858
CORN	1.9	65%	2.9	70%	2.7	185	85	269	351	161	511	535	228	763
SUNFLOWERS														
DRY BEANS	1.8	70%	2.6	80%	2.3	242	0	242	436	0	436	629	0	629
SAFFLOWER	0.1	60%	0.2	60%	0.2	172	0	172	17	0	17	34	0	34
OTHER FIELD														
ALFALFA	3.4	70%	4.9	75%	4.5	138	0	138	469	0	469	676	0	676
ALFALFA - X														
CLOVER SEED														
PASTURE	3.5	65%	5.4	75%	4.7	71	0	71	249	0	249	383	0	383
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS														
ONIONS & CARROTS														
OTHER TRUCK														
ALMONDS	2.7	75%	3.6	80%	3.4	64	0	64	173	0	173	230	0	230
PISTACHIOS	2.6	75%	3.5	80%	3.3	13	0	13	34	0	34	46	0	46
PRUNES														
WALNUTS														
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES														
GRAPES														
EUCALYPTUS														
Totals						**3,139**	**130**	**3,268**	**5,941**	**192**	**6,133**	**9,426**	**264**	**9,690**
Double Crop Acreage						**241**	**0**	**241**						
Total Irrigated Land Area						**2,898**	**130**	**3,027**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-20

Average Agricultural Land and Water Use for Holthouse Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70% 1.0	85% 0.8	88	0	88	62	0	62	88	0	88
RICE												
COTTON												
SUGAR BEETS												
CORN												
SUNFLOWERS												
DRY BEANS	1.8	70% 2.6	80% 2.3	34	0	34	61	0	61	88	0	88
SAFFLOWER												
OTHER FIELD												
ALFALFA	3.5	70% 5.0	75% 4.7	33	0	33	116	0	116	165	0	165
ALFALFA - X												
CLOVER SEED												
PASTURE	3.6	65% 5.5	75% 4.8	120	0	120	432	0	432	660	0	660
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES												
POTATOES												
CUCURBITS	1.1	70% 1.6	80% 1.4	101	0	101	111	0	111	162	0	162
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS												
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**376**	**0**	**376**	**782**	**0**	**782**	**1,163**	**0**	**1,163**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**376**	**0**	**376**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-21

Average Agricultural Land and Water Use for Kanawha Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	5,077	658	5,735	3,554	460	4,015	5,077	526	5,604
RICE	3.2	58%	5.5	63%	5.1	1,536	0	1,536	4,915	0	4,915	8,448	0	8,448
COTTON														
SUGAR BEETS	3.2	65%	4.9	75%	4.3	1,180	401	1,581	3,776	1,283	5,059	5,782	1,724	7,506
CORN	1.9	65%	2.9	70%	2.7	1,162	20	1,182	2,208	38	2,246	3,370	54	3,424
SUNFLOWERS	1.5	65%	2.3	70%	2.1	668	14	682	1,003	20	1,023	1,537	29	1,566
DRY BEANS	1.8	70%	2.6	80%	2.3	437	24	461	787	43	830	1,136	55	1,191
SAFFLOWER	0.1	60%	0.2	60%	0.2	637	3	640	64	0	64	127	1	128
OTHER FIELD	1.6	65%	2.5	70%	2.3	7	0	7	11	0	11	18	0	18
ALFALFA	3.4	70%	4.9	75%	4.5	786	43	829	2,674	145	2,819	3,853	192	4,045
ALFALFA - X														
CLOVER SEED														
PASTURE	3.5	65%	5.4	75%	4.7	395	3	398	1,383	11	1,393	2,133	14	2,147
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES														
POTATOES														
CUCURBITS	1.0	75%	1.3	80%	1.3	106	10	116	106	10	116	137	14	151
ONIONS & CARROTS														
OTHER TRUCK	1.5	70%	2.1	75%	2.0	14	0	14	21	0	21	29	0	29
ALMONDS														
PISTACHIOS														
PRUNES	2.6	65%	4.0	70%	3.7	33	0	33	86	0	86	132	0	132
WALNUTS														
OTHER DECIDUOUS														
KIWI														
CITRUS - OLIVES														
GRAPES														
EUCALYPTUS														
Totals						**12,039**	**1,175**	**13,214**	**20,586**	**2,011**	**22,597**	**31,781**	**2,608**	**34,389**
Double Crop Acreage						**195**	**0**	**195**						
Total Irrigated Land Area						**11,844**	**1,175**	**13,019**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-22

Average Agricultural Land and Water Use for La Grande Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70% 1.0	85% 0.8	111	0	111	78	0	78	111	0	111
RICE	3.2	58% 5.5	63% 5.1	967	0	967	3,094	0	3,094	5,319	0	5,319
COTTON												
SUGAR BEETS												
CORN												
SUNFLOWERS	1.5	65% 2.3	70% 2.1	70	0	70	105	0	105	161	0	161
DRY BEANS												
SAFFLOWER												
OTHER FIELD												
ALFALFA												
ALFALFA - X												
CLOVER SEED												
PASTURE	3.6	65% 5.5	75% 4.8	98	0	98	353	0	353	539	0	539
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES												
POTATOES												
CUCURBITS												
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS												
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**1,246**	**0**	**1,246**	**3,630**	**0**	**3,630**	**6,130**	**0**	**6,130**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**1,246**	**0**	**1,246**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-23

Average Agricultural Land and Water Use for Maxwell Irrigation District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70% 1.0	85% 0.8	75	0	75	53	0	53	75	0	75
RICE	3.2	58% 5.5	63% 5.1	4,728	0	4,728	15,130	0	15,130	26,004	0	26,004
COTTON												
SUGAR BEETS												
CORN												
SUNFLOWERS												
DRY BEANS												
SAFFLOWER												
OTHER FIELD												
ALFALFA												
ALFALFA - X												
CLOVER SEED												
PASTURE												
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES												
POTATOES												
CUCURBITS												
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS												
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**4,803**	**0**	**4,803**	**15,182**	**0**	**15,182**	**26,079**	**0**	**26,079**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**4,803**	**0**	**4,803**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

Table B-24

Average Agricultural Land and Water Use for Reclamation District 108

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	5,115	97	5,212	3,581	68	3,648	5,115	78	5,193
RICE	3.2	60%	5.3	65%	4.9	23,061	0	23,061	73,795	0	73,795	122,223	0	122,223
COTTON	2.3	70%	3.3	75%	3.1	106	0	106	244	0	244	350	0	350
SUGAR BEETS	3.3	65%	5.1	75%	4.4	598	0	598	1,973	0	1,973	3,050	0	3,050
CORN	2.0	65%	3.1	70%	2.9	2,137	0	2,137	4,274	0	4,274	6,625	0	6,625
SUNFLOWERS	1.5	65%	2.3	70%	2.1	303	0	303	455	0	455	697	0	697
DRY BEANS	1.8	65%	2.8	70%	2.6	1,311	0	1,311	2,360	0	2,360	3,671	0	3,671
SAFFLOWER	0.1	60%	0.2	60%	0.2	5,540	61	5,600	554	6	560	1,108	12	1,120
OTHER FIELD	1.7	65%	2.6	70%	2.4	338	0	338	575	0	575	879	0	879
ALFALFA	3.5	70%	5.0	75%	4.7	1,693	0	1,693	5,926	0	5,926	8,465	0	8,465
ALFALFA - X														
CLOVER SEED														
PASTURE	3.6	65%	5.5	75%	4.8	197	0	197	709	0	709	1,084	0	1,084
PASTURE - X														
MEADOW PASTURE														
MEADOW PASTURE - X														
TOMATOES[2]	1.8	70%	2.9	75%	2.7	7,325	0	7,325	13,185	0	13,185	21,243	0	21,243
POTATOES														
CUCURBITS	1.1	70%	1.6	75%	1.5	2,173	0	2,173	2,390	0	2,390	3,477	0	3,477
ONIONS & CARROTS														
OTHER TRUCK	1.6	70%	2.3	75%	2.1	14	0	14	22	0	22	32	0	32
ALMONDS														
PISTACHIOS														
PRUNES	2.6	65%	4.0	70%	3.7	37	0	37	96	0	96	148	0	148
WALNUTS	2.6	70%	3.7	75%	3.5	438	0	438	1,139	0	1,139	1,621	0	1,621
OTHER DECIDUOUS	2.8	70%	4.0	75%	3.7	5	0	5	14	0	14	20	0	20
KIWI														
CITRUS - OLIVES														
GRAPES														
EUCALYPTUS														
Totals						**50,391**	**158**	**50,548**	**111,291**	**74**	**111,365**	**179,806**	**90**	**179,895**
Double Crop Acreage						**1,370**	**0**	**1,370**						
Total Irrigated Land Area						**49,021**	**158**	**49,178**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

[2] Applied water includes cultural practice.

Table B-25

Average Agricultural Land and Water Use for River Garden Fams Company

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN												
RICE	3.2	58% 5.5	63% 5.1	1,645	0	1,645	5,264	0	5,264	9,048	0	9,048
COTTON												
SUGAR BEETS												
CORN	2.0	65% 3.1	70% 2.9	534	0	534	1,068	0	1,068	1,655	0	1,655
SUNFLOWERS	1.5	65% 2.3	70% 2.1	430	0	430	645	0	645	989	0	989
DRY BEANS	1.8	65% 2.8	70% 2.6	203	0	203	365	0	365	568	0	568
SAFFLOWER	0.1	65% 0.2	65% 0.2	1,594	0	1,594	159	0	159	319	0	319
OTHER FIELD												
ALFALFA												
ALFALFA - X												
CLOVER SEED												
PASTURE												
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES [2]	1.8	65% 3.1	70% 2.9	1,966	0	1,966	3,539	0	3,539	6,095	0	6,095
POTATOES												
CUCURBITS	1.1	65% 1.7	70% 1.6	336	0	336	370	0	370	571	0	571
ONIONS & CARROTS												
OTHER TRUCK												
ALMONDS												
PISTACHIOS												
PRUNES												
WALNUTS												
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**6,708**	**0**	**6,708**	**11,410**	**0**	**11,410**	**19,245**	**0**	**19,245**
Double Crop Acreage				**0**	**0**	**0**						
Total Irrigated Land Area				**6,708**	**0**	**6,708**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

[2] Applied water includes cultural practice.

Table B-26

Average Agricultural Land and Water Use for Westside Water District

Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)		Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface	Ground	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70% 1.0	85% 0.8	3,048	844	3,892	2,133	591	2,724	3,048	676	3,723
RICE	3.2	58% 5.5	63% 5.1	784	0	784	2,509	0	2,509	4,312	0	4,312
COTTON												
SUGAR BEETS	3.3	65% 5.1	75% 4.4	51	0	51	168	0	168	260	0	260
CORN												
SUNFLOWERS												
DRY BEANS	1.8	65% 2.8	75% 2.4	703	88	791	1,265	158	1,424	1,968	211	2,180
SAFFLOWER	0.1	60% 0.2	60% 0.2	301	2	303	30	0	30	60	0	61
OTHER FIELD	1.7	65% 2.6	70% 2.4	22	0	22	37	0	37	57	0	57
ALFALFA	3.5	70% 5.0	75% 4.7	47	0	47	165	0	165	235	0	235
ALFALFA - X												
CLOVER SEED												
PASTURE	3.6	65% 5.5	75% 4.8	172	0	172	619	0	619	946	0	946
PASTURE - X												
MEADOW PASTURE												
MEADOW PASTURE - X												
TOMATOES [2]	1.8	70% 2.9	75% 2.7	3,085	2	3,087	5,553	4	5,557	8,947	5	8,952
POTATOES												
CUCURBITS	1.1	70% 1.6	75% 1.5	1,967	142	2,109	2,164	156	2,320	3,147	213	3,360
ONIONS & CARROTS												
OTHER TRUCK	1.6	70% 2.3	75% 2.1	79	0	79	126	0	126	182	0	182
ALMONDS	2.8	75% 3.7	80% 3.5	670	768	1,438	1,875	2,152	4,026	2,478	2,689	5,167
PISTACHIOS												
PRUNES												
WALNUTS	2.6	70% 3.7	75% 3.5	100	0	100	260	0	260	370	0	370
OTHER DECIDUOUS												
KIWI												
CITRUS - OLIVES												
GRAPES												
EUCALYPTUS												
Totals				**11,028**	**1,847**	**12,875**	**16,905**	**3,061**	**19,966**	**26,009**	**3,795**	**29,804**
Double Crop Acreage				**1,115**	**205**	**1,320**						
Total Irrigated Land Area				**9,913**	**1,642**	**11,555**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.

[2] Applied water includes cultural practice.

Table B-27

Summary of Average Agricultural Land and Water Use for Southern Service Area

Crop	Unit ET of Applied Water (acre-feet/acre)	Unit Applied Water (acre-feet/acre)				Net Irrigated Acreage[1] (acres)			ET of Applied Water (acre-feet)			Applied Water (acre-feet)		
		Surface		Ground		Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
GRAIN	0.7	70%	1.0	85%	0.8	36,902	22,938	59,840	25,831	16,057	41,888	36,902	18,350	55,252
RICE	3.2	58%	5.5	63%	5.1	109,171	3,799	112,969	349,346	12,155	361,501	600,438	19,372	619,810
COTTON	2.3	70%	3.3	75%	3.1	2,117	1,684	3,800	4,868	3,872	8,740	6,985	5,219	12,203
SUGAR BEETS	3.3	65%	5.1	75%	4.4	4,177	2,460	6,636	13,783	8,116	21,899	21,300	10,822	32,122
CORN	2.0	65%	3.1	70%	2.9	8,840	4,894	13,733	17,679	9,787	27,466	27,403	14,191	41,594
SUNFLOWERS	1.5	65%	2.3	70%	2.1	839	1,124	1,962	1,258	1,685	2,943	1,929	2,359	4,288
DRY BEANS	1.8	70%	2.6	80%	2.3	6,318	3,559	9,876	11,372	6,405	17,777	16,426	8,185	24,610
SAFFLOWER	0.1	60%	0.2	60%	0.2	16,281	3,936	20,217	1,628	394	2,022	3,256	787	4,043
OTHER FIELD	1.7	65%	2.6	70%	2.4	2,310	1,129	3,438	3,926	1,919	5,845	6,005	2,708	8,713
ALFALFA	3.5	70%	5.0	75%	4.7	7,666	5,936	13,601	26,829	20,774	47,604	38,328	27,897	66,224
ALFALFA - X	2.4	70%	3.4	75%	3.2	34	0	34	82	0	82	116	0	116
CLOVER SEED														
PASTURE	3.6	65%	5.5	75%	4.8	4,343	489	4,831	15,633	1,759	17,392	23,884	2,345	26,229
PASTURE - X	2.5	65%	3.8	75%	3.3	58	0	58	145	0	145	220	0	220
MEADOW PASTURE	3.4	65%	5.2	75%	4.5	0	5	5	0	17	17	0	23	23
MEADOW PASTURE - X														
TOMATOES [2]	1.8	70%	2.9	75%	2.7	23,102	20,207	43,309	41,584	36,373	77,956	66,996	54,559	121,555
POTATOES														
CUCURBITS	1.1	75%	1.5	80%	1.4	16,271	5,085	21,356	17,898	5,594	23,492	24,407	7,119	31,526
ONIONS & CARROTS	2.5	65%	3.8	70%	3.6	17	34	51	43	85	128	65	122	187
OTHER TRUCK	1.6	70%	2.3	75%	2.1	322	484	805	514	774	1,288	740	1,015	1,755
ALMONDS	2.8	75%	3.7	80%	3.5	16,787	6,414	23,200	47,002	17,958	64,960	62,110	22,447	84,557
PISTACHIOS	2.7	75%	3.6	80%	3.4	102	869	971	275	2,346	2,622	367	2,955	3,322
PRUNES	2.6	65%	4.0	70%	3.7	2,187	531	2,718	5,686	1,381	7,067	8,748	1,965	10,713
WALNUTS	2.6	70%	3.7	75%	3.5	2,967	2,060	5,026	7,713	5,355	13,068	10,976	7,208	18,184
OTHER DECIDUOUS	2.8	70%	4.0	75%	3.7	281	8	289	787	22	809	1,124	30	1,154
KIWI	1.8	75%	2.4	80%	2.3	17	0	17	31	0	31	41	0	41
CITRUS - OLIVES	2.3	70%	3.3	75%	3.1	73	48	121	168	110	278	241	149	390
GRAPES	1.6	75%	2.1	80%	2.0	1,671	2,340	4,010	2,673	3,743	6,416	3,508	4,679	8,187
EUCALYPTUS	2.3	85%	2.7	85%	2.7	20	43	63	46	99	145	54	116	170
Totals						**262,867**	**90,070**	**352,936**	**596,798**	**156,779**	**753,577**	**962,565**	**214,623**	**1,177,188**
Double Crop Acreage						**7,983**	**3,464**	**11,446**						
Total Irrigated Land Area						**254,884**	**86,606**	**341,490**						

[1] Net irrigated acreage is equal to 95 percent of the gross acreage.
[2] Applied water includes cultural practice.

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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix H: Water Exchange Element

April 2000

Integrated
Storage
Investigations

CALFED
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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix H: Water Exchange Element

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April 2000

Integrated
Storage
Investigations

CALFED
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Summary

Opportunities exist for using the entire yield of any one of four potential new offstream storage projects to satisfy agricultural demands while benefiting Sacramento River fisheries through reduced diversions and improved temperature control, if implemented. Such a water exchange program would satisfy local agricultural and environmental demands with stored water providing the quality is sufficient for its intended uses. This study indicates that there is sufficient demand by available purveyors to fully use the annual yield for any one project as shown in Table 1. Meeting established water demands with new supplies would cause a corresponding decrease in the diversions from the river, thus creating additional storage in Lake Shasta for other uses that include enhancing fisheries through timed releases and temperature control and satisfying current and future delta outflow requirements.

Table 1. Project Yield, Potential Exchange Demand and Surface Supplies
(1,000 acre-feet)

Project	Annual Yield[1]	Demand[2]	Surface Supplies[2]
Red Bank	41	1,194	1,285
Thomes-Newville	195 - 464	1,169	1,259
Sites	238 - 324	710	752
Colusa	341 - 486	710	752

[1] Represents the potential average annual increase in water supply over the 1922 through 1994 study period range.
[2] Represents an average year condition.

For each of the four projects, the Tehama-Colusa Canal system, including Corning Canal, provides the most promising network for making deliveries since this system is fully developed and deliveries are closely regulated under Central Valley Project contracts. This would be considered the first priority of use. The second priority of use lies within the Glenn-Colusa Irrigation District service area adjacent to the TCC and currently being served via the TCC and Williams Outlet intertie facilities. Through Glenn-Colusa ID facilities, Maxwell ID could be served via existing canals and drains. Depending on the preferred conveyance alternative selection for the U.S. Bureau of Reclamation's Refuge Water Supply Program, both Delevan and Colusa National Wildlife Refuges might also receive supplies through the Tehama-Colusa Canal, thus reducing the current supply that is obtained through Glenn-Colusa ID's direct river diversions during the fall, winter, and spring periods.

The final priority of use would come through delivering water to Reclamation District 108 and River Garden Farms Company via the Colusa Basin Drain, which would require additional facilities and significant monitoring. This level of priority would also include diverting storage from Newville Reservoir to the upper portion of the Glenn-Colusa ID via Stony Creek, which could then supply Provident ID and Princeton-Codora-Glenn ID. This conveyance would be impacted by substantial conveyance losses if new facilities were not constructed.

Based on the potential magnitude of costs for making deliveries, the first priority of use would require no capital expenditures; the second priority of use would require some capital expenditures based on the need for additional conveyance capacities; and the third priority would require capital expenditures for constructing diversion and conveyance structures combined with the potential for significant conveyance losses. The agricultural demands available for each of these priorities of use are shown in Table 2.

Table 2. Potential Average Annual Demand by Priority of Use

(1,000 acre-feet)

Project	Priority of Use		
	First	Second	Third
Red Bank	263	340	591
Thomes-Newville	238	340	591
Sites	171	340	199
Colusa	171	340	199

Meeting a portion of these demands through water exchanges would potentially change or eliminate the time period for lowering of the Red Bluff Diversion Dam Gates as well as reduce the diversions at Glenn-Colusa ID's pumping plant. These benefits extend not only to environmental enhancement, but to farmers through improved timing, reliability, and temperature of water supplies. This program provides all-around benefits for its potential users.

Introduction

Under the North of Delta Offstream Storage Investigation, four potential projects are currently under review to add additional annual yield to the Sacramento River basin. Located in the westside foothills of the Sacramento Valley extending from west of Red Bluff to northwest of Williams, the projects from north-to-south are the Red Bank Project, Thomes-Newville Project, Sites Project, and Colusa Project (see Figure 1). The objective for each project is to capture surplus flows from tributaries to and/or the main stem of the Sacramento River for conveyance to the offstream storage facilities. The conceptual plans to date identify storage projects ranging from 250 to 3,000 taf in capacity with average annual yields of 41 to 486 taf (see Table 3). With these potential yields, this report investigates the opportunities and benefits of using the newly developed supplies to directly offset diversions from the Sacramento River during critical periods of the year.

Figure 1. Overview of the North of Delta Offstream Storage Facilities

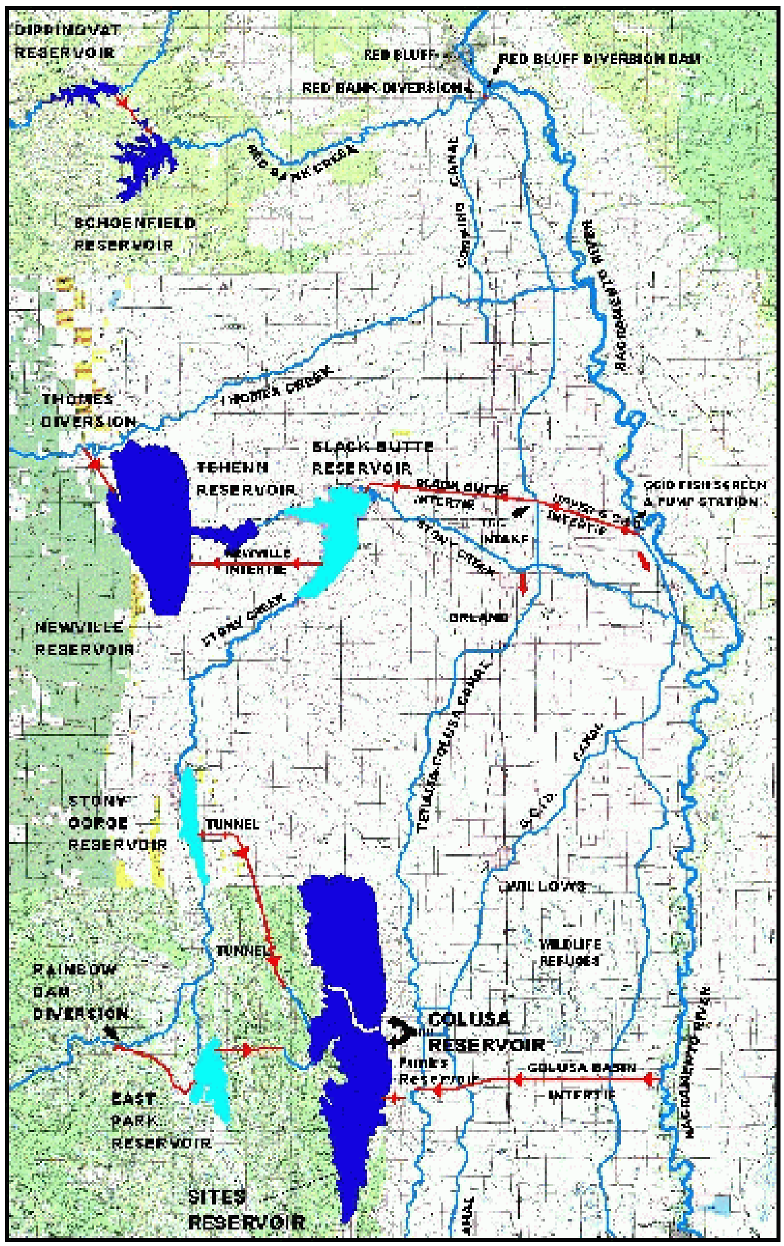


Table 3. Potential Project Storage/Yield
(1,000 acre-feet)

Project	Storage	Annual Yield[1]
Red Bank	250	41
Thomes-Newville	1,900 - 3,000	195 - 464
Sites	1,800	238 - 324
Colusa	3,000	341 - 486

[1] Represents the potential average annual increase in water supply over the 1922 through 1994 study period range.

The Water Exchange Element seeks to identify potential users who could substitute newly developed project yield for direct diversions from the Sacramento River. The potential users are located in the northwestern Sacramento Valley extending 106 miles from Red Bluff in the north to (but not including) Cache Creek in the south. Covering nearly 1,800 square miles, the area is bordered by the Sacramento River on the east and the Coast Range Foothills on the west (see Figure 1). Within the study area, irrigated agricultural development occupies 675,000 acres of land and creates an estimated surface water and groundwater demand of 2,200,000 acre-feet as shown in Table 4. This report presents information on the various aspects of the study area that include the current land use, agricultural water demands, refuge demands, potential water purveyors, project service areas, and program benefits.

Table 4. Study Area Agricultural Acreage and Water Demand

Source	Acreage (1,000 acres)	Demand (1,000 acre-feet)
Surface water	463	1,600
Groundwater	212	600
Total	**675**	**2,200**

Land Use

The land use data used in this study shows the current source of water applied to each field, either surface water, groundwater, or a mix of the two. Acreage data are summarized by crop and water source. The basic unit of analysis is the individual water purveyor. The net irrigated acreage reported has been adjusted to remove the effects of roads, canals, ditches, etc., within the mapped field boundaries.

The evaluation of existing water demands and irrigated crop acreage is based on dwr's land use surveys. The study area data are based on the following land use surveys: Colusa County, 1993; Glenn County, 1993; Tehama County, 1994; and Yolo County, 1997. These years represent the most recently available data. However, planted acreage has increased yearly following the return to full supply availability after the 1987-92 and 1994 droughts.

The study area encompasses nearly 605,000 acres of irrigated crop land as well as acreage dedicated to refuge and private wetland usage. Of the total irrigated crop land shown in Table 5, an estimated 418,000 acres have the potential to use surface water in any one year (the sum of acreages served from surface and mixed water sources). Sources of surface water range from direct diversions from the Sacramento River and Stony Creek to diversions of drain water from the Colusa Basin Drain.

Table 5. Estimated Study Area Irrigated Acreage
(acres)

Water Source	Cropped	Fallow/Idle	Marsh
Surface Water	367,352	33,149	20,634
Mixed Water	50,937	3,595	3,578
Groundwater	186,369	9,884	0
Total	**604,658**	**46,628**	**24,212**

An overview of the crop and water source mapping is presented in Figures 2 and 3, respectively, for lands north of the potential Colusa Basin Intertie and Figures 4 and 5, respectively, for lands south of the potential Colusa Basin Intertie.

Agricultural Demands

The applied water method is used to estimate the amount of water that must be delivered to each field to satisfy the crop's consumptive use requirement. Since the applied water is calculated by water source for each crop, the amount of surface water and/or groundwater utilized on each field within a water purveyor service area or basin can be estimated. When the total applied surface water is summarized for individual water purveyors, it is then compared with diversion data to estimate the quantity of reuse occurring within the service area. Typically, reuse is associated in greater degree with surface water application. Because of the greater cost to the farmer and the well's proximity to the point of application in the Sacramento Valley, groundwater application is generally more efficient, which can reduce on-field losses. This can reduce the amount of potential reuse downstream. The total applied groundwater essentially equals total groundwater extraction. This has become the primary method to determine groundwater extraction by DWR in the northern Sacramento Valley, especially since the aquifer recharge characteristics in some of the areas and the relatively few spring and fall depth to groundwater measurements limit the ability to use other methods to calculate groundwater extraction.

Figure 2. North of Colusa Basin Intertie Agricultural Land Use

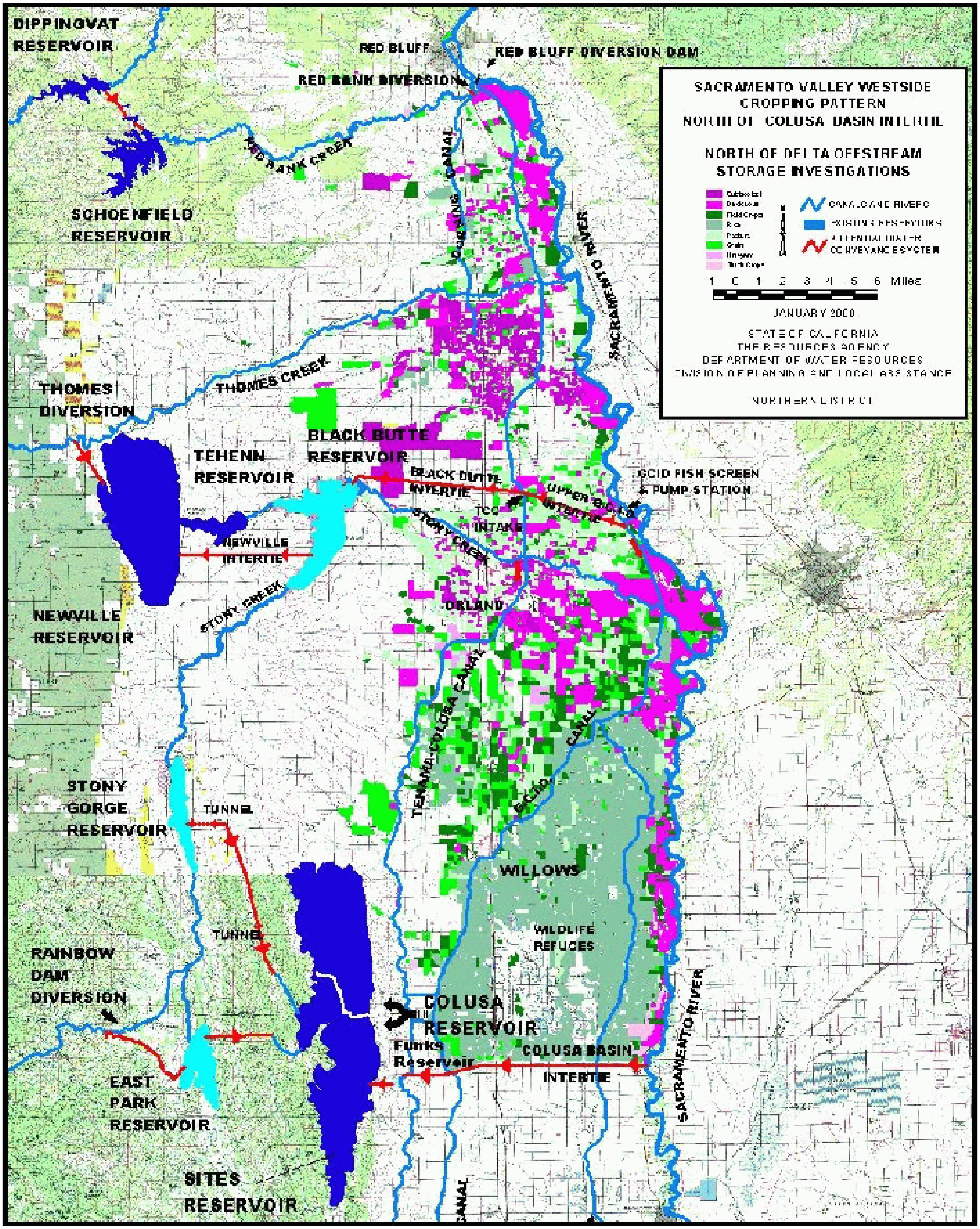


Figure 3. North of Colusa Basin Intertie Irrigation Water Source

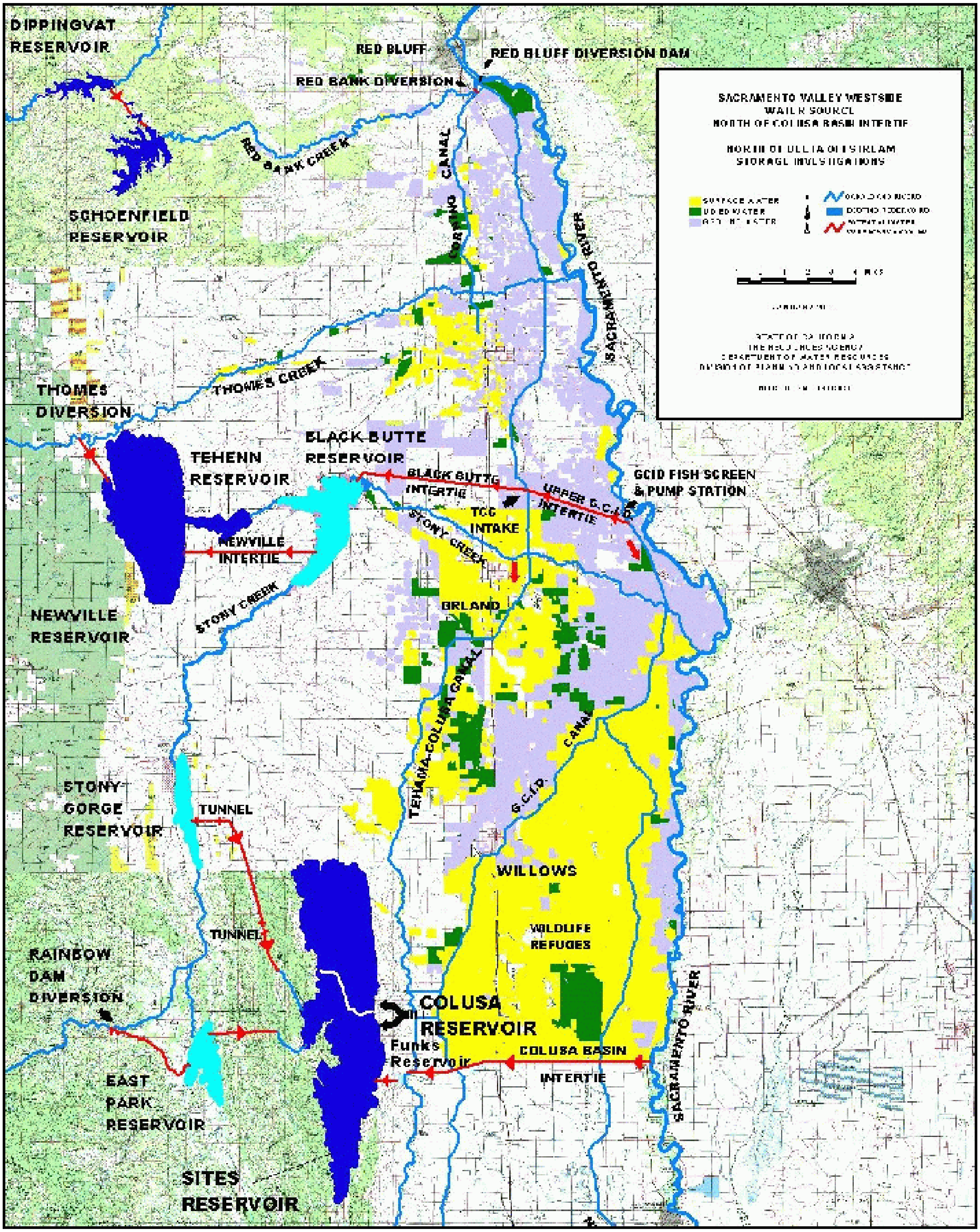


Figure 4. South of Colusa Basin Intertie Agricultural Land Use

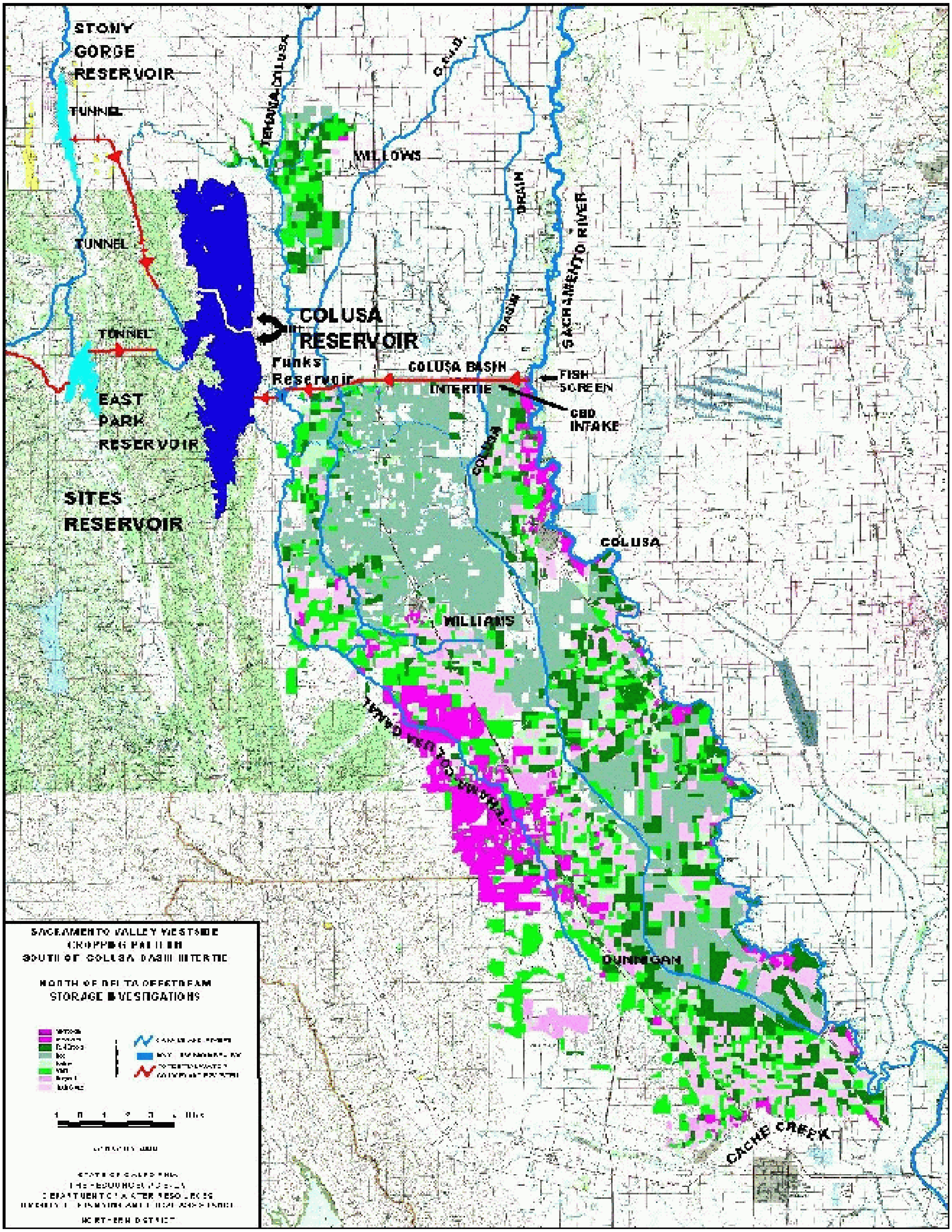
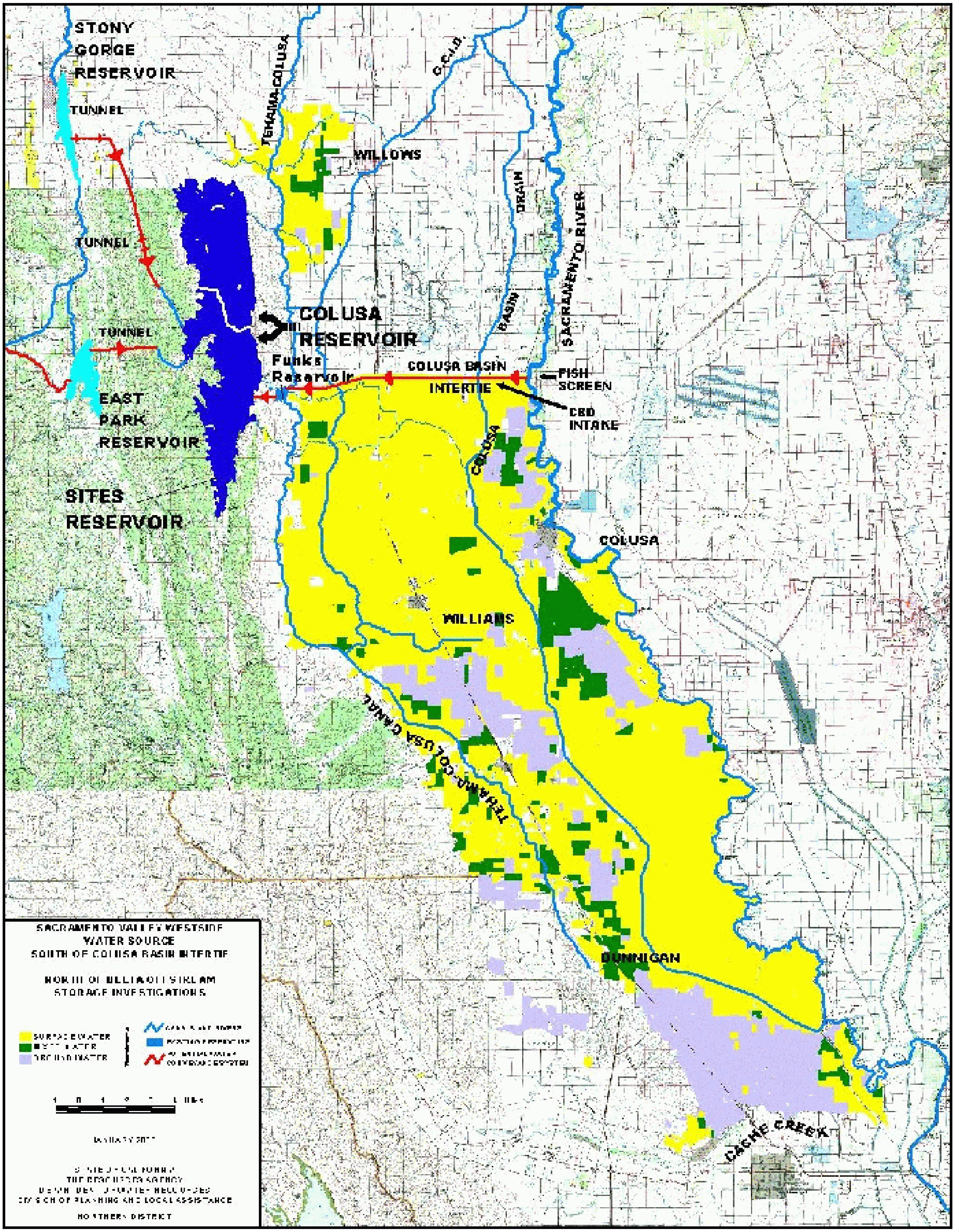


Figure 5. South of Colusa Basin Intertie Irrigation Water Source



For each reported crop category in each region of the study area, a unit evapotranspiration of applied water (ETAW) was derived by using pan evaporation data, crop coefficients, precipitation data, and soil moisture-holding characteristics. Crop coefficients are used to convert pan evaporation data to potential evapotranspiration for each crop category. The difference between potential crop evapotranspiration and effective precipitation is the crop's ETAW. Effective precipitation is determined in part by evaluating the amount of precipitation that would have percolated to the rootzone of the crop being analyzed. The soil moisture-holding characteristics, which are typically defined as the water holding capacity per foot of depth for each soil series, are used in combination with precipitation to determine the soil's potential for storing effective precipitation at any point prior to and during the growing season. This results in a crop-specific calculation of effective precipitation.

For each crop, a soil moisture banking calculation is used to evaluate monthly changes in soil moisture storage due to rainfall, soil surface evaporation, evapotranspiration by vegetation, and application of irrigation water. Working on a water year basis and knowing the specific characteristics about a crop, this banking system computes the storage of precipitation in the rootzone, percolation of precipitation below the rootzone, and extraction by means of soil surface evaporation or crop evapotranspiration on a month by month basis for the entire growing season. Starting with an initial soil moisture storage and then continuing the banking system throughout the season, all computed deficits in soil moisture storage resulting from crop evapotranspiration result in the need for applied irrigation water, which is ETAW.

Applied water requirements for each crop were determined by the use of ETAW and irrigation efficiency data that are summarized in Table 6. Irrigation efficiencies used herein are seasonal application efficiencies developed for each crop category by water source type (i.e., surface, ground). Applied water data have been collected for many years from various water purveyors, individual farmers, and farm advisors throughout the Sacramento Valley. These measured data are used to compute irrigation efficiencies that are compared with ones developed from previous studies and by DWR staff who have the knowledge of methods, practices, and trends in irrigation within the Sacramento Valley.

Table 6. ETAW, Irrigation Efficiencies, and Applied Water

Crop	Unit ETAW (af/acre)	On-Field Surface Water Efficiency	On-field Groundwater Efficiency	Unit Applied Surface Water (af/acre)	Unit Applied Groundwater (af/acre)
Grain	0.7	70%	85%	1.0	0.8
Rice	3.2	58%	63%	5.5	5.1
Dry Beans	1.8	65%	70%	2.8	2.6
Alfalfa	3.5	70%	75%	5.0	4.7
Tomatoes[1]	1.8	70%	75%	2.9	2.7
Melons	1.1	70%	75%	1.6	1.5
Almonds	2.7	75%	80%	3.6	3.4

[1] Applied water includes cultural practice of pre-irrigation and weed control.

Once the irrigation efficiencies are verified and a reasonable estimate for the entire subregion is achieved, they are applied to the unit ETAW values to determine unit applied water, which represents the average amount of irrigation water applied to each acre of land. The applied water values are then reviewed by local farm advisors, water purveyor personnel, and/or farm managers for reasonableness. Then the product of the unit applied water values and the net irrigated acreage data result in the total applied water demand by crop for a given area.

Wildlife Demands

DWR's Land and Water Use programs routinely evaluate land uses that contribute to the management of waterfowl. Typically, waterfowl are managed through federal/State refuges, private wetlands/duck clubs and the flooding of rice lands. DWR's regular land use surveys document the amount of acreage managed and the types of habitat created. In general, the surveys document seasonal marsh, permanent marsh, upland habitat, and forage crop conditions that are managed throughout the year, as well as rice acreage flooded to provide forage for migrating and wintering waterfowl.

In addition to surveys, DWR has relied upon several available sources of information for determining habitat acreage and applied water requirements, primarily: U.S. Fish and Wildlife Service estimates of harvested rice fields flooded for waterfowl; DWR's information files; U.S. Bureau of Reclamation's report *on Refuge Water Supply Investigation, Central Valley Basin, California* (1989); interviews with federal/state refuge managers, private duck club operators, wildlife biologists, water purveyors, and farm advisors; and DWR's winter and summer land use surveys and studies. Year-to-year analyses rely on the aforementioned sources as well as the judgement and knowledge of DWR staff.

To assess the applied water requirements, habitat acreage is divided into four categories: seasonal marsh (flooded for 6 months); permanent marsh (flooded for 9 or 12 months); rice fields (burned, chopped, or rolled then flooded for 6 months); and millet (feed for waterfowl). The demands for each category consist of a combination of the requirements listed below:

Flood-up	-	The amount of water required to recharge a soil profile and flood a field to a specific depth.
Evaporation	-	The amount of evaporation occurring from the flooded field and/or wetted soil surface during the period being analyzed.
Percolation	-	Monthly percolation rates are based on the habitat's specific soil characteristics. A portion of this will create seepage to drains while a smaller portion can percolate to the aquifer depending on conditions.
Circulation Requirement	-	Also known as "flow through water", this requirement helps to prevent diseases such as botulism and cholera from occurring. It also creates outflow from a habitat field.

A major portion of the managed wetlands within the study area are centered within the Sacramento National Wildlife Refuge Complex (Sacramento, Delevan, and Colusa NWRs). USBR planning reports identified the necessary water supplies for optimum habitat management through Level 4 designation as shown in Table 7. The 1992 Central Valley Project Improvement Act guaranteed Level 4 supplies for each of the refuges by 2002. Further investigation will be needed to quantify demands for privately managed wetlands.

Table 7. CVPIA Level 4 Water Supplies for the Sacramento National Wildlife Refuge Complex[1] (in acre-feet)

Month	Sacramento NWR	Delevan NWR	Colusa NWR
January	1,250	2,375	1,200
February	1,250	1,875	800
March	1,250	625	350
April	300	125	770
May	2,250	625	1,440
June	2,750	1,250	2,500
July	4,200	2,250	2,880
August	6,850	3,125	2,880
September	8,700	4,325	3,840
October	8,900	4,375	3,840
November	8,800	4,375	2,400
December	3,500	4,675	2,100
Total	**50,000**	**30,000**	**25,000**
Dec - Apr	7,550	9,675	5,220

[1] United State Bureau of Reclamation. *Report of Refuge Water Supply Investigations*. March 1989.

Water Purveyors

Several criteria were used in selecting the most promising service areas for potential water exchanges. The most important criterion for potential participation in water exchanges is that a user must have a riparian, appropriative, or contract right that guarantees delivery of the specified amount on an annual basis, with the exception of curtailments during drought years. A majority of lands using surface water from the Sacramento River are served under settlement and/or water service contracts with USBR. Secondly, the user must lie within a reasonable distance of major conveyance facilities and have access to them. The need to build additional conveyance facilities must be minimized to hold down project costs. Surface water purveyors are ideally preferred since they typically distribute supplies to multiple users. It is not practical to supply individual users since this would often create higher operating costs in addition to possibly necessitating the construction of new facilities. Finally, the offstream storage supply should only provide greater reliability and timing of existing supplies and will not make up for any deficient water rights.

The water purveyors considered by this study are shown in Figure 6 on pages 14 and 15 and summarized in Table 8, along with their irrigated acreages, water supplies and typical crops. The Orland Unit Water Users Association is not included as a purveyor since it supplies are already obtained within the basin from Stony Creek itself and storage in East Park, Stony Gorge, and Black Butte Reservoirs.

Table 8. Acreage and River Diversion Summary by Water Purveyor

Service Areas	Acreage[1] Irrigated / Idle / Marsh (acres)	Annual River Diversions[2] (acre-feet)	Typical Crop Types
Proberta WD	1,646 / 538 / 0	1,408 - 6,557	rice, pasture, prunes, misc. field, almonds
Thomes Creek WD	1,545 / 596 / 0	1,545 - 8,246	rice, alfalfa, pasture, almonds, prunes, olives
Corning WD	6,960 / 1568 / 15	5,782 – 27,120	olives, eucalyptus, prunes, almonds, pasture, rice, grain
Kirkwood WD	354 / 90 / 0	105 - 834	grain, alfalfa, pasture
Orland-Artois WD	25,466 / 3,044 / 0	13,099 - 83,365	grain, rice, corn, misc. field, alfalfa, almonds, olives
Glenn-Colusa ID	122,798 / 15,104 / 1,922	475,908 - 874,159	grain, rice, misc. field, pasture, tomatoes, melons
Glide WD	5,654 / 428 / 0	3,746 – 17,203	grain, rice, misc. field
Kanawha WD	13,019 / 114 / 0	10,573 - 41,507	grain, rice, sugar beets, corn, misc. field, alfalfa, pasture
Princeton-Codora-Glenn ID	9,798 / 451 / 41	37,080 - 71,061	rice, misc. field, misc. truck, misc. orchard
Provident ID	14,321 / 962 / 38	23,138 - 54,147	rice
Holthouse WD	376 / 189 / 0	479 – 2,583	grain, pasture, melons
4-M WD	1,101 / 241 / 0	1,512 - 3,451	grain, misc. field, alfalfa, melons
Maxwell ID	4,803 / 247 / 2437	0 - 18,876	rice, seasonal marsh, permanent marsh
Glenn Valley WD	580 / 40 / 0	346 – 1,266	grain, rice, dry beans, melons
La Grande WD	1,246 / 114 / 0	2,225 - 7,490	grain, rice, misc. field, pasture
Davis WD	931 / 130 / 0	1,233 - 5,739	grain, tomatoes, melons
Westside WD	11,555 / 341 / 14	13,959 - 39,509	grain, rice, field crops, tomatoes, melons, almonds
Cortina WD	486 / 85 / 0	346 – 1,889	grain, alfalfa, tomatoes, almonds
Colusa County WD	32,659 / 2,515 / 0	17,504 - 65,397	grain, rice, misc. field, tomatoes, melons, almonds, grapes
Reclamation District 108	49,178 / 1,090 / 16	90,516 – 205,432	grain, rice, misc. field, tomatoes, melons
Dunnigan WD	7,916 / 810 / 0	4,388 – 15,996	grain, corn, misc. field, alfalfa, tomatoes, melons, almonds
River Garden Farms Co.	6,708 / 91 / 0	5,897 – 30,204	rice, misc. field, tomatoes, melons

[1] Acreage based on DWR land use surveys: Colusa County, 1993; Glenn County, 1993; Tehama County, 1994; and Yolo County, 1997.

[2] 1970-98 data from USBR.

Figure 6. Water Purveyors

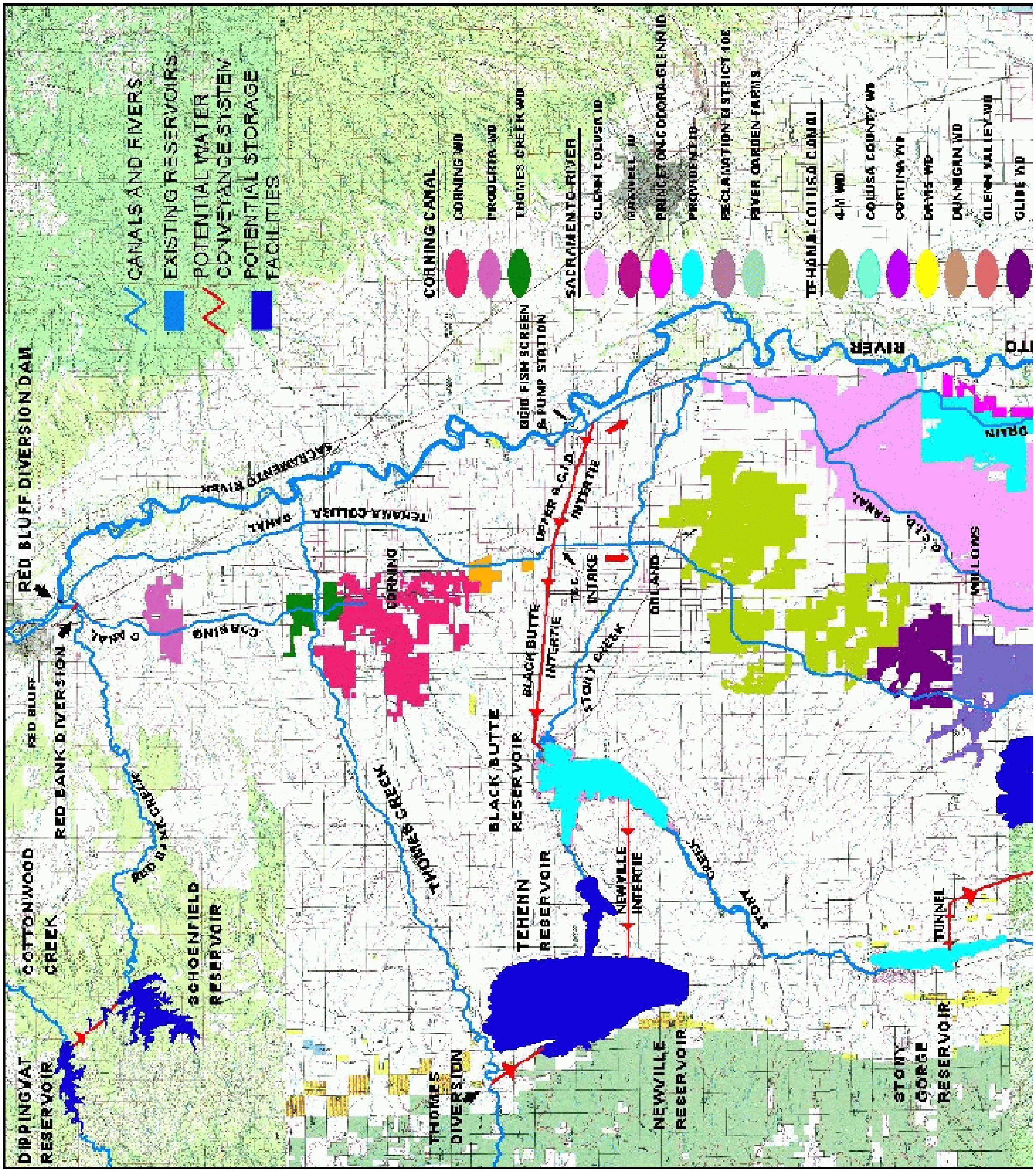
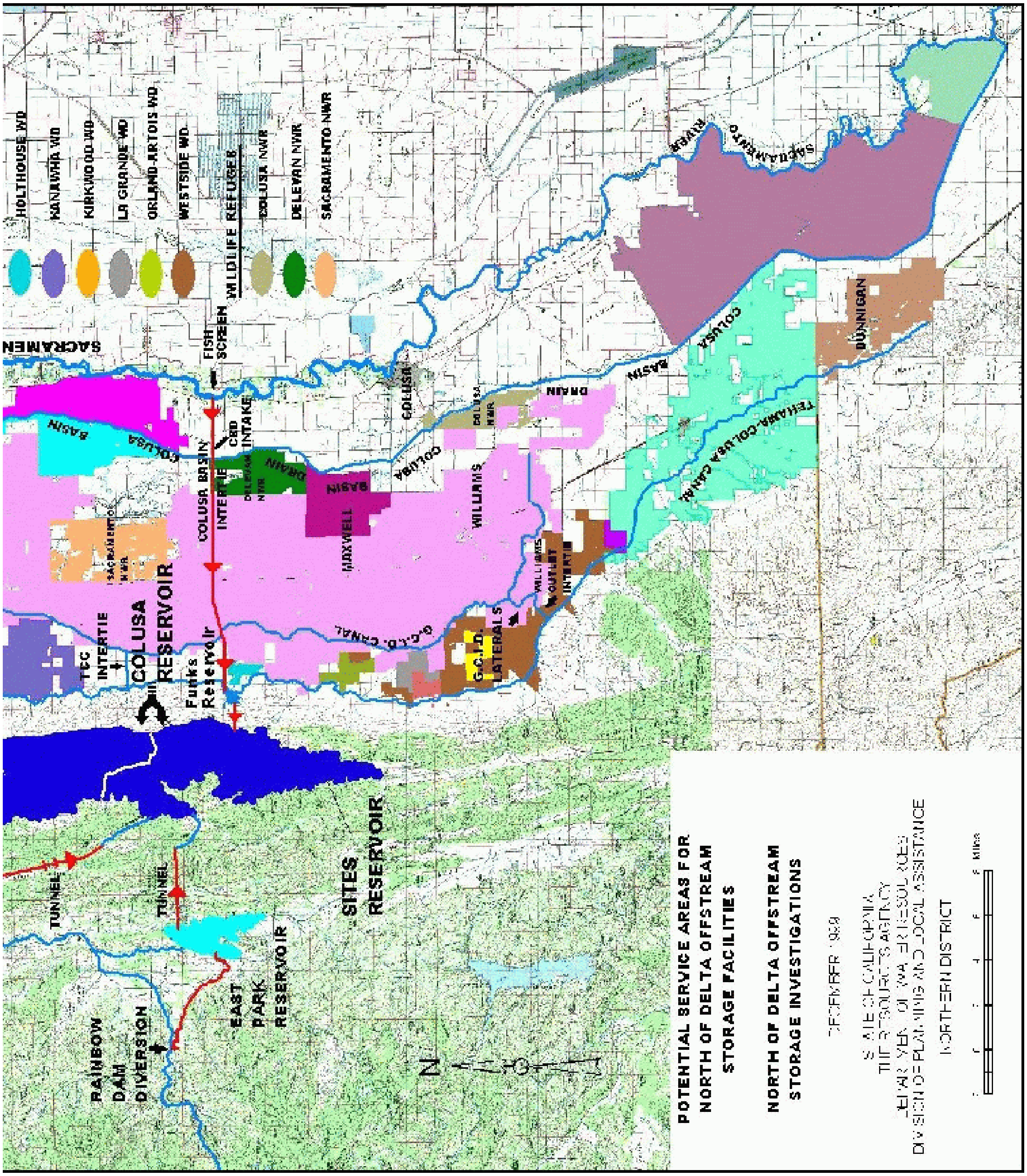


Figure 6. Water Purveyors (cont.)



Potential Exchange Service Areas

One of the primary purposes for this study is to indicate and rank the potential exchange participants that would create the least amount of need for developing new infrastructure, thus minimizing project costs. For the water purveyors previously identified, the total average demands and supplies are summarized by offstream storage project in Table 9. Table 10 summarizes the demands by month.

Table 9. Agricultural Surface Water Demands and Supplies by Potential Exchange Service Area
(1,000 acre-feet)

Project	Demand	Surface Supplies
Red Bank	1,194	1,285
Thomes-Newville	1,169	1,259
Sites	710	752
Colusa	710	752

Table 10. Monthly Agricultural Surface Water Demand in Potential Exchange Service Areas
(1,000 acre-feet)

Project	Offstream Storage Projects			
	Red Bank	Thomes-Newville	Sites	Colusa
January	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0
March	7.5	7.5	6.1	6.1
April	28.8	27.8	20.2	20.2
May	130.4	127.0	77.7	77.7
June	256.0	250.8	150.6	150.6
July	310.3	304.3	185.0	185.0
August	263.3	258.2	155.5	155.5
September	181.8	178.9	106.0	106.0
October	15.0	13.4	8.3	8.3
November	0.7	0.7	0.5	0.5
December	0.0	0.0	0.0	0.0
Total	**1,193.8**	**1,168.6**	**709.9**	**709.9**

Red Bank

The Red Bank Project is the northernmost of the four potential offstream reservoir and conveyance facilities currently under study. The Red Bank Project would capture and store excess flows from the South Fork of Cottonwood Creek, a tributary to the Sacramento River near the town Cottonwood at the northern end of the Sacramento Valley. With a storage potential of nearly 250 taf and an annual yield of 41 taf, this project could provide water service to the Corning and Tehama-Colusa canal system. Water would be released to Red Bank Creek from Schoenfield Dam and conveyed downstream to a diversion facility near, but upstream from, its confluence with the Sacramento River.

This proposed facility would then convey water to the TCC, where it could be used downstream or pumped to the Corning Canal. No additional facilities would be needed downstream on the Tehama-Colusa or Corning Canals to deliver water to existing water purveyors. Since Red Bank Creek often becomes dry by June and remains in that condition until after the fall rains have adequately recharged the drainage system and creek bed, the optimum conveyance of stored water would occur during periods when the surface flow is occurring. Conveyance during the hot, dry summer would be less effective due to evaporation and potential percolation to groundwater.

Combined, the Tehama-Colusa and Corning Canal service areas receive average surface water deliveries of 319 taf (as shown in Table 11) for roughly 339 taf of demand that includes a portion of Glenn-Colusa ID. Ideally, the Red Bank Project could be used to supply early irrigation season demands, thus delaying the need for the lowering of the Red Bluff Diversion Dam gates. Combining the Red Bank Project yield with the present 405 cfs pumping capacity (24,400 acre-feet per month maximum diversion) at the Red Bluff Diversion Dam and available CVP storage in Black Butte Reservoir would allow the Red Bluff Diversion Gates to raised until approximately mid-June during average year conditions. During dry year scenarios, this combined supply may only satisfy demands through mid-May, but would alleviate the need for temporary gate closures prior to May 15. This would at least increase the supply reliability to the farmers on these systems while enhancing the fisheries on the upper Sacramento River.

Thomes-Newville

The Thomes-Newville Project would consist of a reservoir on the North Fork of Stony Creek and a diversion facility located on Thomes Creek for conveyance to the reservoir. To maximize yield, additional water could be captured from the high flows on the Sacramento River. Up to 3,000 cfs could be diverted at the Red Bluff Diversion Dam, conveyed southward via the TCC to a new "Black Butte Intertie" that would convey water from the canal to Black Butte Reservoir. From Black Butte Reservoir, the supply would be pumped to Newville Reservoir via the Newville Intertie facility shown in Figure 6. Another 3,000 cfs could be diverted through the Glenn-Colusa ID Pumping Plant (which will have state-of-the-art fish screen facilities) at Sacramento River Mile 154.8 and conveyed via a new facility identified as the Upper GCID Intertie to the Black Butte Intertie.

Table 11. Average Monthly Surface Water Deliveries[1]
(1,000 acre-feet)

Month	Corning Canal	Tehama-Colusa Canal	Total
January	0.0	0.4	0.4
February	0.0	1.3	1.3
March	0.3	5.2	5.5
April	1.2	20.9	22.1
May	4.0	48.9	52.9
June	5.5	53.2	58.7
July	6.2	65.2	71.4
August	6.0	58.1	64.1
September	3.8	21.2	25.0
October	1.4	12.7	14.1
November	0.4	2.6	3.0
December	0.0	0.8	0.8
Total	**28.8**	**290.5**	**319.3**

[1] Average of 1985-89, 1993 and 1995-98 (non-drought years) deliveries.

If no intertie facilities were constructed, yield from Newville Reservoir would be released via North Fork Stony Creek to Black Butte Reservoir, where it would then be released to Stony Creek. Roughly 10 miles downstream from Black Butte Reservoir, the supply would be diverted to the TCC via the existing Constant Head Orifice structure. If the Black Butte Intertie were constructed, it could convey flows back to the Tehama-Colusa Canal, thus avoiding the need for additional structures in Stony Creek.

Introducing offstream storage supplies at this point on the TCC would allow for service to 13 downstream surface water purveyors. Also, based on the canal's geometry and slope, water could be conveyed upstream to Kirkwood Water District. Downstream, Glenn-Colusa ID, which diverts a relatively small portion of its current total supply through the TCC and Williams Outlet Intertie facilities, could supply a portion of its lower service area.

If the available yield exceeds the aforementioned service area demands, the remaining supply could be conveyed downstream via either Stony Creek or the GCID Intertie for diversion into the GCID Canal for use in the upper portion of the Glenn-Colusa ID's service area above the TCC Intertie and in Princeton-Codora-Glenn ID and Provident ID via releases to the Colusa Basin Drain. Other options could include releasing water from the end of the GCID Canal to the Colusa Basin Drain for conveyance to Reclamation District 108 and River Garden Farms Company.

Sites/Colusa

Located approximately 6 miles west the town of Maxwell, both the Sites and Colusa projects would provide offstream storage in the Antelope Valley portion of the Stone Corral and Funks creek basins. Colusa Reservoir will be a larger version of Sites Reservoir incorporating additional storage facilities to the north.

Various combinations of diversions from the Stony Creek system, the

Tehama-Colusa Canal, the Colusa Basin Drain, and the Sacramento River would be included to fill the potential 1.2 to 1.9 maf Sites Reservoir and the 3.0 maf Colusa Reservoir. Potential facilities (Figure 6) could include: canals and tunnels from both East Park and Stony Gorge reservoirs on Stony Creek; a Funks Intertie facility that would convey water from the TCC at Funks Reservoir to the project reservoir; and a combination of Colusa Basin Intertie reaches that could connect the GCID Canal, Colusa Basin Drain and/or the Sacramento River to the Funks Reservoir. At minimum, the TCC and the GCID Canal could divert surplus Sacramento River flows with a combined capacity of nearly 5,000 cfs at the existing Funks Reservoir site on the Tehama-Colusa Canal. In reverse, the Funks and Colusa Basin interties could then convey stored surface water to users within the Colusa Basin.

The TCC provides the most convenient potential service area without the need for any additional conveyance facilities. Downstream TCC water users would include: (north-to-south) Glenn-Colusa ID (via TCC and Williams Outlet interties), Holthouse WD, 4-M WD, La Grande WD, Glenn Valley WD, Davis WD, Westside WD, Cortina WD, Colusa County WD, Dunnigan WD. The TCC service area could include the potential service via reverse gravity flows to a portion of Glide WD at TCC Mile 48.52 and all of Kanawha WD that lies upstream from Funks Reservoir. If the Colusa Basin Intertie were developed from the Colusa Basin Drain to the Glenn-Colusa ID Main Canal for diverting excess winter flows in the drain, this same intertie could convey water to the Colusa Basin Drain in combination with the GCID Canal to supply to Maxwell ID, Reclamation District 108 and River Garden Farms Company. Currently, Reclamation District 108 has some diversion capacity at its Riggs Ranch Pumping Plant on the Colusa Basin Drain while River Garden Farms Company facilities on the drain have yet to be investigated. In both cases, additional capacity and/or new pumping facilities will need to be constructed if large quantities of water become available.

Supplying Refuges

The offstream storage projects could also increase water supply reliability and reduce the need for direct river diversions during fish migration periods for the Sacramento, Delevan, and Colusa NWRs (see Figure 6). The most opportune period for deliveries is November through April. Deliveries from offstream storage could reduce or eliminate the need for Glenn-Colusa ID to make direct river diversions during this period. However, to deliver these supplies, additional releases will be required to overcome potentially significant conveyance losses.

Sacramento NWR could be supplied only from the Thomes-Newville Project by providing conveyance to the upper portion of the GCID Canal via the Upper GCID Intertie or Stony Creek. Deliveries to both Delevan and Colusa NWRs could be made through the GCID Canal via the TCC and Williams Outlet interties from any one of the potential projects and are contingent upon studies by USBR's for year-round conveyance to meet CVPIA refuge water requirements. Supplies to Delevan NWR could easily be routed from the GCID Canal via Willits Slough/Hunters Creek or Lateral 41-1 to the north end of the refuge. For Colusa NWR, supplies could be routed through Glenn-Colusa ID's laterals or diverted via Willits Creek to the Colusa Basin Drain for diversion at the north end of the refuge.

Summary of Exchange Potential

Table 12 summarizes the analysis of the individual offstream storage projects and their potential exchange service areas. The method of conveyance is highly contingent upon the facilities developed for diverting surplus river and tributary flows to the storage sites. The projects are ranked by the potential for satisfying the demand for a purveyor. In some instances, a portion of the demand met by a purveyor may require minimal or no additional facility costs where as the other portion of the demand may require significant costs for making the deliveries. Costs could include but are not limited to creating additional conveyance capacity in canals, laterals, drains, and/or pumping/diversion facilities.

Benefits

The Water Exchange Element of the Offstream Storage Investigation could create positive benefits to both the environmental and agricultural communities. Once significant environmental issue associated with offstream storage is the introduction of higher temperature water into the network of natural and constructed waterways.

The west side of the Sacramento Valley affords the opportunity to use any one of the project yields to satisfy (through exchange) a portion of nearly 1.2 maf of agricultural demands by 22 local purveyors that have entitlements from the river. The potential exists for the Sacramento National Wildlife Refuge Complex to use these supplies since the refuges receive their supplies through local purveyors identified in this study. Exchange of project yield for existing surface supplies would permit proportional reductions in surface diversions (with appropriate adjustments for conveyance losses involved with this exchange, which have not been determined thus far). The reduction in river diversions would result in additional storage in Shasta Lake for release during periods that would enhance the fish migration, spawning and Delta outflow. Releasing water from Shasta Lake affords the opportunity to better regulate river temperatures and to maintain higher flows in longer stretches of the river.

Table 12. Agricultural Surface Water Demand Conveyance Priority by Purveyor

(1,000 acre-feet)

First Priority (1) - Minimal Cost
Second Priority (2) - Minimal to Moderate Cost
Third Priority (3) - Moderate to Significant Cost

Priority	Water Purveyor	Demand Potential by Project: Red Bank	Thomes-Newville	Sites	Colusa	Method of Conveyance
1	Corning WD	18.4				Corning Canal
1	Proberta WD	3.3				Corning Canal
1	Thomes Creek WD	3.5				Corning Canal
1	Kirkwood WD	0.6	0.6			Tehama-Colusa Canal
3	Glenn-Colusa ID (Upper)	267.6	267.6			Stony Creek / Upper GCID Intertie to GCID Main Canal
1	Orland-Artois WD	58.4	58.4			Tehama-Colusa Canal
1	Glide WD (Upper)	7.5	7.5			Tehama-Colusa Canal
3	Princeton-Codora-Glenn ID	46.3	46.3			Stony Creek / Upper GCID to GCID Main Canal to Colusa Basin Drain
3	Provident ID	78.3	78.3			Stony Creek / Upper GCID Intertie to GCID Main Canal To Colusa Basin Drain
1	4-M WD	2.2	2.2	2.2	2.2	Tehama-Colusa Canal
1	Colusa County WD	73.5	73.5	73.5	73.5	Tehama-Colusa Canal
1	Cortina WD	1.5	1.5	1.5	1.5	Tehama-Colusa Canal
1	Davis WD	1.8	1.8	1.8	1.8	Tehama-Colusa Canal
1	Dunnigan WD	15.9	15.9	15.9	15.9	Tehama-Colusa Canal
2	Glenn-Colusa ID (Lower)	314.1	314.1	314.1	314.1	TCC & Williams Outlet Interties to GCIC Main Canal or Sacramento River Intertie to GCID Main Canal
1	Glenn Valley WD	1.3	1.3	1.3	1.3	Tehama-Colusa Canal
1	Glide WD (Lower)	9.4	9.4	9.4	9.4	Tehama-Colusa Canal
1	Holthouse WD	1.2	1.2	1.2	1.2	Tehama-Colusa Canal
1	Kanawha WD	31.8	31.8	31.8	31.8	Tehama-Colusa Canal
1	La Grande WD	6.1	6.1	6.1	6.1	Tehama-Colusa Canal
2	Maxwell ID	26.1	26.1	26.1	26.1	GCID Main Canal & laterals/drains, Colusa Basin Drain via Sacramento River Intertie
3	Reclamation District 108	179.8	179.8	179.8	179.8	Sacramento River Intertie to Colusa Basin Drain
3	River Garden Farms Co.	19.2	19.2	19.2	19.2	Sacramento River Intertie to Colusa Basin Drain
1	Westside WD	26.0	26.0	26.0	26.0	Tehama-Colusa Canal
1	First Priority Total	262.4	237.2	170.7	170.7	
2	Second Priority Total	340.2	340.2	340.2	340.2	
3	Third Priority Total	591.2	591.2	199.0	199.0	
	Total Demand	1,193.8	1,168.6	709.9	709.9	

Benefits would also accrue to the agricultural sector through improved water supply timing, reliability, and temperature. Users on the Tehama-Colusa and Corning Canals would benefit greatly from the increased early season availability and timing that would be the result of the project's capability of directly suppling these systems. Currently, with the raising of the Red Bluff Diversion Dam gates from September 15 through May 15 of each year, supplies become limited based on the capacity of the current pumping facility that replaces the gravity diversion. During certain periods, demands exceed supply availability. The offstream storage supplies could augment the pumped supplies to reduce the period that the gates need to be lowered for gravity diversions. Or, if one of the larger yielding projects were implemented, the necessity to lower the gates might be eliminated altogether. This would provide a huge benefit to the fisheries, but could sharply reduce the recreational benefits created by Lake Red Bluff. Finally, farmers prefer to use surface supplies that are warmer than those found within the Sacramento River, especially since there has been increased temperature regulation for fisheries with the completion of the Shasta Lake Temperature Control Device. The warmer offstream storage supply would benefit not only seed germination, but crops in general.

The benefits that could be achieved through water exchange are summarized in Table 13.

Table 13. Summary of Water Exchange Program Benefits

Agriculture	Environment	
	Refuges	Sacramento River / Delta
Improved timing	Improved timing	Reduced diversions during key migration periods
Increased reliability	Increased reliability	Improved temperature regulation throughout river
Reduced Sacramento River Diversions	Reduced diversions from Sacramento River	Reduce or eliminate lowering of Red Bluff Diversion Dam Gates

Summary

This analysis has examined the potential water purveyors that could be conveniently served from each project. Their acreage, demands, and supplies are summarized in relation to the potential project that might serve them. The yield in any one of the projects could be fully used for in-basin water demands that will offset diversions from the river. This will provide significant fishery benefits that include leaving cooler water in the river, fewer diversions with less magnitude during certain periods of the year, and changing the time period of gate closure at the Red Bluff Diversion Dam. In addition, agricultural water users would benefit from improved timing and reliability of water deliveries and warmer water.

DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

Appendix I: Road Relocation Studies

August 2000

Integrated
Storage
Investigations

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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix I: Road Relocation Studies

Report prepared by:
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Associate Engineer, Water Resources

Northern District
California Department of Water Resources

August 2000

Integrated
Storage
Investigations

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PROGRAM

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Introduction

This report identifies roads that would be inundated by the Sites, Colusa, or Thomes-Newville Project Reservoirs (see Figure 1), and suggests potential alternative road relocation alignments. Transportation will still be needed around a new reservoir, so alternative road alignments are being considered. For Sites or Colusa Reservoirs, existing road access would have to be maintained from Maxwell to Lodoga, and for a Newville Reservoir, access would be needed around the reservoir on the southeast, northeast, and northwest sides.

Residents who commute from Lodoga to communities east of Sites Reservoir travel daily through the proposed Sites Reservoir area. Also, vacationers travel this route to get to East Park Reservoir from Interstate 5. If any of the projects are constructed the sponsor has an obligation to replace roads or provide alternate access from roads owned by individuals, counties, or other agencies.

Project Description

Sites Reservoir would be a 1.2 to 1.8 million acre-foot reservoir, located eight miles west of Maxwell. This reservoir could be expanded to the north, resulting in the 3.0 million acre-foot Colusa Reservoir. Newville Reservoir would be a 1.9 to 3.0 million acre-foot reservoir, located 18 miles west of Orland.

Inundated Roads

Both the Sites and Colusa Reservoirs would inundate portions of the Maxwell-Sites Road and the Sites-Lodoga Road, blocking travel between Maxwell and Lodoga. These roads are owned and maintained by Colusa County. About 4 miles of east-west access would be inundated. Around 6 miles of the gravel Huffmaster Road south of the town of Sites would also be inundated, although this is a private road and provides access mostly within the Sites Reservoir area. A road connecting the Maxwell-Sites Road and the area just south of Sites Reservoir would have to be constructed as part of the Sites or Colusa projects.

The Newville Reservoir site has access from the northwest and north via Round Valley Road, from the east via Newville Road and from the south via Road 306. The reservoir would flood about 2-1/2 miles of Round Valley Road, 6 miles of Garland Road, and 2 miles of Road 306. Connections between Newville Road and Round Valley Road, as well as Road 306, will have to be reestablished if the Thomes-Newville Project is constructed.

Alternative Alignments Considered

The Sites or Colusa Reservoirs would require access looping around the south or north ends of the reservoirs, as shown on Figure 2. There are two existing, alternative access routes to reach Lodoga from Maxwell (the southern teal-colored line and the northern light brown-colored line), although these take much longer to drive than the Mawell-Sites and Sites-Lodoga roads. The first starts at Maxwell, then goes south on Interstate-5 to Highway 20 West, west on

Highway 20 to Leesville-Lodoga Road, then north to Lodoga. The other starts at Maxwell, then goes north on Interstate-5 to Willows, west on Highway 162 to Elk Creek, then south on Road 306 to Lodoga. However, several alternative road alignments were evaluated, and these alternatives could shorten the time and distance from Maxwell to Lodoga compared to the existing north and south alternative routes.

Newville Reservoir inundates 19 miles of county roads that connect the Newville, Round Valley, and Route 306 roads. These roads would have to be reconnected outside the reservoir. The topography outside the reservoir is such that alternative roads could be built fairly close to the reservoir to maintain these access connections (see Figure 4). There are no existing alternative routes short enough for consideration.

Initial Analysis of Alternatives

This analysis considers distances, slopes, and approximate driving times. No attempt has yet been made to determine cut and fill quantities for roads, which is the main factor in determining the cost.

Logan Ridge forms the eastern boundary of Sites or Colusa Reservoir, and it is difficult to cross except where streams run through the ridge. However, Sulphur Gap at the south end of Sites Reservoir, and the gap created by Hunters Creek at the north end, provide potential access for roads around Sites Reservoir. Therefore, the six alternative new alignments around Sites Reservoir all go through these gaps.

Colusa Reservoir would inundate the potential relocated road north of Sites Reservoir, necessitating either a new alignment farther to the north, or the southern route previously mentioned. Two alignments north of Colusa Reservoir, starting from Highway 162 west of Willows, use existing roads for most of their lengths.

Similar to Sites and Colusa Reservoirs, Rocky Ridge forms the eastern boundary of Newville Reservoir. The only convenient access through the ridge is along North Fork Stony Creek, through the Newville Dam location. Newville Road passes through the gap, providing access to Round Valley Road at the north end of the reservoir site. However, this is the main dam site for Newville Reservoir. A dam at Chrome Gap would cut off access from the south, while reservoir flooding would inundate part of Round Valley Road on the northwest side of the reservoir. Therefore, all proposed alignments bypass existing roads through the most convenient gaps.

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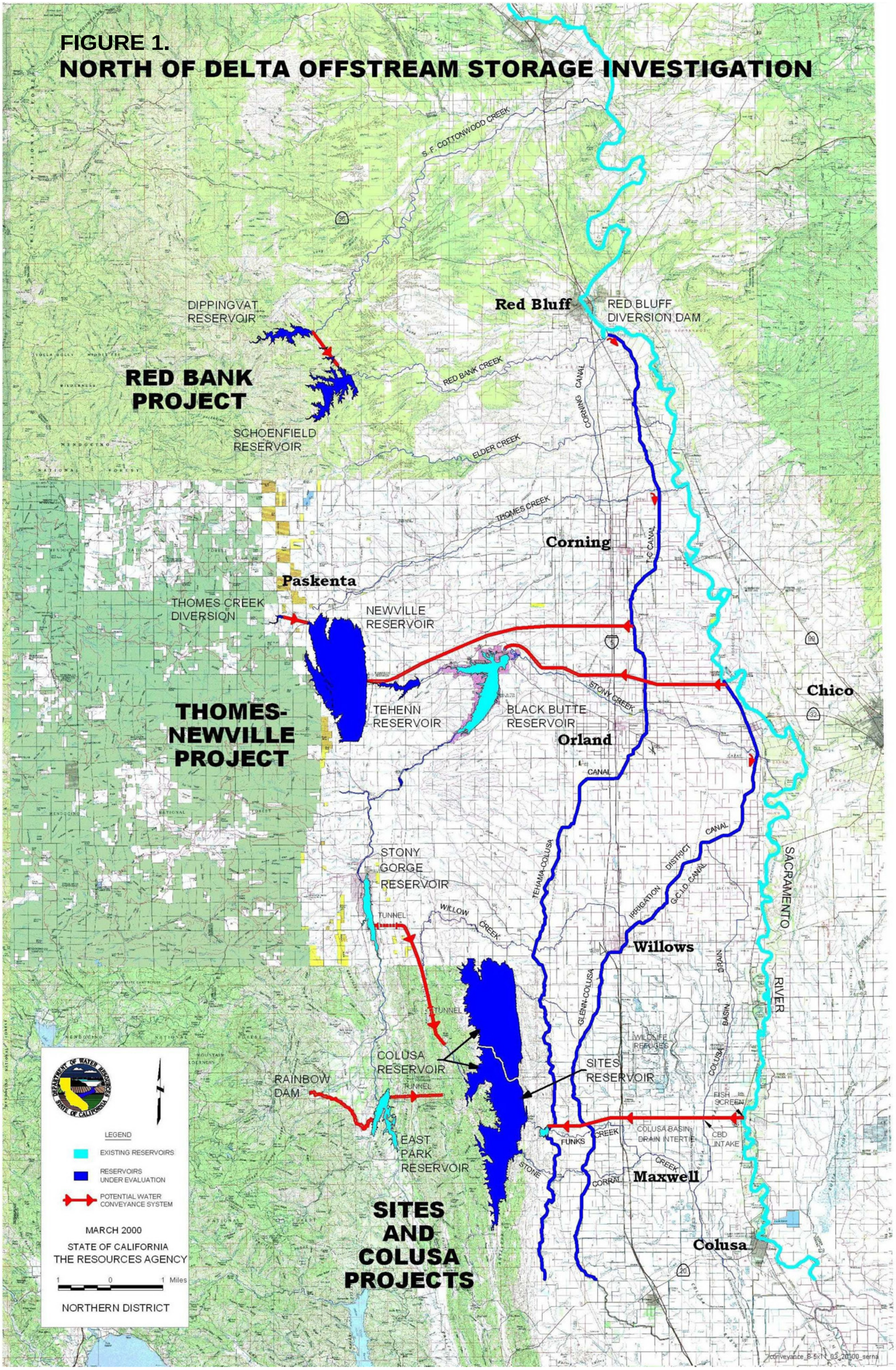

FIGURE 1.
NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION

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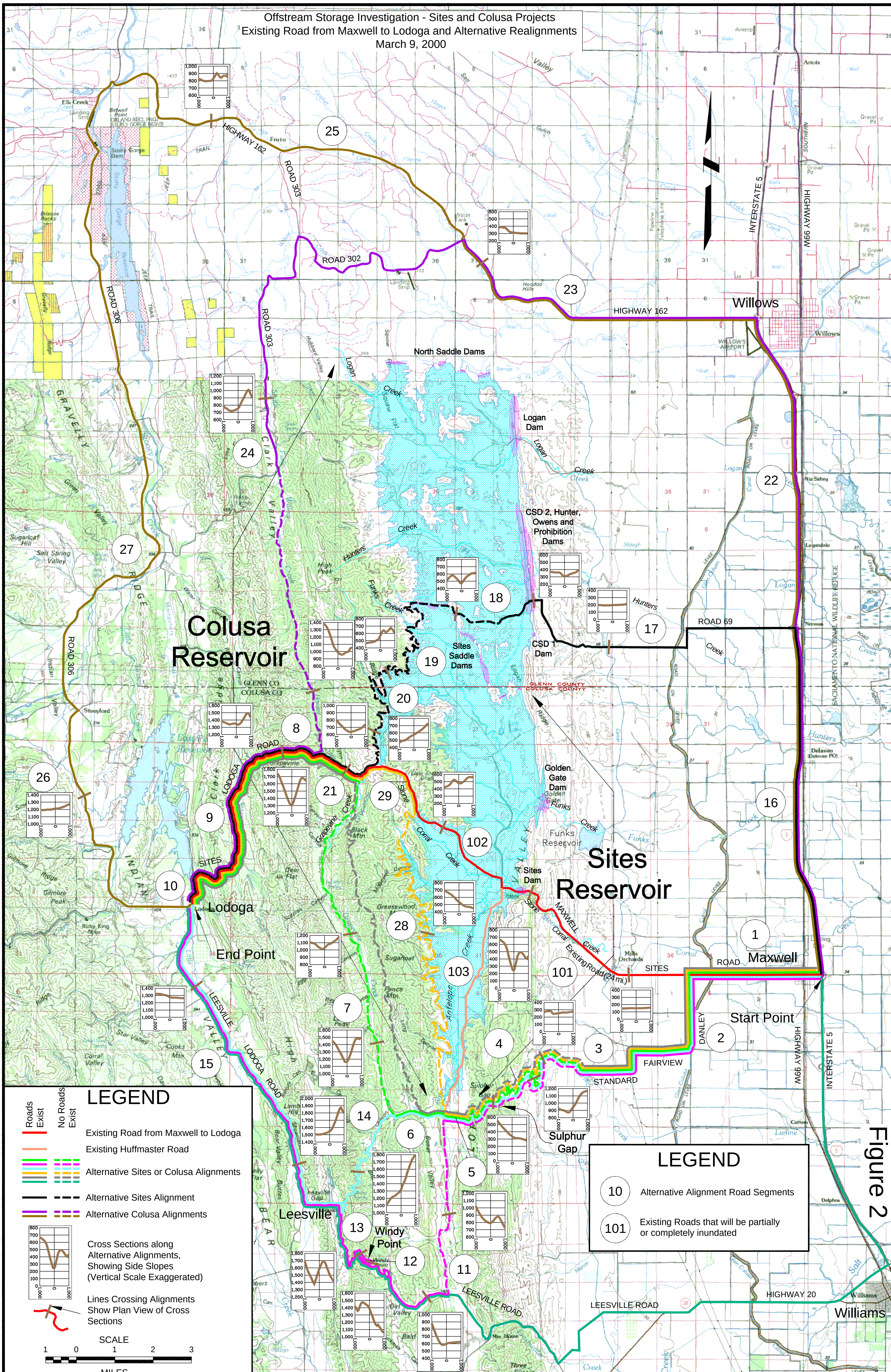

Offstream Storage Investigation - Sites and Colusa Projects
Existing Road from Maxwell to Lodoga and Alternative Realignments
March 9, 2000
Colusa Reservoir
Sites Reservoir
North Saddle Dams
Logan Dam
CSD 2, Hunter, Owens and Prohibition Dams
CSD 1 Dam
Sites Saddle Dams
Golden Gate Dam
Sites Dam
Willows
Maxwell
Start Point
Lodoga
End Point
Leesville
Windy Point
Sulphur Gap
Williams
HIGHWAY 162
ROAD 302
ROAD 303
ROAD 306
ROAD 69
INTERSTATE 5
HIGHWAY 99W
SITES
LODOGA ROAD
MAXWELL
SITES ROAD
DANLEY
FAIRVIEW
STANDARD
LEESVILLE ROAD
LODOGA ROAD
HIGHWAY 20
Existing Road (24 mi.)
LEGEND
Roads Exist
No Roads Exist
Existing Road from Maxwell to Lodoga
Existing Huffmaster Road
Alternative Sites or Colusa Alignments
Alternative Sites Alignment
Alternative Colusa Alignments
Cross Sections along Alternative Alignments, Showing Side Slopes (Vertical Scale Exaggerated)
Lines Crossing Alignments Show Plan View of Cross Sections
SCALE
1 0 1 2 3
MILES
LEGEND
10 Alternative Alignment Road Segments
101 Existing Roads that will be partially or completely inundated
Figure 2

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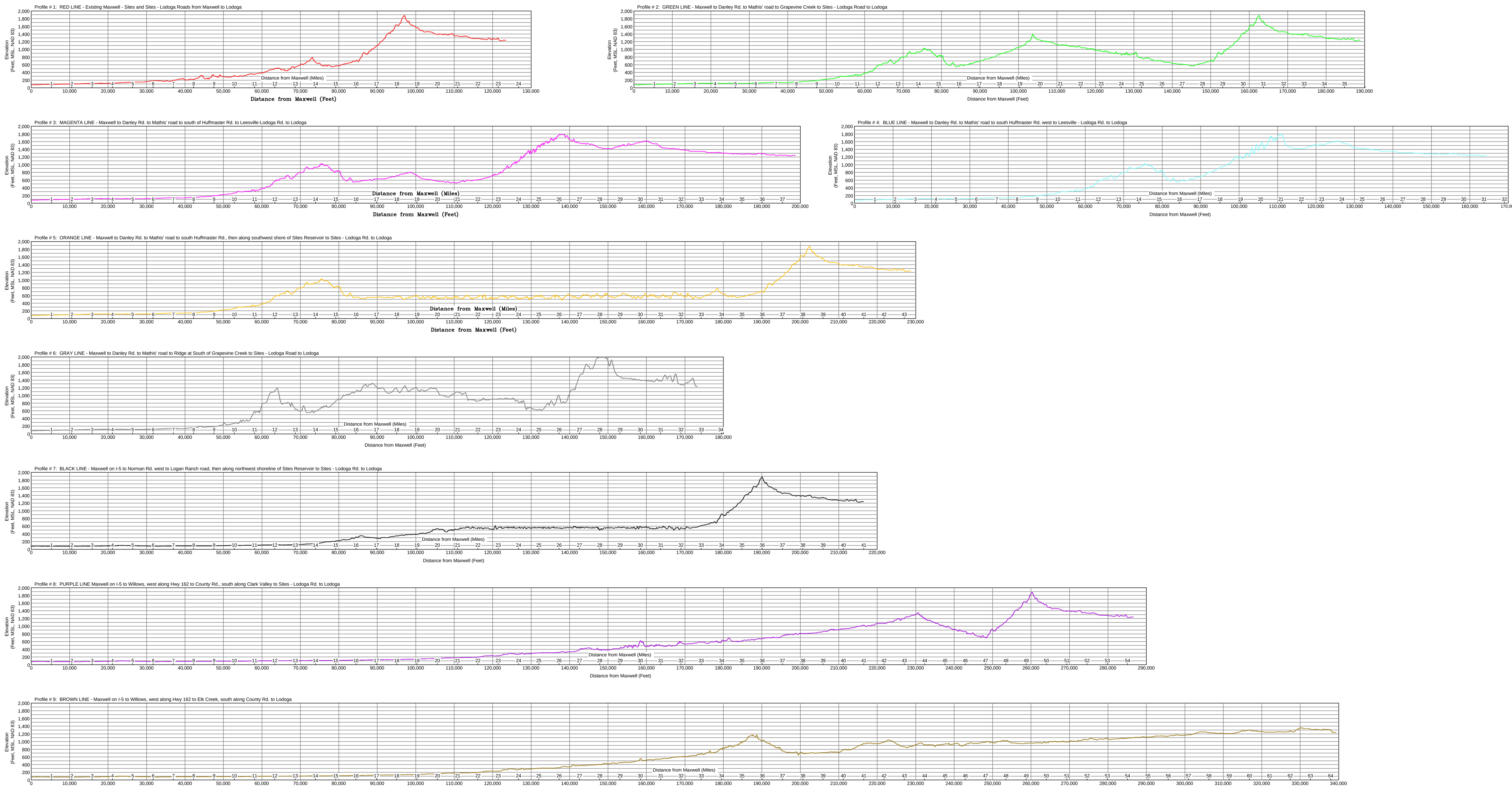
Offstream Storage Investigation - Sites and Colusa Projects
Profile of Existing Maxwell to Lodoga Alignment and Alternative Realignments
March 9, 2000

Figure 3



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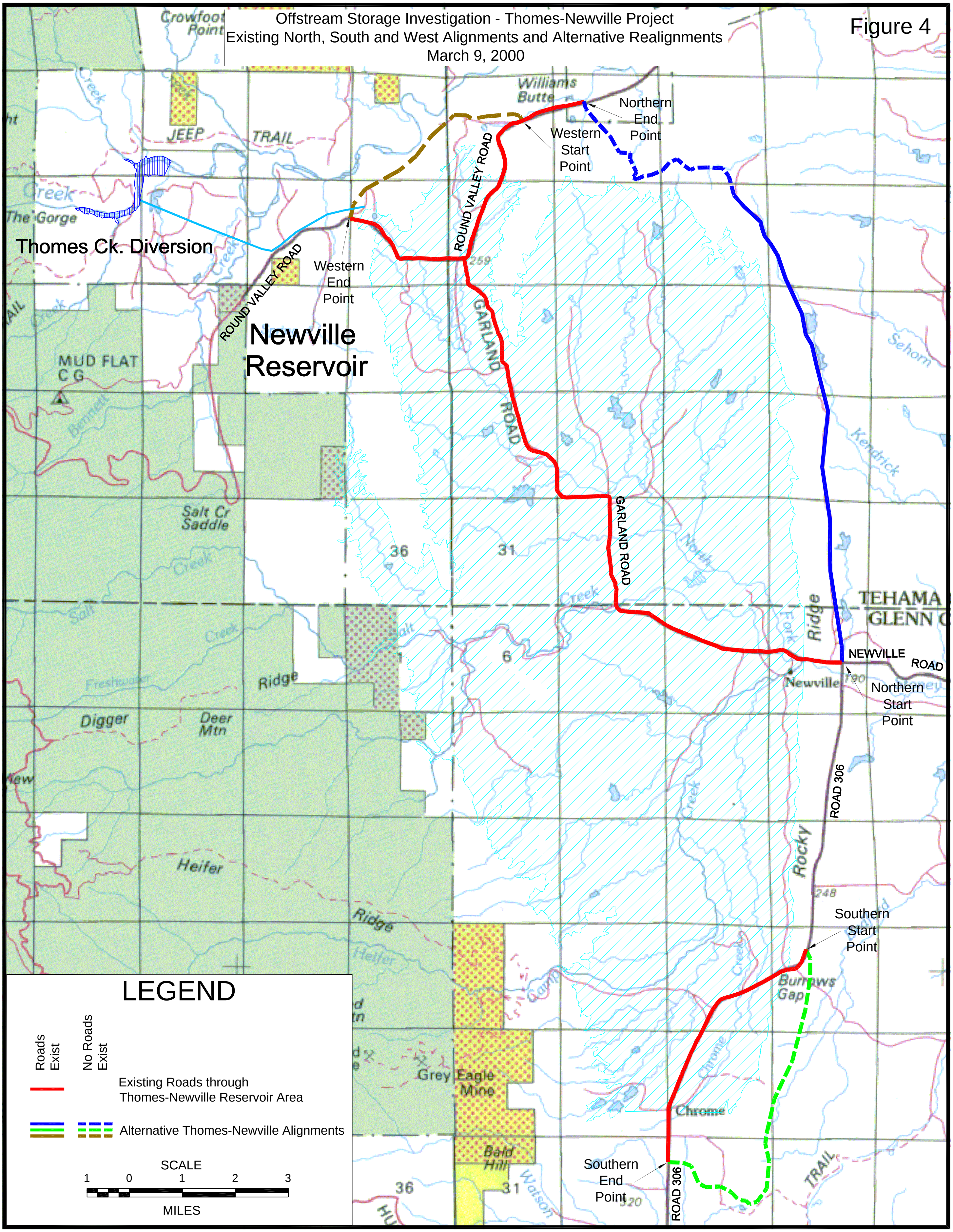

Offstream Storage Investigation - Thomes-Newville Project
Existing North, South and West Alignments and Alternative Realignments
March 9, 2000
Figure 4
Thomes Ck. Diversion
Newville Reservoir
Western End Point
Western Start Point
Northern End Point
Northern Start Point
Southern Start Point
Southern End Point
ROUND VALLEY ROAD
GARLAND ROAD
NEWVILLE ROAD
ROAD 306
LEGEND
Roads Exist
No Roads Exist
Existing Roads through Thomes-Newville Reservoir Area
Alternative Thomes-Newville Alignments
SCALE
1 0 1 2 3
MILES

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In choosing new alignments, topography was the major controlling factor. State of California highway standards will be used to design new roads. The standards specify the maximum allowable profile grade (along the length of the road) as six percent. Side slopes cannot be too steep or it becomes very expensive and environmentally disruptive to cut back slopes to ensure stability. These factors tend to limit the number of new alignments. Therefore, road alignments that minimize both longitudinal and transverse slopes were chosen for routing around all three potential reservoirs. Figures 3 and 5 show the existing ground profiles of existing and proposed alignments. Figure 2 shows side slopes for the Sites and Colusa Reservoir road alignments at selected typical locations, which give an indication of the terrain.

Once the alternative alignments were chosen, the distances, average profile grades, and average horizontal curvature was estimated. Since earthwork volumes and preliminary costs have not been determined, the goal in this evaluation is to determine approximate driving times using alternative road lengths, slopes, and horizontal curvature.

Table 1 shows approximate driving times for each alternative alignment. The Sites and Colusa proposed alignments are listed in order of increasing driving time, although this is not a recommendation for any particular alignment. Note that the existing route has a much shorter driving time than the next shortest route (33 vs. 55 minutes). The Thomes-Newville proposed alignments are not listed by driving time, because there is only one alternative for each existing route.

We assumed that the average driver will go about 60 miles per hour on a flat, straight, two-lane road, and that average speed will be reduced by both the slope (longitudinal steepness) and horizontal curvature of the road. This is not a process based on standard engineering practice, but simply an empirical procedure we devised as a starting point for comparing alternatives. Since these alignments are approximate and will change, no detailed analysis has been done. These driving times are for comparison purposes and do not necessarily predict actual values. Road slope was classified low if it averaged less than two percent, moderate for slopes of two to four percent and high for slopes greater than four percent. The speed reductions used here are none for low slopes, 10 percent for moderate slopes, and 20 percent for high slopes. Horizontal curvature has a greater impact on driving speed. The speed reductions used here are none for low curvature, 30 percent for moderate curvature, and 60 percent for high curvature.

Other Tables and Figures

Tables 2 and 3 show the road segments and calculations used to determine driving times. Figure 1 is an overall project location map for Sites, Colusa, and Thomes-Newville projects. Figure 2 shows existing and alternative road relocation alignments for Sites and Colusa Reservoirs, as well as, numbered road segments used for driving time calculations. Figure 3 shows profiles of existing and alternative road alignments for Sites and Colusa Reservoirs. Figure 4 shows existing and alternative road relocation alignments for Newville Reservoir.

Figure 5 shows profiles of existing and alternative road alignments for Newville Reservoir.

Photos 1 through 8 show selected Sites Reservoir alternative alignments.

Future Work Needed

The next phase in this analysis will determine cut and fill volumes and make preliminary cost estimates for each alignment. Even some of the alignments with shorter driving times could be very expensive because of steep side slopes. For example, the Blue Line and Magenta Line alignments to the south of Sites Reservoir go through areas with several miles of side slopes in excess of two vertical feet for every horizontal foot, requiring a great amount of slope cut back and stabilization work.

Also, stream crossings must be considered. Bridges can add large costs, although all the streams except Stone Corral Creek are ephemeral and have infrequent high flows. This factor could influence the selection of the preferred alignment.

Construction and recreation access roads will be planned and designed in the next phase of this analysis. These roads will be needed along the east side of Sites or Colusa Reservoirs.

Table 1. Existing and Alternative Driving Routes for the Sites, Colusa And Thomes-Newville Projects Listed in Increasing Order of Driving Time

Line on Figure 2	Route Designation and Segment Numbers from Table 2	Route Description	Total Distance (miles)	Total Approx. Driving Time (minutes)
Sites Or Colusa Projects				
Red Line	South of Sites Reservoir 1-101-102-29-21-8-9-10	Existing I-5 at Maxwell to Lodoga	25	33
Blue Line	South of Sites Reservoir 1-2-3-4-5-6-14-15	I-5 at Maxwell to Danley to Mathis Rd. to south Huffmaster Rd. west to Leesville Lodoga Rd. to Lodoga	34	55
Black Line	North of Sites Reservoir 16-17-18-19-20-21-8-9-10	I-5 at Maxwell on I-5 to Norman Rd. west to Logan Ranch rd., then along northwest shoreline of Sites Reservoir to Sites Lodoga Rd. to Lodoga	41	56
Magenta Line	South of Sites Reservoir 1-2-3-4-5-11-12-13-15	I-5 at Maxwell to Danley to Mathis Rd. to south of Huffmaster Rd. to Leesville Lodoga Rd. to Lodoga	41	58
Green Line	South of Sites Reservoir 1-2-3-4-5-6-7-8-9-10	I-5 at Maxwell to Danley to Mathis Rd. to Grapevine Creek to Sites Lodoga Rd. to Lodoga	38	59
Gray Line	South of Sites Reservoir 1-2-3-4-5-6-Ridge East of Grapevine Creek-8-9-10	I-5 at Maxwell to Danley to Mathis Rd. to the Ridge east of Grapevine Creek to Sites Lodoga Rd. to Lodoga	> 38	> 59
Brown Line	North of Colusa Reservoir 16-22-23-25-26	I-5 at Maxwell on I-5 to Willows, west along Hwy 162 to Elk Creek, south along County Rd. 306 to Lodoga	64	64
Purple Line	North of Colusa Reservoir 16-22-23-24-9-10	I-5 at Maxwell on I-5 to Willows, west along Hwy 162 to County Rd. 303, south along Clark Valley to Sites Lodoga Rd. to Lodoga	54	68
Orange Line	South of Sites Reservoir 1-2--3-4-5-28-29-21-8-9-10	I-5 at Maxwell to Danley to Mathis Rd. to south Huffmaster Rd., then along southwest shore of Sites Reservoir to Sites Lodoga Rd. to Lodoga	46	96
Thomes-Newville Project				
Line on Figure 4				
Northern Red Line	1	North - Existing Newville Road to Garland to Round Valley Road	9	13
Southern Red Line	4	Proposed North - Newville Road to Round Valley Road	7	21
Northwestern Red Line	2	South - Existing County Road 306	3	3
Northern Blue Line	5	Proposed South - Newville Road to County Road 306	4	5
Southern Green Line	3	Northwest - Existing Round Valley Road	3	4
Northwestern Brown Line	6	Proposed Northwest - Round Valley Road to Round Valley Road	2	3

Table 2. Maxwell to Lodoga Existing and Alternative Road Realignment Segments

Road Segment	Segment Description (Refer to Figure 2)	Segment Length (miles)	Average Profile Grade [1]	Average Horizontal Curvature	Driving Speed (mph) [2]	Driving Time (minutes)
1	Existing I-5 at Maxwell to 6 miles west, Maxwell Sites Rd.	6.1	low	low	60	6
2	Existing Danley and Fairview Rds.	5.3	low	moderate	40	8
3	Existing Mathis dirt rd. to Sulphur Gap	1.7	moderate	moderate	40	3
4	Existing Mathis dirt rd. to Sulphur Gap	3.2	high	high	20	10
5	Existing Mathis dirt rd. to Huffmaster Rd.	2.3	moderate	moderate	40	3
6	Existing part of dirt rd. to west of south Huffmaster Rd.	1.4	low	moderate	40	2
7	Proposed Rd. along upper Grapevine Creek	10.2	moderate	moderate	40	15
8	Existing part of Sites Lodoga Rd.	1.0	moderate	moderate	40	2
9	Existing part of Sites Lodoga Rd.	6.3	moderate	moderate	40	9
10	Sites Lodoga Rd. north of Lodoga	0.9	moderate	moderate	40	1
11	Proposed Rd. south of Huffmaster Rd., to Leesville Lodoga Rd.	7.4	low	low	60	7
12	Existing part of Leesville Lodoga Rd.	3.1	high	high	20	9
13	Existing part of Leesville Lodoga Rd.	1.3	low	low	60	1
14	Existing part of dirt rd. to west of south Huffmaster Rd., to Leesville Lodoga Rd.	4.2	high	high	20	13
15	Existing Leesville Lodoga Rd. south of Lodoga	10.2	low	low	60	10
16	Existing I-5 at Maxwell to Norman Rd.	9.1	low	low	60	9
17	Existing Norman Rd. west of I-5	8.0	low	low	60	8
18	Existing part of Logan Ranch dirt rd.	3.8	moderate	moderate	40	6
19	Proposed part of road along northwest Sites Reservoir shore	2.4	moderate	high	20	7
20	Proposed part of road along northwest Sites Reservoir shoreline to Sites Lodoga Rd.	9.0	moderate	moderate	40	14
21	Existing part of Sites Lodoga Rd.	0.4	moderate	low	55	0
22	Existing I-5 Norman Rd. to Willows	8.3	low	low	60	8
23	Existing part of Hwy 162 west of Willows	8.7	low	low	60	9
24	Existing County Road 303 (half paved, half dirt) from Hwy 162 through Clark Valley to Sites Lodoga Rd.	20.9	moderate	moderate	40	31
25	Existing part of Hwy 162 and paved County Rd. 306 around Stony Gorge Reservoir to north of East Park Reservoir	24.8	low	low	60	25
26	Existing part of paved County Rd. 306 from north of East Park Res. to Lodoga	13.3	low	low	60	13
27	Existing dirt rd. from north of East Park Reservoir to Lodoga	9.8	moderate	moderate	40	15
28	Proposed road along southwest Sites Reservoir shoreline	17.0	moderate	high	20	51
29	Existing part of Sites Lodoga Rd.	1.7	moderate	moderate	40	3
101	Existing Maxwell Sites Rd. within and east of Sites Reservoir	5.3	low	moderate	40	8
102	Existing Sites Lodoga Rd. within and west of Sites Reservoir	3.5	moderate	low	55	4
103	Existing Huffmaster Rd. within Sites Reservoir	6.2	low	moderate	40	9

Notes:

[1] Low profile grade is less than 2 percent
Moderate profile grade is 2 percent to 4 percent
High profile grade is greater than 4 percent

[2] Driving speed starts at 60 mph, and is reduced by the following percentages:
- Low profile grade - zero
- Moderate profile grade - 10 percent
- High profile grade - 20 percent
- Low horizontal curvature - zero
- Medium horizontal curvature - 30 percent
- High horizontal curvature - 60 percent

Speed reductions are multiplied. For example, a road segment with medium profile grade and medium horizontal curvature would have a speed of [60 mph * (1 - 0.10) * (1 - 0.2)] = 45 mph (rounded to the nearest 5 mph)

Table 3. Thomes-Newville Existing and Alternative Road Realignment Segments (refer to Figure 2)

Road Segment	Segment Description (Refer to Figure 2)	Segment Length (miles)	Average Profile Grade [1]	Average Horizontal Curvature	Driving Speed (mph) [2]	Driving Time (minutes)
1	North - Existing Newville Road to Garland to Round Valley Road	8.5	moderate	moderate	40	13
2	South - Existing Newville to County Road 306	2.6	low	low	60	3
3	Northwest - Existing Round Valley Road	2.8	moderate	moderate	40	4
4	Proposed North - Newville Road to Round Valley Road	6.9	moderate	high	20	21
5	Proposed South - Newville Road to County Road 306	3.5	moderate	moderate	40	5
6	Proposed Northwest - Round Valley Road to Round Valley Road	2.2	moderate	moderate	40	3

Notes: [1]. Low profile grade is less than 2 percent
Moderate profile grade is 2 percent to 4 percent
High profile grade is greater than 4 percent
[2]. Driving speed starts at 60 mph, and is reduced by the following percentages:

Low profile grade - zero
Moderate profile grade - 10 percent
High profile grade - 20 percent
Low horizontal curvature - zero
Medium horizontal curvature - 30 percent
High horizontal curvature - 60 percent

Speed reductions are multiplied. For example, a road segment with medium profile grade and medium horizontal curvature would have a speed of
[60 mph * (1 - 0.10) * (1 - 0.2)] = 45 mph (rounded to the nearest 5 mph)

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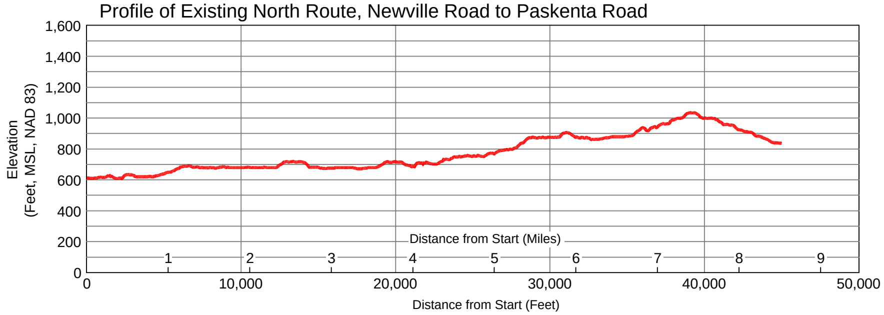
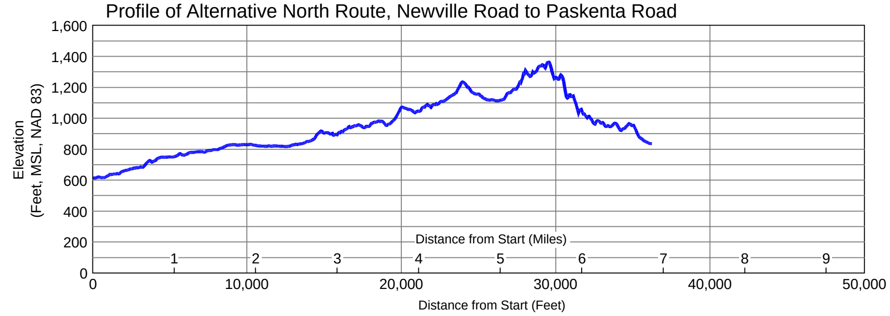
Offstream Storage Investigation - Thomes-Newville Project
Profile of Existing North, South and West Alignments and Alternative Realignments
March 9, 2000

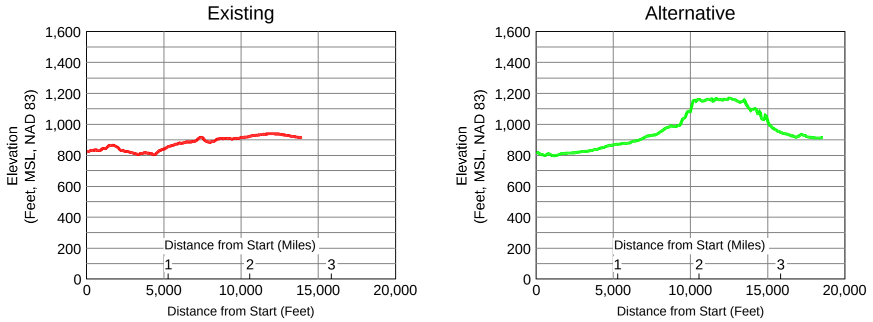
Profile of Existing North Route, Newville Road to Paskenta Road



Profile of Alternative North Route, Newville Road to Paskenta Road



Profiles of South Route, County Road 303



Profiles of West Route, Paskenta Road to County Road

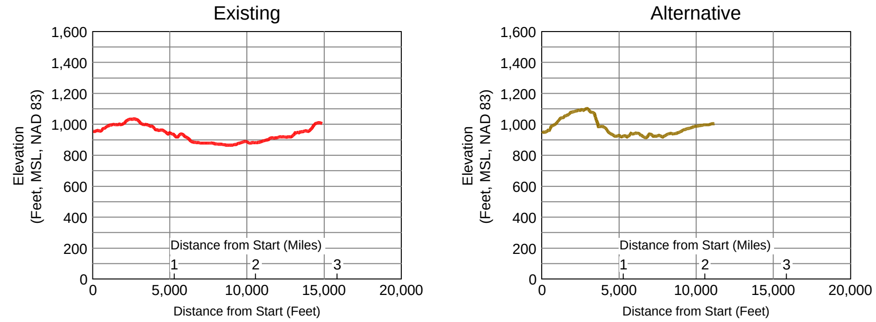


Figure 5

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Photos of Existing and Proposed Access Around Sites Reservoir

Photo 1. T-C Canal looking east

Photo 2. T-C Canal looking west to Sulphur Gap

Photos 1 and 2 show the east end of alternative alignments that would go south of Sites or Colusa Reservoirs. Photo 1 is taken from a bridge over the Tehama-Colusa Canal on Standard Road, looking east toward Maxwell. Photo 2 is taken from the same place, looking west toward Sulphur Gap.

Photo 3. Sulphur Gap, looking east

Photo 4. North of Sulphur Gap, to west

Photo 3 shows the Sacramento Valley as seen from Sulphur Gap. It shows the steep rise up to Sulphur Gap. Photo 4 is taken from north of Sulphur Gap, looking west into the potential Sites Reservoir area.

Photo 5. South Grapevine Creek Alignment

Photo 6. Windy Point, looking southeast

Photo 5 shows the south end of the Grapevine Creek alternative alignment. Photo 6 shows Leesville Road to the south, looking down from Windy Point. This photo illustrates the steepness of some of the terrain through which alternative road alignments must pass.

Photo 7. Leesville-Lodoga Road looking west

Photo 8. NW Sites Reservoir area

Photo 7 shows the Leesville-Lodoga Road, looking west at the community of Leesville. This valley road alignment has a flat slope, but it would have to be widened and improved in order to serve re-routed traffic from Maxwell. Photo 8 is taken from inside the northwest portion of the Sites Reservoir area, looking northwest. The northern alternative road alignment around Sites Reservoir (Black Line) would be about halfway up the slopes of the hills in the background of this photo.

State of California, Gray Davis, Governor
The Resources Agency, Mary D. Nichols, Secretary for Resources
Department of Water Resources, Thomas M. Hannigan, Director

Steve Macaulay, Chief Deputy Director
Jonas Minton, Deputy Director
L. Lucinda Chipponeri, Assistant Director for Legislation
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In coordination with CALFED

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Special thanks to DWR's Northern District staff,
who drafted many chapters of this progress report and conducted many of the studies that form its core.

**formerly with Department of Water Resources*

Attachment A

Inventory Of Existing Regional Reservoir-Based Recreation Facilities

Black Butte Lake (USACE)
Stony Gorge Reservoir (USBR)
East Park Reservoir (USBR)
Indian Valley Reservoir (BLM)

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In the eastern foothills of the Coast Range there are four reservoirs, all between 10 and 50 miles from Sites, that offer lake-oriented recreation at varying levels of development. The recreation lands around all of these reservoirs are managed by federal agencies. In addition to recreation, the reservoirs provide benefits such as flood protection and water storage for downstream users. Attendance estimates for each of these reservoirs are presented in Table 1 in the body of this report.

Black Butte Lake

Black Butte Lake is owned and operated by the U.S. Army Corps of Engineers. It is located on Stony Creek approximately 8 miles west of the town of Orland in Glenn County. There are six recreation areas, a dam overlook, and several nature trails. Each recreation area includes restrooms and fishing access with a range of other facilities. This reservoir has the most developed recreational facilities of the four discussed. Recreation lands surrounding the reservoir total about 4,000 acres.

Orland Buttes Recreation Area contains 35 camping sites, a two-lane boat ramp with 50 parking spaces, a fish cleaning station and two sets of bathrooms. The campsites have been built on a steep slope and have been tiered with retaining walls at each site, as well as for the parking areas. Traffic counters have been installed in the road leading to the area to measure vehicle traffic. Also, a trailhead for the Simpson Arch Overlook is located within this recreation area.

Grizzly Flat Recreation Area on the west shore is a day-use area primarily for hunting and fishing access. The terrain and vegetation is composed of low rolling hills and grassy, oak woodland. A graveled road leads into the area where many undeveloped roads branch off of it. There is no camping, fire building, all terrain vehicle use, or woodcutting permitted. There are a few portable bathrooms around the area, but there are no permanent facilities here.

Big Oak Trail is located at the southern end of the reservoir and leads to the lake through a willow and cottonwood forest. There is a portable bathroom and information kiosk at the trailhead. No camping or fires are allowed here.

Observation Point is near Black Butte Dam and is an overlook area with a view of the main body of the lake, the dam, and the outlet structure. A maintained grassy area has five picnic sites and permanent bathrooms. There is parking for 50 vehicles. Traffic counters have been placed in the road leading to this area to help estimate attendance.

Eagle Pass Recreation Area is located near the dam overlook. It has a three-lane boat ramp with 62 parking spaces. Across a small cove is a grassy picnic area with 24 sites including two for groups. Seventeen of the sites are shaded with ramadas and there is parking for 26 vehicles plus an overflow area. Trees have been planted in the area and provide shade for the tables without ramadas.

Anglers Cove, and a 75-acre **OHV Park**, are located on the northwest shore. This area is accessed from Newville Road at the intersection of Black Butte Road. At the ATV park, there is a gravel parking area with several spaces for camping. The entire area is composed of rolling grass-covered hills with a few oak trees and shrubs. Within the ATV park there are many trails and roads and very few trees or shrubs. Below the water line within the cove several dead snags have not been removed, presumably to enhance the fish habitat.

Buckhorn Recreation Area is also along Newville Road, west of Anglers Cove. This is the most developed area at Black Butte Reservoir. There is a two-lane boat ramp along with a marina and store that is operated on a seasonal basis. The boat ramp parking area contains 54 parking spaces for vehicles and trailers. A large grassy field is located in the central portion of the area for picnicking and game-playing, and nearby is a fish cleaning station. There is also a fairly new children=s play area, as well as a new outdoor amphitheater. The Buckhorn nature trail is a short loop and has interpretive signs that explain some of the plants and wildlife found in the area.

Burris Creek Recreation Area is on the west branch of the reservoir. This area is similar to Grizzly Flat, but is considerably smaller. It is connected to Grizzly Flat by a service road (closed to public vehicles) and an equestrian trail. It is comprised of oak woodland habitat with one main access road and several spurs that lead to areas for picnicking or fishing. The lake at this point is quite shallow, so even small drawdown creates a large mud flat down to where Burris Creek flows into the reservoir. Facilities include a portable bathroom, and a car counter in the entrance road to provide use estimates.

Stony Gorge Reservoir

Upstream of Black Butte Lake on Stony Creek is Stony Gorge Reservoir. It is owned and operated by the U.S. Bureau of Reclamation. Their primary purpose is to provide irrigation water for use by the Orland Unit Water Users' Association, but recreation is also a project benefit. The water level at this reservoir fluctuates widely through the seasons and can affect recreation use. According to USBR, recreation use is high in the spring and early summer, but drops off in the latter half of summer and into autumn as the water level decreases. All of the recreation areas at Stony Gorge are accessed from State Route 162, just east of the intersection with Road 306, near the town of Elk Creek. The road that leads to the reservoir is Road 304.

Pines Group Camp and Picnic Area is the first recreation area along Road 304, located on the northwest tip of the reservoir. The picnic area has three tables spaced out beneath gray pines and large oak trees. The group camping area has a large stone fire pit and a large brick barbecue. There are also large concrete pipes, presumably for children to play on, and permanent restrooms. Use of this area is subject to reservation.

Grimy Gulch is next (south) along the road, with a mixed picnic area and campground. There are 40 unimproved sites in this area, all of which have tables, but not all have fire pits or barbecues.

Skippers Point is adjacent to Grimy Gulch and contains a lighted one-lane boat ramp and a picnic area with 12 tables that each have a barbecue. There is also a pay phone at this area. Additional recreation areas south of Skippers Point and Grimy Gulch are open only seasonally.

Elk Creek Picnic Area has four sites.

Hidden Point, Stony Point, and Fig Orchard 1 and 2 Campgrounds. Hidden and Stony Point are each individual camping sites located on an oak-covered point, with a portable bathroom at each site. Fig Orchard 1 and Fig Orchard 2 are designed in a more traditional loop orientation with fire rings, barbecues, and picnic tables at each site. There are a combined 32 sites at these two areas.

East Park Reservoir

Upstream in the Stony Creek watershed, south from Stony Gorge Reservoir, is East Park Reservoir. East Park is similar to Stony Gorge--similar in size, level of development, and owned and operated by USBR for the same purpose. The reservoir is located approximately 20 miles west of Maxwell near the town of Stonyford. There are two zones of developed recreation at the lake, one on the west shore and another along the east shore. Both are relatively primitive, although some permanent restroom construction has occurred in the last year.

The access road to the east shore begins 1 mile north of Lodoga from Sites-Lodoga Road. This is a gravel road that is only open during the recreation season (approximately April-October). It heads north at first along an extensive high quality wetland with a large marsh adjacent to many acres of lacustrine, rooted, aquatic vegetation. There are six named recreation areas along this shore, but several of these locations run together, making it appear that there are just four separate areas.

Coyote Flat/Big Boot is the first campground along this route. The campsites are not marked except for fire rings that appear to have been constructed by visitors. The most recent improvement (within the last year) is the construction of a permanent restroom with vault toilets.

Rattlesnake Point is the next area, proceeding north. There is an unmarked, two-lane, unpaved boat ramp and 10 to 15 picnic tables scattered around the area. Although we did not observe anyone camping here, the presence of fire rings suggests that overnight use does occur.

Last Chance/Rocky Ridge is further north. This is a camping area similar to the others except that it is a bit more spread out. There are no designated campsites except for fire rings scattered throughout the vicinity. A road loops through the area and winds along close to the shoreline where there are several secluded places for camping. Some, but not all, of the sites have picnic tables.

Chisolm Cove is the last area along the east shore. This is a group camping area that is subject to reservation. There are nine picnic tables and a permanent vault toilet here.

The west shore is accessed from the town of Stonyford via East Park Road. This gravel road heads east from the town past a few homes and then across a large, treeless plain to the reservoir. The road splits at a "T" intersection heading north and south. To the north the road leads to the spillway which is an interesting attraction due to the unusual arch and staircase type architecture. There is a portable restroom located here. A secondary road winds along the shoreline heading south from the spillway. This road has two designated and several informal camping and picnicking spots.

Shale Point is the first designated recreation area and has 12 tables scattered around a small point. The vegetation is quite degraded here and bare dirt dominates the area.

Burrow Ridge is the other area and extends along several points and coves. There are several portable restrooms and many picnic tables located throughout the area, and there is an informal (unpaved) one-lane boat ramp on one of the points.

Indian Valley Reservoir

Indian Valley Reservoir is located on the North Fork of Cache Creek in a secluded area of the Coast Range. It is surrounded by wildlands managed by Bureau of Land Management; the reservoir is owned and operated by the Yolo County Water Agency. The main access is from the south via State Route 20 and Walker Ridge Road. This unpaved road provides scenic views of the surrounding country and of Indian Valley Reservoir as it descends to the lake. The reservoir can also be accessed via Bartlett Springs Road from Bear Valley to the east. From the reservoir this road winds along a narrow canyon, and then climbs up to the top of the ridge to the intersection with Walker Ridge Road.

Blue Oak Recreation Area is a small undeveloped campground located along a small intermittent stream as the road descends from Walker Ridge Road to the dam. The first portion of this area contains two camping sites and a pit toilet. To the west of this location a couple of access points from the main road drop down to the intermittent stream. These areas are not developed and there are no sanitary facilities, but there are fire rings and other signs of camping activity.

Indian Valley Reservoir Marina is near the dam. It is the most developed recreational area and contains a marina, store, and an unpaved boat ramp. Fees are charged for all types of activities including parking, boat launching, and overnight use.

Kowalski Spring Camp is accessed by a one-mile trail from the dam. The trail winds along the shoreline, around a narrow arm of the reservoir, to the primitive campsite that is accessible to hikers and boaters only.

Wintun Camp is an undeveloped camping area located on Walker Ridge, east of the reservoir. There is a water spigot and a fire ring but no sanitary facilities. The road distance of this camp from the reservoir makes it unlikely that many lake recreationists use this site but, according to BLM, this is a popular camping area year-round.

The north end of the reservoir has no developed facilities, but several miles of shoreline access is provided by Bartlett Springs Road. Several points have been utilized as camping areas as is evident by the fire pits and roads in the flats near the waterline. The BLM map shows a boat ramp at this end of the reservoir, but upon firsthand inspection of the area no developed or marked ramp could be found. However, it seems that users are able to launch boats in several locations due to the open access to the water and gentle slope of the shoreline.

Attachment B

Suitable Lands And Hypothetical Layouts
For
Sites Reservoir Recreation Facilities

Peninsula Hills Recreation Area
Stone Corral Recreation Area
Saddle Dam Boat Ramp
Lurline Headwaters Recreation Area
Dunlap Island Boat-In Facilities

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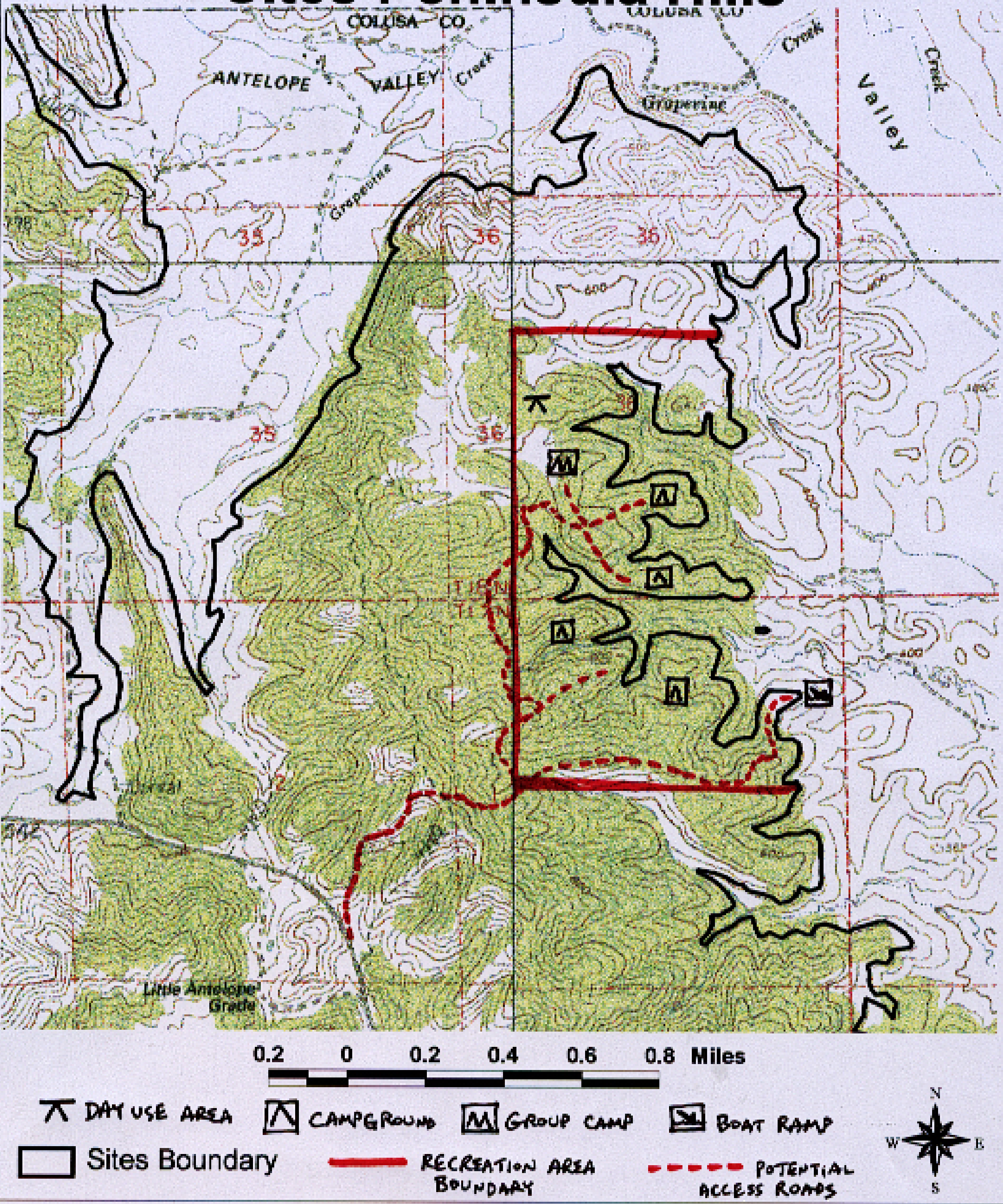
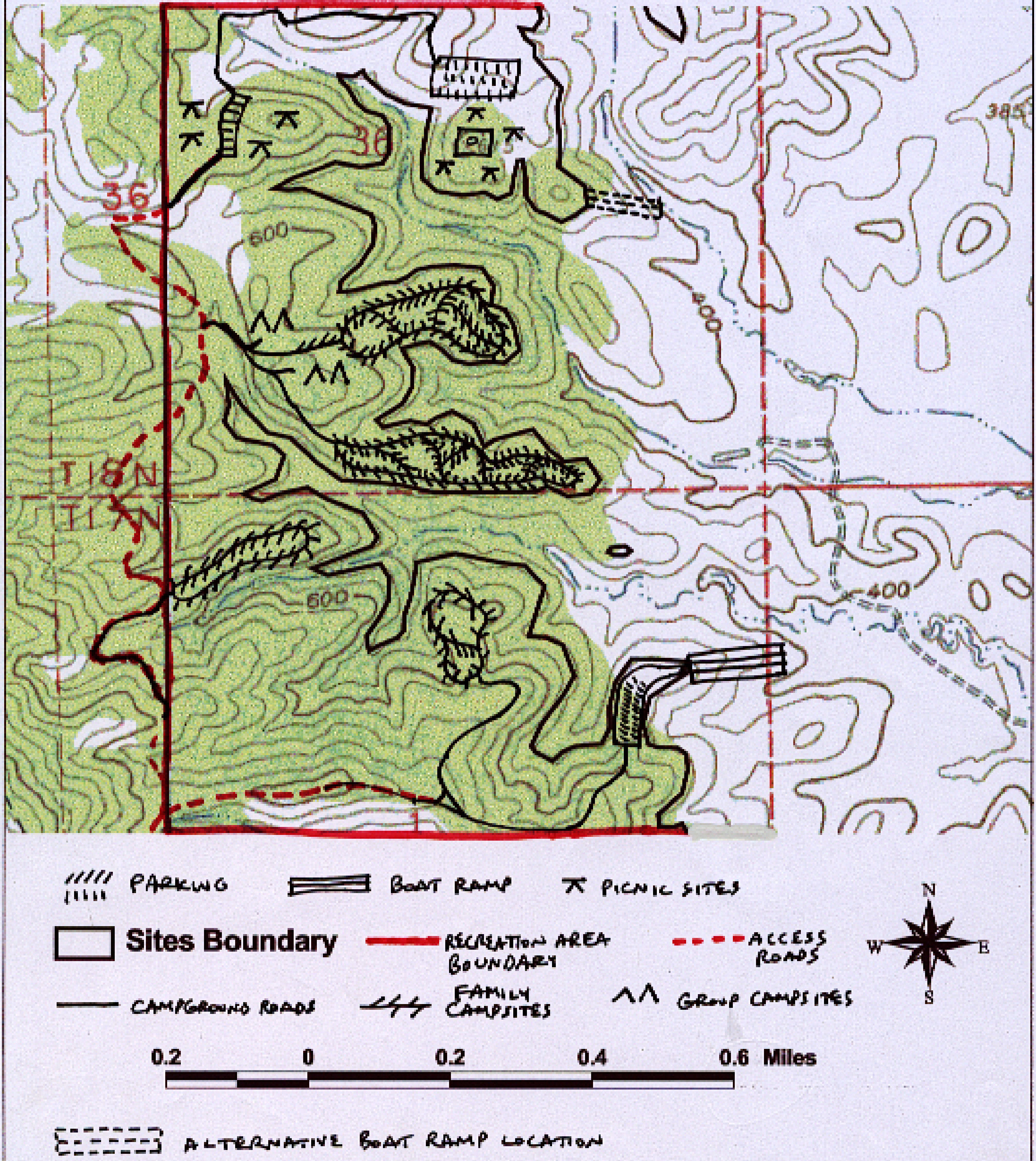
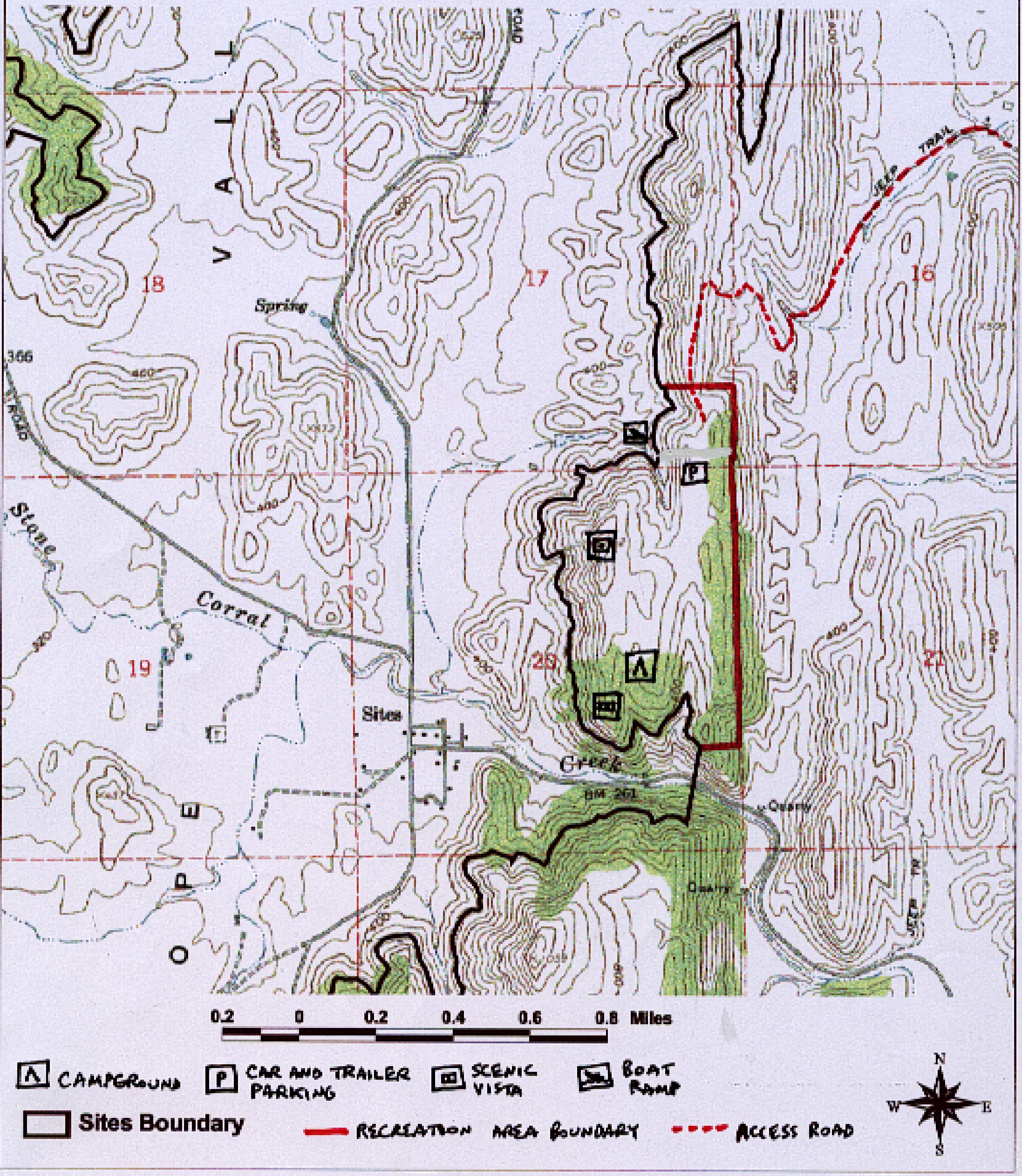
Sites Peninsula Hills



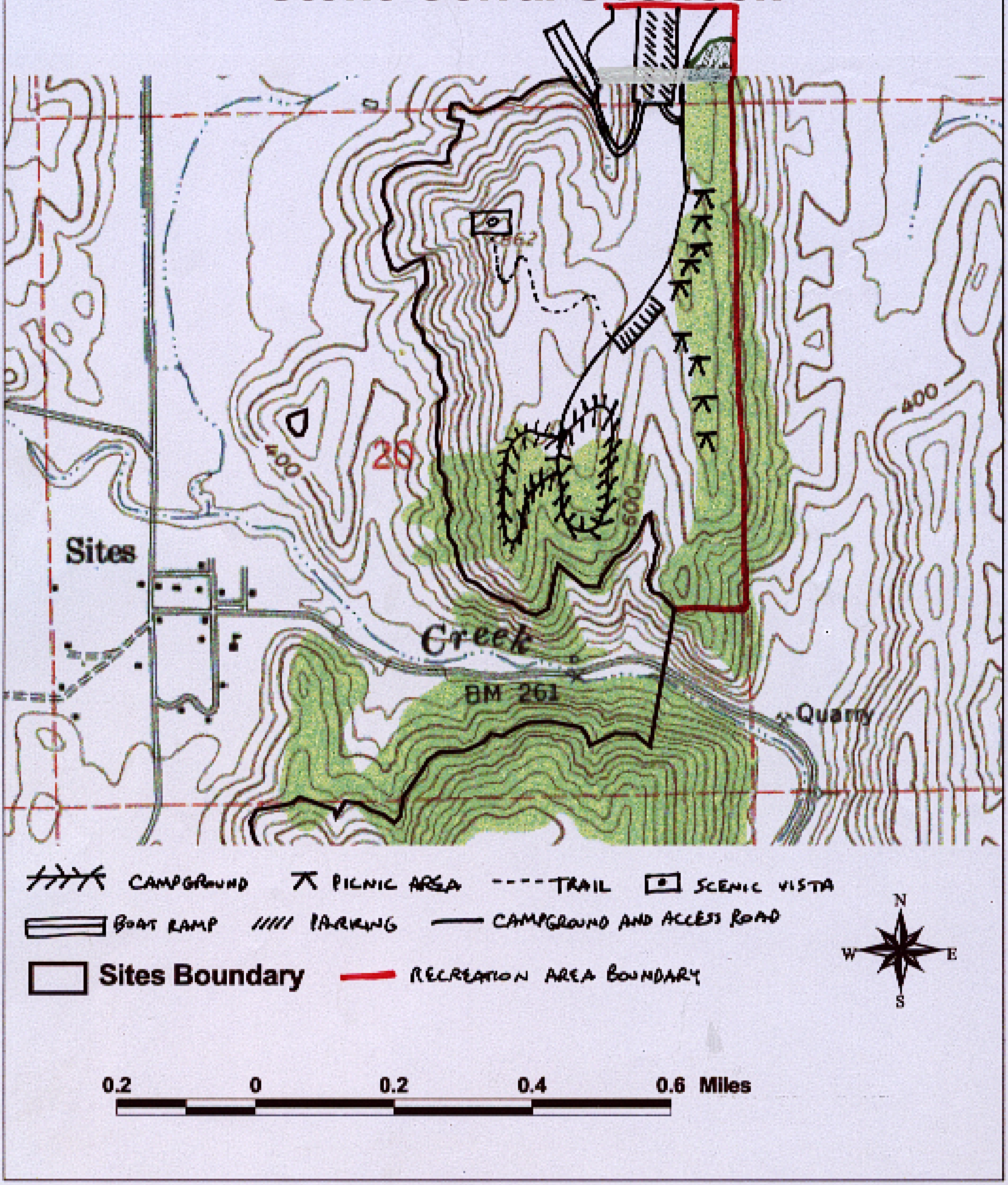
Sites Peninsula Hills



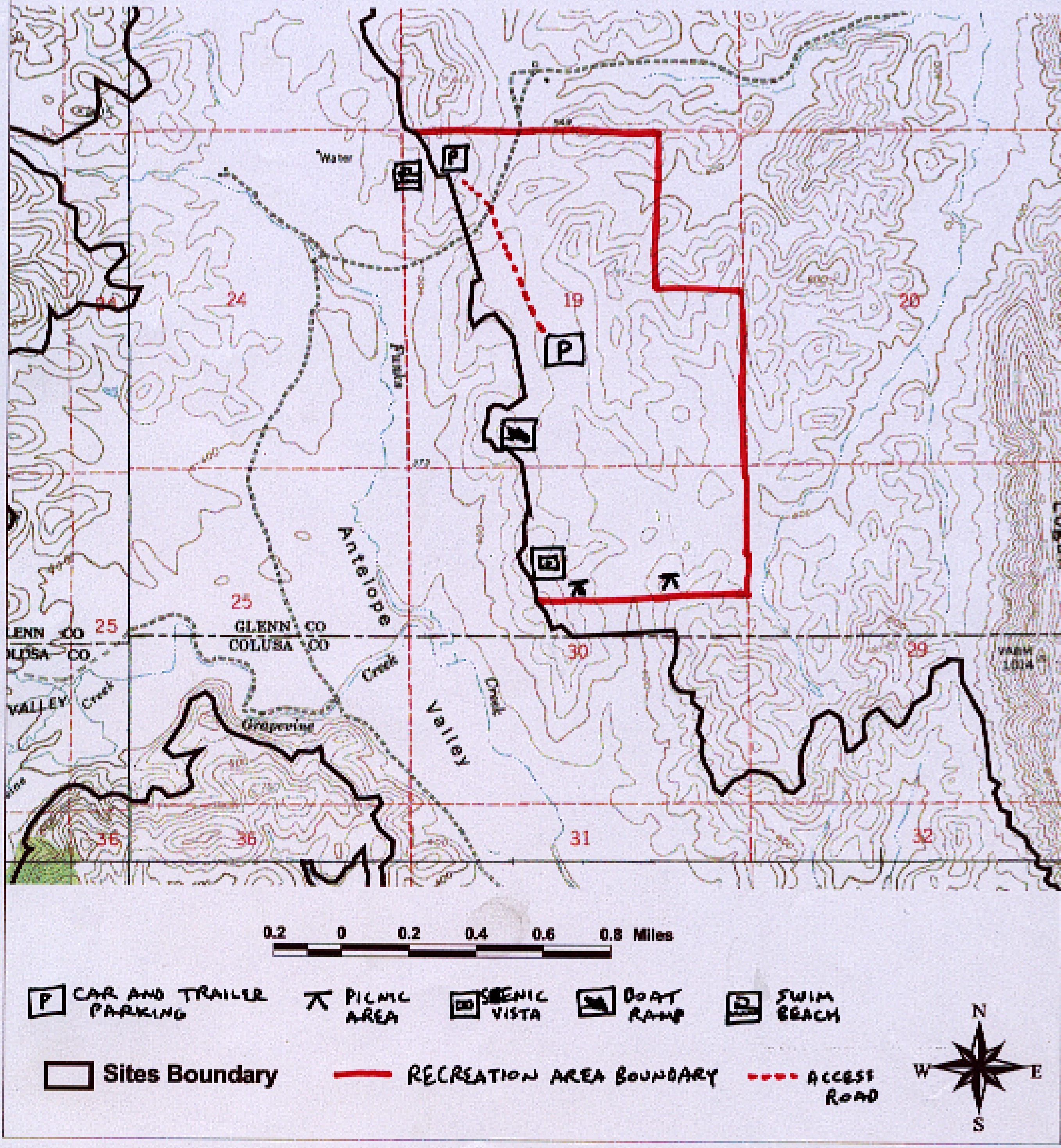
Stone Corral Overlook



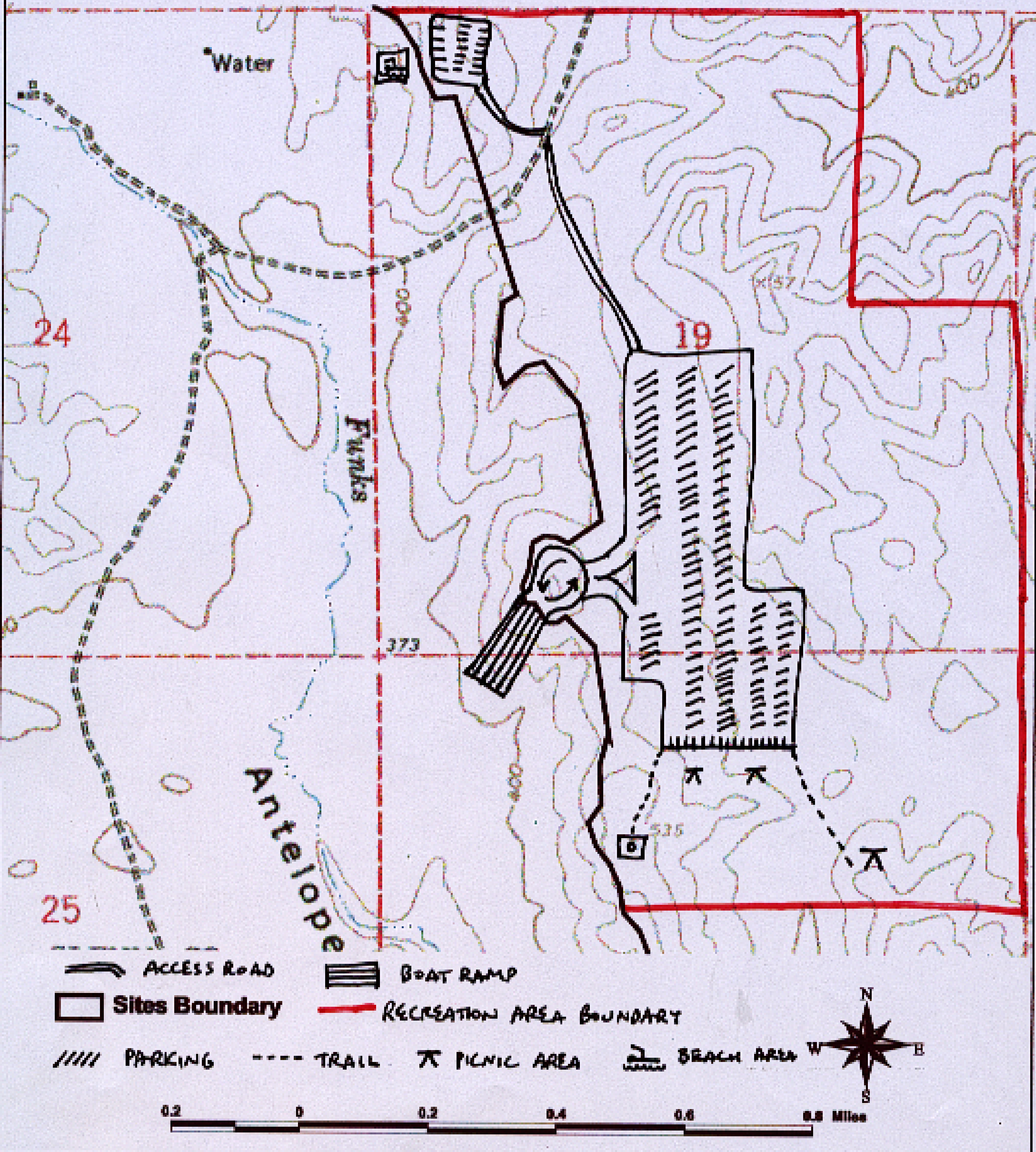
Stone Corral Overlook



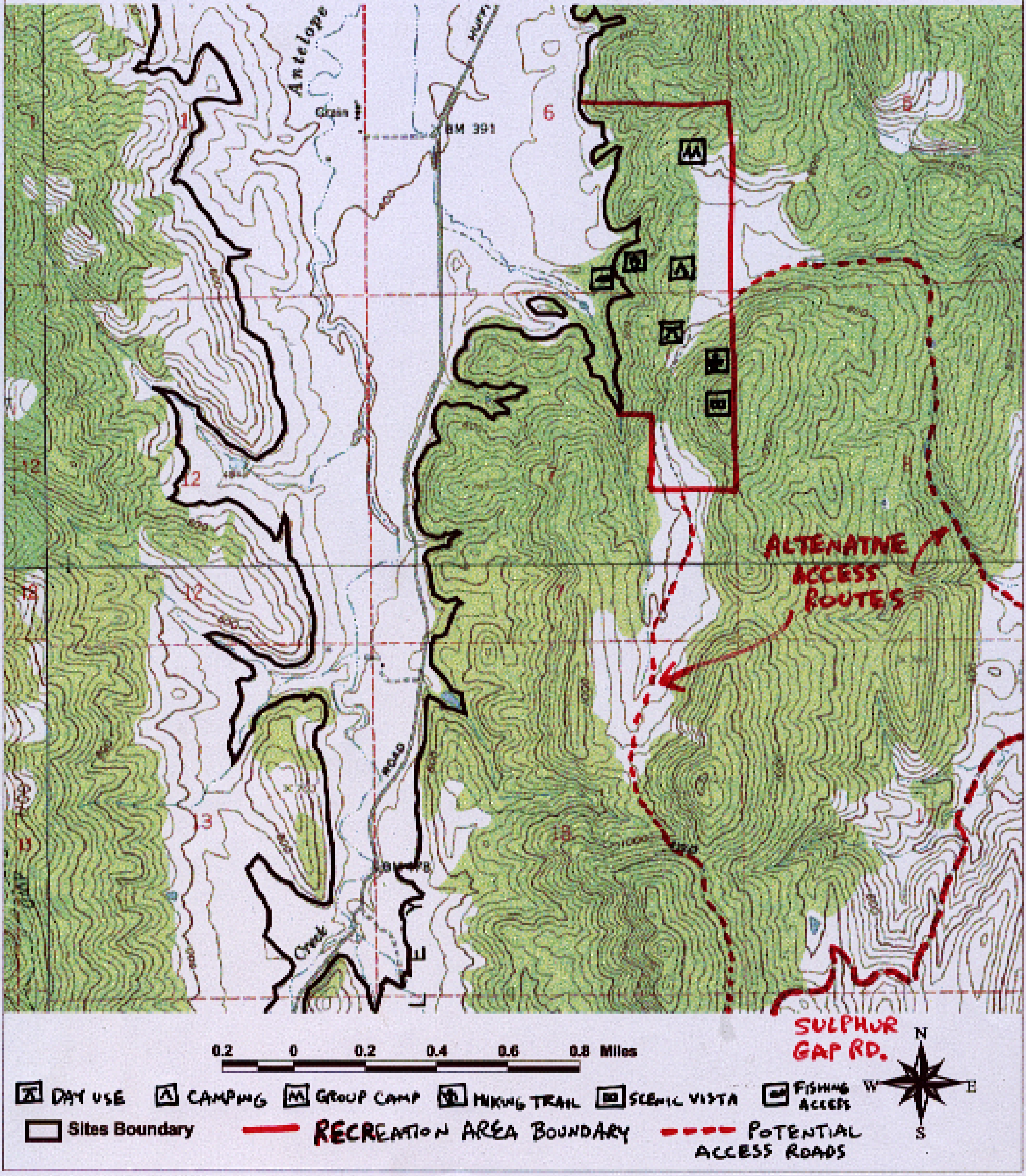
Saddle Dam Boat Ramp



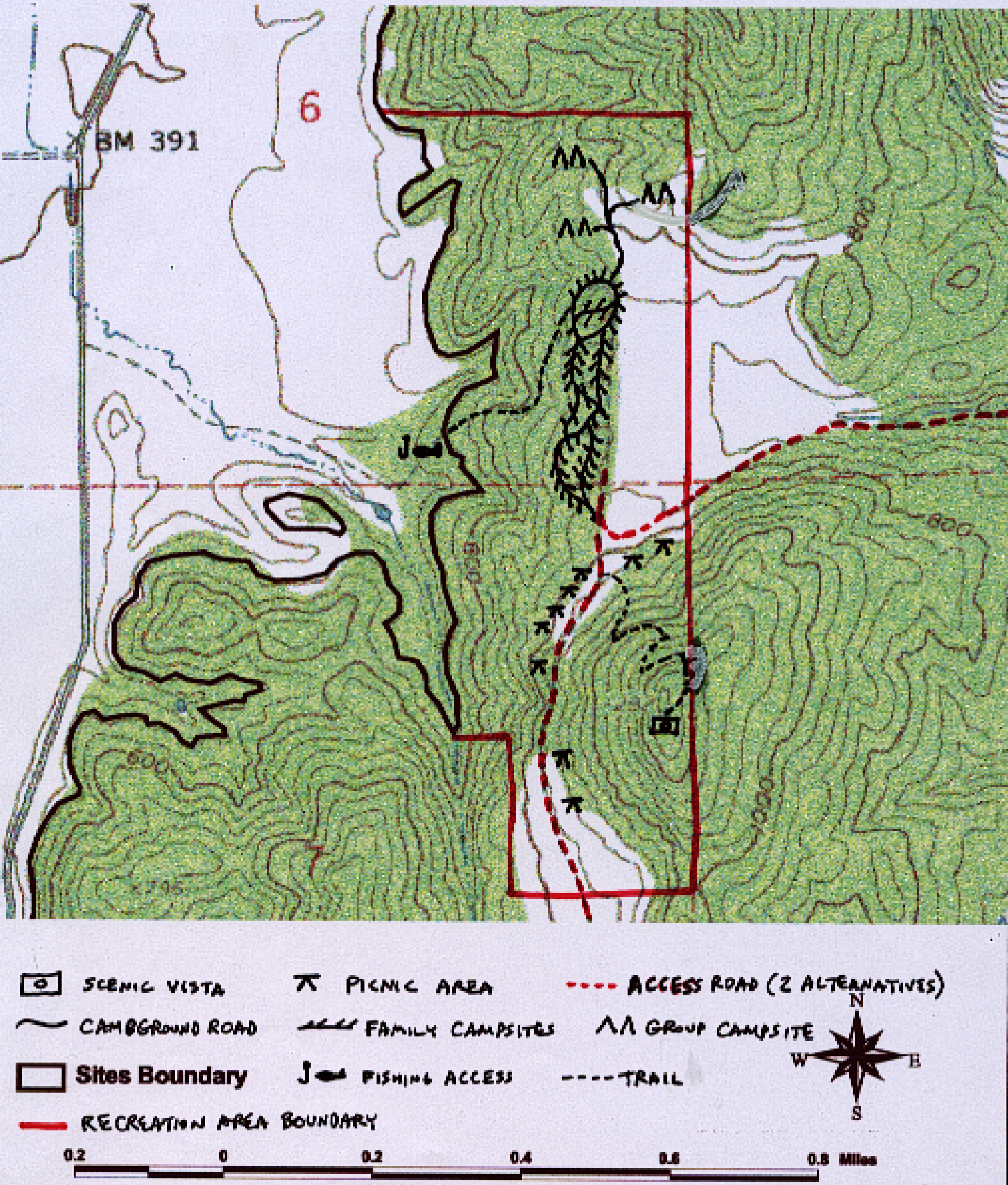
Saddle Dam Boat Ramp



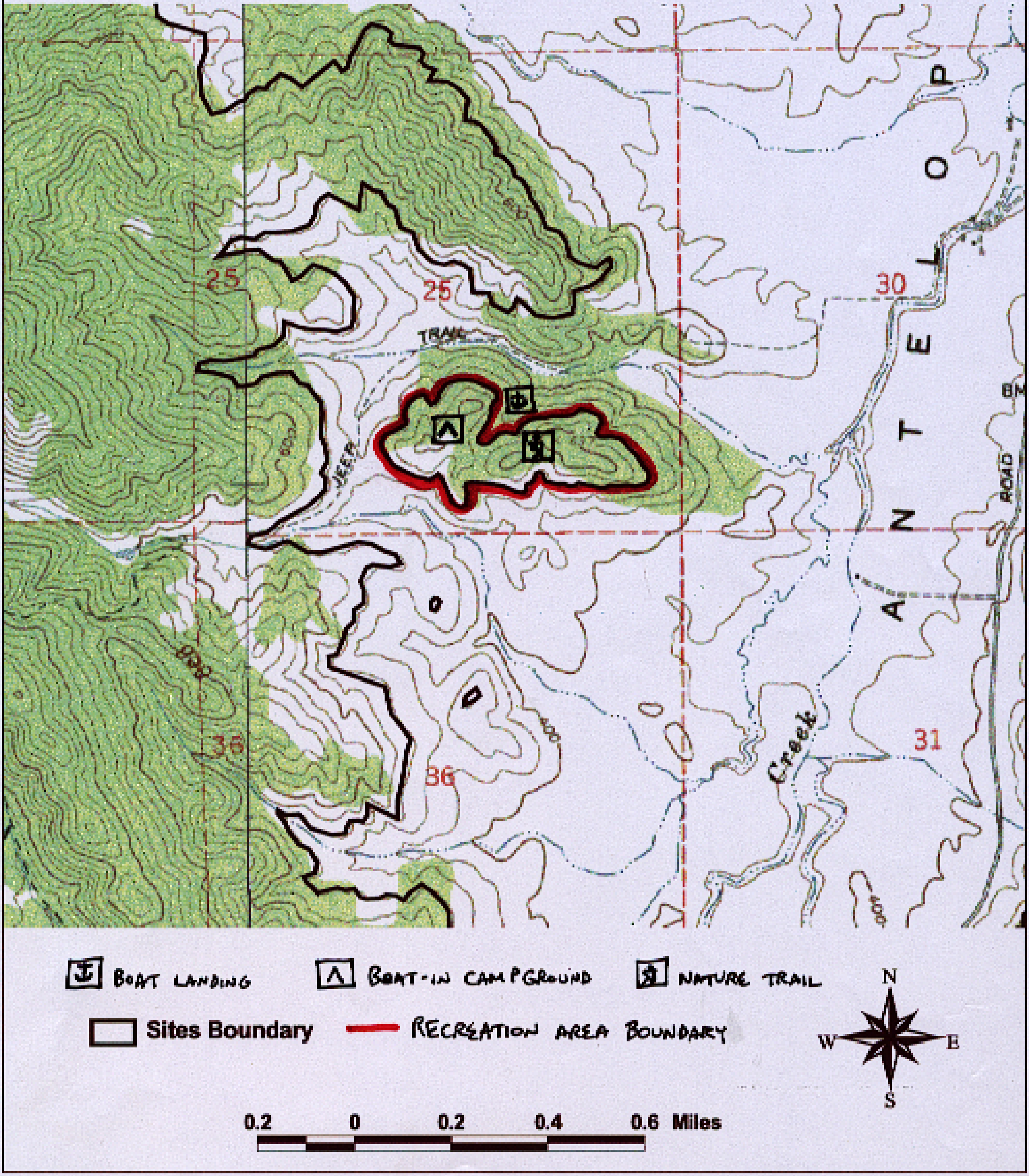
Lurline Headwaters



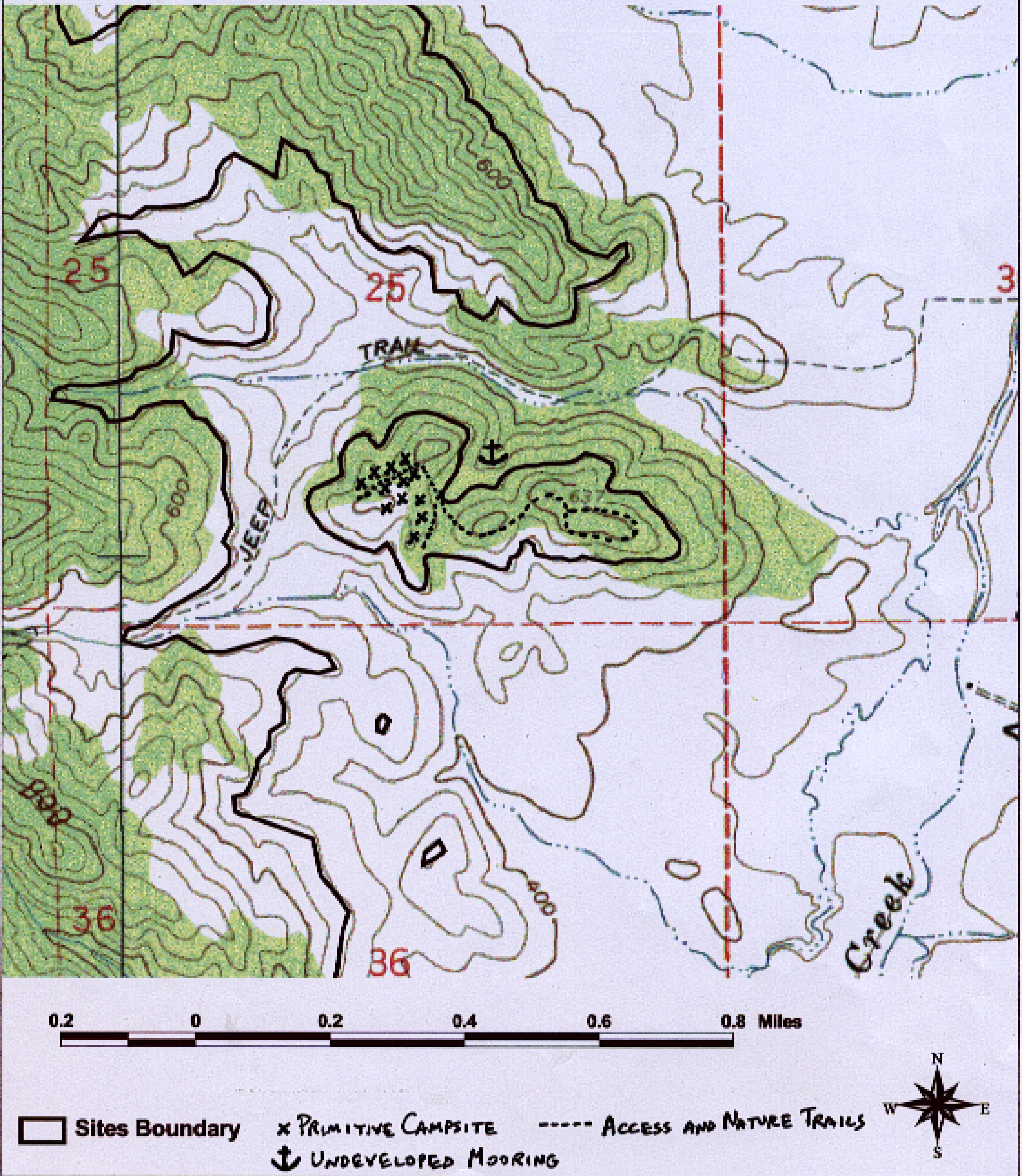
Lurline Headwaters



Dunlap Island



Dunlap Island



Attachment C

Travel Distance From Regional Population Centers
To
Sites Reservoir

Index Map
Area Within 10 Miles
Area Between 10 - 25 Miles
Area Between 25 - 50 Miles
Area Between 50 - 75 Miles
Area Between 75 - 100 Miles
Area Between 100 - 125 Miles
Area Between 125 - 150 Miles

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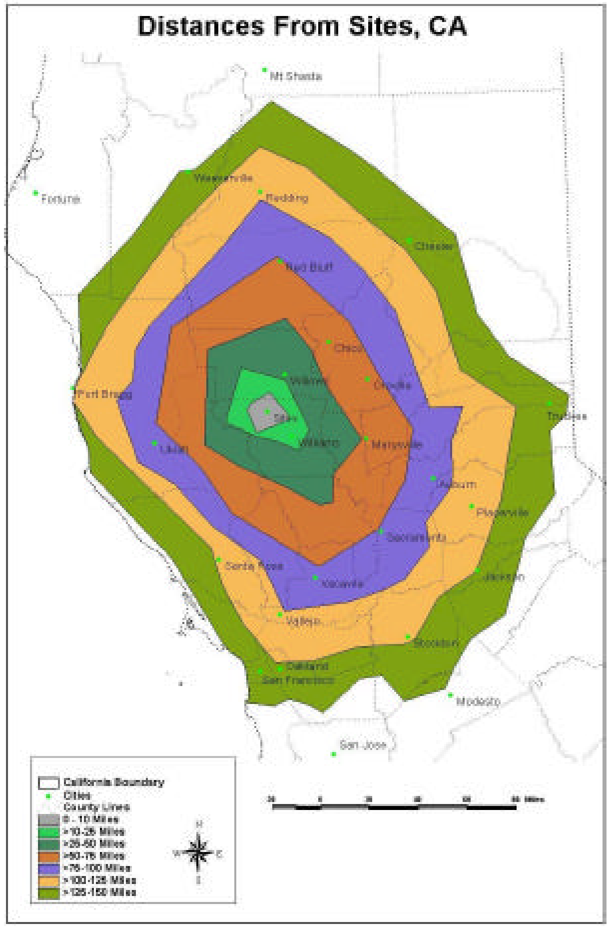
Distances From Sites, CA
Mt Shasta
Fortune
Redding
Red Bluff
Chester
Fort Bragg
Ukiah
Marysville
Auburn
Placerville
Santa Rosa
Vacaville
Vallejo
Stockton
Oakland
San Francisco
Modesto
San Jose
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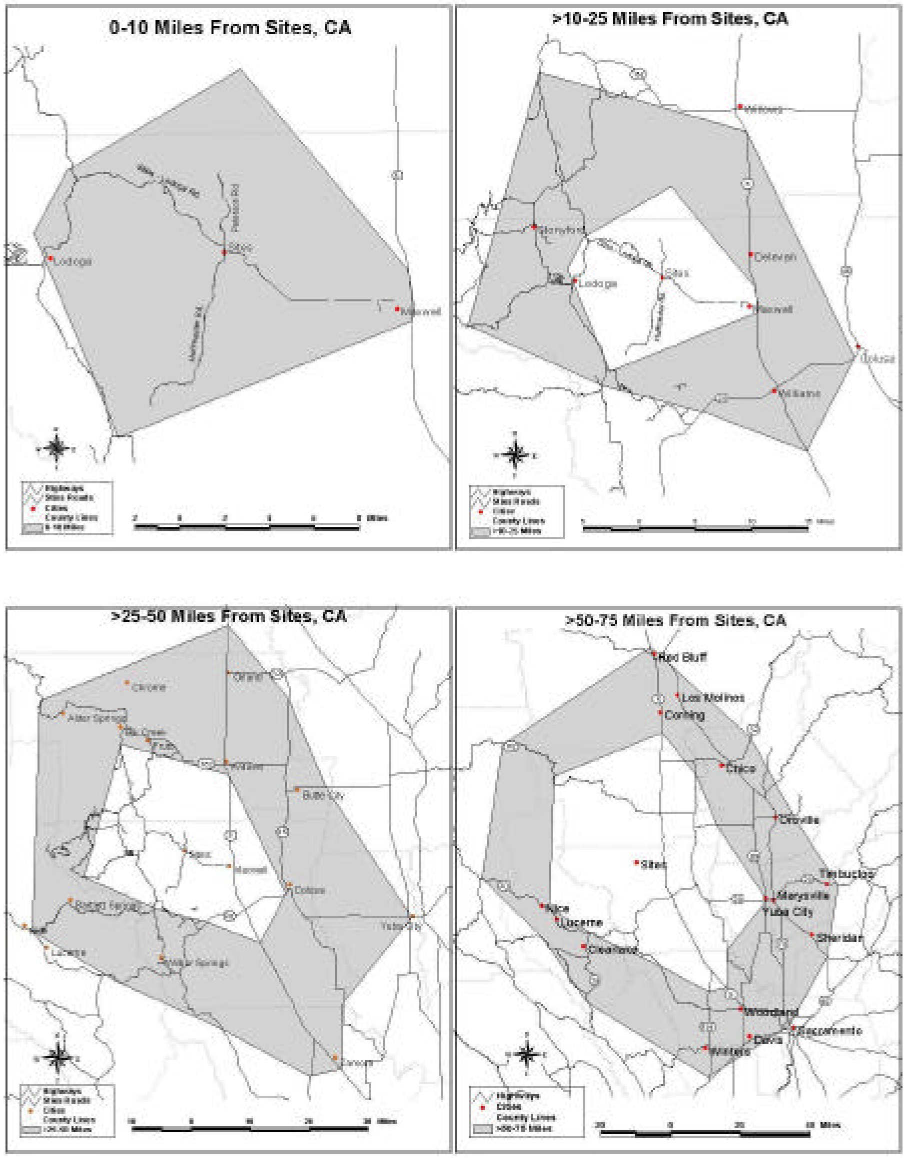
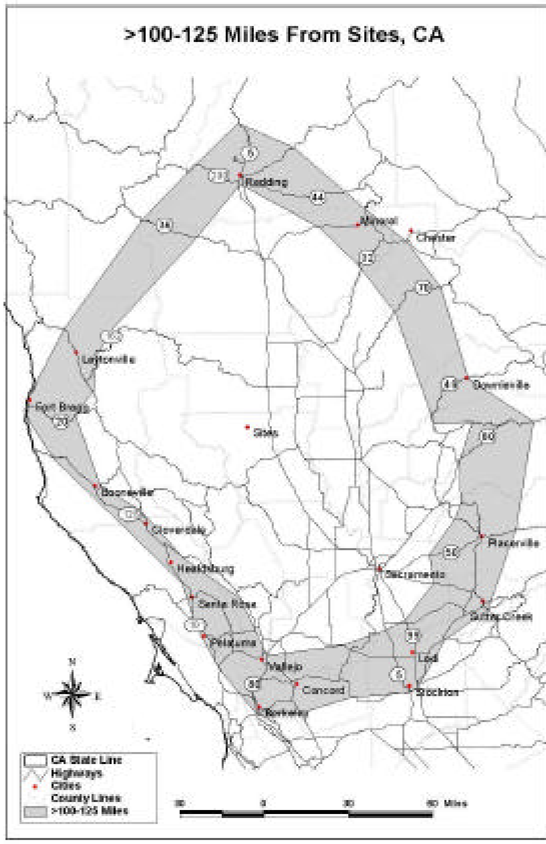
>100-125 Miles
>125-150 Miles


0-10 Miles From Sites, CA
Sites
Lodoga
Maxwell
>10-25 Miles From Sites, CA
Willows
Stonyford
Sites
Lodoga
Delevan
Maxwell
Colusa
Williams
>25-50 Miles From Sites, CA
Butte City
Yuba City
>50-75 Miles From Sites, CA
Red Bluff
Los Molinos
Corning
Chico
Oroville
Sites
Timbuctoo
Marysville
Yuba City
Nice
Lucerne
Clearlake
Sheridan
Woodland
Sacramento
Davis
Winters


>100-125 Miles From Sites, CA
Redding
Mineral
Chester
Laytonville
Fort Bragg
Downieville
Sites
Booneville
Cloverdale
Placerville
Healdsburg
Sacramento
Santa Rosa
Sutter Creek
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Vallejo
Lodi
Concord
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Berkeley
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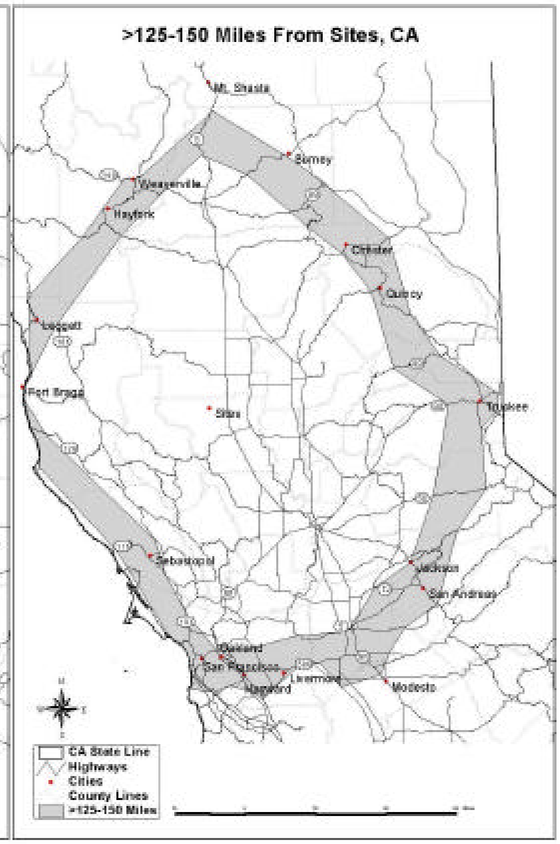
Cities
County Lines
>100-125 Miles
Miles


>125-150 Miles From Sites, CA
Mt. Shasta
Burney
Weaverville
Hayfork
Chester
Quincy
Leggett
Fort Bragg
Truckee
Sites
Sebastopol
Jackson
San Andreas
Oakland
San Francisco
Livermore
Hayward
Modesto
CA State Line
Highways
Cities
County Lines
>125-150 Miles

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Attachment D

Photographs Of
Sites Reservoir Shoreline Areas

Photo Captions

1. View to the southwest of the peninsula formed by Sites Reservoir.
2. Peninsula Hills campground area.
3. View to the north from the southern boat ramp at Peninsula Hills.
4. Structures within the inundation zone below the Peninsula Hills area.
5. View to the west into the reservoir from the Stone Corral Overlook area.
6. Sites Dam site from Stone Corral Overlook.
7. Funks Reservoir as seen from the Stone Corral area.
8. Campground area at Stone Corral Overlook.
9. Conglomerate rocks at the Saddle Dam Boat Ramp.
10. Potential parking area for the Saddle Dam Boat Ramp.
11. View across Antelope Valley to the southwest from the Saddle Dam Boat Ramp.
12. Overhead view of the Lurline Headwaters area.
13. Lurline Headwaters campground.
14. Antelope Valley from just above the Lurline Headwaters area.
15. South facing view from Dunlap Island.
16. Stock ponds like this could be used to help establish a fishery in the reservoir.

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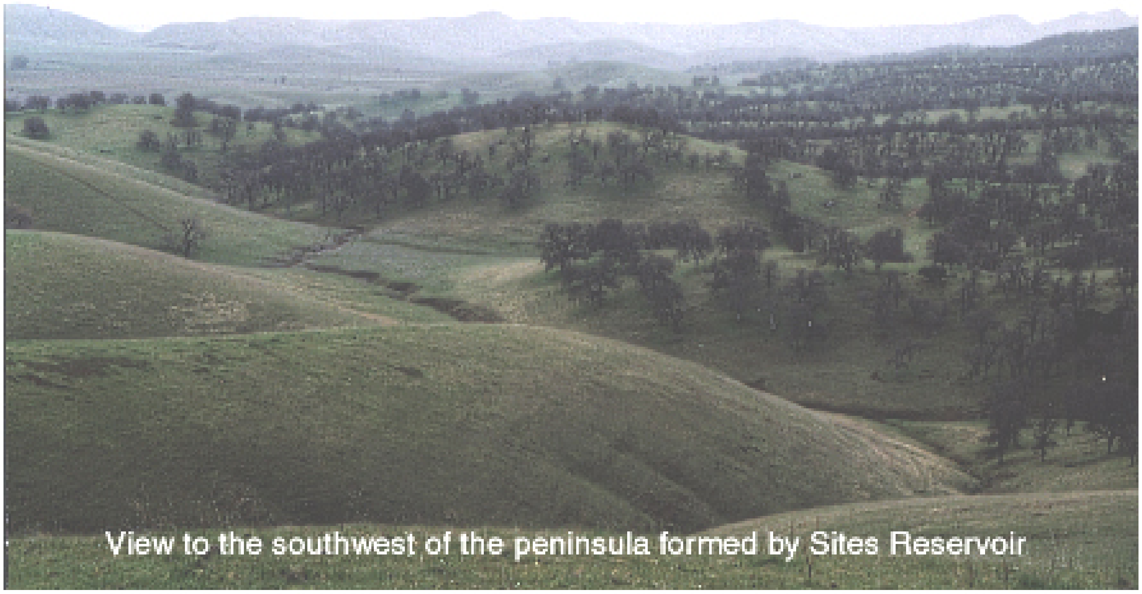

View to the southwest of the peninsula formed by Sites Reservoir

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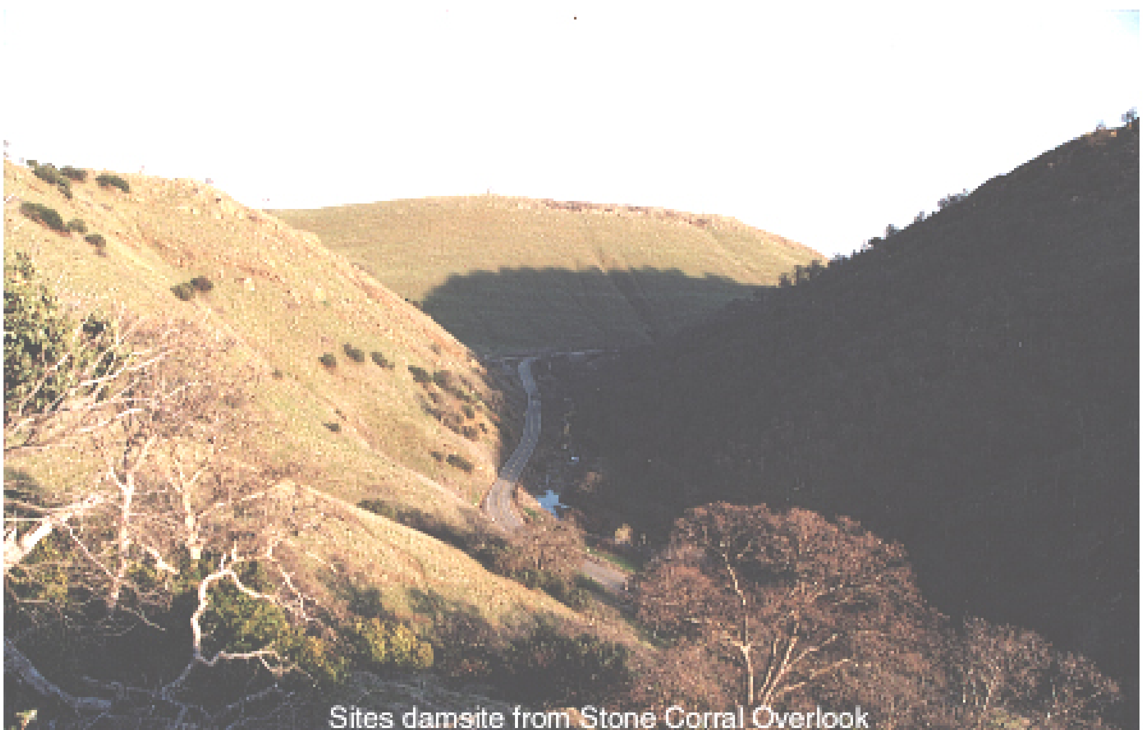
View to the north from the southern boat ramp at Peninsula Hills.

Structures within the inundation zone below the Peninsula Hills area.

View to the west into the reservoir from the Stone Corral Overlook area

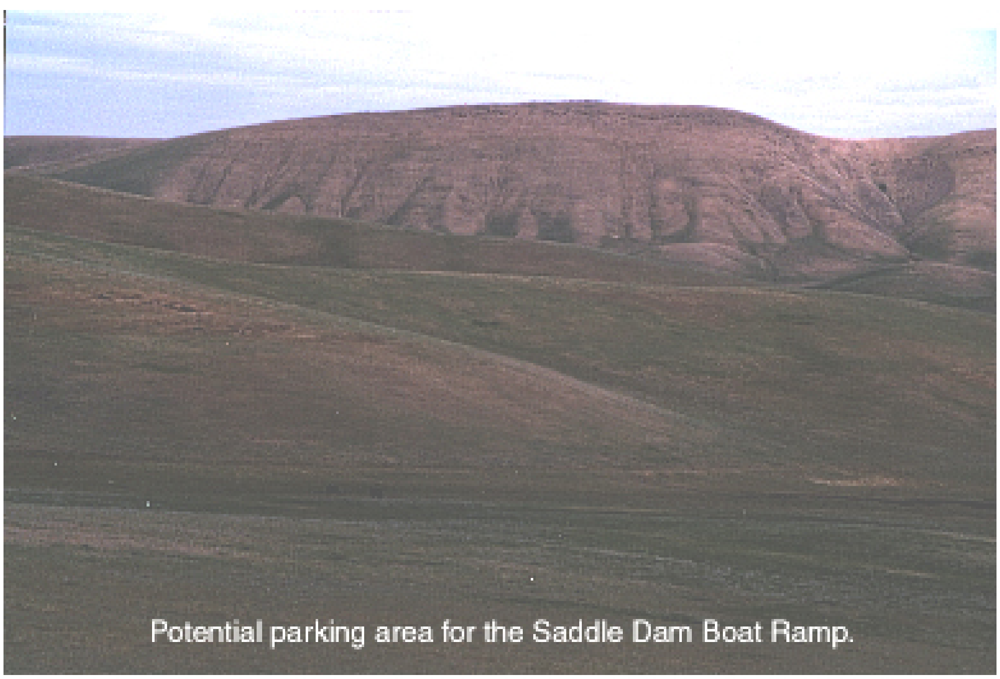


Sites damsite from Stone Corral Overlook

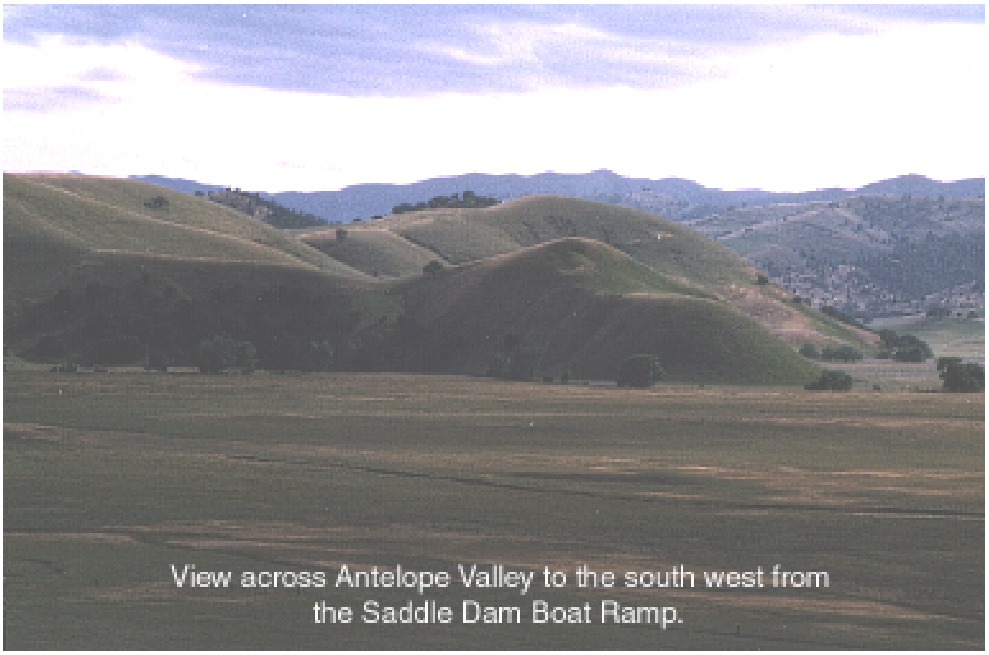
Funks Reservoir as seen from the Stone Corral area.

Campground area at Stone Corral Overlook.

Conglomerate Rocks at the Saddle Dam Boat Ramp.



Potential parking area for the Saddle Dam Boat Ramp.



View across Antelope Valley to the south west from
the Saddle Dam Boat Ramp.

Overhead view of the Hurline Head
waters area

Lurline Headwaters campground.

Antelope Valley from just above the Lurline Headwaters area.

South facing view from Dunlap Island.

Stock ponds like this could be used to help establish a fishery in the reservoir.

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Special thanks to DWR's Northern District staff,
who drafted many chapters of this progress report and conducted many of the studies that form its core.

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DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

Appendix J: Recreation Requirements and Opportunities: Sites Reservoir Alternative

April 2000

Integrated
Storage
Investigations

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North of the Delta
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Appendix J: Recreation Requirements and Opportunities: Sites Reservoir Alternative

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April 2000

Integrated
Storage
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Introduction

In late 1997, DWR began a two-year reconnaissance level study of North of the Delta Offstream Storage under Proposition 204-the Safe, Clean, Reliable Water Supply Act approved by voters in 1996. In early 1999, CALFED consolidated all storage investigations under a comprehensive program called Integrated Storage Investigations. The North of the Delta Offstream Storage Investigation was incorporated into one of seven ISI program elements.

The North of the Delta Offstream Storage Investigation continues engineering, economic, and environmental impact analyses to determine the feasibility of four north of the Delta storage projects. The four potential alternatives are Sites Reservoir, Colusa Project, Thomes-Newville Project, and Red Bank Project. Phase I, currently underway, includes preliminary field surveys of environmental resources and extensive field surveys of cultural resources, geological, seismic and foundation studies, and engineering feasibility evaluation. Phase II will start when CALFED's Record of Decision for the Programmatic EIR/EIS is completed and if north of Delta offstream storage is consistent with CALFED's preferred program alternative. Phase II will include preparation of project-specific environmental documentation, final project feasibility reports, and the acquisition of permits necessary to construct the project identified as most feasible.

Recreation is one valuable benefit provided by public and private water supply projects. While the ultimate responsibility for planning and development of recreation facilities is normally borne by the agency leading reservoir development, and this program is still in a stage where the merits of alternatives are being reviewed and evaluated, it is wise to begin scrutiny of opportunities and issues earlier in the process. This helps ensure that benefits are maximized and the many facets of planning are coordinated.

This report is the first in a series, intended to describe the potential of North of the Delta offstream storage alternatives to provide recreation opportunities and benefits. Herein are reported the results of a 1999 reconnaissance investigation of recreation opportunities for the Sites Reservoir alternative. The results of a 2000 investigation into the recreation potential of the Thomes-Newville Reservoir alternative will be prepared during summer of 2000 under a separate cover. Investigation, evaluation, and reports of the recreation potential of other alternatives may be prepared thereafter, if warranted.

Since recreation opportunities are often created by water facility development, and because recreation use provides economic benefits which may contribute to overall project feasibility, this report was prepared to supplement the various engineering and environmental studies of the Offstream Storage Program. It provides planners with the information necessary to efficiently consider recreation benefits if other engineering, environmental, and land acquisition activities proceed.

This report identifies the recreation potential, and discusses the feasibility of recreational facility development, at the proposed Sites Reservoir. The reservoir would be located in Antelope Valley (Colusa County) about 7 miles west of the town of Maxwell, in the eastern foothills of the Coast Range and, as currently conceived, would impound about 1.8 million acre-feet when full to elevation 520 feet. Two major dams and several saddle dams would inundate Antelope Valley (Figure 1). Evaluation of recreation potential of alternative Offstream Storage reservoirs will be prepared at a later date; Sites Reservoir was selected as the first subject of study because of a general lack of previous study of recreation potential at the 1.8 maf formulation.

This report includes a review of relevant past recreation planning documents, an inventory of similar reservoir-based recreation facilities and use in the region, a general assessment of the need for recreational facilities, descriptions of areas potentially suitable for recreation development, identification of potential access to these areas, hypothetical layouts of potentially suitable facilities, mileage range maps intended for later calculation of potential recreation demands and economic benefits, a list of data needs for future feasibility-level recreation planning, and photographs.

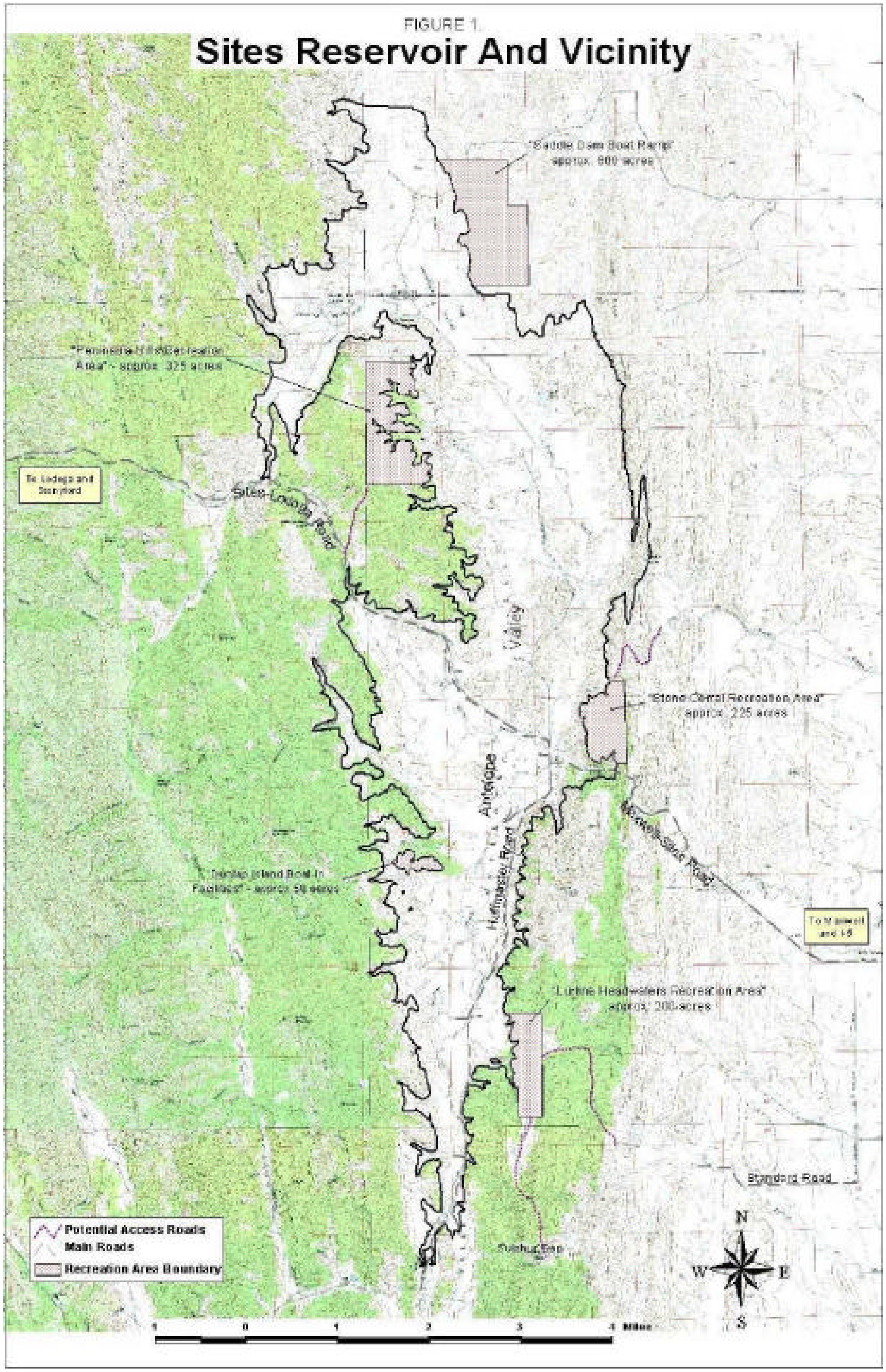

FIGURE 1.
Sites Reservoir And Vicinity

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Summary

Shoreline areas at the proposed Sites Reservoir would present a relatively limited number of opportunities for the establishment of recreation facilities. Steep topography and the potentially large fluctuations in water surface elevation indicated in some current operation scenarios combine to make many areas unsuitable, including most identified in a 1965 report on this subject. However, after thorough map review and field visits to all "shoreline" locations, we identified four shore-based areas with excellent potential for development of traditional recreation facilities. A fifth area would offer boat-in access and is suitable for primitive facilities. Total shoreline lands necessary for development of all suitable areas would total about 1,350 acres. Additional land or easements may be required for construction of access roads to these areas.

This report also includes an inventory of existing recreation facilities at four local reservoirs: Black Butte, Stony Gorge, East Park, and Indian Valley. All of these regional recreation opportunities are much smaller than Sites Reservoir, and most facilities developed there are relatively primitive. Sites Reservoir would be large, suggesting that demand for recreation at Sites may be relatively high. Additional study, including a recreation use survey at an existing reservoir, is required to reasonably estimate potential demand for facilities and use at Sites. However, a reservoir this size could reasonably be expected to support several hundred thousand recreation-days of use per year.

Obligations and responsibilities for planning, development, and operation of any recreation facilities at Sites Reservoir will vary depending on which agency undertakes reservoir development. Federal agencies are bound by the Federal Water Project Recreation Act, whereas State Water Project facilities accommodate recreation as directed by the Davis-Dolwig Act. If a State or local agency operates a water project with power generation benefits, the Federal Energy Regulatory Commission will require a recreation plan. The responsibility for final recreation planning will be borne by the agency deemed most appropriate when project feasibility studies are complete.

Previous Studies

The construction of an offstream storage facility on the westside of the Sacramento Valley has been under consideration as a water supply option for several decades. While engineering aspects of Sites Reservoir and other potential westside reservoirs have received more extensive study and evaluation, examination of the recreation potential of Sites Reservoir has previously been of limited scope. Only one report about Sites recreation exists (NPS 1965), and that was done for a different-sized reservoir. Other reports have discussed recreation planning for potential Newville, Rancheria, Cottonwood Creek, and other Upper Sacramento River offstream storage and conveyance alternatives (DWR 1965; DWR 1968; DWR 1970; DPR 1967; DPR 1968; DOI 1967; USACE 1978).

The U.S. Department of the Interior, National Park Service investigated the recreation potential of Sites Reservoir in a 1965 report for the U.S. Bureau of

Reclamation's West Sacramento Canal Unit planning. This report identified some locations that could be developed as recreation areas at the reservoir, and made estimates of use and projections of costs and benefits. Most useable areas identified by NPS are located in the north end of the reservoir, except for a few that are on the west shore in the southern portion of the reservoir. The NPS study examined a USBR project formulation that featured a 480-foot elevation Sites Reservoir with only about 30 feet of average annual fluctuation.

Study Area and Assumptions

Access. The most direct access to Sites Reservoir is the Maxwell-Sites Road that provides access to and from Interstate 5. Other primary routes may become established after construction of the dams and the relocation of the inundated portion of this road around the reservoir. An assumption during this planning effort was that the road to Lodoga would be relocated around the north of the reservoir, though it may connect to I-5 several miles north of Maxwell. This road will also be the primary route to towns west of Sites Reservoir, such as Lodoga and Stonyford, and into the southwest portion of the Mendocino National Forest.

Huffmaster Road, which currently runs from the town of Sites down Antelope Valley to the south, would likely be rerouted along Mills Orchard Road (south of Maxwell-Sites Road). Heading south from Maxwell-Sites Road, it would likely turn to the west where it currently terminates at Standard Road.[1] From Standard Road, it would cross into the Antelope Valley through Sulphur Gap and meet the current Huffmaster Road just south of Sites Reservoir=s southernmost high water mark. The alignment of these roads would be close to one area suitable for recreation development, although additional new access roads would still be required. Rerouted access will also need to be created to the communication towers that are located on the ridge south of the Sites Dam site. This access could also be provided via the Sulphur Gap alignment, perhaps in conjunction with recreation access roads.

Topography. Sites Reservoir would be situated in a broad valley with moderately sloped mountains on the west, precipitous slopes on the east, and a gently sloping valley floor to the north and south. The north end of the reservoir will require a series of saddle dams for impoundment. The steep topography of east side of the reservoir limits the feasibility of most recreation development there. Some southern and western areas have the opposite problem: gently sloping land below the high water line would make the water's edge rapidly become distant from developed areas during normal operations. Sparse vegetation and the exposed nature of lands adjacent to the northern areas limits the attractiveness of facility development there.

The west shore of Sites Reservoir would have numerous coves, peninsulas, and islands. This shore is not nearly as steep as the east shore and there are several areas that would be suitable locations for recreational facilities. In the middle of the valley, just to

[1] This alignment would prevent severing access to the existing Mathis Ranch to the north (along Fairview Road).

the north of the current location of the town of Sites, is a series of low, rolling hills. After inundation, the tops of several of these hills will remain exposed, creating about a half-dozen small islands in the middle of the reservoir. Several other islands will be formed along the west shore of the reservoir; the largest of these (about 50 acres) is the only one that is forested.

Seasonal Weather Variances. The Sites area experiences the typical Mediterranean pattern of cool, wet winters and dry, hot summers. Spring and fall could be described as pleasant. Annual precipitation averages 15 to 18 inches (NPS 1965). The area is close enough to the Sacramento Valley to occasionally be affected by valley fog in the winter. In the summer, temperatures can reach into the 90- and 100-degree range.

The implications of local weather for recreation potential is probably best illustrated by patterns observed at other local reservoirs such as Black Butte Lake, where USACE reports that peak use spans the months of March through August, and attendance is especially low during November through January.

Demographics and Local Economy. The Antelope Valley is a sparsely populated rural portion of north-central Colusa County. The population of a few dozen people is scattered throughout the valley with a small concentration (about 20) in the Sites townsite. The primary economic activity is cattle ranching and some non-irrigated crop production (irrigated crops are grown a short distance east of the valley).

To the east of the Sites Reservoir location is the town of Maxwell, a farm community with a few services and a population of about 1,400. This town is located just off of Interstate 5 and would be the closest town to the reservoir. It would be the most likely center for recreation-related services such as bait and tackle shops, motels, fuel, and restaurants if Sites Reservoir were constructed. Services such as these also exist in Williams, a town 9 miles south of Maxwell; Williams' services are currently oriented to the freeway traveler (rather than lake recreationists).

Existing Regional Recreational Use. Existing, public, reservoir-based recreation in the general vicinity is provided by four regional reservoirs: Black Butte Lake, East Park Reservoir, Stony Gorge Reservoir, and Indian Valley Reservoir. These reservoirs are significantly smaller than the proposed Sites Reservoir but are similar in terms of topography and relative remoteness. A range of facility development is present at these reservoirs but only Black Butte Lake has more than primitive facilities. A thorough description of each reservoir's facilities is compiled in Attachment A. Estimates of recreation use, provided by the respective managing agencies, are presented in Table 1.

Table 1. Annual total recreation use at four regional reservoirs (recreation-days in thousands).

Year	Reservoir			
	Black Butte	Stony Gorge	East Park	Indian Valley
1985	355	35	80	n/a
1986	414	32	80	n/a
1987	270	34	81	n/a
1988	323	34	81	n/a
1989	384	35	101	n/a
1990	343	66	66	n/a
1991	361	31	108	n/a
1992	416	32	80	n/a
1993	400	34	81	n/a
1994	372	34	81	n/a
1995	364	35	101	n/a
1996	336	66	66	n/a
1997	292	31	108	n/a
1998	n/a	n/a	n/a	38
Average	**335**	**38**	**86**	**n/a**

Suitable Recreation Development Lands

The suitability of lands to support reservoir-based recreation is influenced by many factors. Topography, access, physical/aesthetic setting, reservoir operations, anticipated use, and competing uses are important to consider. The following section discusses how these variables generally influence the recreation potential of the 1.8 maf Sites Reservoir alternative.

Based on our evaluation of these factors--using USGS maps and field visits to all Sites Reservoir shoreline areas--we identified a total of five areas which could potentially support development of recreation facilities without unusual or extensive additional engineering work (Figure 1). Some small additional wayside areas will probably be desirable where realigned roads are near the reservoir shoreline, but no alignment plan has been developed yet so these areas will be identified at a later date.

Lands underlying and immediately surrounding potential recreation areas total about 1,350 acres. Access road easements are not included in this estimate, but potential access alignments are illustrated in detailed site maps (Attachment B). We gave these areas tentative names to facilitate their description and discuss them below.

Conclusions about the suitability of these areas are based on a 1.8 maf reservoir with a maximum surface elevation of 520 feet. If a reservoir of another size is proposed, these areas would have to be reassessed to determine whether they would remain feasible as recreation sites. Existing trees, shrubs, grasslands, and rock outcrops contribute to the aesthetic qualities of many of the areas discussed below, and preservation of these features was assumed.

Peninsula Hills Recreation Area

The Peninsula Hills Recreation Area is located on the west shore of Sites Reservoir on what would be a large peninsula. It is nearly directly west across the reservoir from the Golden Gate Dam site. The area is comprised of a series of small coves and peninsulas that will be excellent for fishing and hiking. It is sheltered from north winds and a couple of small islands just off shore will add to the unique qualities of this area. Total acreage required for facilities described below is illustrated in Figure 1 and Attachment B and amounts to about 325 acres. Additional land may be required for access, water supply, and sewage disposal facilities.

The Peninsula Hills Area is exceptionally well suited for a large campground which could be implemented in several stages (the topography is conducive to several discrete but relatively adjacent loops). Fully developed, this campground could contain over 200 sites and some group facilities. There are two potential locations for a boat ramp, one to the north of the campground and one to the south of the campground. Both sites are large enough and of suitable slope for a four- (or more) lane ramp. Adjacent to the southernmost boat ramp is room for about 100 parking spaces (thereby making a two-lane ramp the appropriate size). The northern ramp location has an area over twice this size for parking (appropriate for a four- or six-lane ramp). Despite the smaller size, the preferred location would be the ramp to the south of the potential campground; this would decrease the traffic volume going past the campground, thereby decreasing noise and vehicle exhaust fumes in the area.

Access to the Peninsula Hills area, if development occurred there, would be from the relocated Sites-Lodoga Road. The most reasonable route would utilize a portion of the old Sites-Lodoga Road, east of where the new alignment would intersect the present road. Almost 2 miles of new access road would be required to connect the existing road with the usable areas of this peninsula. A variation of an existing jeep trail, up and over a steep ridge through a narrow gap and then down into the heart of the peninsula, is the most likely alignment.

Stone Corral Recreation Area

The Stone Coral Recreation Area would be located just to the north of the Sites dam. An oak woodland area along the ridge is of sufficient size and level topography to be suitable for a campground of about 50 sites (10 acres). The shoreline in this area is steep, limiting opportunities for placement of a boat ramp, but one small canyon to the north of the campground may accommodate two lanes (parking for over 100 car/trailer combinations would fit in the grassy flat north of the campground). Shoreline fishing would be attractive because of the relatively deep water.

Excellent views in many directions can be found on this ridge. A trail from the campground south, to an overlook of the reservoir and the Sites Dam site, would be one of the best places for presentation of interpretive information to visitors about the cultural and natural history of the area. The overlook site is surrounded by aesthetic rock formations and could accommodate several interpretive displays (perhaps photographs of the area before the reservoir was built and information about Antelope Valley's history and the construction of the reservoir) as well as a few benches and picnic tables. About 225 acres would be required for facilities described above (Figure 1; Attachment B).

Saddle Dam Boat Ramp

A variety of alignments of the saddle dams necessary along Sites' northeast shore are possible. During recreation reconnaissance we assumed the westernmost alignment (Figure 1) would be the most likely, and this configuration would allow for the largest boat ramp and support facilities on the east shore. An east shore development is desirable because most recreation users will come from that direction, and it requires at least 12 additional miles of travel (one-way) to reach Peninsula Hills (location of the next-largest boat ramp, which has limited capacity). If a more eastern saddle dam alignment were constructed, the facilities described below could not reasonably be relocated elsewhere.[2]

Several of the hills separating the saddle dams are large enough to support construction of a boat ramp, but the one near the southwest corner of Section 19 (T18N, R4W) is the most ideal (Attachment B). The southeastern sides of the latter hill are of the proper slope and are expansive enough to accommodate a ramp of a dozen lanes. Expansive parking areas for hundreds of cars and trailers could be created in the barren grassland east of the saddle dams (center of southern half of Section 19, south to center of northern half of Section 30); other day-use facilities could be located on surrounding hills and slopes. It would probably be desirable and feasible to enhance aesthetics through tree-planting and other landscaping.

The amount of parking necessary is best determined by the number of lanes of boat ramp constructed, which in turn will be determined based on expectations of recreation use. This area also offers good opportunity for facility expansion if future needs require it. Generally, 50 parking spaces should be provided for each boat ramp lane, and 50 spaces requires about three-quarters of an acre (DPR 1967). Considering lands for access, day-use, and other facilities, about 600 acres would be required to develop the maximum recreation potential of this area (Figure 1; Attachment B).

Parking, support, and day-use areas associated with the Saddle Dam Boat Ramp, though outside the reservoir, are at lower elevation than the reservoir's full pool. Thus, final assessment of the suitability of these areas for recreation will require completion of

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[2] With an eastern saddle dam alignment, recreation problems arise because areas level enough for parking and support facilities are undesirably far from the launching area. Slopes of eastern hills (potential ramp locations) generally do not reach below elevation 460 at suitable slope.

geological, soils, and engineering studies to evaluate the potential for seepage and other construction problems. It should also be noted that when the reservoir pool is high, a ready gravity-fed water supply (via siphon) would be available to irrigate landscaping (or create mitigation wetland areas). Even at lower reservoir levels, the lift to pump such a water supply would be much lower than at other areas.

Lurline Headwaters Recreation Area

The Lurline Creek headwaters are located on the eastern slopes of the ridge forming the southeast shore of Sites Reservoir. The top of the ridge and associated saddles, separating Lurline Creek from Sites Reservoir, would be the southernmost area suitable for developed recreation. About 2 miles of rough existing road would need to be upgraded to access this area, connecting it to the Sulphur Gap realignment of Huffmaster Road.

Lurline Headwaters Recreation Area could not provide ready shoreline access or a boat ramp--an existing ranch road could serve as a foot trail, but developed facilities would be about a quarter-mile from the shoreline (shoreline areas are generally too steep to allow construction of reasonable parking or turnaround areas). However, it is the largest area combining suitable slope, sufficient area, and aesthetic vegetation on the east shore. It is characterized by an open meadow surrounded by oak grassland, bordered by steep mountains, and situated so as to allow tantalizing views of the reservoir. It could support both camping and day-use, and creates an opportunity for a trail to the top of an adjacent (unnamed) 1,282-foot peak that offers outstanding views. Approximately 50 campsites, one or two group sites, and several dozen picnic units could be accommodated amongst the 50 acres of relatively level land in this area (Attachment B). Additional land for water supply and sanitary facilities may be required, depending on the level of development determined to be appropriate to meet recreation needs, but would probably fit within the greater area delineated. About 200 acres is the minimum needed to fully develop the recreation potential of this area (Figure 1).

Dunlap Island Boat-in Facilities

Dunlap Island would be the largest island, approximately 50 acres, formed by a full Sites Reservoir. It is located off the southwest shore and would remain separated from the mainland until the reservoir was drawn down to about 470 feet. There would still be reasonably good water access to the area with water surface as low as 380 feet; however, boat ramps would not be usable with water below 420 feet. This area would provide boaters with an area to camp off of the mainland near a secluded bay. The island has four distinct hilltops and their slopes and saddles are a mosaic of vegetation types including manzanita, grey pine, blue oak, and seasonal grasses. Only a few acres of Dunlap Island would be suitable for campground development, allowing comfortable spacing of perhaps a dozen campsites (Attachment B). Development of this area would have to be semi-primitive (no water supply, but including sanitary facilities) because of the remoteness.

Because Dunlap Island is within Sites Reservoir, it is assumed that this acreage will already be included among lands acquired for reservoir development. Thus, the 50 acres are not included in the total of additional shoreline lands desirable for potential recreation development.

Other Trails and Fishing Access

Several other recreation facilities may be appropriate at Sites Reservoir, though sufficient information about project features is not yet available to propose them for a specific location. These are features such as signed fishing access, trails and trail networks (hiking, bicycling, equestrian), and specially-designated hunting and off highway vehicle areas. Use of such facilities occurs at other regional reservoirs and it is presumable that demand for these facilities would occur at Sites. Listed below are some general observations about how these facilities might be incorporated into a future recreation plan.

Sites Reservoir Loop Trail. A multi-use trail for hiking, biking, and equestrians extending around Sites Reservoir to form a loop could connect all of the recreation areas at Sites Reservoir. Beginning at the Sites Dam and heading north, the trail could extend along the crest of Logan Ridge to the outlet works. Here it would cross the narrow isthmus left after construction and then head across the Golden Gate Dam. From this point it could continue along the treeless Logan Ridge for approximately 3 miles where it would then drop off the ridge into Antelope Valley. At this point, the northern end of the reservoir is impounded by a combination of natural barriers (small hills) and a series of saddle dams. The trail could either utilize the saddle dams and hilltops along the shoreline to cross the valley or could cut across the grassy plain in a northwesterly direction to the northernmost and longest saddle dam. It might share some of this route with the relocated Sites-Lodoga Road. If this is the case then a bike lane would need to be added to ensure a safe path for all traffic.

Once the trail traversed Antelope Valley it would enter the hills that form Sites Reservoir's western shoreline. Here it would turn south and meander along the west shore's many inlets and peninsulas. Several overlook, fishing access, or small picnic areas could be located along this portion of the trail; however, it would be unlikely that sanitation facilities or potable water could be provided.

When the trail intersected with the old Sites-Lodoga Road, it would head to the east for approximately one-half mile along the road, which would also be used for access to the Peninsula Hills Recreation Area. A bike lane would be needed here. Where the new road turns to the north to go to the recreation area, the trail would continue along the old road alignment to the reservoir shoreline following Stone Corral Creek.

From the point where Stone Corral Creek flows into the reservoir, the trail would follow the west shoreline for 8 to 10 miles through steep terrain of oak woodland and open grassland. This portion of the trail would be the most remote section and would meander around the numerous coves and peninsulas. This might be an appropriate area to designate for primitive or wilderness camping.

The best route to continue from the southern end of the reservoir, north to close the loop at Sites Dam site, is somewhat less clear. Options exist to use part of the alignment of the relocated Huffmaster Road through Sulphur Gap and/or other old ranch roads and Lurline Headwaters and radio tower access roads, establishing a more "inland" alignment. Or portions of the trail could be constructed at lower elevations along the shoreline through oak grasslands of moderate slope.

Vista Points. More often than not, the ridges and hilltops surrounding Sites Reservoir offer commanding views of the Sutter Buttes, Black Butte, Mt. Shasta, Mt. Lassen, Snow Mountain, the Sacramento Valley, and other foothill valleys and mountain ranges of the Mendocino National Forest. Almost all these features are simultaneously visible from some of the peaks east of the reservoir. Wildlife and wildflowers also occur seasonally. Depending on the alignment of realigned and recreation access roads, wayside trailheads might be established at convenient points to lead visitors to some of these dramatic vistas.

Fishing Access. The relocation of Sites-Lodoga Road would offer the best opportunity for dispersed shoreline fishing access. This would be the only road circumnavigating the reservoir within close proximity to the shoreline. Points around the reservoir on the new roads could be designated as fishing access, as could remnants of existing roads that may otherwise be abandoned. The best points would typically be in areas where the shoreline is steep enough that the fishing waters are moderately deep, but not so steep as to make footing treacherous.

Pre-project Fishing Enhancement. Sites Reservoir would inundate several existing stock ponds. Some of these ponds are large and persistent enough to support fish under current conditions. They are available as a resource to raise brood stock as a seed population to accelerate establishment of a recreational fishery after Sites Reservoir is filled (when these areas are over-flooded, the fish can escape and begin populating the reservoir). This approach was used at Eastside Reservoir at the recommendation of the Department of Fish and Game.

Cartop Boat Ramps. Abandoned roads, such as the western portion of the Sites-Lodoga Road, the southern portion of Huffmaster Road, and several ranch roads, may potentially serve as cartop boat ramps. Such relatively undeveloped access is often popular with local residents who seek shoreline access away from more heavily used developed facilities (CSUC 1997). As long as old roadbeds and alignments remain safe, or can be maintained, such access can provide recreation benefits.

Stone Corral Coldwater Fishery. Sites Dam plans have tentatively included a release valve to allow discharge of reservoir water into Stone Corral Creek. This discharge would be cold water from the bottom of the reservoir and, if maintained year-round, would help establish a coldwater sport fishery below Sites Dam. Local coldwater angling opportunities are essentially nonexistent, and this type of recreation often has a relatively high benefit value. Tailwater fisheries are often of high quality. However, much of the land downstream from Sites Dam is in private ownership, with perhaps some opportunity for public access immediately below the dam.

If there is public access below the Sites Dam discharge, it is likely to be a popular location for anglers. This opportunity should be further evaluated once project formulation and dam operation criteria are decided.

Estimated Present and Future Recreation Use

Present Recreation Use

Recreation use and opportunity is currently quite limited within the project area. All of the land in Antelope Valley is privately owned and most is posted against trespass, thereby preventing general public access. Recreational activity that does take place is primarily by the landowners, their families and friends, and employees and probably amounts to only a few hundred recreation-hours per year. On these agricultural lands, hunting is the most common activity. Upland game birds, deer, and wild boar are the most sought after species. Occasional horseback riding and OHV use has been observed. Fishing is an infrequent activity because of the intermittent nature of the streams in the Antelope Valley, but DWR personnel have observed children fishing Stone Corral Creek just downstream of the location of the proposed Sites Dam site. There are many stock ponds located throughout the area and several are large enough to support populations of bass, sunfish, and catfish. It is not known if these ponds are fished by the owners or others.

Potential Recreation Use

A lake the size of Sites Reservoir has the potential for many types of recreation activities for a large number of people. Water-related activities can include boating, waterskiing, personal water craft use, fishing, and swimming. Land-based uses could include camping, hiking, biking, horseback riding, picnicking, hunting, and sightseeing. A reservoir at this location would be accessible year-round, but a great majority of the recreation use would occur during the traditional recreation season, typically March through September. Other factors could also conceivably influence the popularity of Sites Reservoir: State health advisories apply to consumption of sport-fish from many waters in western California, and additional study may still determine if the fishery at Sites Reservoir might be more or less attractive (than other local waters) to anglers.

Initial recreation development is normally based on estimated demand during the early years of the project. Table 1 suggests that Sites Reservoir may attract several hundred thousand recreation-days per year. However, the limited amount of lands suitable for recreation development (and the limited amount of facilities those lands can accommodate) may limit the number of recreationists expected at Sites Reservoir by limiting the maximum persons-at-one-time (PAOT). Even if full development of all four major shoreline recreation areas (excluding Dunlap Island) were feasible, there would be proportionately few facilities present compared to reservoirs much smaller (e.g., Black Butte) or modestly larger (e.g., Lake Oroville). Thus, facilities at Sites Reservoir might be expected to be filled to capacity more frequently than at other reservoirs. There would be negligible opportunity to expand facilities to meet increased future demand.

To properly estimate the recreation demand and amount of use expected at Sites Reservoir, recreation planners would use the Comparable Demand Method. This method assumes that use at a new reservoir would be similar to use at a similar existing reservoir. A recreation use survey at the existing reservoir is the basis for assumptions about the recreation activities and home origin of the visitors at the proposed facility.

In preparation for future work, we have prepared a set of maps which illustrate the travel distance from Sites to surrounding population centers at discrete distances (Attachment C). Comparison of frequency of visitation from analogous areas surrounding an existing comparable reservoir will be the basis for estimating demand for recreation from the population surrounding Sites. This analysis is beyond the scope and capability of this brief study, but some recommendations for future work are worth consideration.

The comparable reservoir selected as the basis for future estimates may likely be either Black Butte, Oroville, or San Luis. There are pros and cons to each choice. Lake Oroville, about 70 miles away, is substantially larger and surrounded by a complex of afterbays and many recreation areas, but relatively recent recreation use data is available (CSUC 1997). Black Butte Reservoir is substantially smaller than Sites, but has similar facilities and would conceivably draw visitors from the same population areas. Attendance data at Black Butte is collected by traffic counters, but a recreation use survey would be necessary to determine the frequency of various types of use occurring and the origin of the visitors there. San Luis Reservoir was used as the comparable reservoir when the Los Banos Grandes Reservoir was planned (Rischbieter and Hinton 1993), and LBG was to be similar in size to Sites, but San Luis draws visitors from much different population centers. Also, existing detailed San Luis visitor use survey data is becoming outdated (Tittel 1986), and another recreation survey would likely be necessary.

A Visitor Characteristics Summary for the four main developed areas of Black Butte Lake, derived from USACE surveys in 1994, gives some insight to types of use occurring there (Table 2). Additional information for all Black Butte areas collectively was summarized for 1985 (Table 3); the most recent similar information found for East Park and Stony Gorge dates back to 1980. Visitor origin data is typical of other reservoirs such as Oroville and San Luis: roughly three-quarters of the use is by people who live less than 50 miles away.

Alternatives to Full Sites Reservoir Development

There may still be unforseen obstacles that could preclude full development of the apparent recreation potential of Sites Reservoir. There may be no agency obligated or willing to invest in or operate recreation facilities, or the costs of infrastructure development may be prohibitively high for anything more than primitive facilities. Therefore, alternatives to full development must still be considered. Lesser or no facility development would not meet the anticipated recreation demand, greatly limiting the use and recreation benefits provided by Sites Reservoir.

Table 2. Black Butte Lake Visitor Characteristics Summary (derived from USACE 1994 Visitor Estimation and Recording System [VERS] Surveys).

Recreation Area	Eagle Pass	Buckhorn	Orland Buttes	Observation
		General use breakdown (percentage of visitors):		
Day Use	98.5	71.1	71.7	100.0
Overnight Use	1.5	28.9	28.3	0.0
		Percent of visitors engaging in these activities:		
Camping	0.0	28.6	27.1	0.0
Picnicking	53.7	33.7	36.3	10.0
Boating	46.6	24.9	26.9	0.0
Boat Fishing	15.0	8.5	24.0	0.0
Shore Fishing	16.4	14.6	16.5	65.0
Water-Skiing	20.9	4.5	0.0	0.0
Swimming	48.4	57.8	53.1	0.0
Sightseeing	22.2	15.7	23.7	30.0
		General per-visit statistics:		
Camping Stay	0.0 days	1.83 days	1.65 days	0.0 days
Day Use Stay	3.54 hours	3.32 hours	2.94 hours	1.40 hours
Weekend Use	52%	57%	45%	
People/Vehicle	2.60	2.98	2.85	1.60

Table 3. Black Butte Lake Visitor Characteristics Summary, collected by USACE in 1985

(J. J. Holmberg, USACE, personal communication), and comparable information for Stony Gorge and East Park Reservoirs (1980). Note: n/a = not available; n/m = not meaningful; * = includes boat fishing.

Activity	Percent User Participation[3]		
	Black Butte	**Stony Gorge**	**East Park**
Day Use	86.5	73.1	58.9
Camping	13.5	26.9	41.1
Picnicking	20.5	11.0	2.8
All Boating	29.0	n/m	n/m
Water Skiing	12.1	25.1	14.9
Boat Fishing	10.5	n/a	n/a
Shore Fishing	16.5	20.1*	20.7*
Swimming	35.6	5.7	7.9
OHV Use	0.2	n/a	n/a
Hiking	1.9	n/a	n/a
Sightseeing	24.0	4.1	3.3
Other	7.2	4.3	0.9
Use Characteristic			
Length of Camping Stay (days)	2.5		
Length of Day Use Stay (hours)	2.8		
Average Number of People per Vehicle	2.6		
Percent Weekend Use	45.0		
Percent Overnight Use	13.5		
Origin Radius (miles)	**Percent Of Visitors**		
0 - 25	49	n/a	n/a
26 - 50	25	n/a	n/a
51 - 75	4	n/a	n/a
75 - 100	0.7	n/a	n/a
Beyond 100	21	n/a	n/a

Lesser or Minimal Development. The option of lesser or minimal development could be exercised for several reasons. In the event that actual reservoir operations were

[3] These percentages add up to more than 100% for Black Butte Reservoir (visitors engaged in more than one activity during their stay). This behavior is not reflected at the other reservoirs because of differing data collection and reporting methods.

even more severe than reservoir operation criteria assumed for this study, requiring extreme drawdown from year to year, recreation potential (and recreational fishery values) would be greatly diminished. In such a case, primitive facilities (similar to those at Stony Gorge and East Park) would suffice to support some visitors when the reservoir is usable. Cartop boat ramps could be maintained where abandoned roads extend to the water's edge. Dispersed tables for primitive camping and day-use could be located in areas near relocated roads. Some development could occur at the best areas identified herein, but a reservoir with frequent severe drawdown, especially during the prime recreation season, will not attract enough visitors to warrant full development of most (if any) areas. The cost of development of recreation facilities, especially access roads, might not be justified if use (and recreation benefits) are low.

Offsite Development. If the developer or operator of Sites Reservoir were to have an obligation to plan for recreation use, and if the recreation development potential of Sites Reservoir is inadequate to meet demand, there are abundant opportunities to enhance or expand existing reservoir-based recreation at other local reservoirs. Therefore, offsite development at nearby reservoirs may be an option to mitigate unmet recreation demand at Sites Reservoir. Both East Park and Stony Gorge are surrounded by attractive shoreline and have virtually no high-standard facilities. Primitive facilities are abundant. Upgrading primitive facilities (campgrounds, boat ramps) to higher standards would increase regional recreation opportunities and the local capacity for higher quality recreation.

Additional Data Required For Future Planning

Several additional pieces of information are required before feasibility-level recreation planning can proceed. These include selection of reservoir operating criteria; selection of the agency responsible for the development of Sites Reservoir (to clarify the obligation for recreation planning and level of development); determination of the costs for land for recreation facilities and roads; a tally of the population residing in the areas likely to be served by Sites Reservoir (Attachment D); and a contemporary survey of current use at one or two nearby existing reservoirs.

The recreation benefits afforded each visitor are directly related to the frequency that facilities are usable and aesthetic. Operations that cause the shoreline to recede from facilities, especially during the prime recreation season, will result in less benefit than operations resulting in a more stable pool. Frequent fluctuation and severe drawdown can diminish the quality (and value) of a sport fishery. The benefits the project affords to each visitor, and cumulatively each year of the project, will depend on the operating criteria selected.

Obligations and responsibilities for planning, development, and operation of any recreation facilities at Sites Reservoir depend on which agency undertakes reservoir development. Federal agencies are bound by the Federal Water Project Recreation Act, which would also apply in the case of a joint federal-State project (e.g., CALFED). California's Davis-Dolwig Act would apply only if Sites Reservoir were developed as a State Water Project facility. If a State or local agency operates a water project with power generation benefits, the Federal Energy Regulatory Commission will require a recreation plan. The responsibility for final recreation planning will be borne by the agency deemed most appropriate when project feasibility studies are complete, and a likely recreation agency is determined.

Cost estimates for construction, operation, and maintenance of Sites Reservoir recreation facilities were not calculated during this investigation. Actual facilities would cost several million dollars, and cost for access roads would also be substantial. Costs will vary depending on the level of development proposed and other unknown factors such as alignment of relocated roads. Land acquisition costs should be the first consideration if project developers wish to maintain a variety of recreation options. Additional lands or easements may be required for access roads and other resource values.

Attachment D identifies zones within California from which recreationists are most likely to be drawn (it is unlikely that a significant number of visitors would originate from out of state, because of the travel distance involved). Department of Finance estimates or U.S. Census results need to be analyzed to estimate the population within each polygon illustrated in Attachment D. The resulting estimates will be used in conjunction with the Comparable Demand Method of predicting Sites Reservoir attendance based on measured attendance at a similar, existing reservoir.

Contemporary, detailed attendance and recreation use data from one or two existing local reservoirs is necessary to adequately predict the likely attendance at Sites Reservoir. Black Butte Lake, plus one of the other Stony Creek reservoirs, would probably be most appropriate because of their location, but each is substantially smaller than Sites Reservoir. Current efforts to monitor use at these reservoirs is minimal, so it is recommended that sampling (visitor counts and interviews) be done over a season-long period to obtain information adequate to predict use at Sites. Data collected recently at larger Lake Oroville (CSUC 1996) should also be considered, but Lake Oroville is not an ideal comparison to Sites because the density of population near Oroville is much greater.

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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix L: Water Supply and Operation Studies

January 2001

Integrated
Storage
Investigations

CALFED
BAY-DELTA
PROGRAM

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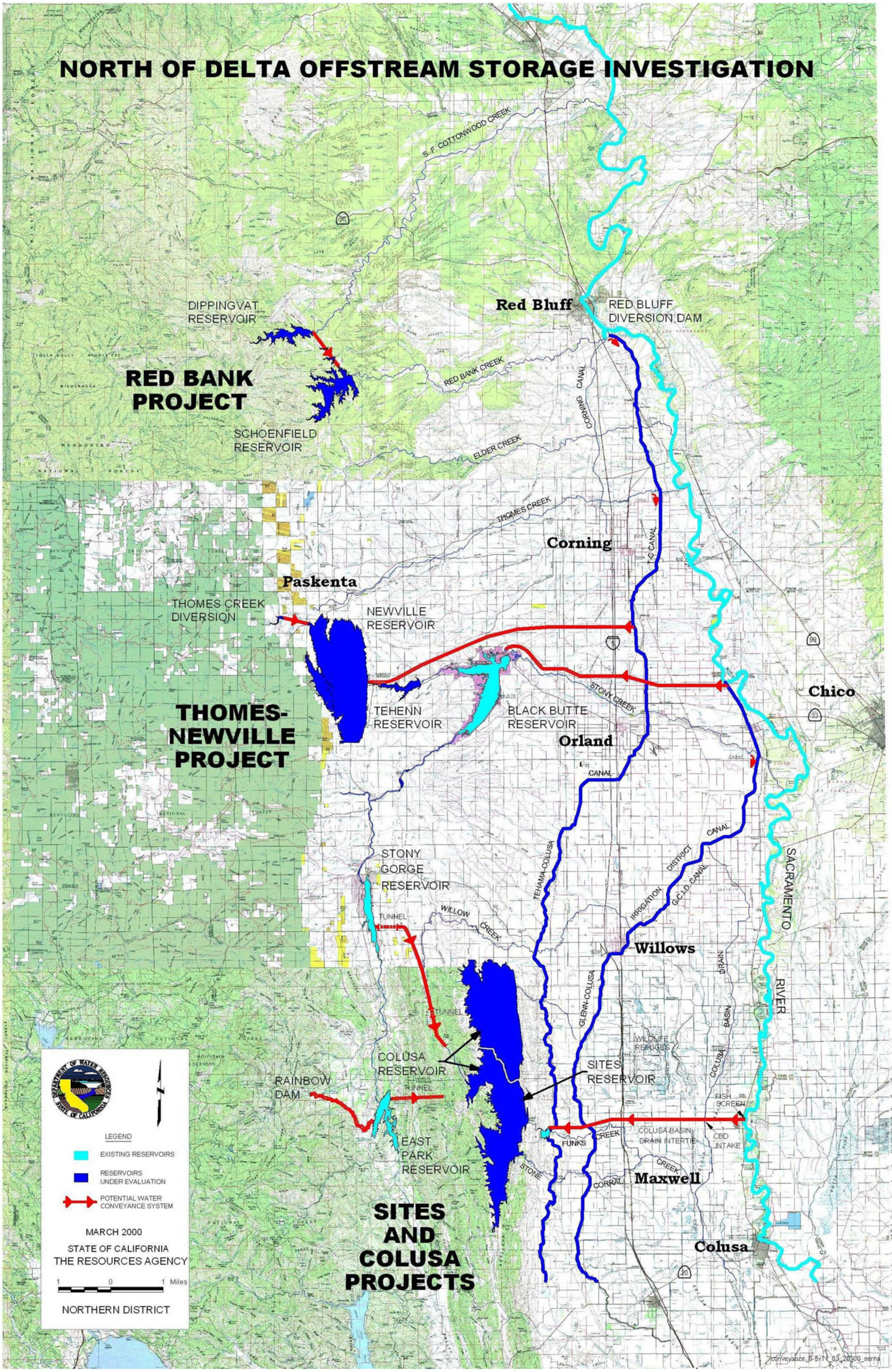
Introduction

In general, water supply sources for an offstream surface water project include both the natural inflow to the proposed reservoir and one or more streams that do not naturally flow into the reservoir. The natural inflow to offstream reservoirs is typically relatively small, while diversions from other streams provide a significant portion of the water stored. The water supply source options for the north of the Delta offstream storage projects include the Sacramento River and a number of westside tributaries. The water supplies associated with these streams and the offstream projects can be characterized by two distinct, yet related evaluations. First, a general hydrologic evaluation of a specific stream indicates the amount of water supply potentially available for use, based on historic streamflows and local uses. Second, the water supply benefit (or yield) and impacts of a specific project formulation can be evaluated based on a with- and without-project comparison of deliveries, streamflows and other operational characteristics of existing water supply systems. These benefits and impacts are developed with operation studies that simulate reservoir system operations of the Central Valley Project and State Water Project. For the tributary streams, the hydrologic evaluation of potential water supplies is used as input to an operation study analysis of a proposed project. The Sacramento River hydrology has been previously developed and is included in all operation studies.

The North of the Delta Offstream Storage Investigation has focused on four alternative offstream storage projects: Sites, Colusa, Thomes-Newville, and Red Bank, as shown in Figure 1. In Phase I of this investigation, hydrologic analyses were performed on various streams to determine the flow that could be diverted to potential offstream reservoirs. Operation studies were then conducted to determine both water supply benefits and impacts associated with various initial project formulations. The streams analyzed in this report include Stony Creek, Grindstone Creek, Thomes Creek, Red Bank Creek, South Fork Cottonwood Creek, the Colusa Basin Drain, and the Sacramento River.

A proposed Grindstone Reservoir water supply source option was evaluated at a cursory level. Ranges of reservoir and diversion capacities were considered. The cursory analysis of Grindstone Reservoir indicated a number of undesirable characteristics related to this option. While these characteristics would not make the Grindstone Reservoir option technically infeasible, a number of other options appear to be more feasible at this stage of evaluation. Therefore, Grindstone Reservoir as an optional source has been set aside.

In addition, as part of its "Findings and Recommendations," *North of the Delta Offstream Storage Investigations Progress Report* suggests that the Red Bank Project studies be discontinued. Because the Red Bank Project was intensively studied around 1993, comparatively less hydrologic evaluations and no new operation studies have been conducted during this investigation. However, results of Phase I investigations of Grindstone and Red Bank are included in this report for reference.



NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION
S.F. COTTONWOOD CREEK
Red Bluff
RED BLUFF DIVERSION DAM
DIPPINGVAT RESERVOIR
RED BANK PROJECT
SCHOENFIELD RESERVOIR
RED BANK CREEK
CORNING CANAL
ELDER CREEK
THOMES CREEK
Corning
T-C CANAL
Paskenta
THOMES CREEK DIVERSION
NEWVILLE RESERVOIR
STONY CREEK
Chico
TEHENN RESERVOIR
BLACK BUTTE RESERVOIR
Orland
THOMES-NEWVILLE PROJECT
CANAL
STONY GORGE RESERVOIR
TUNNEL
WILLOW CREEK
TEHAMA-COLUSA
IRRIGATION DISTRICT CANAL
G.C.I.D. CANAL
SACRAMENTO RIVER
Willows
GLENN-COLUSA
DRAIN
BASIN
TUNNEL
COLUSA RESERVOIR
RAINBOW DAM
TUNNEL
SITES RESERVOIR
WILDLIFE REFUGES
COLUSA
FISH SCREEN
EAST PARK RESERVOIR
FUNKS CREEK
COLUSA BASIN DRAIN INTERTIE
CBD INTAKE
STONE CORRAL CREEK
Maxwell
SITES AND COLUSA PROJECTS
Colusa
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
POTENTIAL WATER CONVEYANCE SYSTEM
MARCH 2000
STATE OF CALIFORNIA
THE RESOURCES AGENCY
1 0 1 Miles
NORTHERN DISTRICT

There are frequent periods when streamflow becomes surplus to the needs of local watershed, the Sacramento River, and Sacramento-San Joaquin Delta and, then, flows to the ocean. This surplus water has been identified as potentially available for diversion to proposed offstream reservoirs. Basic operating criteria require that no diversion be made unless surplus conditions exist for both the Sacramento River and the Delta. Also, the instream needs of the local stream must be met.

To identify when surplus conditions have occurred in the Delta and in the Sacramento River (at Wilkins Slough), modeled flows were obtained from monthly CALFED operation studies. Surplus conditions exist at Wilkins Slough when the flow of the Sacramento River there exceeds 4,000 cubic feet per second (240 taf per month). In wet years the criterion is 5,000 cfs (300 taf/month). Wilkins Slough is the Sacramento River Navigational Control Point, or NCP, that is used in DWR reservoir system simulation models.

Mean daily flow hydrologic analyses for the 50-year period of water years 1945 through 1994 were used to determine the potential diversions from streams. The diversion period was limited to the months of November through March to avoid impacting existing water rights. These hydrologic analyses were completed using Excel spreadsheets constructed by DWR Northern District staff. Because these evaluations were based on daily data and because the reservoir system simulation model requires monthly data, daily Delta conditions were classified from monthly data. These estimates are preliminary and considered appropriate for Phase I investigations. Additional operation studies will be run to more precisely identify the water development potential of a Sites, Colusa, Thomes-Newville, or Red Bank project under various project formulation assumptions. Only initial runs using simplifying assumptions have been completed to date. Also, Phase II work will need to be completed on water sources identified through the Phase I initial evaluation process.

Hydrologic Analyses

Several spreadsheet analyses, or runs, were made for most streams under consideration as supply source options in order to generate curves of divertible water associated with various diversion capacities. These curves may be used in subsequent studies to help identify optimum project formulations. Some runs were developed assuming that diversions from other streams were concurrently taking place using a common conveyance conduit, thereby reducing the available diversion capacity for each stream.

Table 1 summarizes the initial hydrologic evaluations, showing estimated divertible flow and the diversion sources. These divertible flow computations were independent of where the surplus water would be going. However, a proposed destination is indicated here for each water supply source option. This table does not list all possible options nor does it list all analyses performed for each potential component or water supply source. The table lists only options that are estimated to provide relatively large amounts of water compared with the designated diversion capacity. Summary tables and charts for all the options evaluated are presented in later sections of this report. Detailed spreadsheets of the individual stream analyses discussed in this report are available through the California Department of Water Resources Northern District. Because this information is preliminary, it will be used to help select among potential alternatives but not to identify an exact water yield of any optional source. Table 1 indicates that the Sacramento River offers by far the largest potential source of water supply to an offstream storage project.

Table 1. Summary of water supply diversion analyses. November-March divertible flow (taf) (1945-1994)

Run	Analysis	Estimated avg. Nov– Mar Divertible Flow (taf)
1.	Stony Gorge Reservoir with no operating storage and a 1,500 cfs capacity diversion to Sites or Colusa Reservoir	70.2[1]
2.	Grindstone Reservoir with 67 taf of operating storage and a 750 cfs capacity diversion to Stony Gorge Reservoir (Run 1 in concurrent operation)	67.9
3.	Combined Grindstone and Stony Gorge (Runs 1+2)	138.1
4.	Stony Gorge Reservoir with 30 taf of operating storage and a 1,500 cfs capacity diversion to Sites or Colusa Reservoir	111.6[1]
5.	Stony Creek to Glenn Colusa Irrigation District Canal, 1,700 cfs capacity diversion	104.0
6.	Stony Creek to Newville Reservoir, 3,000 cfs capacity diversion	141.5
7.	Thomes Creek to Tehama-Colusa Canal, 2,100 cfs capacity diversion	108.9
8.	Thomes Creek to Newville Reservoir, 5,000 cfs capacity diversion	124.3
9.	Red Bank Creek to TCC, 2,100 cfs capacity diversion	23.6
10.	SF Cottonwood Creek to NF Red Bank Creek to TCC (Run 9 in concurrent operation)	52.9
11.	Combined Red Bank and SF Cottonwood Creeks (Runs 9+10)	76.4
12.	Red Bank Creek to TCC (Run 7 in concurrent operation)	13.7
13.	SF Cottonwood Creek to NF Red Bank Creek to TCC (Runs 7 and 12 in concurrent operation)	46.6
14.	Thomes, Red Bank, and SF Cottonwood to TCC (Runs 7+12+13)	169.2
15.	Colusa Basin Drain, 3,000 cfs capacity diversion	125.8
16.	Rainbow Diversion Dam with a 300 cfs diversion capacity and East Park Reservoir with a 1,200 cfs diversion capacity to Sites or Colusa Reservoirs	30.1[1]
17.	Sacramento River at Butte City, 5,000 cfs capacity diversion, 10,000 cfs minimum instream flow	587.3

[1] Stony Gorge and East Park options have been re-evaluated, and results used in the operation studies are included in the "Adjustments to Stony Creek Hydrology and Water Supply" section that appears later in this chapter.

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In this report, the terms "instream," "surplus," and "divertible" flow are defined as follows:

- Instream flow is that required for stream maintenance and fish flows. This water is considered unavailable for diversion.
- Surplus flow is that available for capture after downstream rights and other legal or operational constraints have been met.
- Divertible flow is the amount of surplus flow that can be taken from a stream, limited by the capacity of the diversion but not by the storage capacity of an offstream reservoir. Operation studies will determine how much of this divertible flow can be stored in a given offstream storage facility and ultimately delivered to water users.

Percentages of average November through March divertible flow associated with various streamflow ranges were also determined. For example, the flow of the Sacramento River was divided into six 10,000-cfs incremental flow ranges up to 60,000 cfs. A final range includes all flows above 60,000 cfs, for a total of seven flow ranges. The evaluation of the divertible flow associated with the flow ranges is helpful in characterizing these optional water supply sources. Attachments to this document include tables and graphs summarizing the flow, divertible flow, and divertible flow by range for the following streams:

- Thomes Creek
- Stony Creek
- Sacramento River
- Colusa Basin Drain
- Red Bank Creek
- South Fork Cottonwood Creek

Stream Hydrology

This section contains Phase I analyses of the quantity of water that could potentially be diverted from Stony, Thomes, South Fork Cottonwood, and Red Bank Creeks, the Colusa Basin Drain, and the Sacramento River for storage in a north of the Delta offstream reservoir. Additional feasibility-level water supply analyses should be completed for those sources selected for further consideration, possibly leading to project construction. This analysis was designed to facilitate the initial screening selection process among optional water sources and alternatives. Water supply sources and conveyances are optional because no single source or conveyance is sufficient to adequately fill any of the proposed offstream projects, with the exception of the Red Bank Project. The singular diversion source considered for the Red Bank Project has been South Fork Cottonwood Creek. Analyses of the remaining three projects — Sites, Colusa and Thomes-Newville — include initial formulations with multiple water supply sources and/or conveyance.

These initial formulations provide alternative water supply packages for further evaluation and refinement.

Original analyses of Stony Gorge and East Park Reservoirs described in their subsections are similar to those that appear later in this report, but only the results of the adjusted analyses, described in a later subsection, were used in the operation studies described in the second chapter of this report. The criteria were originally established to minimize impacts to existing water users and project operators. However, comments from members of the Technical Advisory Group indicated that an adjusted operation of the Stony Creek reservoirs was appropriate for Phase I evaluation. More specifically, discussions with representatives of the Orland Unit Water Users' Association led to a number of revised criteria and assumptions related to operation of the existing Stony Creek water projects. The revised criteria and assumptions are described in "Adjustments to Stony Creek Hydrology and Water Supply" of this report.

Stony Gorge/Grindstone Reservoirs and Stony Creek

Stony Creek, with a drainage area of 777 square miles, is the largest westside Sacramento River tributary between Cottonwood Creek and the Colusa Basin Drain. At the gage below Black Butte Lake (USGS 11388000), its average annual runoff is 386 taf (historic, 1955-1997) (Hillaire 1997). A major tributary to Stony Creek is Grindstone Creek with a drainage area of 156 square miles and 101 taf average annual runoff at the gage near Elk Creek (USGS 11386500; historic 1936, 1937, 1966-1972). Black Butte Lake, at 143 taf capacity, is the biggest of three existing large reservoirs in the Stony Creek watershed. Stony Gorge Reservoir is located on Stony Creek, upstream of Black Butte Lake near the community of Elk Creek in Glenn County. A slab and buttress dam forms Stony Gorge Reservoir, with a capacity of 50.3 taf between elevations 728.0 (top of outlet pipe) and 841.0 feet (crest of spillway).

During the period 1945 through 1994, the average November through March inflow to Stony Gorge Reservoir was 151.3 taf. The release downstream was 114.0 taf, and the end of March storage of Stony Gorge Reservoir was 47.1 taf. The maximum storage was 54.6 taf on March 26, 1971, indicating over 4 feet of surcharge. Historically, the winter operation of Stony Gorge Reservoir has included a 10-foot lake level cushion. But the reservoir is not explicitly operated for flood control purposes, and it is to be filled as soon as possible (Massa 1999).

Table 2 shows the 1945 through 1994 historic average end-of-month storage of Stony Gorge Reservoir.

Table 2. Stony Gorge Reservoir.
Average end of month storage (taf) (1945-1994)

October	November	December	January	February	March
9.9	15.1	23.5	31.1	40.5	47.1

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The first analysis determined how much water could be diverted from Stony Gorge Reservoir to Sites or Colusa Reservoir by just diverting reservoir inflow without taking advantage of the storage capability of Stony Gorge. This formulation was intended to minimize any negative impacts on Stony Gorge Reservoir's water supply to the Orland Unit Water Users' Association or other creek or Sacramento River diverters. The winter instream demand of Stony Creek below Stony Gorge Reservoir was assumed to be 25 cfs. This demand can be easily changed if future studies indicate some other release level is justified. Impacts to Black Butte Lake were not taken into account in this analysis. Additional analyses should be performed to evaluate the potential impacts. Historical daily inflow to Stony Gorge Reservoir was obtained by DWR Northern District staff from the United States Bureau of Reclamation.

Below are the criteria for this initial Stony Gorge diversion analysis.

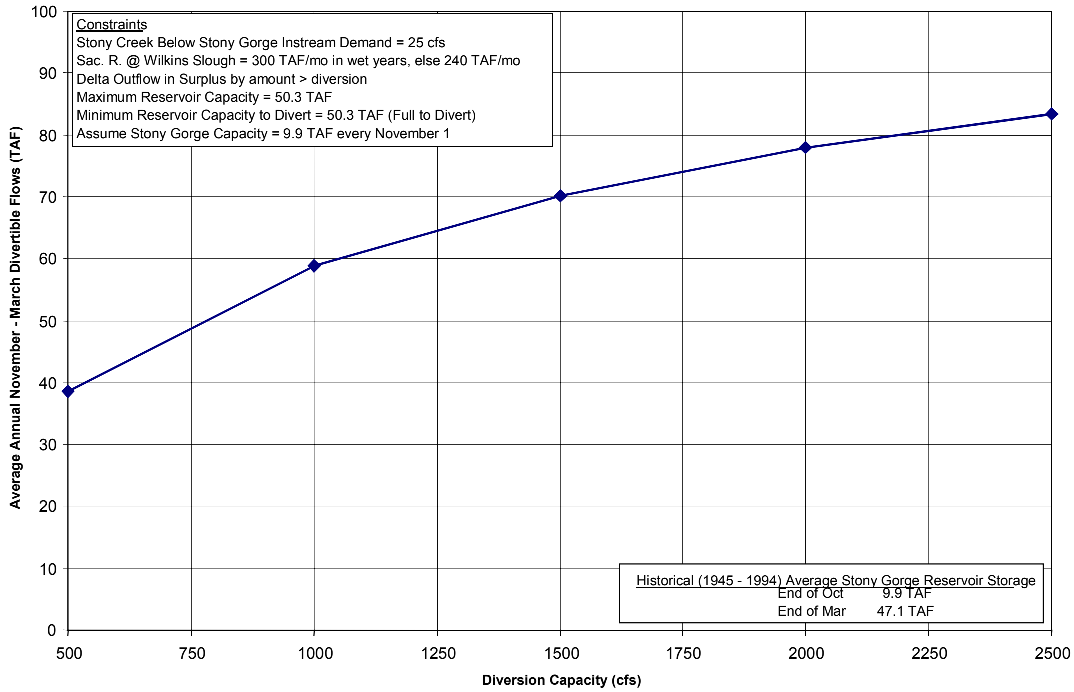
- Surplus conditions must exist in the Delta (estimated from CALFED operation studies monthly data) when diversions occur.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough (estimated from CALFED operation studies) when diversions occur; 300 taf per month in wet years; else 240 taf/month.
- Stony Creek below Stony Gorge Reservoir must be flowing at 25 cfs or greater when diversions occur. Instream flow shortages (up to 25 cfs) during the analysis period will be met with Stony Gorge Reservoir storage releases if available and prior to diversions.
- Storage in Stony Gorge Reservoir set to 9.9 taf (1945 – 1994 average end of October storage) on November 1 of every water year.
- Stony Gorge Reservoir must be at or above the spillway crest (storage is 50.3 taf) when diversions occur.
- Losses due to evaporation are assumed to be negligible.

Analyses considered five sizes of diversion from Stony Gorge to Sites: 500, 1,000, 1,500, 2,000, and 2,500 cfs. Average annual November through March divertible flow ranged from 38.7 taf with a 500 cfs capacity diversion to 83.4 taf with a 2,500 cfs capacity diversion. Table 3 and Figure 2 summarize the findings of these diversion analyses. (For more detail, see Attachment 1)

Table 3. Summary of average monthly divertible flows using Stony Gorge Reservoir inflow (taf) (1945-1994).

Month	Diversion capacity (cfs)				
	500	1,000	1,500	2,000	2,500
November	0.1	0.1	0.1	0.1	0.1
December	2.7	4.2	5.1	5.8	6.3
January	9.2	15.4	19.2	21.7	23.7
February	1.5	18.0	22.0	24.9	27.1
March	15.1	21.2	23.9	25.4	26.3
Nov to Mar	**38.7**	**58.8**	**70.2**	**77.9**	**83.4**

Figure 2. Average annual divertible Stony Creek flows at Stony Gorge Reservoir (1945-1994)



The diversion capability of Stony Gorge Reservoir when a portion of its available storage capacity is used to regulate inflow for diversion to offstream storage was evaluated next. The capacity of Stony Gorge Reservoir is about 30 taf between the elevations of 841 feet, which is the spillway crest, and 810 feet, which is the elevation assumed here for diversions to Sites or Colusa Reservoir. This analysis does not account for impacts to Black Butte Lake. The criteria for this second Stony Gorge Reservoir diversion analysis are:

- Surplus conditions must exist in the Delta when diversions occur.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough when diversions occur.
- Stony Creek below Stony Gorge Reservoir must be flowing at 25 cfs or greater when diversions occur. Instream flow shortages (up to 25 cfs) during the analysis period will be met with Stony Gorge Reservoir storage releases when possible and prior to diversions.
- Storage in Stony Gorge Reservoir is set to 9.9 taf (1945–1994 average end of October storage) on November 1 of every water year.
- Stony Gorge Reservoir must be at or above 20.3 taf (maximum capacity 50.3 taf minus 30 taf) when diversions occur.

This analysis, using up to 30 taf of Stony Gorge storage, was run with diversion capacities of 500, 1,000, 1,500, 2,000 and 2,500 cfs. The average annual November through March divertible flow estimates ranged from 63.0 taf with a

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500 cfs capacity diversion to 123.2 taf with a 2,500 cfs capacity diversion. A 1,500 cfs diversion capacity yields a divertible flow of 111.6 taf. Therefore, using 30 taf of storage in Stony Gorge Reservoir (with 1,500 cfs capacity diversion) provides an additional 41.4 taf divertible flow, a 59 percent increase (Table 4). However, because this analysis was set up to divert as much water as possible as long as the reservoir was at or above 20.3 taf storage, up to 30 taf of potential reduction in supply to the Orland Unit Water Users' Association could theoretically occur in a given year. This potential impact could likely be mitigated by an exchange, with deliveries from the offstream reservoir rather than Stony Creek.

Table 4. Average annual divertible flows (taf) (November through March) using up to 30 taf of Stony Gorge Reservoir storage

Diversion capacity (cfs)	500	1,000	1,500	2,000	2,500
Avg. divertible flow (taf)	63.0	95.8	111.6	119.5	123.2

After completing the original Stony Gorge analyses, an analysis of a potential Grindstone Reservoir that would regulate flows of Grindstone Creek for diversion to Stony Gorge Reservoir and then to Sites or Colusa Reservoir was developed. A dam and reservoir could be located on Grindstone Creek about 3 miles upstream from the Paskenta to Elk Creek road. The estimated daily inflow to this proposed Grindstone Reservoir is based on the Grindstone Creek near Elk Creek gage data (USGS 11386500; 1965–1972) and streamflow estimates from regression with the Elder Creek near Paskenta gage data (USGS 11379500; 1948–1995), adjusted by an area-precipitation ratio of 0.924. The regression of Grindstone Creek to Elder Creek is a simple ratio based on monthly flows and has a correlation coefficient of 0.95. The Elder Creek record was extended back through 1945 by monthly regression (correlation coefficient = 0.91) with the Thomes Creek near Paskenta gage (USGS 11382000; 1920–1997).

For the Grindstone Reservoir evaluation, four reservoirs and four diversion capacities were analyzed as shown in Table 5. The criteria for the combined Grindstone and Stony Gorge Reservoirs diversion analyses include the following.

- Surplus conditions must exist in the Delta when diversions occur.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough when diversions occur.
- Stony Creek below Stony Gorge Reservoir and Grindstone Creek below Grindstone Reservoir are subject to instream flow requirements of 25 cfs. Instream flow shortages up to 25 cfs during the analysis period have been met with reservoir storage releases when possible and prior to diversions.
- Operating storage in Grindstone Reservoir has been set to zero on November 1 of every water year.
- Storage in Stony Gorge Reservoir has been set to 9.9 taf (1945–1994 average end of October storage) on November 1 of every water year.
- Stony Gorge Reservoir must be at or above the spillway crest (storage is 50.3 taf) when diversions occur.

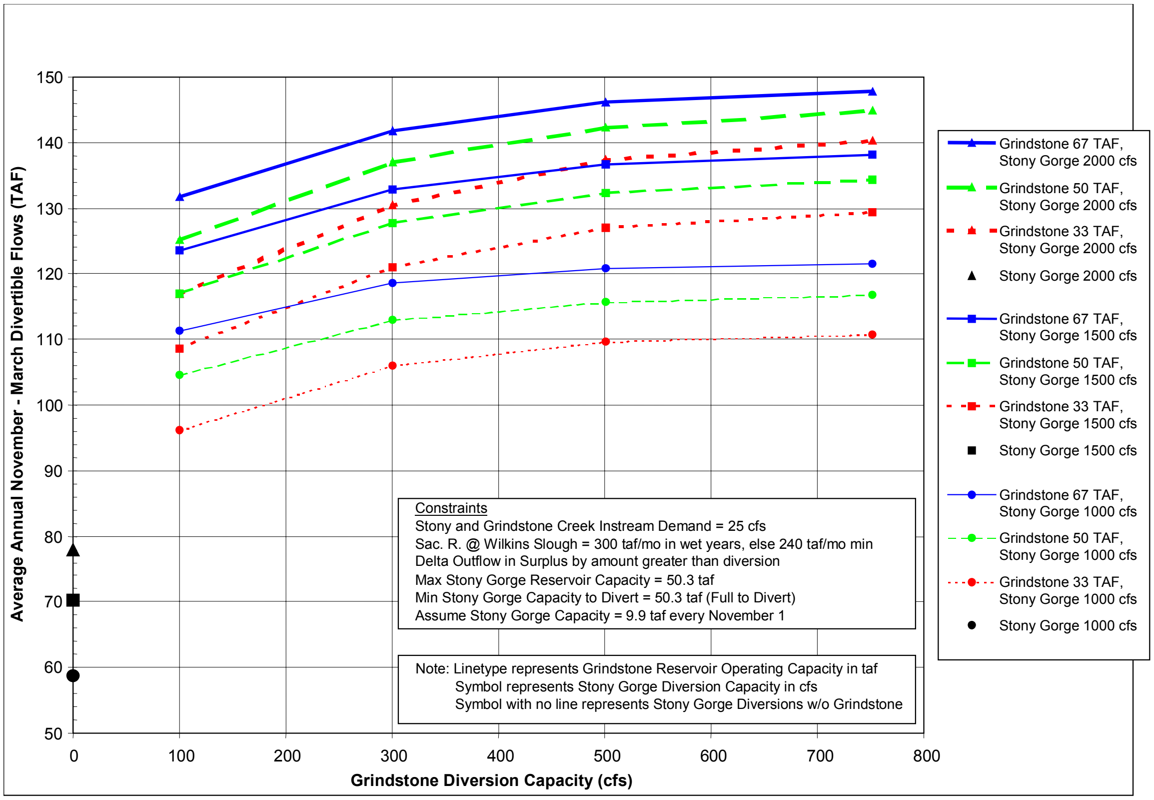
- Operating storage remaining in Grindstone Reservoir at the end of March will be diverted to Sites or Colusa reservoir via Stony Gorge Reservoir as soon as possible and is, therefore, included in the sum of divertible water from Grindstone.
- Losses due to evaporation are assumed to be negligible.

Four operating capacities for a proposed Grindstone Reservoir were evaluated: 0, 33, 50, and 67 taf. Operating capacity at Grindstone Reservoir would be the usable storage above the diversion outlet invert at elevation 880 feet. The four Grindstone to Stony Gorge diversion capacities evaluated were 100, 300, 500, and 750 cfs. The average annual November through March divertible flow from Grindstone to Stony Gorge, including the storage remaining at the end of March, ranged from 10.5 to 70.0 taf. Table 5 and Figure 3 summarize the results of these evaluations. (For more detail, see Attachment 1.)

Table 5. Summary of average annual divertible flows (1945-1994). Grindstone, Stony Gorge, and Grindstone to Stony Gorge to Sites

Grindstone to Stony Gorge Reservoir					Stony Gorge to Sites Reservoir		Stony Gorge and Grindstone to Sites Reservoir			
Diversion capacity (cfs)				Reservoir capacity (taf)	Diversion capacity (cfs)	From Table 3	Grindstone diversion capacity (cfs)			
100	300	500	750				100	300	500	750
					1,000	58.8				
10.5	20.7	24.1	26.6	0	1,000		69.3	79.5	82.9	85.4
37.3	47.1	50.8	52.0	33	1,000		96.1	105.9	109.6	110.8
45.8	54.1	57.0	57.9	50	1,000		104.6	112.9	115.8	116.7
52.4	59.8	62.0	62.7	67	1,000		111.2	118.6	120.8	121.5
					1,500	70.2				
11.6	24.6	29.7	32.7	0	1,500		81.9	94.8	100.0	102.9
38.4	50.8	56.8	59.2	33	1,500		108.6	121.0	127.0	129.4
46.8	57.5	62.0	64.0	50	1,500		117.0	127.7	132.3	134.3
53.4	62.6	66.4	67.9	67	1,500		123.6	132.8	136.7	138.1
					2,000	77.9				
12.2	26.6	33.1	36.9	0	2,000		90.1	104.5	111.0	114.8
39.0	52.6	59.5	62.4	33	2,000		116.9	130.5	137.4	140.4
47.3	59.2	64.4	66.9	50	2,000		125.2	137.1	142.3	144.8
53.9	64.0	68.3	70.0	67	2,000		131.8	141.9	146.2	147.9

Figure 3. Average annual divertible Grindstone and Stony Creek flows from Grindstone and Stony Gorge Reservoirs (1945-1994)



After running Stony Gorge analyses and various configurations of the Grindstone Reservoir analyses, the results indicated that a physical connection between Grindstone Reservoir and Stony Gorge Reservoir might not be necessary to substantially increase the divertible flows to Sites or Colusa Reservoir. Similar results may be achievable through operational modifications of Stony Gorge and Grindstone Reservoirs. Grindstone Reservoir storage could meet a major share of downstream demands normally supplied by Stony Gorge Reservoir. Stony Gorge Reservoir could then be operated to maximize diversions to Sites or Colusa Reservoir without adversely affecting downstream water users. This type of formulation is essentially a water exchange to increase the total yield of Stony Creek without affecting existing water rights or operations.

In summary, the average annual November through March divertible flow from the connected Grindstone and Stony Gorge configuration ranged from 69.3 to 147.9 taf, depending on reservoir and diversion capacities (Table 5). The average annual November through March divertible flow from Stony Gorge Reservoir only, using up to 30 taf of reservoir storage to divert to Sites or Colusa Reservoir, ranged from 63.0 to 123.2 taf, about 10 to 20 percent less (Table 4). These results indicate that a physical connection between Grindstone and Stony Gorge may not be required to achieve similar project yields.

Stony Creek water could also be diverted into the Glenn-Colusa Irrigation District Canal near Hamilton City and then pumped into Sites or Colusa Reservoir. The maximum capacity of the GCID canal at the proposed Sites Project pump location is 1,700 cfs. The daily flow of Stony Creek at the diversion location was estimated using the Stony Creek below Black Butte Dam gage data (USGS 11388000; 1956–1994) and the estimated streamflows from regression with the Stony Creek near Hamilton City gage data (USGS 11388500; 1941–1973). This regression of the Stony Creek data is a straight ratio based on monthly flows and has a correlation coefficient of 0.99. Below is a list of the conditions that must be met before diversion can occur:

- Surplus conditions must exist in the Delta.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough.
- The Stony Creek instream flow requirement below the GCID canal crossing is assumed to be 50 cfs.

The instream flow requirement of Stony Creek below the diversion was assumed to be 50 cfs. Flows in excess of the maximum diversion are released downstream to Stony Creek. Diverting to the GCID canal from Stony Creek would require the construction of either a low dam or pump diversion structure. These types of structures would likely require fishery impact mitigation.

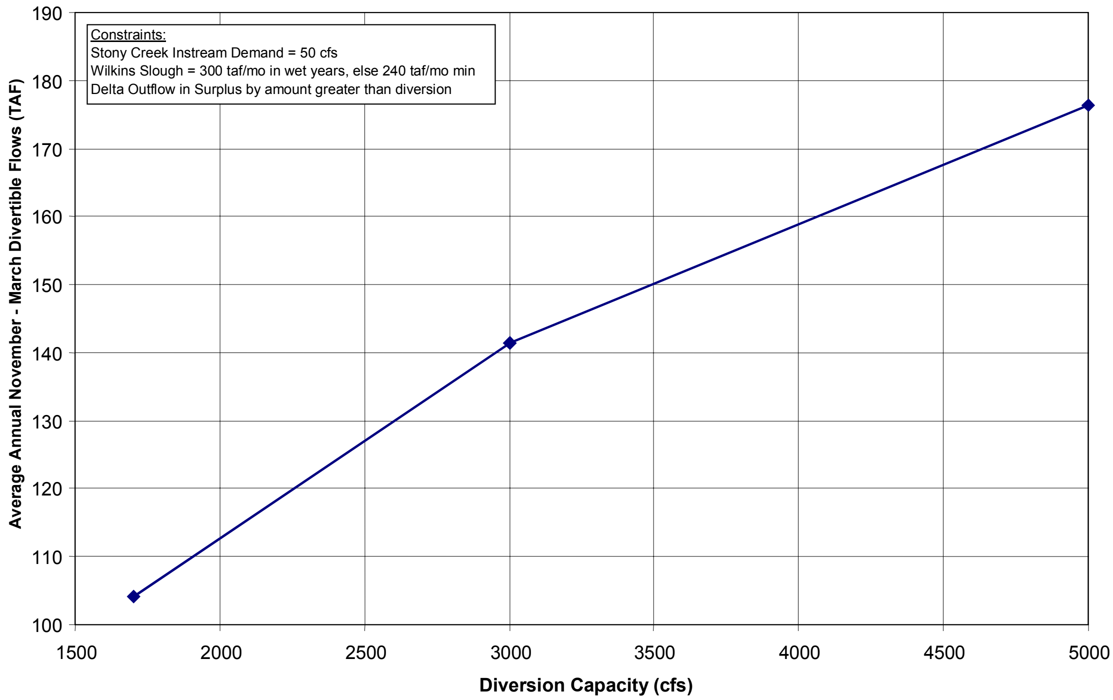
Pumping surplus Stony Creek water from Black Butte Lake has also been considered for helping to fill Newville Reservoir, which is part of the Thomes-Newville Project. Using the same data and downstream constraints as for diverting to the GCID canal, pumping capacities of 3,000 and 5,000 cfs were evaluated. Water available for diversion west to Newville Reservoir (3,000 or 5,000 cfs) or south to Sites or Colusa Reservoir (1,700 cfs) is shown in Table 6 and Figure 4.

Table 6. Summary of historic and divertible monthly flows (taf) at Stony Creek below Black Butte Dam (1945-1994)

Month	Stony Creek below Black Butte Dam	Divertible flow with diversion capacity of:		
		1,700 cfs	3,000 cfs	5,000 cfs
November	5.5	2.4	2.8	3.0
December	32.0	14.6	19.5	23.3
January	72.5	29.8	42.2	54.3
February	76.2	30.6	43.2	56.1
March	48.3	26.7	33.8	39.6
Nov to Mar	234.5	104.0	141.5	176.3

Stony Creek could also be diverted into the Tehama-Colusa Canal in a similar way as diverting to the GCID canal for water supply to Sites or Colusa Reservoir. The maximum capacity of the T-C Canal at the proposed Sites pump location is 2,100 cfs. An interpolation using Figure 4 indicates an average annual November through March divertible flow to the T-C canal would be about 115 taf. (For more detail, see Attachment 1.)

Figure 4. Average annual divertible Stony Creek flows below Black Butte Dam (1945-1994)



East Park Reservoir

East Park Reservoir is located on Little Stony Creek approximately 18 miles upstream of Stony Gorge Reservoir. It is formed by a concrete arch dam and has been in operation since 1910. The East Park Reservoir operating capacity is 48.2 taf between elevations 1,131.7 (invert of sluice gate) and 1,198.2 feet (crest of spillway). Its capacity is increased to 51 taf with the addition of flashboards. Additional water is diverted to East Park Reservoir from Stony Creek at Rainbow Diversion Dam. The current capacity of this diversion is about 200 to 250 cfs.

East Park Reservoir water could be diverted to Sites or Colusa Reservoir through a single tunnel, approximately 3 miles long. This is a shorter and less expensive system than that required from Stony Gorge to Sites or Colusa Reservoir, but the available water supply is also reduced. A daily diversion analysis determined how much water could be diverted from East Park to Sites or Colusa Reservoir. This analysis did not account for impacts to Stony Gorge or Black Butte Reservoirs. As in the Stony Gorge diversion option, an adjusted evaluation of diversion from East Park is shown later in this chapter.

For this original evaluation, three diversion capacities from East Park to Sites or Colusa Reservoir and four diversion capacities from Rainbow Diversion Dam to East Park Reservoir, as shown in Table 7, were considered. The available inflows to East Park and Rainbow were estimated using contributing watershed area-precipitation ratios applied to the recorded inflow of Stony Gorge Reservoir. East Park Reservoir has a watershed area of 97.4 square miles with an average annual rainfall of 33 inches. Rainbow Diversion Dam forms a forebay and diverts part of the high flows of Stony Creek into the 7-mile-long East Park Feed Canal to supplement the natural inflow to East Park Reservoir. (USBR n.d.) The Rainbow reservoir watershed has an area of 102.1 square miles with an average annual rainfall of 43 inches. The Stony Gorge Reservoir watershed, which contains both East Park Reservoir and Rainbow Diversion Dam watersheds, has an area of 302.0 square miles with an average annual rainfall of 33 inches. From these reservoir drainage areas and associated precipitation information, the inflow to East Park Reservoir was estimated as 31 percent of the Stony Gorge inflow (or area-precipitation ratio of 0.31); the inflow to Rainbow reservoir was estimated as 45 percent of the Stony Gorge inflow (or area-precipitation ratio of 0.45). The criteria for the original Rainbow/East Park analysis include the following.

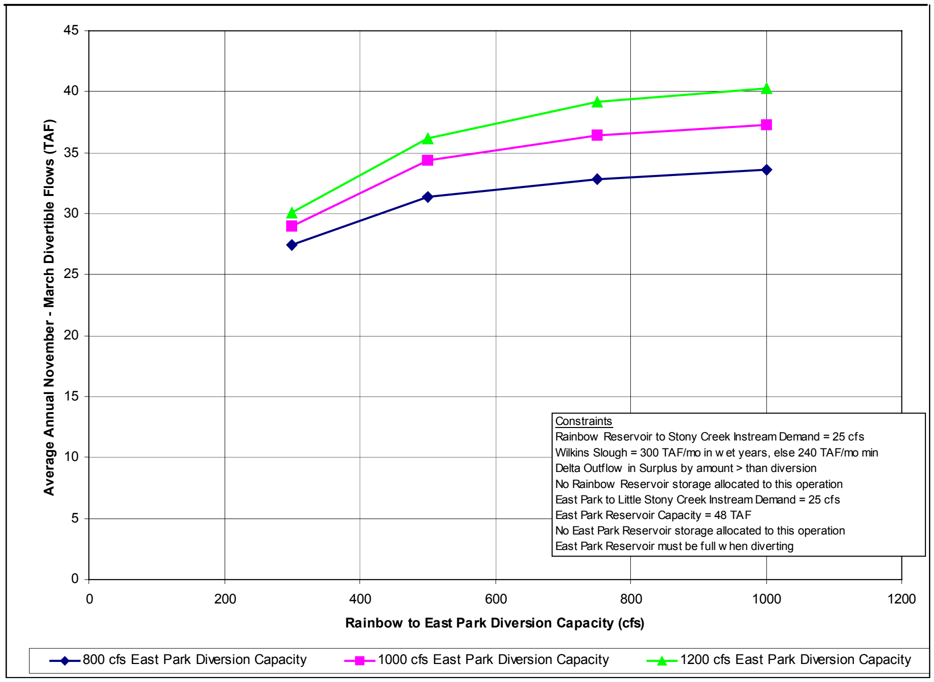
- Surplus conditions must exist in the Delta when diversions occur.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough when diversions occur.
- East Park and Rainbow Reservoir storage is not used to regulate flows for diversion.
- East Park Reservoir must be full when diverting to Sites or Colusa Reservoir.
- Losses due to evaporation are assumed to be negligible because of the small reservoir volume and winter diversion period.
- The instream demand flow of both Stony and Little Stony Creeks below the reservoirs is assumed to be 25 cfs each (total 50 cfs).

With minimal enlarging of the diversion and canal capacity from Rainbow to East Park to the design capacity of 300 cfs, an annual average of 27.4 to 30.1 taf of water could be diverted to Sites or Colusa Reservoir during the November through March period. An average of 40.3 taf per year could be diverted with a 1,000 cfs canal from Rainbow forebay to East Park Reservoir in conjunction with a 1,200 cfs diversion tunnel from East Park Reservoir to Sites or Colusa Reservoir. Table 7 and Figure 5 summarize the results of this analysis. (For more detail, see Attachment 1.)

Table 7. Summary of annual divertible flows (taf) (November through March) (1945-1994) using expanded Rainbow Diversion and East Park Reservoir

East Park to Sites Diversion Capacity (cfs)	Rainbow Dam to East Park Reservoir diversion capacity (cfs)			
	300	500	750	1,000
800	27.4	31.4	32.8	33.6
1,000	29.0	34.4	36.4	37.3
1,200	30.1	36.2	39.2	40.3

Figure 5. Average annual divertible flows from Rainbow Diversion Dam and East Park Reservoir (1945-1994)



Thomes Creek

Thomes Creek flows eastward through Tehama County and enters the Sacramento River south of the City of Tehama. A USGS gaging station located near Paskenta has been in operation since 1920 (USGS 11382000; 1920–1997). The drainage area at the gage is 203 square miles, with an average annual runoff of 213 taf for the period of record. The average annual rainfall for the watershed above the gage is 47.5 inches.

A diversion analysis was performed using the Paskenta gage data to determine how much water could be diverted from Thomes Creek at the Tehama-Colusa Canal crossing just south of the City of Tehama. Diverting to the T-C Canal would require construction of either a low dam or pump diversion structure. At the T-C Canal, the watershed area is 294 square miles with an average rainfall of 40.2 inches. The area-precipitation ratio at the T-C Canal applied to the flow at the gage would be 1.22. However, the gage flows of Thomes Creek are used here instead of using estimated flows at T-C Canal. The increase in flow between the gage and the diversion point could be used to alleviate the sediment problem that will occur when diverting to the T-C Canal. Below is a list of the assumed conditions that must be met before diversion can occur.

- Surplus conditions must exist in the Delta.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough.
- Thomes Creek must be flowing at 50 cfs or greater.

The instream flow requirement of Thomes Creek below the diversion was assumed for this report to be 50 cfs. This estimate can be changed if future study justifies a different flow. The maximum diversion to the T-C Canal is 2,100 cfs, which is the existing canal capacity near Funks. Flows in excess of the maximum diversion are released downstream to Thomes Creek. The average divertible flow from Thomes Creek to the canal is 108.9 taf for the November through March period. Thomes Creek frequently has high flows during April and May as well. For this study, the analysis was limited to the months of November through March to avoid any conflict with existing water rights and operations.

An upstream reservoir was considered for Thomes Creek to regulate flows and thereby increase the diversion potential to the T-C Canal. The average total November to March flow of Thomes Creek at Paskenta is 150.9 taf. According to this Thomes Creek analysis, 108.9 taf was divertible and 132.2 taf was surplus based on instream flow needs and Sacramento River constraints. Some of the remaining 23.3 taf of surplus flow could possibly be diverted if an upstream reservoir were constructed, but this additional amount does not appear large enough to warrant further consideration of upstream storage.

Thomes Creek has also been evaluated as a source of supply for the Thomes-Newville Project. This water supply source could be developed by constructing a small diversion dam on Thomes Creek upstream from the town of Paskenta and by constructing a tunnel and canals to carry the water to Newville Reservoir. The four diversion capacities evaluated were 2,500, 5,000, 7,500, and 10,000 cfs. This analysis indicates that 112.6 to 129.7 taf is divertible, on a run of the river basis (without using on-stream storage), during the months of November through March. Table 8 and Figure 6 summarize the findings of the Thomes Creek diversion analyses. (For more detail, see Attachment 1.)

Table 8. Average monthly summary of divertible flows (taf) (1945-1994) from Thomes Creek at Paskenta

	Diversion capacity (cfs)				
Month	2,100	2,500	5,000	7,500	10,000
November	6.8	6.9	7.2	7.2	7.2
December	17.8	18.5	20.7	21.5	22.1
January	26.2	27.5	31.9	33.6	34.2
February	27.6	28.6	32.1	33.2	33.5
March	30.5	31.1	32.4	32.7	32.8
Nov to Mar	**108.9**	**112.6**	**124.3**	**128.2**	**129.7**

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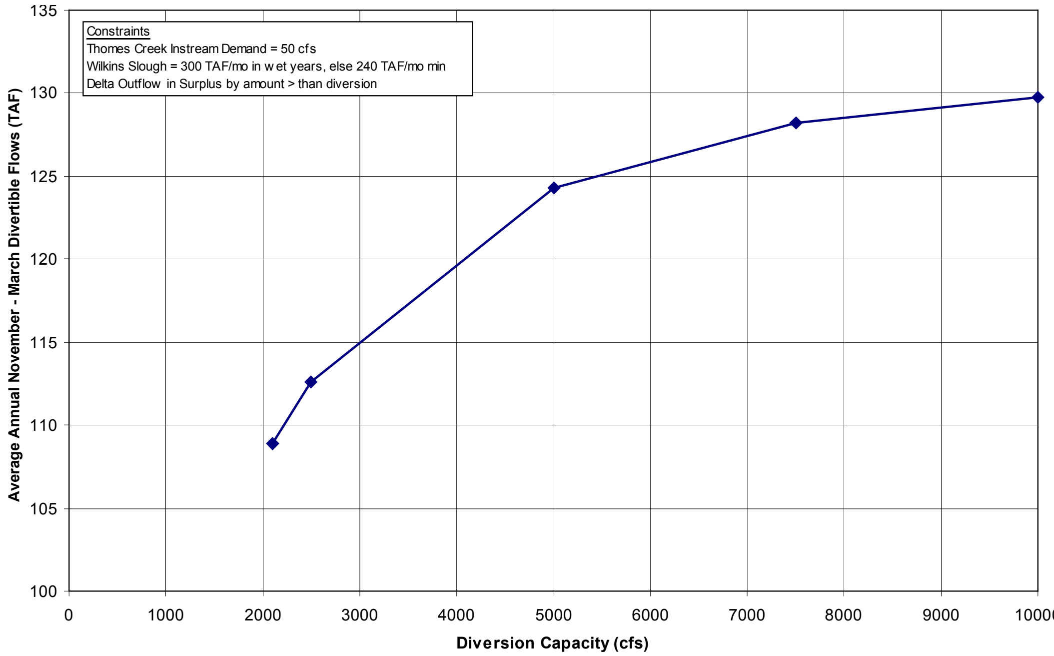
Figure 6. Average annual divertible flows Thomes Creek at Paskenta (1945-1994)



South Fork Cottonwood/Red Bank Creeks

During this investigation, a recommendation was made to discontinue the Red Bank Project studies (see *Progress Report* recommendations). The Red Bank Project was most recently investigated in the early 1990s. The Red Bank Project would consist of the proposed Dippingvat Dam and Reservoir on South Fork Cottonwood Creek and proposed Schoenfield Dam and Reservoir on Red Bank Creek. As formulated in the 1990s investigation, this project would divert surplus water from South Fork Cottonwood Creek to Schoenfield Reservoir, which would have a larger capacity but little natural inflow. An operation study performed in 1993 (Brown 1993) determined the local irrigation season firm yield of the project for 1922 through 1991 to be 43 taf per year. This firm yield was assumed to be delivered at the Corning Canal or Tehama-Colusa Canal and did not account for instream transportation losses, which could be large. To obtain the firm yield, Schoenfield Reservoir was operated within the study to meet a constant monthly release of 7.1 taf/month during the April through September irrigation season with limited shortages and without encroaching into dead storage. Using this operating rule, the only shortages during the 1922–1991 hydrologic period occurred in August and September 1937 and totaled 14 taf.

South Fork Cottonwood Creek at Dippingvat Dam has a drainage area of 132 square miles and an average annual runoff of 96 taf per year (1922-1991). The flow of South Fork Cottonwood Creek at Dippingvat Dam was estimated as 0.1698 (area-precipitation ratio) times the flow of Cottonwood Creek near Cottonwood

(USGS 11376000; 1940–1996). Red Bank Creek at the gage near Red Bluff (USGS 11378800; 1960-1994) has a drainage area of 91.8 square miles and an average annual runoff of 35 taf per year (1948–1994). The flow of Red Bank Creek for water years 1945-1959 is based on a monthly regression (0.88 correlation coefficient) with Elder Creek near Paskenta (USGS 11379500).

For this investigation, Red Bank and South Fork Cottonwood Creeks were analyzed together to determine how much water could be diverted from Red Bank and South Fork Cottonwood Creeks into the Tehama-Colusa Canal at its settling basin, immediately downstream of the fish screens. These flows would be diverted before they reached the Sacramento River. For this configuration, Schoenfield Reservoir would not be constructed. Dippingvat Reservoir would be used to divert South Fork Cottonwood Creek water into North Fork Red Bank Creek and thence to Red Bank Creek and diverted into the T-C Canal for transport to Sites or Colusa Reservoir. A diversion structure on Red Bank Creek near the Red Bluff Diversion Dam and a short canal to the T-C settling basin would be constructed.

Dippingvat Dam and Reservoir, as well as the diversion tunnel to North Fork Red Bank Creek, are assumed to be the same as that of the Red Bank Project described in the 1993 report. The proposed Dippingvat Reservoir would have 17 taf of dead storage, 20 taf of conservation storage, and 68 taf of flood storage. The capacity of the diversion tunnel was assumed to be 800 cfs. Earlier operation and sizing studies determined that this configuration of Dippingvat Reservoir would divert most of the South Fork Cottonwood Creek surplus to Red Bank Creek for storage in Schoenfield Reservoir with minimal spills and also provide flood control as recommended by the U.S. Army Corps of Engineers. The maximum diversion capacity to the T-C Canal from Red Bank Creek is assumed to be 2,100 cfs, the capacity of the canal at Funks Reservoir.

As with the other analyses, surplus conditions must exist both in the Delta and the Sacramento River at Wilkins Slough before diversions can occur. The instream flow requirements are assumed to be 75 cfs and 25 cfs for South Fork Cottonwood Creek and Red Bank Creek, respectively. These demands are based on those provided by the California Department of Fish and Game for the previous Red Bank Project studies. The South Fork Cottonwood Creek supports salmonids, but Red Bank Creek supports only warm water fish. The downstream flow must be met before diversion can occur. Storage at Dippingvat Reservoir would be used to meet the 75 cfs instream flow demand of South Fork Cottonwood Creek, but only natural flows would be used to meet the Red Bank Creek requirement. DFG staff have suggested that fishery mitigation may be required on South Fork Cottonwood Creek, but possibly not required on Red Bank Creek. The operating storage in Dippingvat Reservoir is assumed to be zero on November 1 in every year. Table 9 summarizes the results of this analysis.

Table 9. Summary of historic and divertible monthly flows (taf) (1945-1994) from Red Bank and South Fork Cottonwood Creeks to Tehama-Colusa Canal

Month	Red Bank Creek	RB divertible (2,100 cfs)	SF Cottonwood Creek	SF Cottonwood divertible (800 cfs)	RB + SF Cottonwood divertible (2,100 cfs)
November	1.1	0.8	3.9	1.8	2.6
December	4.0	3.3	13.1	8.0	11.3
January	8.7	7.3	20.2	14.1	21.4
February	7.9	6.7	20.1	15.1	21.8
March	6.9	5.4	18.7	13.9	19.3
Nov to Mar	**28.6**	**23.5**	**75.9**	**52.9**	**76.4**

The operation of Dippingvat Reservoir is assumed to continue through April and May to determine how much water could be stored and then made available for diversions to the T-C Canal while the Red Bluff Diversion Dam gates are up. The average annual November through March divertible flow from South Fork Cottonwood and Red Bank Creeks to the Tehama-Colusa Canal is 76.4 taf. An additional 6.8 taf of water stored in Dippingvat Reservoir during April and May could be used to help meet the requirements of the upper reaches of the T-C Canal during the period when the Red Bluff Diversion Dam gates are up. If more water is needed for Red Bluff Diversion Dam operations, the quantity of water available in Dippingvat Reservoir during this period could be increased by sending less water south for offstream storage during February and March.

South Fork Cottonwood and Red Bank Creeks, assuming that diversions were also occurring from Thomes Creek to the T-C Canal, were also analyzed. This analysis defines the amount of water that can be derived from Thomes, South Fork Cottonwood, and Red Bank Creeks combined. Facilities required for this project formulation include the existing T-C Canal and Dippingvat Reservoir plus low diversion dams on Thomes and Red Bank Creeks. In this analysis, Thomes Creek diversions have first priority, followed by Red Bank Creek, then South Fork Cottonwood Creek. Table 10 summarizes the results of this analysis. (For more detail, see Attachment.)

Table 10. Summary of monthly divertible flows (taf) (1945-1994) from Thomes, Red Bank, and SF Cottonwood Creeks to Tehama-Colusa Canal. Listed by priority

Month	Thomes Cr. (2,100 cfs) 1st Priority	Red Bank Cr. (2,100 cfs) 2nd Priority	SF Cottonwood Cr. (800 cfs) 3rd Priority	Thomes + Red Bank + SF Cottonwood Divertible
November	6.8	0.6	1.8	9.2
December	17.8	1.9	6.6	26.3
January	26.2	3.4	11.4	41.1
February	27.6	3.9	13.7	45.2
March	30.5	3.9	13.1	47.5
Nov to Mar	**108.9**	**13.7**	**46.6**	**169.2**

Colusa Basin Drain

The Colusa Basin Drain flows southward through Glenn, Colusa, and Yolo Counties and enters the Sacramento River at the Town of Knights Landing. A DWR gaging station at Highway 20 near the City of Colusa has been in operation since 1924. The drainage area at Highway 20 is 973 square miles, and the average annual runoff is 496 taf per year (1942–1997). An analysis using the November through March daily data from this gage determined how much water could be diverted from the Colusa Basin Drain into Sites or Colusa Reservoir. Below is a list of the conditions that must be met before diversion can occur.

- Surplus conditions must exist in the Delta.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough.
- Colusa Basin Drain flow past the diversion point must be at least at 200 cfs to meet downstream water user needs.

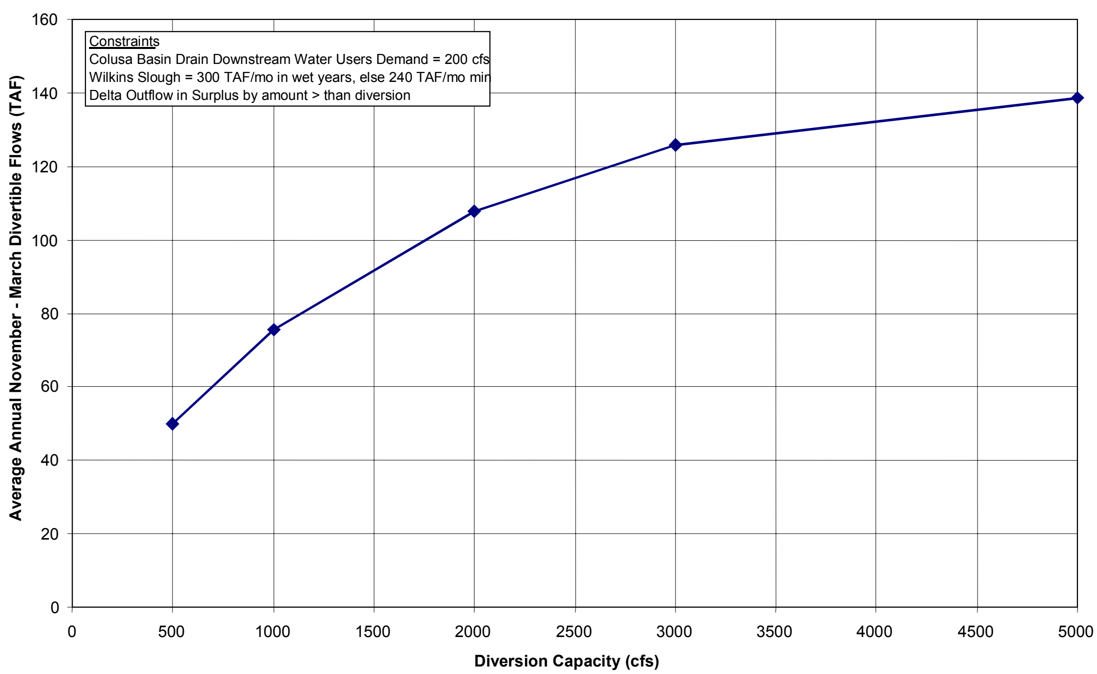
This Colusa Basin Drain flow requirement is based on estimated existing water use during the diversion period (November through March). According to DWR Northern District Land and Water Use staff, approximately 20,000 acres of rice land and wetlands are flooded for waterfowl habitat during winter months downstream of Highway 20. For this analysis, it was assumed that 1 cfs per 100 acres is required to flood these lands, which results in a 200 cfs downstream demand for the Colusa Basin Drain. This estimated flow requirement is probably sufficient for maintenance of flooded fields but may not be sufficient to account for initial flooding requirements. The initial flooding demand flow and duration should be refined during Phase II analyses.

Five alternative diversion capacities from the Colusa Basin Drain were considered: 500, 1,000, 2,000, 3,000, and 5,000 cfs. Diverting from the CBD to Sites or Colusa Reservoir would require the construction of a canal and pumping stations. The average annual divertible flow ranged from 49.9 taf with a 500 cfs diversion up to 138.8 taf with a 5,000 cfs diversion. Table 11 and Figure 7 summarize the findings of these analyses. (For more detail, see Attachment 1.)

Table 11. Average monthly summary of divertible flows (taf) (1945-1994) at Colusa Basin Drain at Highway 20

	Diversion Capacity (cfs)				
Month	500	1,000	2,000	3,000	5,000
November	6.4	8.4	9.7	9.7	9.7
December	9.7	14.3	19.0	21.0	21.9
January	12.6	19.9	30.6	37.1	41.6
February	11.6	19.3	29.7	36.0	41.6
March	9.6	13.6	18.7	22.0	23.8
Nov to Mar	**49.9**	**75.6**	**107.6**	**125.8**	**138.8**

Figure 7. Average annual divertible Colusa Basin Drain flows at Highway 20 (1945-1994)



Sacramento River

The hydrology of the Sacramento River is an integral part of the data comprising the DWR reservoir system simulation models. Therefore, as part of this water availability analysis, a cursory evaluation of the relative quantity of water available at one location on the river (Butte City gage) for general comparison purposes was sufficient. In the operation studies, the river data already contained in the reservoir simulation model are used. The information developed and reported here is helpful in allowing comparisons with the previously described water supply sources but is not ultimately used in the operation studies.

A daily diversion analysis study of the Sacramento River using the Butte City gage data (USGS 11389000) was completed. The drainage area of the Sacramento River at Butte City is 12,080 square miles with an average annual runoff of 9.4 maf (historic ,1939–1995). As with the other analyses, the CALFED operation study results were used to determine when there are surplus conditions in the Delta and the river. The period of analysis is 1945 through 1994. Below is a list of the conditions that must be met before diversion can occur.

- Surplus conditions must exist in the Delta.
- Surplus conditions must exist in the Sacramento River at Wilkins Slough (flow of the Sacramento River exceeds 240 taf/month, except for wet years when the criterion is 300 taf/month).
- For this analysis, an additional surplus condition requirement for the Sacramento River is included, with an assumption that a 10,000 cfs flow or bout 595 taf a month, is required at Butte City.

The minimum diversion flow requirement of 10,000 cfs is just one optional requirement that has been discussed in connection with potential Sacramento River diversions to offstream storage. The following five alternative diversion capacities from the Sacramento River into a canal running to Sites or Colusa Reservoir were considered: 1,000, 2,500, 5,000, 7,500, and 10,000 cfs. Diverting from the Sacramento River at low and moderate flows would require the construction of a pumping station at the canal entrance. Two to three other pump lifts would be required to convey the water into Sites or Colusa Reservoir. The average annual November through March divertible flow ranged from 139.0 taf with a 1,000 cfs capacity diversion up to 995.7 taf with a 10,000 cfs capacity diversion. The analysis shows that an average of 587.3 taf of water is divertible between November and March with a 5,000 cfs capacity diversion (Table 12).

An additional analysis assuming that a trigger flow of 60,000 cfs must be reached in the river before any diversions can occur was developed. A trigger flow is a minimum required flow that must be met at least once in a water year before diversion can be made to an offstream project. In this analysis, the trigger flow requirement is in addition to the 10,000 cfs minimum diversion flow described above. This trigger flow is another potential criterion CALFED has considered. Under this diversion restriction, the average annual November through March divertible flow ranged from 81.8 taf with a 1,000 cfs diversion to 684.6 taf with a 10,000 cfs diversion. With a diversion capacity of 5,000 cfs, 378.4 taf can be diverted (Table 13). In these analyses, the trigger flow requirement reduces the divertible flow by about 30 to 40 percent as compared to the divertible flow computation only requiring the 10,000 cfs diversion flow described above. Tables 12 and 13 and Figure 8 summarize the findings of these analyses. (For more detail, see Attachment 1)

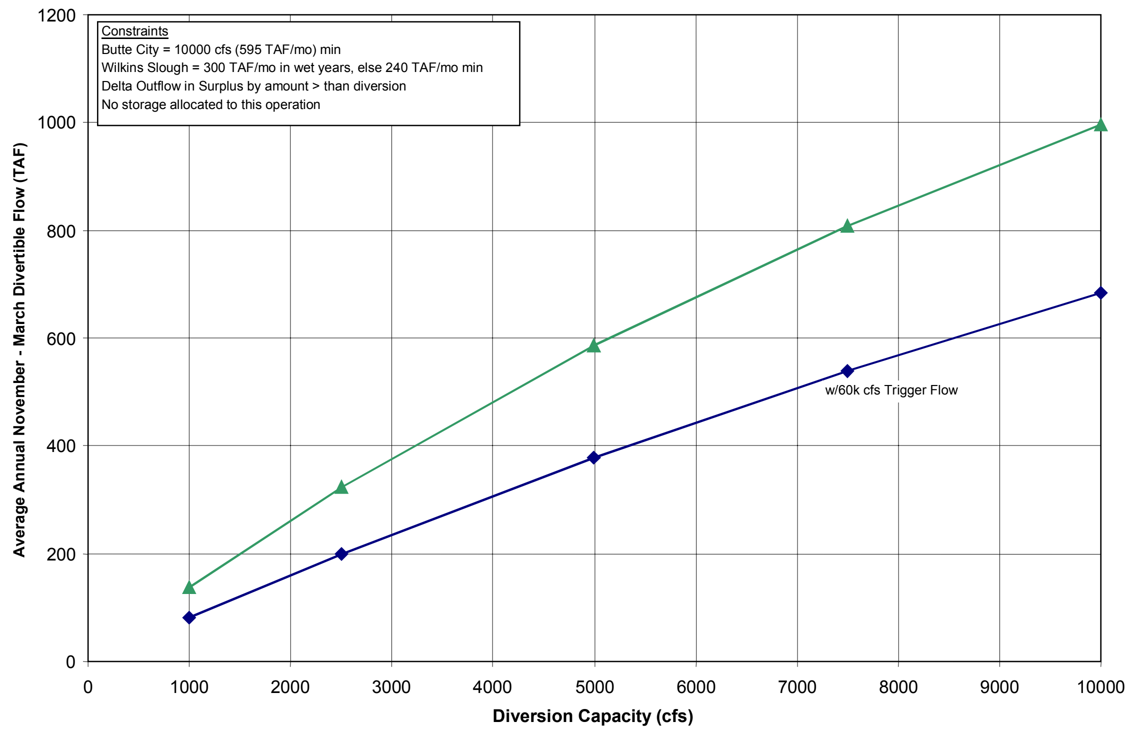
Table 12. Average monthly summary of divertible flows (taf) (1945-1994) Sacramento River at Butte City

Month	Sac. River at Butte City	Diversion Capacity (cfs) 1,000	2,500	5,000	7,500	10,000
November	549.1	11.1	24.8	40.6	50.8	58.5
December	994.5	25.7	58.5	101.2	137.2	168.4
January	1,351.3	31.6	75.7	142.0	200.2	251.5
February	1,385.4	34.1	81.1	151.7	213.5	267.8
March	1,180.3	36.5	84.8	151.7	205.6	249.5
Nov to Mar	**5,460.7**	**139.0**	**324.9**	**587.3**	**807.4**	**995.7**

Table 13. Average monthly summary of divertible flows (taf) (1945-1994) Sacramento River at Butte City w/60k cfs trigger flow

Month	Sac. River at Butte	Diversion Capacity (cfs) 1,000	2,500	5,000	7,500	10,000
November	549.1	1.1	2.7	5.4	7.8	10.0
December	994.5	7.7	19.1	38.1	56.9	74.4
January	1,351.3	20.7	51.4	100.5	146.8	190.6
February	1,385.4	24.7	60.0	114.7	163.7	207.6
March	1,180.3	27.6	65.0	119.8	164.6	202.1
Nov to Mar	**5.460.7**	**81.8**	**198.3**	**378.4**	**539.8**	**684.6**

Figure 8. Average annual divertible Sacramento River flows at Butte City (1945-1994)



Adjustments to Stony Creek Hydrology and Water Supply

Subsequent to the initial evaluations of optional water supply sources, members of the North of the Delta Offstream Storage Investigation Technical Advisory Group requested that DWR refine its treatment of options from the upper watershed of Stony Creek; specifically, the Stony Gorge Reservoir and East Park Reservoir diversion options. Based on input from TAG members and local project operators, some adjustments were made to the assumptions related to these optional sources. These adjustments did generate corresponding changes in streamflow volume and the water supply characteristics of these sources. Following is a more comprehensive description of the Stony Creek options and results of the new analyses using the adjusted operating criteria.

The major surface water projects in the Stony Creek basin include the Orland Project and Black Butte Dam and Lake. The Orland Project is one of the oldest reclamation projects (USBR) in the country and includes two main dams to store water, East Park and Stony Gorge. The project is locally operated by the Orland Unit Water Users' Association and provides irrigation water for up to 20,000 acres near Orland. East Park Dam and Reservoir are located on Little Stony Creek, about 33 miles southwest of Orland. The capacity of East Park Reservoir is about 51 taf. In addition to the inflow from Little Stony Creek, East Park receives water from Rainbow Diversion Dam on the mainstem. The East Park Feed Canal is about 7

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miles long with a design capacity of 300 cfs. Stony Gorge Dam and Reservoir are located about 18 miles downstream of East Park at the confluence of Little Stony and Stony Creeks. The capacity of Stony Gorge Reservoir is about 50 taf.

The U.S. Army Corps of Engineers developed Black Butte Dam and Lake, approximately 22 miles downstream of Stony Gorge and 9 miles west of Orland, primarily for flood control in the early 1960s. Black Butte is operated in coordination with a number of other agencies including the OUWUA and the U.S. Bureau of Reclamation for water supply. In addition, the City of Santa Clara generates hydroelectric power. The capacity of the lake is about 143 taf, with up to 137 taf allocated to flood control reservation during the November through March period.

Stony Creek Water Supply Source Options

A number of options have been considered for diverting Stony Creek flows during high runoff periods to offstream storage including:

- diversion from Black Butte Lake to Newville Reservoir,
- diversion from lower Stony Creek into existing T-C and GCID Canals for conveyance to Sites or Colusa Reservoirs,
- diversion from East Park Reservoir to Sites or Colusa Reservoirs,
- diversion from Stony Gorge Reservoir to Sites or Colusa Reservoirs, and
- diversion from proposed Grindstone Reservoir to Stony Gorge Reservoir and rediversion to Sites or Colusa Reservoirs.

The Grindstone Reservoir water supply source option was evaluated at a cursory level, as described earlier. Ranges of reservoir and diversion capacities were considered. The analysis of Grindstone Reservoir indicated a number of undesirable characteristics related to this option including susceptibility to large landslides, relatively large embankment quantities for the dam and saddles, relatively high sediment load in the creek, and proximity to a fault. While these characteristics would not make the Grindstone Reservoir option infeasible, a number of other options appear to be more feasible at this stage of evaluation. Therefore, Grindstone Reservoir as an optional water supply source has been set aside, and adjusted analyses of the Grindstone/Stony Gorge option were not included in this report.

The following adjusted analysis has focused on the reservoir diversions to Sites or Colusa Reservoirs. Simplified operation simulations using the historic hydrology and current reservoir operations have been used to estimate potential water supply diversions from East Park and Stony Gorge Reservoirs. Potential water supply diversions are simply the amount of water that can be diverted from a source with given conveyance capacities, instream flow, and other operational requirements. Unimpaired inflow to Stony Gorge Reservoir was determined based on historic outflow and changes in storage in East Park and Stony Gorge. Inflow to East Park and Rainbow were estimated based on the unimpaired Stony Gorge inflow. The area of the watersheds above Stony Gorge, East Park, and Rainbow diversion were determined. Watershed areas were then combined with historic average precipitation data to develop ratios for estimating streamflows at the ungaged reservoir location. Area-precipitation ratios of 0.45 and 0.31 were used for Rainbow and East Park, respectively. This means that this approach estimates that 45 percent of the unimpaired inflow to Stony Gorge flows past the Rainbow location and 31 percent flows into East Park.

A review of available data and discussions with local project operators provided helpful information. For example, a review of monthly reservoir storage indicates that a significant shift in Orland Project reservoir operations occurred subsequent to construction of Black Butte in 1963. After Black Butte was built, water in storage at the end of the irrigation season in the Orland Project reservoirs increased an average of about 16 taf. This effect indicates that Orland Project users have received some benefit from development of the Black Butte Project. Local project operators helped refine current project operating criteria, including estimates of instream water releases below the dams.

Criteria were established to determine the potential water supply diversions from Orland Project reservoirs including the following.

- Instream flow requirements for the creeks below East Park, Stony Gorge, and Black Butte were set at 10, 10, and 30 cfs, respectively. These are based on operators' estimates of current operating practices. There are no current regulatory requirements for these portions of the creeks.
- Diversion is limited to the November through April period to avoid potential impacts to existing projects. This diversion period is one month longer than for the other source options described earlier. The longer diversion period is appropriate since the conveyance for these options is independent of existing delivery systems.
- Diversion is limited such that reservoir storage was equal to or greater than historic levels in all three existing reservoirs, if possible. This requirement means that diversion to offstream storage would not impact historic end-of-the-month storage in Black Butte, Stony Gorge, or East Park.
- A minimum diversion storage level of 20 taf was established to provide adequate tunnel submersion for the proposed gravity conveyance.

A range of conveyance capacities was evaluated to determine optimal sizing of diversion and conveyance facilities. For Stony Gorge, conveyance of 500, 1,000, 1,500, and 2,000 cfs was considered; for East Park, conveyance of 800, 1,000, and 1,200 cfs; the feeder canal from Rainbow to East Park was sized at 300, 500, 750, and 1,000 cfs. A 300 cfs capacity for the Rainbow source will require some improvements to diversion facilities as well as the canal itself. The current capacity is estimated to be 200 to 250 cfs, although the design capacity was 300 cfs.

Potential water supply diversions were analyzed for the above range of facilities for the 1964 through 1994 period. This period was chosen based on the previously mentioned effect of Black Butte and the data requirements of CALSIM, the reservoir system simulation model. The potential water supply diversion data was then extended to the standard CALSIM period, 1922 through 1994, by correlation with the Sacramento River Index. The potential water supply diversion data was then used as hydrologic input to the CALSIM model for offstream storage operation studies. Average potential water supply diversions from Stony Creek sources are shown in Table 14 for the 1922–1994 period.

Table 14. Average potential water supply diversions (taf). Stony Creek Reservoir options

Diversion and conveyance (cfs)	Existing Rainbow[1]	300 cfs Rainbow	500 cfs Rainbow	750 cfs Rainbow	1,000 cfs Rainbow
Stony Gorge (500)	60				
Stony Gorge (1,000)	90				
Stony Gorge (1,500)	107				
Stony Gorge (2,000)	117				
East Park (800)		60	66	68	69
East Park (1,000)		62	70	74	76
East Park (1,200)		63	71	77	80

[1] The existing Rainbow diversion and conveyance capacity is estimated between 200 and 250 cfs.

Water Supply Contribution

Water supply contribution is the amount of water actually diverted in an operation study to an offstream reservoir from a specific source. Water supply contribution is shown here for the Stony Creek reservoir sources because some of the local entities showed an interest in how much water from Stony Creek was actually being stored in the offstream reservoirs. Table 15 shows the water supply contribution associated with a few source and conveyance packages and is an output from CALSIM. Water supply contribution to an offstream reservoir is dependent on potential water supply diversions and a number of other hydrologic and operational variables that are input to the CALSIM model. These variables include capacity of the offstream reservoir, water supply diversions from other sources, instream flow requirements, Delta conditions, demands, and Delta diversion facilities. Water supply contribution is especially helpful in describing the relative importance of individual water supply sources in multiple source alternatives. Because the Stony Creek reservoir options are in every case combined with other sources, water supply contribution evaluations will be beneficial in determining the effectiveness of these optional sources.

Table 15. Water Supply contribution (taf) from sources to 1.8 maf Sites Reservoir

Conveyance package	Stony Creek	Sacramento River	Colusa Basin Drain	Total
2,000 cfs tunnel from Stony Gorge	117			117
2,100 cfs T-C canal 1,800 cfs GCID canal		143 159		302
2,100 cfs T-C canal 1,800 cfs GCID canal 2,000 cfs tunnel from Stony Gorge	58	127 141		326
2,100 cfs T-C canal 1,800 cfs GCID canal 3,000 cfs canal from CBD		121 134	71	326

In Tables 14 and 15, a 2,000 cfs diversion from Stony Gorge to 1.8 maf Sites Reservoir indicates a potential water supply diversion and water supply contribution of 117 taf, meaning that all of the potential diversion is, in fact, diverted. This formulation is shown for illustrative purposes because this source by itself will not fill the reservoir. If Stony Gorge were the singular source of water supply, the full potential water supply (117 taf) would be contributed from Stony Creek. However, when other sources are added as shown in the third package, the contribution from Stony Creek is reduced by roughly half to 58 taf. This result indicates that by adding conveyance from the Sacramento River, the reservoir is now filling, and not all of the potential supply from Stony Creek can be diverted to offstream storage. In addition, Table 15 indicates that the water supply contributions associated with Stony Creek and Colusa Basin Drain are very similar.

Yield is difficult to assign to a specific source for a project with multiple sources of water. The portion of total water supply contribution from a specific source is an indicator of the yield from that source using a specific project formulation. Yield of a given offstream reservoir project can be determined by computing the difference between deliveries with and without the project and is discussed in the section of Chapter 2 describing CALSIM results.

Other Factors Related to the Stony Creek Options

Factors other than potential water supply diversions, water supply contribution, and yield may be considered in evaluating the upper Stony Creek reservoir diversion options. Using Stony Creek as a water supply source may offer a number of unique advantages compared to other sources. Because the East Park and Stony Gorge diversions are from existing reservoirs, fishery impacts and their associated mitigation costs may be significantly less. While Stony Creek would probably not provide enough water for an offstream reservoir by itself, maximizing diversion from Stony Creek sources would provide opportunities to limit diversions from the Sacramento River, for example. Since potential Stony Creek diversions are at greater elevation than Colusa or Sites Reservoir, no pumping is required and additional hydroelectric power may be generated. All of the other source options must be lifted a minimum of 120 to 320 feet from Funks Reservoir. Many of the source options require an additional lift to get the water to Funks Reservoir.

Finally, conveyance from East Park or Stony Gorge Reservoirs to Sites or Colusa would be independent of existing conveyance systems. All of the other source options are dependent upon T-C Canal at least to get water into Sites or Colusa. As described in the previous analyses, diversions for these other sources were limited to November through March so that existing project operations would not be impacted. This independence described above means that water could continue to be conveyed to offstream storage after deliveries begin in the T-C and GCID service areas.

Operation Studies

After Phase I hydrologic analyses were completed for the North of the Delta Offstream Storage Investigation, operation studies were developed for the projects under consideration. Project operation studies provide helpful information such as water supply yield and impacts associated with proposed projects. Two important characteristics of a surface water project are the size of its increased water supply or yield and the cost of the project. Costs associated with north of the Delta offstream storage projects are being developed and refined. The new or additional yield that a proposed project could generate is predicted by conducting operation studies. An operation study is an accounting process over a historic period using recorded or estimated streamflows. This accounting includes all water hypothetically supplied to, stored in, lost to seepage and evaporation, and released from a proposed reservoir. Operation studies are performed using a computer-based reservoir system simulation model.

CALSIM, DWR's most current operation study model, allows an operation simulation of a project under investigation simultaneously with other major reservoir systems such as the Central Valley Project and the State Water Project. The operation simulation uses the 1922 through 1994 hydrologic sequence. For tributary streams, hydrologic information used in CALSIM is based on the hydrologic analyses described in the first chapter. However, for the Sacramento River, the hydrologic input to CALSIM is the standard Sacramento River hydrologic data set used in all CALSIM studies. CALSIM's predecessor DWRSIM was used extensively by CALFED in its programmatic evaluation of the water resources of the Delta and its tributaries.

For a project operation study, water is released on a schedule representing project water demands at some point in the future (in this investigation, the year 2020). The difference between the total system water delivery with and without the project under investigation is considered to be the water supply yield attributable to the proposed project. The model is run using average monthly flows; whereas water supply hydrology information for various streams was developed using average daily flow data, as previously described. Although the model is running on monthly time steps, the result is refined enough to determine water supply yield estimates that are acceptable for making comparisons between competing alternatives.

The general formulation of CALSIM operation studies is:

- runs on a monthly basis for years 1922 through 1994;
- models operations and flows of the Sacramento and San Joaquin River systems, with coordinated operation of CVP and SWP Reservoirs;
- meets water demands of water users based on historical use, contractual requirements, operational constraints, and available water supply; and
- generates data to estimate water supply, power use and power generation, fishery maintenance flows, recreation use, and Delta flow requirements.

The initial operation studies described here are useful in providing general comparisons of project formulations and operations. Additional refinements and improvements will be made to future operation studies as investigations continue. For Phase I of the North of the Delta Offstream Storage Investigation, 42 CALSIM operation studies were run. These studies included 3 base studies, 31 for the Sites Project, 4 for the Colusa Project, and 4 for the Thomes-Newville Project. These operation studies incorporate various optional sources of water and conveyance facilities for filling the reservoirs to allow identification of a preferred source and conveyance alternative for each project. The 1993 operation studies for the Red Bank Project were considered adequate for this phase of evaluation.

Three base studies were used in this set of modeling studies. Table 16 highlights the general formulations and provides a quantitative comparison of the base studies: Base Study 2, Base Study 6 and Base Study 7. Deliveries shown are the CALSIM estimated total deliveries to SWP and CVP customers, including a surrogate demand. Base Study 2 reflects the standard assumptions including the existing Harvey O. Banks Delta Pumping Plant capacity, existing Trinity River instream flow requirements, and existing Sacramento River operating guidelines for flows. Base Studies 6 and 7 model the effect of increased capacity at Banks Pumping Plant and proposed instream flow requirements for the Trinity River, respectively. The standard assumptions used in the North of the Delta Offstream Storage Investigation operation studies are described in Attachment 2.

Table 16. Base studies of the North of the Delta Offstream Storage Investigation. CALSIM operation studies

Base Study No.	Assumptions	Drought delivery (taf)	Avg. delivery (taf)	Drought yield[2] (taf)	Avg. yield[2] (taf)
2	Standard Assumptions[1]	3,951	5,763	na	na
6	Standard Assumptions + Banks PP = 10,300 cfs	4,030	5,947	79	184
7	Standard Assumptions + proposed Trinity River flows (Average = 595 taf)	3,817	5,723	-134	-40

[1] The Standard Assumptions are described in Attachment 2.
[2] Yield is computed by comparing the delivery to Base Study 2.

The DWR South Delta Improvements Program is proposing facilities and operational change, designed "to (1) improve water levels and circulation in the South Delta channels for local agricultural diversions; and (2) improve South Delta hydraulic conditions to increase diversion into Clifton Court Forebay to maximize the frequency of full pumping capacity at Banks Pumping Plant..” (DWR 1996) Current pumping restrictions at Banks are based on the 1981 Criteria, which limits pumping to 6,680 cfs and a maximum of 8,500 cfs for three months. The SDIP includes proposals to use the full physical capacity at Banks of 10,300 cfs. A comparison of the base studies indicates that without an offstream storage project, increasing the capacity at Banks in the South Delta would increase the average system yield by about 184 taf; drought yield is increased by 79 taf. These yields are computed here for reference by comparing Base Study 6 deliveries and Base Study 2 deliveries. The remaining studies that model the increased pumping capacity at Banks (Studies 11, 12, 13, 14, and 33) are compared against the larger system yield of Base Study 6.

One of the potential operational changes being considered for the CVP is a modification in Trinity River instream flow requirements that would impact diversion from the Trinity to Sacramento Valley CVP reservoirs. U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County have studied and proposed increasing Trinity River instream flows below Lewiston Reservoir from an average existing requirement of 340 taf to 595 taf per year. These proposed instream flow requirements for the Trinity River would reduce the average system yield by about 40 taf; drought yield would be reduced by 134 taf. A yield is computed here for reference by comparing Base Study 7 deliveries and Base Study 2 deliveries. The remaining studies that include the proposed Trinity River flow requirements (Studies 23 and 32) are compared against this lesser system yield indicated in Base Study 7.

Other formulations included in this study set are related to potential flow requirements for the Sacramento River associated with an offstream project. No base studies for potential Sacramento River requirements were run since these requirements are related to offstream storage project operation only. The potential requirements studied include trigger flows of 40,000 and 60,000 cfs and minimum diversion flows of 7,000, 10,000, and 13,000 cfs. A trigger flow is a minimum required flow that must be met at least once in a water year before diversion can be made to an offstream project. Once the trigger is achieved, only current restrictions related to Sacramento River flow would limit diversion. A minimum diversion flow is a continuing requirement that must be met at all times for diversion to offstream storage to be allowed. While there is some reduction in yield for an offstream project associated with potential Sacramento River minimum diversion flows, potential trigger flow yields are reduced more significantly.

For the Sites and Colusa projects, nine possible diversion locations were considered as sources of water to fill the reservoir: the Sacramento River at Red Bluff Diversion Dam; the Sacramento River at the Glenn-Colusa Irrigation District pumps; the Sacramento River at Chico Landing; the Sacramento River at mile 158.5 (opposite Moulton Weir); Colusa Basin Drain; Stony Gorge Reservoir; East Park Reservoir; Thomes Creek at the Tehama-Colusa Canal crossing; and lower Stony Creek at the Glenn-Colusa Canal crossing.

For the Thomes-Newville Project, five possible diversion locations were considered: Thomes Creek about 5 miles upstream from Paskenta; Stony Creek at Black Butte Lake; the Sacramento River at the Red Bluff Diversion Dam; the Sacramento River at the GCID pumps; and Thomes Creek at the T-C Canal crossing. As previously mentioned, early 1990s operation studies of the Red Bank Project were considered sufficient during this phase of the investigation.

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Project Yield

The computation of project yield is one of the most useful outputs from an operation study. Yields are computed by comparing total system-wide deliveries with a proposed project to the deliveries under a base study. The base study is the same study in all ways but without the addition of the project under investigation. Table 17 summarizes the yields or increase in system deliveries for specific north of the Delta offstream storage project formulations completed to date. Average and drought yields have been determined for each study. An average yield is the average increase in system deliveries for the 1922 through 1994 period. Similarly, drought yield is the average increase in system deliveries during the 1928 through 1934 drought period.

Table 17. Increase in system deliveries or yield from CALSIM operation studies of initial project formulations for North of the Delta Offstream Storage Investigation

Study No.	T-C Canal	GCID Canal	New Canal	Chico Landing	Colusa Drain	East Park	Stony Gorge	Thomes Creek	Stony Creek	Base Study	Additional Assumptions[1]	Drought Yield[2] ('28-'34)	Average Yield[2] ('22-'94)
	←------------- Source Conveyance Capacity (cfs) -------------→											←------ (taf) ------→	
1.8 maf Sites Project:													
3	2,100	1,800								2		290	268
3b	2,100									2		159	242
4	2,100	1,800			3000					2		310	277
5	2,100	1,800					1000			2		290	268
8	2,100	1,800					2000			2		296	282
8a							2000			2		36	98
9	2,100	1,800				800				2		292	275
9a	2,100	1,800				1000				2		293	277
10	2,100	1,800				1200				2		295	278
11	2,100	1,800								6	Banks PP[3] = 10,300 cfs	282	349
12	2,100	1,800					1000			6	Banks PP = 10,300 cfs	299	354
13	2,100	1,800				800				6	Banks PP = 10,300 cfs	295	351
14	2,100	1,800			3000					6	Banks PP = 10,300 cfs	315	370
15	2,500	2,500								2		294	282
16	2,500	2,500			3,000					2		336	284
17			5,000		3,000					2		365	284

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Study No.	T-C Canal	GCID Canal	New Canal	Chico Landing	Colusa Drain	East Park	Stony Gorge	Thomes Creek	Stony Creek	Base Study	Additional Assumptions[1]	Drought Yield[2] ('28-'34)	Average Yield[2] ('22-'94)
	←------------- Source Conveyance Capacity (cfs) -------------→											←------ (taf) ------→	
24	2,100	2,900								2		294	279
25	2,100	2,900			3,000					2		336	286
38		5,000			3,000					2		331	286
39		2,900		2100	3,000					2		349	285
40	2,100		2,900		3,000					2		342	284
41	3,200	1,800			3,000					2		339	287
42	5,000				3,000					2		338	288
43				5000	3,000					2		360	284
44	2,100	1,800					1,500			2		293	269
23	2,100	1,800			3,000					7	Proposed Trinity flows	335	274
											Sacramento River Flow Requirement:		
18	2,100	1,800			3,000					2	Diversion Min=7,000 cfs	314	266
19	2,100	1,800			3,000					2	Div Min = 10,000 cfs	277	254
20	2,100	1,800			3,000					2	Div Min = 13,000 cfs	227	251
21	2,100	1,800			3,000					2	Trigger = 40,000 cfs	192	228
22	2,100	1,800			3,000					2	Trigger = 60,000 cfs	160	200
3.0 maf Colusa Project:													
30	2,100	1,800			3,000					2	Div Min = 10,000 cfs	277	313
31	2,100	1,800			3,000					2	Trigger = 60,000 cfs	159	236
32	2,100	1,800			3,000					7	Proposed Trinity flows	398	328
33	2,100	1,800			3,000					6	Banks PP = 10,300 cfs	412	428

Study No.	T-C Canal	GCID Canal	New Canal	Chico Landing	Colusa Drain	East Park	Stony Gorge	Thomes Creek	Stony Creek	Base Study	Additional Assumptions[1]	Drought Yield[2] ('28-'34)	Average Yield[2] ('22-'94)
	←------------- Source Conveyance Capacity (cfs) -------------→											←------ (taf) ------→	
1.9 maf Thomes-Newville Project:													
34								5,000	3,000	2		146	213
35	2,200							5,000	3,000	2		319	275
3.0 maf Thomes-Newville Project:													
36								5,000	3,000	2		146	248
37	2,200							5,000	3,000	2		377	315

[1] All operation studies use Standard Assumptions as described in Attachment 2, except as noted here.
[2] Yields determined by comparing deliveries to those of the base study indicated and described in Table 14.
[3] Harvey O. Banks Delta Pumping Plant

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The average project yields for north of the Delta offstream storage range from 98 to 428 taf. The 98-taf yield is associated with a 2,000 cfs conveyance from Stony Gorge Reservoir for the 1.8 maf Sites Project. This study formulation is not an actual alternative but indicates the maximum amount of yield associated with the Stony Gorge source since no other sources would fill up storage space in the reservoir. The 428-taf yield is associated with the 3.0 maf Colusa Project and increased capacity at Banks Pumping Plant. A basic formulation that includes 1.8 maf Sites Reservoir and diversion from the Sacramento River using existing T-C and GCID conveyance yields 268 taf in average years and 290 taf in drought years.

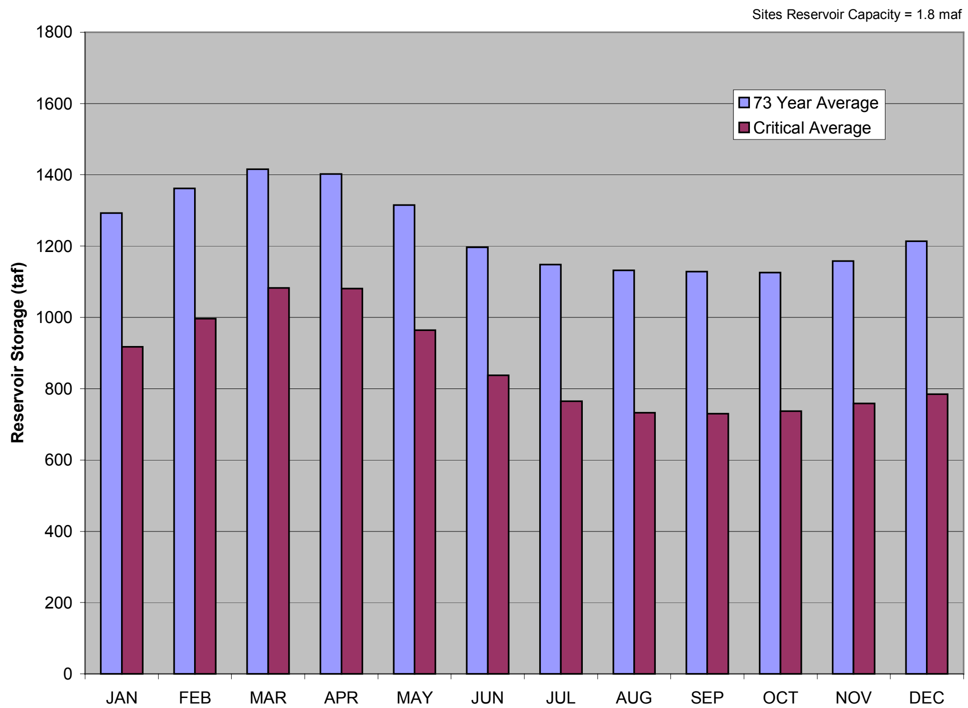
As mentioned previously, potential Sacramento River flow requirements associated with diversion to offstream storage impact project yields to varying degrees. For example, a comparison of Study 4 and Study 18 indicates that a Sacramento River minimum diversion flow requirement of 7,000 cfs reduces the Sites Project drought yield only 4 percent. However, a 60,000 cfs Sacramento River trigger flow requirement reduces the same Sites Project formulation drought yield by 28 percent and the average yield by 48 percent. This estimated yield decrease is based on a comparison of Studies 4 and 22, where the average yield is reduced from 310 taf to 160 taf.

The average yield for the Thomes-Newville Project ranges from 146 taf to 377 taf. The 146 taf yield is associated with a 5,000 cfs diversion from Thomes Creek and a 3,000 cfs diversion from Black Butte Lake to a 1.9 maf Newville Reservoir. An increase in reservoir capacity to 3.0 maf and the addition of 2,200 cfs conveyance from the Sacramento River through T-C Canal increases the average yield to 377 taf. The corresponding drought yields are 213 and 315 taf for the 1.9 and 3.0 maf Thomes-Newville Project formulations respectively.

Project Impacts

In addition to project yield, the operation studies also enable an assessment of impacts to Sacramento River flow and storage in existing reservoirs. By comparing with and without project flows in specific reaches of the river, an estimate of streamflow changes related to north of the Delta offstream project operation could be made. Figure 9 illustrates the average impact of project operation on Sacramento River flows below potential river diversions. The project formulation used for the with-project analysis includes the 1.8 maf Sites Project with Sacramento River diversion and conveyance through existing T-C and GCID canals. This figure is based on data associated with streamflow below the GCID diversion near Hamilton City.

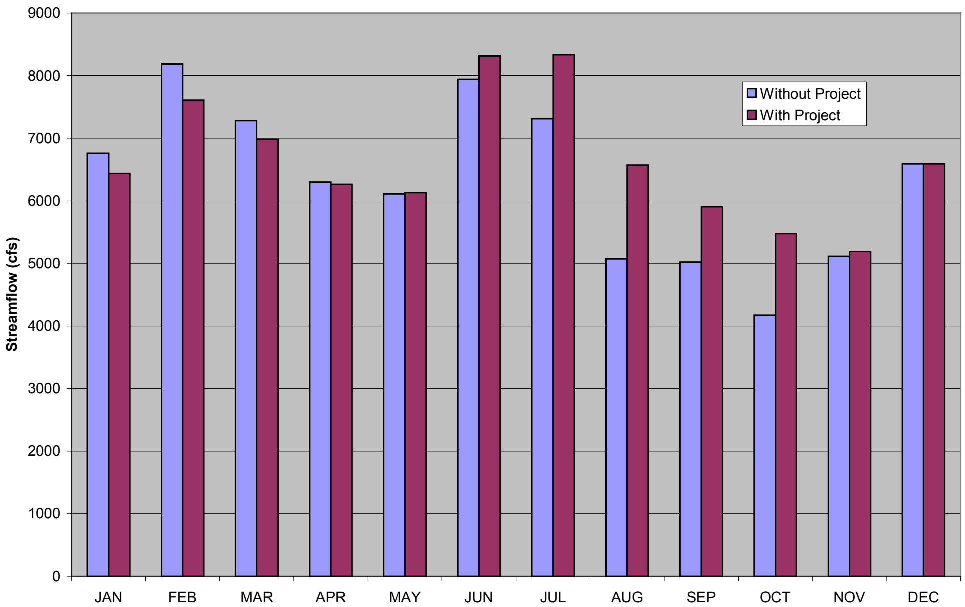
Figure 9. Offstream storage project. Potential Sacramento River streamflow impacts below GCID Canal. 73 year average



Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

In general, average streamflows are reduced November through April and increased July through October. This result is anticipated since diversion to offstream storage is confined to November through March and the additional flows in the river associated with increased deliveries are most apparent July through October. During critical years, flow impacts are more dramatic since the critical average flows are less than the 73 year average. The critical drought years are 1924, 1929, 1931, 1933, 1934, 1976, 1977, 1988, 1990, 1991, 1992, and 1994. Figure 10 shows graphically the critical year Sacramento River streamflow impacts associated with operation of the offstream storage project described above. Again, this figure is based on data associated with streamflows below the GCID diversion near Hamilton City. For this project formulation, critical flows are decreased January through March, but increased June through October.

Figure 10. Offstream storage project. Potential Sacramento River streamflow impacts below GCID Canal. Critical year average

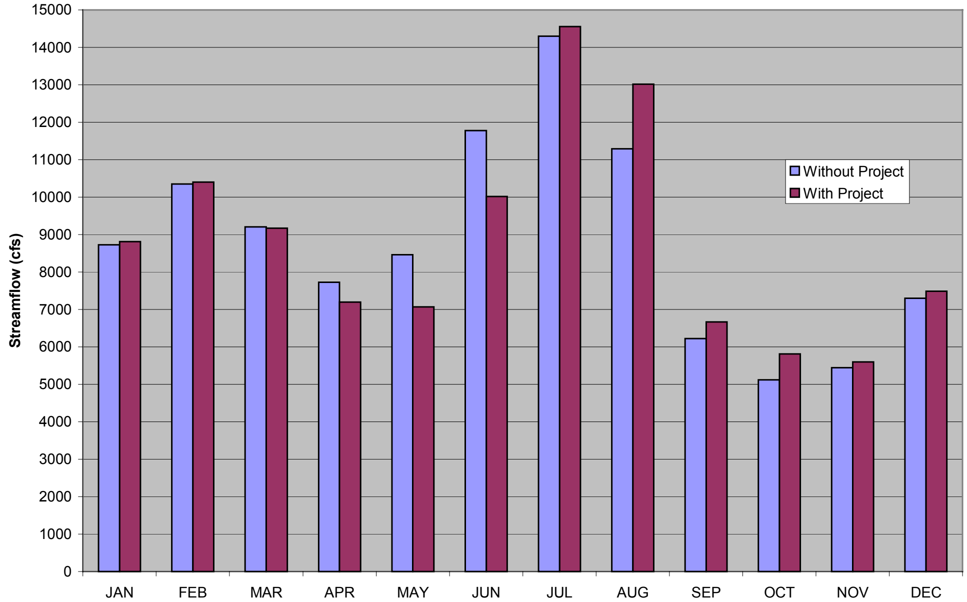


Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

Note that these impacts are specific to the project formulation described above as well as the base condition (without project) previously described. Changes to either the project formulation or the base conditions will alter the results of the impact analysis. However, these evaluations are indicative of the types of impacts that can be anticipated with operation of an offstream reservoir project north of the Delta.

Figures 11 through 14 illustrate the Sacramento River streamflow impacts for the reach below Keswick (downstream of Shasta Dam) and below T-C Canal (downstream of the Red Bluff Diversion Dam). The streamflow impacts below Keswick and below the T-C diversion are generally similar to those previously described for below the GCID diversion, in average and critical years.

Figure 11. Offstream storage project. Potential Sacramento River streamflow impacts below Keswick. 73 year average



Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

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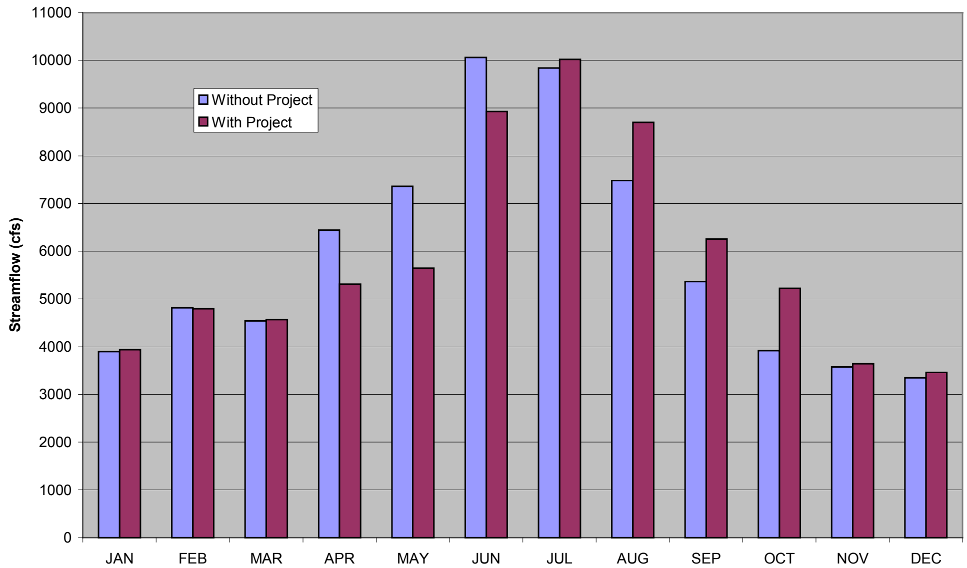
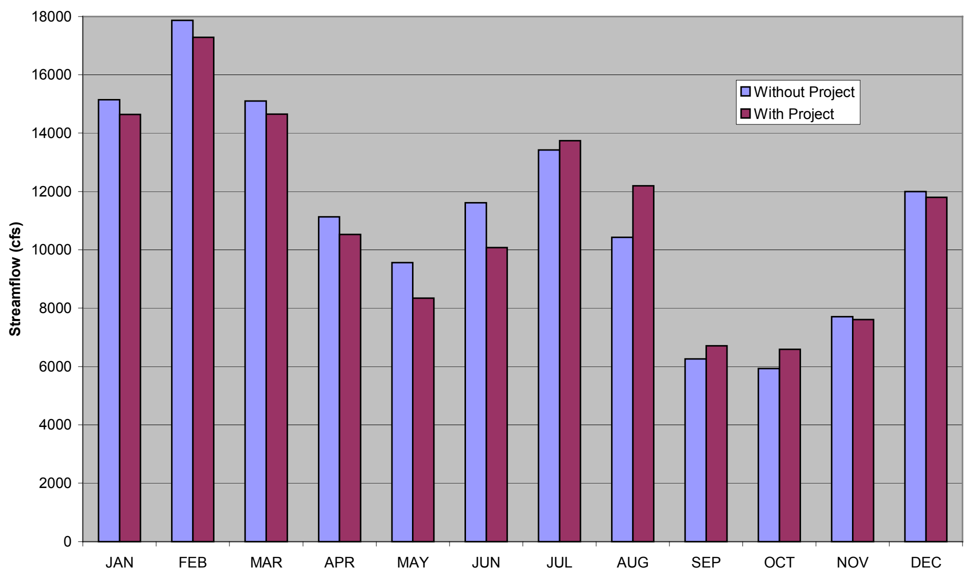
Figure 12. Offstream storage project. Potential Sacramento River streamflow impacts below Keswick. Critical year average



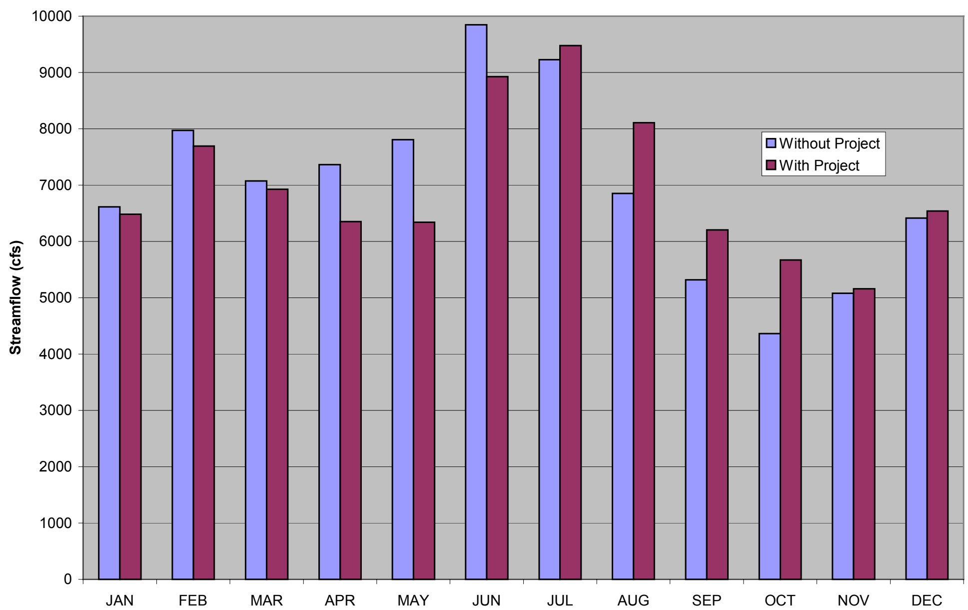
Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

Figure 13. Offstream storage project. Potential Sacramento River impacts below Tehama-Colusa Canal. 73 year average



Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

Figure 14. Offstream storage project. Potential Sacramento River streamflow impacts below Tehama-Colusa Canal. Critical year average

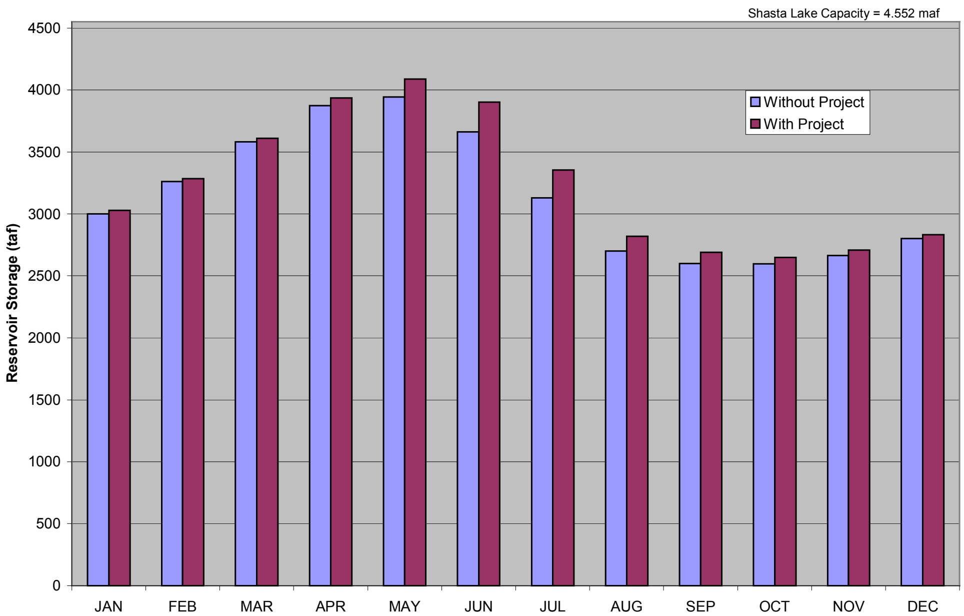


Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

This flow information will be evaluated more thoroughly in Phase II of the investigation. In addition to general overview of flow impacts for the Sacramento River, scientists from the University of California will be assessing potential impacts of the flow changes in the river related to operation of an offstream reservoir project. Two studies will focus on river meander migration impacts and associated habitat evolution impacts. These studies are described in greater detail in Chapter 6 of the *Progress Report*.

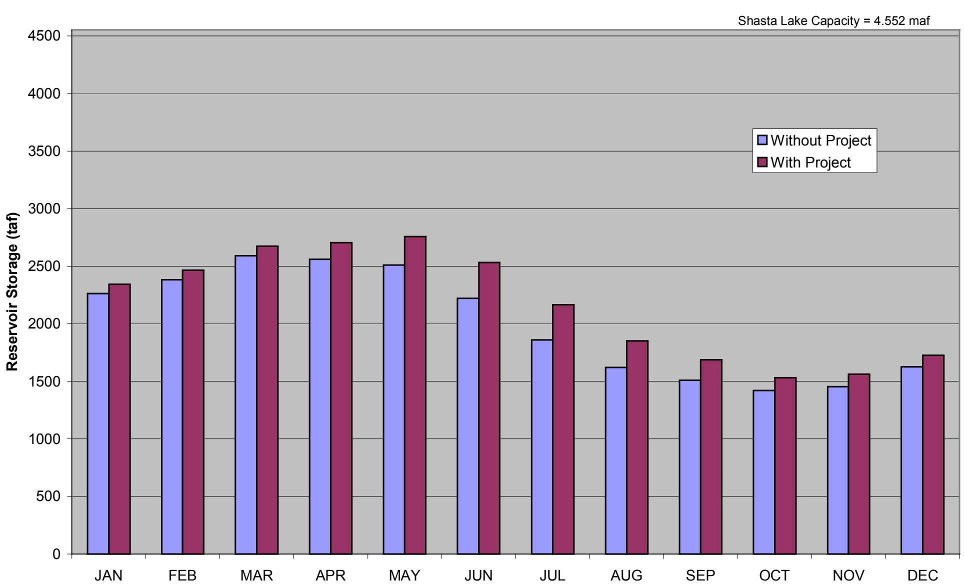
A comparison of storage in Shasta and Oroville reservoirs with and without an offstream project indicates the expected change in storage levels in these existing reservoirs associated with north of the Delta offstream project operation. Figures 15 and 16 illustrate reservoir storage changes for Shasta Lake for average and critical years respectively. In general, storage in Shasta Lake is increased in every month for both average and critical years. The largest increases related to offstream storage operation are anticipated in June and July of critical years, with increases of over 300 taf in storage.

Figure 15. Offstream storage project. Potential Shasta Lake storage impacts. 73 year average



Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

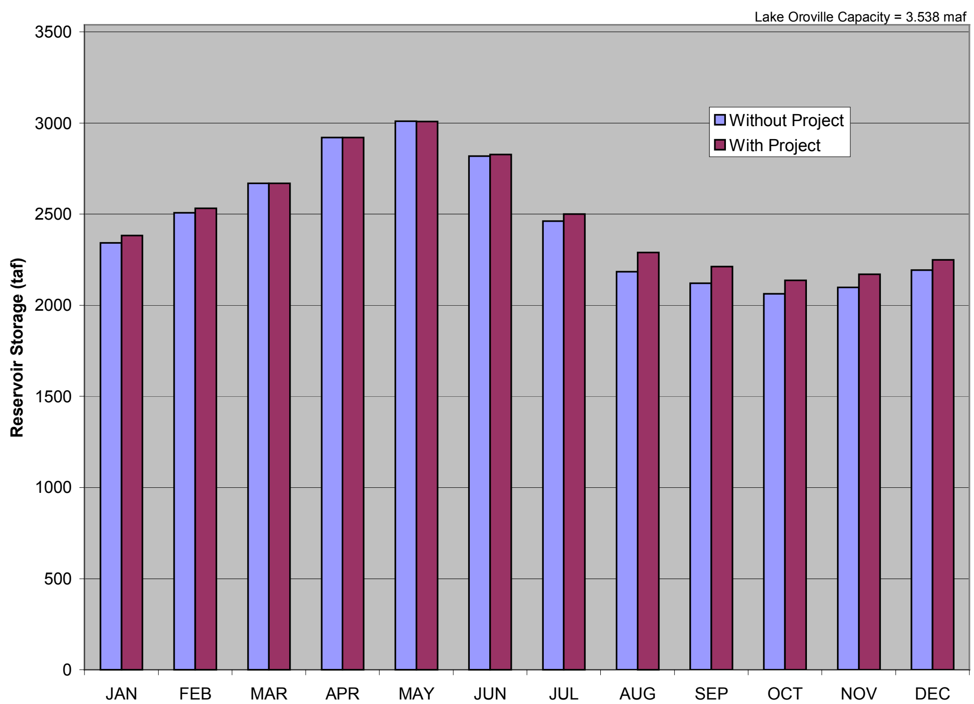
Figure 16. Potential Shasta Lake storage impacts. Critical year average



Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

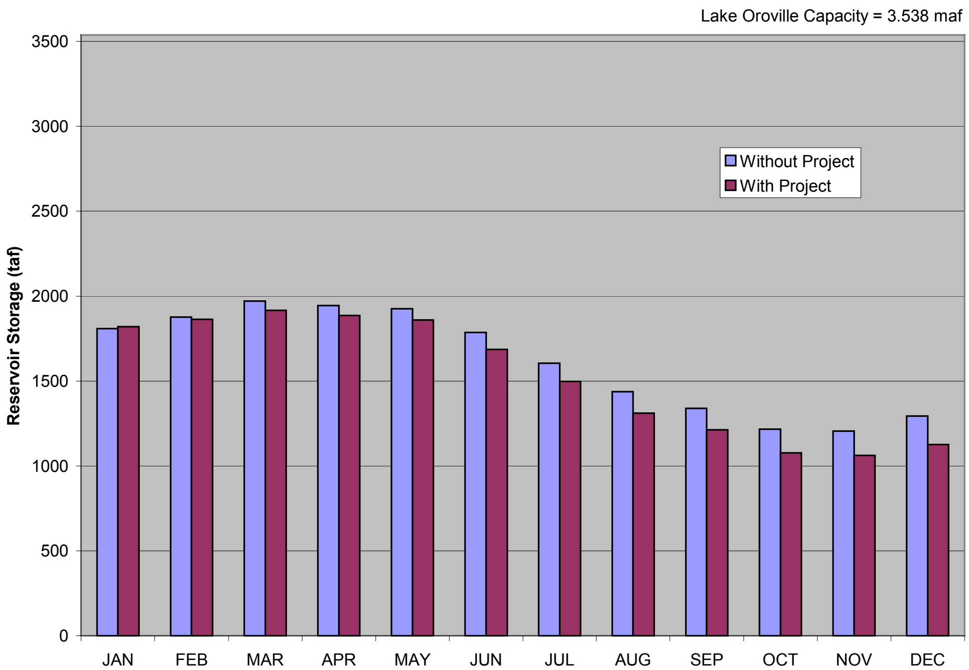
Figures 17 and 18 show the Lake Oroville storage impacts associated with Sites Project operation, using existing conveyance through T-C and GCID canals for both average and critical years. In Oroville, changes in end-of-month storage are significantly less. However, in critical years, there are storage reductions in all months except January. The largest anticipated storage reduction is in December of critical years.

Figure 17. Offstream storage project. Potential Lake Oroville storage impacts. 73 year average



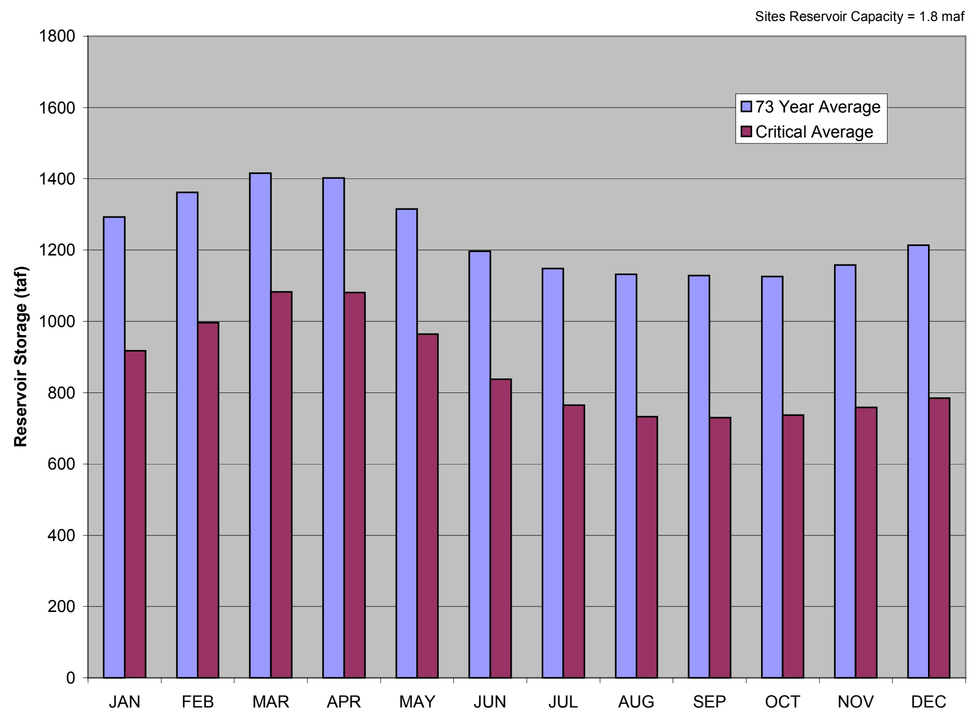
Note: "With Project" includes 1.8 maf Sites Reservoir with existing T-C and GCID Conveyance from Sacramento River

Figure 18. Offstream storage project. Potential Lake Oroville storage impacts. Critical year average



Finally, Figure 19 shows the end-of-month storage of Sites Reservoir using the basic project formulation described previously. Based on this formulation, storage peaks in March or April and reaches a minimum in September or October. Monthly storage levels are typically around 400 acre-feet less in critical years than in average years.

Figure 19. Sites Project reservoir storage



Note: Sites project includes 1.8 maf Sites Reservoir with existing T-C and GCID conveyance from Sacramento River

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ATTACHMENT 1

Phase 1 Hydrology – Tables and Graphs

This attachment contains tables and graphs summarizing flow for the following stream; and for some, divertible flow and divertible flow by range. These tables are presented here as illustrative examples. The full range of data is available in California Department of Water Resources Northern District office.

- Stony Creek at Stony Gorge Reservoir..........................Tables 1-1, 1-2, 1-3
- Grindstone Creek at Grindstone Reservoir .... Tables 1-4, 1-5
- Stony Creek below Black Butte Lake ....Tables 1-6, 1-7, 1-8; Figure 1-1
- Little Stony Creek at East Park Reservoir........................... Tables 1-9, 1-10
- Thomes Creek at Paskenta....................Tables 1-11, 1-12, 1-13; Figure 1-2
- South Fork Cottonwood Creek ....Tables 1-14, 1-15, 1-16; Figure 1-3
- Red Bank Creek....................................Tables 1-17, 1-18, 1-19; Figure 1-4
- Colusa Basin Drain at Highway 20........Tables 1-20, 1-21, 1-22; Figure 1-5
- Sacramento River at Butte City.............Tables 1-23, 1-24, 1-25; Figure 1-6

Table 1-1. Monthly Inflow to Stony Gorge Reservoir

Summarized from daily inflows obtained from USBR data sheets
and from digital data obtained from the Willows USBR ofice.

	Inflow to Stony Gorge (TAF/Month)										Water
								Nov-Mar	Nov-Apr	Nov-May	Year
Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Total	Total	Total	Class
1945	6.9	10.3	5.2	25.8	7.0	17.5	7.4	55.2	72.7	80.1	B
1946	7.8	72.4	37.5	12.3	9.5	11.2	4.8	139.4	150.7	155.5	A
1947	6.5	5.6	0.8	12.2	15.6	4.5	1.4	40.7	45.2	46.6	D
1948	2.3	2.2	11.1	1.5	4.4	27.8	10.1	21.5	49.3	59.5	A
1949	1.3	1.7	1.9	5.8	61.8	29.6	10.5	72.4	102.0	112.5	D
1950	2.4	1.1	11.0	16.6	11.4	19.0	9.8	42.5	61.5	71.3	B
1951	11.6	39.1	53.7	52.0	25.4	9.8	15.5	181.8	191.6	207.1	W
1952	4.5	39.8	67.1	76.9	51.8	38.4	25.4	240.0	278.4	303.8	W
1953	4.7	46.8	116.5	17.6	23.0	22.6	18.1	208.5	231.1	249.2	W
1954	5.4	1.6	39.0	42.0	36.3	39.5	12.2	124.3	163.9	176.1	A
1955	8.1	11.2	4.3	1.7	2.0	8.6	10.6	27.2	35.9	46.5	D
1956	2.0	86.3	118.0	86.7	33.3	22.3	20.8	326.2	348.6	369.4	W
1957	1.3	1.0	7.3	33.0	22.4	14.6	18.6	64.9	79.5	98.1	B
1958	4.2	17.1	46.2	213.9	92.3	79.7	28.5	373.7	453.4	481.9	W
1959	2.7	2.1	19.6	34.8	18.2	10.0	12.9	77.4	87.3	100.3	D
1960	0.2	2.0	6.1	46.6	29.6	15.4	9.2	84.4	99.8	109.0	B
1961	5.4	17.0	9.9	20.5	9.9	13.7	9.9	62.7	76.4	86.3	D
1962	4.8	9.6	2.5	34.0	35.1	19.0	9.8	86.0	105.0	114.8	B
1963	3.4	8.0	4.9	69.7	28.1	70.5	23.4	114.2	184.6	208.0	W
1964	10.7	1.0	10.2	2.6	3.3	4.3	9.3	27.7	32.0	41.3	D
1965	9.9	121.0	100.0	24.6	19.2	50.2	20.3	274.7	324.9	345.2	W
1966	14.3	4.9	38.4	41.0	21.4	27.0	15.3	120.1	147.1	162.4	B
1967	10.0	29.4	68.7	39.9	31.7	34.2	35.4	179.7	213.9	249.4	W
1968	1.8	6.4	26.4	65.2	28.1	11.8	13.7	127.9	139.7	153.3	B
1969	3.6	20.7	100.1	98.0	63.8	40.8	26.9	286.2	327.1	353.9	W
1970	2.3	36.8	171.2	53.2	30.8	12.4	15.6	294.4	306.8	322.4	W
1971	11.0	50.1	53.0	21.2	44.5	23.2	19.4	179.8	203.0	222.4	W
1972	6.9	7.4	10.6	6.7	16.5	14.7	20.7	48.1	62.8	83.4	B
1973	10.6	21.4	72.3	118.9	59.0	25.9	12.9	282.2	308.1	321.0	W
1974	38.6	49.1	107.0	27.9	80.4	53.9	23.4	302.9	356.8	380.2	W
1975	4.1	5.2	4.6	55.1	94.3	32.4	23.2	163.3	195.7	219.0	A
1976	2.3	2.2	1.6	2.8	2.4	16.3	0.6	11.3	27.6	28.2	C
1977	0.8	0.5	0.7	0.7	0.9	8.9	-1.5	3.6	12.5	10.9	C
1978	1.1	17.4	111.2	89.5	64.8	30.7	28.2	283.9	314.6	342.8	W
1979	0.6	0.8	10.4	24.2	37.6	18.0	11.6	73.7	91.7	103.3	D
1980	6.5	19.8	108.7	133.1	53.4	21.8	10.8	321.5	343.3	354.1	W
1981	5.0	4.8	23.3	20.5	21.0	13.2	4.0	74.7	87.9	91.8	D
1982	33.6	63.9	61.7	60.5	55.3	90.5	24.6	275.0	365.5	390.1	W
1983	17.6	50.2	111.9	152.0	176.8	67.0	50.0	508.6	575.6	625.6	W
1984	44.9	132.8	25.7	31.9	26.9	12.3	9.3	262.3	274.6	283.8	W
1985	29.8	17.3	0.6	7.9	10.4	19.3	7.6	66.0	85.3	92.9	D
1986	3.1	8.1	31.7	242.8	94.4	18.5	8.4	380.1	398.7	407.0	W
1987	1.3	1.9	2.6	8.9	23.5	4.0	9.6	38.1	42.1	51.7	C
1988	1.4	22.0	50.7	16.1	5.9	4.9	5.6	96.1	101.0	106.6	C
1989	4.5	0.8	2.5	1.6	44.8	10.7	4.8	54.2	64.9	69.7	B
1990	1.8	0.8	7.5	8.3	10.6	9.8	11.2	29.1	38.9	50.1	C
1991	3.1	0.5	0.6	3.6	35.7	18.5	7.7	43.5	62.0	69.6	C
1992	0.2	1.2	1.8	39.6	28.0	8.7	4.4	70.9	79.6	84.0	C
1993	0.9	29.5	120.5	100.3	52.6	20.5	16.4	303.9	324.4	340.8	W
1994	1.4	5.3	4.0	15.3	12.0	3.7	3.3	38.0	41.7	45.0	D
Total								7564.8	8766.6	9478.0	
Min	0.2	0.5	0.6	0.7	0.9	3.7	-1.5	3.6	12.5	10.9	
Max	44.9	132.8	171.2	242.8	176.8	90.5	50.0	508.6	575.6	625.6	
Average	7.4	22.2	40.1	46.3	35.3	24.0	14.2	151.3	175.3	189.6	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-2. Divertible Flows of Stony Gorge Inflow
1500 cfs Diversion Capacity (TAF/Month)

<u>Contraints:</u>
Stony Creek Bl S.G. Instream Demand = 25 cfs
Sac. R. @ Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo and Delta Outflow in Surplus
Stony Gorge Reservoir must be full

Water Year	Nov	Dec	Jan	Feb	Mar	Nov - Mar Total (TAF)	End of Mar Storage (TAF)	Water Year Class
1945	0.0	0.0	0.0	0.0	3.4	3.4	50.3	B
1946	0.0	19.9	35.9	0.0	7.9	63.8	50.3	A
1947	0.0	0.0	0.0	0.0	0.0	0.0	41.8	D
1948	0.0	0.0	0.0	0.0	0.0	0.0	22.2	A
1949	0.0	0.0	0.0	0.0	24.2	24.2	50.3	D
1950	0.0	0.0	0.0	0.0	0.0	0.0	44.5	B
1951	0.0	7.3	34.2	44.8	23.9	110.2	50.3	W
1952	0.0	1.0	58.4	54.7	50.1	164.2	50.3	W
1953	0.0	7.1	70.0	16.2	21.4	114.7	50.3	W
1954	0.0	0.0	1.1	34.7	33.8	69.6	50.3	A
1955	0.0	0.0	0.0	0.0	0.0	0.0	29.1	D
1956	0.0	21.3	77.3	47.6	31.8	177.9	50.3	W
1957	0.0	0.0	0.0	0.0	18.1	18.1	50.3	B
1958	0.0	0.0	15.8	82.2	66.6	164.6	50.3	W
1959	0.0	0.0	0.0	12.9	0.0	12.9	50.2	D
1960	0.0	0.0	0.0	9.2	27.4	36.6	50.3	B
1961	0.0	0.0	0.0	5.0	8.4	13.4	50.3	D
1962	0.0	0.0	0.0	0.0	28.7	28.7	50.3	B
1963	0.0	0.0	0.0	36.1	9.9	46.0	50.3	W
1964	0.0	0.0	0.0	0.0	0.0	0.0	30.3	D
1965	0.0	25.6	70.2	23.2	0.0	119.0	50.3	W
1966	0.0	0.0	12.7	32.7	19.9	65.3	50.3	B
1967	0.0	0.0	27.5	32.9	29.0	89.5	50.3	W
1968	0.0	0.0	0.0	35.5	26.6	62.1	50.3	B
1969	0.0	0.0	48.1	72.1	60.6	180.8	50.3	W
1970	0.0	0.0	63.6	49.3	29.3	142.2	50.3	W
1971	0.0	17.7	37.8	0.0	36.5	92.0	50.3	W
1972	0.0	0.0	0.0	0.0	0.7	0.7	50.3	B
1973	0.0	0.0	44.4	67.8	55.5	167.7	50.3	W
1974	0.0	40.6	56.0	26.5	56.3	179.4	50.3	W
1975	0.0	0.0	0.0	20.0	68.4	88.4	50.3	A
1976	0.0	0.0	0.0	0.0	0.0	0.0	12.2	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	9.9	C
1978	0.0	0.0	49.3	59.0	53.6	162.0	50.3	W
1979	0.0	0.0	0.0	0.0	25.8	25.8	50.3	D
1980	0.0	0.0	40.4	50.5	49.0	139.9	50.3	W
1981	0.0	0.0	0.0	3.8	19.5	23.3	50.3	D
1982	0.0	31.1	58.1	41.6	43.4	174.2	50.3	W
1983	0.0	19.2	45.6	77.3	90.4	232.5	50.3	W
1984	3.0	62.8	25.0	29.6	25.4	145.8	50.3	W
1985	0.0	3.7	0.0	5.5	8.9	18.1	50.3	D
1986	0.0	0.0	0.0	66.0	63.5	129.6	50.3	W
1987	0.0	0.0	0.0	0.0	0.0	0.0	40.9	C
1988	0.0	0.0	29.2	0.0	0.0	29.2	50.2	C
1989	0.0	0.0	0.0	0.0	2.8	2.8	50.3	B
1990	0.0	0.0	0.0	0.0	0.0	0.0	25.0	C
1991	0.0	0.0	0.0	0.0	0.0	0.0	44.1	C
1992	0.0	0.0	0.0	0.0	23.8	23.8	50.3	C
1993	0.0	0.0	57.4	61.8	50.6	169.7	50.3	W
1994	0.0	0.0	0.0	0.0	0.0	0.0	30.1	D
Total						3512.0		
Min	0.0	0.0	0.0	0.0	0.0	0.0	9.9	
Max	3.0	62.8	77.3	82.2	90.4	232.5	50.3	
Average	0.1	5.1	19.2	22.0	23.9	70.2	45.8	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

This analysis is for a 1500 cfs diversion capacity.
As stated above, the Delta and Sacramento River at Wilkins Slough must be in surplus if diversions are to occur.
The instream demand of Stony Creek has been set to 25 cfs, which must be met prior to diversions.
Assume Stony Gorge Capacity = 9.9 TAF every November 1 which is historic 1945-94 average end of October storage
Maximum Reservoir Capacity = 50.3 TAF = Capacity at Spillway
Minimum Reservoir Capacity to Divert = 50.3 TAF = **FULL**
Inflow exceeding maximum storage capacity and diversion capacity is released down Stony Creek.

Table 1-3. Divertible Flows of Stony Gorge Inflow

1500 cfs Diversion Capacity (TAF/Month)

Contraints:

Stony Creek Bl S.G. Instream Demand = 25 cfs

Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo and Delta Outflow in Surplus

Limit usage of Stony Gorge storage to upper 30 TAF

Water Year	Nov	Dec	Jan	Feb	Mar	Nov - Mar Total (TAF)	End of Mar Storage (TAF)	Water Year Class
1945	0.0	3.7	0.0	24.2	5.5	33.4	20.3	B
1946	0.0	38.7	64.0	0.0	7.9	110.7	20.3	A
1947	0.0	0.0	0.0	7.5	14.0	21.5	20.3	D
1948	0.0	0.0	0.0	0.0	1.9	1.9	20.3	A
1949	0.0	0.0	0.0	0.0	54.8	54.8	20.3	D
1950	0.0	0.0	0.0	14.4	9.9	24.2	20.3	B
1951	0.0	37.3	44.5	58.3	23.9	163.9	20.3	W
1952	0.0	25.5	70.1	76.4	50.2	222.2	20.3	W
1953	0.0	38.1	83.8	32.8	21.4	176.1	20.3	W
1954	0.0	0.0	31.1	40.6	34.8	106.4	20.3	A
1955	0.0	5.8	2.7	0.0	0.3	8.8	20.3	D
1956	0.0	38.7	92.2	76.5	58.8	266.3	20.3	W
1957	0.0	0.0	0.0	16.0	32.0	48.1	20.3	B
1958	0.0	7.9	36.0	83.3	92.2	219.5	47.0	W
1959	0.0	0.0	9.5	33.4	0.0	42.9	20.2	D
1960	0.0	0.0	0.0	39.2	28.0	67.3	20.3	B
1961	0.0	8.4	7.6	19.1	8.4	43.4	20.3	D
1962	0.0	0.0	0.0	28.3	33.5	61.8	20.3	B
1963	0.0	0.0	1.4	68.3	9.9	79.5	20.3	W
1964	0.0	0.0	7.1	1.3	1.5	10.0	20.3	D
1965	0.0	29.8	92.2	37.5	0.0	159.5	20.3	W
1966	2.5	3.4	36.9	39.6	19.9	102.2	20.3	B
1967	0.0	26.6	32.7	62.9	30.1	152.4	20.3	W
1968	0.0	0.0	20.6	49.9	40.7	111.1	20.3	B
1969	0.0	10.3	63.9	83.3	90.4	248.0	20.3	W
1970	0.0	26.0	68.3	80.6	29.3	204.2	20.3	W
1971	0.0	47.7	51.5	0.0	39.6	138.8	23.6	W
1972	0.0	1.4	9.0	5.2	15.0	30.7	20.3	B
1973	0.0	18.6	63.9	83.3	86.0	251.8	20.3	W
1974	26.7	47.5	68.1	44.6	64.8	251.8	34.3	W
1975	0.0	0.0	0.0	52.6	76.4	129.1	36.6	A
1976	0.0	0.0	0.0	0.0	0.0	0.0	12.2	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	9.9	C
1978	0.0	6.0	82.6	83.3	77.0	248.9	20.3	W
1979	0.0	0.0	0.0	21.5	36.1	57.6	20.3	D
1980	0.0	9.1	80.1	61.7	81.3	232.2	20.3	W
1981	0.0	0.0	14.6	19.1	19.5	53.3	20.3	D
1982	21.9	48.0	74.5	56.2	46.3	247.0	30.7	W
1983	5.8	48.6	45.9	83.3	92.2	275.8	50.3	W
1984	33.0	78.7	54.8	30.5	25.4	222.4	20.3	W
1985	18.0	15.8	0.0	5.5	8.9	48.1	20.3	D
1986	0.0	0.0	20.2	78.3	92.2	190.7	31.3	W
1987	0.0	0.0	0.0	0.0	20.6	20.6	20.3	C
1988	0.0	10.1	49.1	0.0	0.0	59.2	20.2	C
1989	0.0	0.0	0.0	0.0	32.8	32.8	20.3	B
1990	0.0	0.0	0.0	0.0	4.7	4.7	20.3	C
1991	0.0	0.0	0.0	0.0	23.8	23.8	20.3	C
1992	0.0	0.0	0.0	28.0	26.5	54.5	20.3	C
1993	0.0	15.8	86.1	83.3	70.9	256.1	20.3	W
1994	0.0	0.0	0.0	9.8	0.0	9.8	20.3	D
Total						5579.8		
Min	0.0	0.0	0.0	0.0	0.0	0.0	9.9	
Max	33.0	78.7	92.2	83.3	92.2	275.8	50.3	
Average	2.2	13.0	29.3	34.4	32.8	111.6	22.2	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

This analysis is for a 1500 cfs diversion capacity.
As stated above, the Delta and Sacramento River at Wilkins Slough must be in surplus if diversions are to occur.
The instream demand of Stony Creek has been set to 25 cfs, which must be met prior to diversions.
Assume Stony Gorge Capacity = 9.9 TAF every November 1 which is historic 1945-94 average end of October storage.
Maximum Reservoir Capacity = 50.3 TAF = Capacity at Spillway.
Minimum Reservoir Capacity to Divert = 20.3 TAF, use 30 TAF of storage to maximize diversions.
Inflow exceeding maximum storage capacity and diversion capacity is released down Stony Creek.

Table 1-4. Estimated Monthly Inflow to proposed Grindstone Reservoir

Based on measured flow of Grindstone Creek near Elk Creek (USGS 11386500) for 1965 – 1972 and correlation with Elder Creek near Paskenta (USGS 11379500; 1948 – 1995) and Thomes Creek at Paskenta (USGS 11382000; 1920 – 1997) for missing years.
Proposed Grindstone Reservoir Dam located on Grindstone Creek in T21N R6W Sec 18.

		Inflow to Grindstone (TAF/Month)				Nov-Mar	Water Year
Water Year	Nov	Dec	Jan	Feb	Mar	Total	Class
1945	1.6	5.7	1.5	17.1	2.1	28.1	B
1946	4.9	36.5	18.4	2.8	9.2	71.8	A
1947	1.6	1.1	0.0	7.7	12.4	22.8	D
1948	0.1	0.0	16.3	0.6	1.2	18.2	A
1949	0.0	0.7	0.1	2.2	51.5	54.4	D
1950	0.0	0.0	5.9	8.6	6.4	20.8	B
1951	3.6	17.5	19.2	21.1	5.7	67.1	W
1952	0.7	29.8	29.4	30.7	28.5	119.1	W
1953	0.9	35.6	46.7	8.6	6.2	97.9	W
1954	2.3	0.0	42.4	29.9	23.0	97.6	A
1955	4.3	7.8	1.8	0.2	0.2	14.3	D
1956	0.6	67.9	62.4	45.0	17.1	192.9	W
1957	0.0	0.0	2.6	26.2	13.3	42.1	B
1958	0.8	12.5	32.2	170.3	61.2	277.0	W
1959	0.0	0.0	13.8	20.8	7.3	41.9	D
1960	0.0	0.0	1.8	37.3	16.6	55.7	B
1961	0.1	7.7	9.8	20.6	7.8	46.0	D
1962	0.8	2.6	0.6	22.4	17.2	43.5	B
1963	1.0	4.2	10.6	39.7	16.9	72.4	W
1964	7.1	0.1	4.8	0.4	0.0	12.4	D
1965	9.6	72.5	49.5	8.3	3.9	143.7	W
1966	4.2	4.0	25.1	11.6	14.8	59.8	B
1967	4.0	14.7	36.4	13.0	13.3	81.3	W
1968	0.3	2.9	13.2	32.5	12.1	61.1	B
1969	1.1	7.5	70.7	35.1	32.8	147.1	W
1970	0.5	15.1	127.7	23.2	14.4	181.0	W
1971	8.0	31.6	50.2	11.6	36.9	138.3	W
1972	1.4	3.8	13.0	11.9	21.4	51.5	B
1973	15.5	17.7	46.2	51.3	31.7	162.4	W
1974	31.8	31.4	77.7	11.0	48.9	200.8	W
1975	0.0	4.2	0.7	31.8	70.0	106.7	A
1976	0.0	0.0	0.0	1.3	0.7	2.0	C
1977	0.0	0.0	0.0	0.0	0.9	0.9	C
1978	0.8	15.1	90.4	45.2	46.5	198.0	W
1979	0.0	0.0	4.7	11.7	21.6	38.0	D
1980	4.2	7.3	35.8	63.5	22.0	132.7	W
1981	0.0	6.2	32.5	15.5	15.2	69.5	D
1982	20.1	37.7	18.3	29.2	27.9	133.2	W
1983	5.4	29.4	54.7	77.1	134.5	301.1	W
1984	17.3	72.5	15.8	6.0	6.7	118.3	W
1985	17.2	7.0	0.1	4.9	2.9	32.1	D
1986	0.5	3.4	14.7	115.8	45.7	180.1	W
1987	0.0	0.0	0.0	4.0	12.0	16.0	C
1988	0.0	19.6	20.3	5.4	2.7	48.0	C
1989	2.9	0.1	0.6	0.0	26.8	30.5	B
1990	0.0	0.0	3.4	0.2	0.8	4.4	C
1991	0.0	0.0	0.0	0.1	24.4	24.5	C
1992	0.0	0.9	2.4	34.2	35.4	73.0	C
1993	0.0	8.3	42.4	42.6	33.8	127.2	W
1994	0.0	0.1	1.4	6.1	2.6	10.2	D
Total						4269.5	
Min	0.0	0.0	0.0	0.0	0.0	0.9	
Max	31.8	72.5	127.7	170.3	134.5	301.1	
Average	3.5	12.9	23.4	24.3	21.3	85.4	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-5. Divertible Flows of Grindstone Inflow

750 cfs Diversion Capacity (TAF/Month)

Contraints:
Grindstone Creek Instream Demand = 25 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

Grindstone Reservoir Operating Capacity = 67 TAF
Stony Gorge Reservoir to Sites Reservoir Diversion Capacity = 1500 cfs
Stony Gorge Reservoir must be full to divert.

Water Year	Nov	Dec	Jan	Feb	Mar	Nov - Mar Total (TAF)	end of Mar Storage (TAF)	Total (TAF)	Water Year Class
1945	1.1	4.7	0.0	15.7	1.4	22.9	0.0	22.9	B
1946	4.2	9.4	37.5	5.2	7.7	63.9	0.0	63.9	A
1947	1.1	0.8	0.0	7.1	10.9	19.9	0.0	19.9	D
1948	0.0	0.0	12.3	0.0	0.7	13.1	0.0	13.1	A
1949	0.0	0.4	0.0	1.7	37.3	39.5	12.6	52.1	D
1950	0.0	0.0	5.1	7.3	5.1	17.5	0.0	17.5	B
1951	3.1	16.0	11.9	25.7	4.2	60.9	0.0	60.9	W
1952	0.4	16.4	23.7	27.2	36.0	103.7	9.6	113.3	W
1953	0.7	30.8	18.7	37.0	4.6	91.9	0.0	91.9	W
1954	2.1	0.0	23.8	33.7	34.0	93.7	0.0	93.7	A
1955	3.8	6.6	1.0	0.0	0.0	11.4	0.0	11.4	D
1956	0.0	15.2	13.6	30.2	45.5	104.6	36.8	141.3	W
1957	0.0	0.0	2.3	8.9	28.7	39.9	0.0	39.9	B
1958	0.4	11.7	15.6	1.1	23.7	52.5	67.0	119.5	W
1959	0.0	0.0	12.5	19.4	0.0	31.9	0.0	31.9	D
1960	0.0	0.0	1.3	35.9	15.0	52.3	0.0	52.3	B
1961	0.0	7.0	6.4	20.3	6.3	40.0	0.0	40.0	D
1962	0.0	2.4	0.0	21.3	15.6	39.3	0.0	39.3	B
1963	0.9	3.4	2.3	32.9	14.3	53.7	0.0	53.7	W
1964	6.0	0.0	4.2	0.1	0.0	10.3	0.0	10.3	D
1965	2.4	4.8	21.8	41.6	29.9	100.5	0.0	100.5	W
1966	3.1	2.5	23.5	10.3	13.3	52.7	0.0	52.7	B
1967	3.0	13.1	5.5	35.4	17.2	74.3	0.0	74.3	W
1968	0.0	1.5	11.8	12.2	29.5	55.0	0.0	55.0	B
1969	0.1	6.0	13.3	11.3	31.3	62.0	64.8	126.8	W
1970	0.0	14.0	3.8	30.6	45.4	93.8	24.2	118.0	W
1971	6.6	30.1	19.9	28.8	19.7	105.1	15.7	120.7	W
1972	0.8	2.3	11.5	9.5	20.9	44.9	0.0	44.9	B
1973	14.5	16.7	17.3	14.8	32.7	96.0	57.3	153.3	W
1974	26.2	29.2	22.8	41.0	32.2	151.4	42.1	193.5	W
1975	0.0	3.9	0.4	29.9	14.1	48.3	54.9	103.2	A
1976	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.5	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	13.5	25.1	22.8	30.0	91.4	53.5	144.9	W
1979	0.0	0.0	4.3	10.8	13.3	28.4	6.8	35.2	D
1980	3.3	6.6	19.1	18.7	34.1	81.7	45.1	126.8	W
1981	0.0	6.0	15.1	30.8	13.7	65.6	0.0	65.6	D
1982	19.2	14.3	32.7	22.4	34.9	123.5	2.8	126.3	W
1983	4.7	21.1	11.6	6.0	1.8	45.2	67.0	112.2	W
1984	16.2	15.5	45.9	28.4	5.1	111.1	0.0	111.1	W
1985	16.1	5.6	0.0	3.8	1.5	26.9	0.0	26.9	D
1986	0.0	3.1	9.9	15.9	23.8	52.8	60.9	113.7	W
1987	0.0	0.0	0.0	3.5	10.5	14.0	0.0	14.0	C
1988	0.0	17.8	18.7	0.0	0.0	36.5	0.0	36.5	C
1989	0.0	0.0	0.0	0.0	25.3	25.3	0.0	25.3	B
1990	0.0	0.0	2.8	0.0	0.4	3.3	0.0	3.3	C
1991	0.0	0.0	0.0	0.0	23.0	23.0	0.0	23.0	C
1992	0.0	0.0	1.2	29.8	36.8	67.8	0.0	67.8	C
1993	0.0	6.8	18.3	19.2	38.1	82.4	39.8	122.2	W
1994	0.0	0.0	1.2	5.1	0.0	6.4	0.0	6.4	D
Total						2732.3		3393.1	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	26.2	30.8	45.9	41.6	45.5	151.4	67.0	193.5	
Average	2.8	7.2	11.0	16.3	17.4	54.6	13.2	67.9	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

*Note: End of March storage will be diverted to Sites Reservoir via Stony Gorge reservoir as possible during subsequent months.

Table 1-6. Monthly Flows of Stony Creek below Black Butte Lake

Data for years 1956-1994 is for Stony Creek below Black Butte USGS 11388000.
Data for years 1945-1955 is based on correlation with Stony Creek near Hamilton City USGS 11388500.

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
		Stony Creek below Black Butte Lake (TAF/Month)									
1945	6.2	11.9	11.1	33.2	15.8	17.6	7.3	78.2	95.8	103.2	B
1946	8.9	130.1	65.5	15.1	16.4	19.3	6.4	236.0	255.3	261.7	A
1947	5.8	6.0	6.0	14.8	23.8	8.4	6.0	56.4	64.8	70.9	D
1948	5.8	6.0	9.2	5.6	6.0	30.0	17.9	32.7	62.6	80.5	A
1949	5.8	6.0	6.0	6.6	106.6	36.5	10.4	131.0	167.5	178.0	D
1950	5.8	6.0	13.8	27.2	26.3	13.5	6.8	79.1	92.6	99.4	B
1951	9.5	70.0	83.4	80.6	38.8	7.6	7.4	282.4	290.1	297.5	W
1952	8.8	50.8	129.1	142.5	101.6	64.6	27.8	432.7	497.3	525.1	W
1953	6.0	83.5	209.7	26.3	21.9	25.4	25.2	347.4	372.8	398.0	W
1954	8.0	8.2	50.1	82.5	66.4	67.8	10.4	215.3	283.1	293.5	A
1955	10.7	21.6	14.3	10.1	6.8	8.8	7.8	63.5	72.3	80.1	D
1956	0.9	126.2	187.1	130.6	61.8	42.4	43.0	506.7	549.0	592.0	W
1957	1.7	0.7	4.0	30.1	42.2	15.5	15.0	78.8	94.2	109.3	B
1958	8.3	27.5	90.0	479.9	160.2	133.7	48.2	765.8	899.6	947.7	W
1959	1.4	1.4	22.6	61.0	24.1	9.4	6.9	110.6	119.9	126.8	D
1960	1.3	0.7	2.8	73.3	52.9	10.3	6.8	131.1	141.4	148.2	B
1961	2.2	14.7	14.6	38.0	24.6	14.0	7.0	94.0	108.0	115.1	D
1962	1.2	5.7	2.0	37.8	65.7	30.9	7.2	112.4	143.2	150.5	B
1963	1.9	13.8	8.1	132.6	54.0	142.7	31.6	210.4	353.1	384.6	W
1964	0.3	0.9	0.9	0.7	1.8	4.7	5.0	4.5	9.2	14.2	D
1965	0.0	209.1	184.0	25.6	3.2	36.5	19.5	421.9	458.4	477.9	W
1966	0.9	0.0	37.0	69.1	14.0	11.2	9.7	121.1	132.3	142.0	B
1967	3.3	2.0	147.2	75.2	12.8	42.8	38.2	240.5	283.3	321.4	W
1968	2.8	2.3	2.5	126.0	5.8	22.1	22.9	139.4	161.5	184.4	B
1969	2.0	1.7	235.9	194.4	71.4	21.6	36.4	505.3	526.9	563.3	W
1970	3.0	3.6	346.2	136.2	11.2	12.0	11.8	500.3	512.3	524.1	W
1971	1.7	60.2	108.3	2.3	36.9	50.1	24.8	209.5	259.6	284.3	W
1972	2.4	1.7	2.0	1.8	5.7	18.0	16.0	13.5	31.5	47.5	B
1973	2.0	10.5	185.3	194.1	91.7	13.5	54.7	483.5	497.1	551.8	W
1974	3.2	95.7	264.6	11.2	93.4	121.1	34.0	468.0	589.1	623.1	W
1975	1.4	2.1	2.1	68.0	197.0	25.8	37.8	270.5	296.2	334.1	A
1976	2.8	3.1	2.4	2.3	2.3	2.1	4.9	12.9	15.0	19.9	C
1977	0.7	0.3	0.0	0.0	0.0	3.8	1.0	1.0	4.8	5.8	C
1978	0.2	0.0	237.8	171.8	107.1	12.2	53.4	516.9	529.2	582.6	W
1979	2.4	3.3	3.3	5.8	10.8	20.2	33.9	25.7	45.8	79.7	D
1980	2.7	3.1	182.1	243.0	64.5	12.7	18.3	495.4	508.1	526.4	W
1981	2.6	1.8	2.0	21.0	13.1	8.9	21.2	40.6	49.5	70.7	D
1982	22.0	116.6	124.7	93.5	42.9	128.2	97.0	399.7	528.0	624.9	W
1983	6.2	102.2	193.9	261.3	488.2	39.8	121.6	1051.8	1091.7	1213.3	W
1984	70.7	301.1	57.1	3.9	4.0	21.0	14.8	436.9	457.9	472.7	W
1985	9.8	40.3	3.2	3.5	2.7	7.2	15.5	59.4	66.5	82.0	D
1986	9.0	3.6	17.2	460.0	140.1	4.4	7.0	630.0	634.4	641.5	W
1987	2.7	1.6	1.3	1.2	1.3	5.8	6.7	8.1	13.9	20.5	C
1988	1.8	10.3	99.9	4.5	5.5	3.6	4.4	122.0	125.6	130.0	C
1989	0.7	0.8	0.5	0.6	5.2	9.2	15.8	7.7	16.9	32.7	B
1990	3.6	1.9	5.9	1.4	1.9	5.2	3.9	14.7	19.9	23.8	C
1991	0.8	0.5	0.6	0.4	0.6	2.6	5.8	3.0	5.5	11.3	C
1992	2.6	0.5	0.6	15.8	31.0	3.3	7.1	50.6	54.0	61.0	C
1993	1.7	22.1	244.6	179.4	30.3	34.4	16.1	478.0	512.4	528.5	W
1994	8.5	8.1	1.5	7.5	3.2	17.5	6.8	28.7	46.2	53.0	D
Total	274.7	1601.6	3624.2	3809.5	2415.5	1419.8	1065.1	11725.5	13145.3	14210.4	
Min	0.0	0.0	0.0	0.0	0.0	2.1	1.0	1.0	4.8	5.8	
Max	70.7	301.1	346.2	479.9	488.2	142.7	121.6	1051.8	1091.7	1213.3	
Average	5.5	32.0	72.5	76.2	48.3	28.4	21.3	234.5	262.9	284.2	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-7. Divertible Flows of Stony Creek to Glenn-Colusa Irrigation District Canal
1700 cfs Diversion Capacity (TAF/Month)

Contraints:
Stony Creek below diversion Demand = 50 cfs
Sac. R. @ Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
1945	3.2	8.9	0.0	30.2	12.7	14.2	4.3	55.0	69.1	73.4	B
1946	5.9	46.5	54.8	0.0	13.3	0.0	0.0	120.6	120.6	120.6	A
1947	2.9	2.9	2.9	12.0	20.7	5.4	0.0	41.5	46.8	46.8	D
1948	0.0	0.0	6.1	0.0	2.9	27.0	14.8	9.0	36.0	50.8	A
1949	0.0	2.9	2.9	3.8	69.8	33.5	0.0	79.5	113.0	113.0	D
1950	0.0	0.0	10.7	24.4	23.2	10.5	3.7	58.3	68.9	72.5	B
1951	6.5	57.1	44.7	64.9	35.8	4.7	4.4	209.0	213.7	218.0	W
1952	5.8	36.4	86.2	87.9	81.4	61.0	24.7	297.7	358.7	383.4	W
1953	3.0	54.8	98.2	23.6	18.8	22.5	22.1	198.4	220.9	243.0	W
1954	5.0	5.1	38.9	62.9	61.3	54.0	0.0	173.2	227.2	227.2	A
1955	7.7	18.6	11.2	0.0	3.7	5.7	3.8	41.2	46.9	50.6	D
1956	0.0	45.8	101.6	60.8	58.7	39.4	39.9	267.0	306.4	346.3	W
1957	0.1	0.0	2.4	19.7	39.2	0.0	12.0	61.4	61.4	73.4	B
1958	5.7	24.5	57.8	94.4	90.5	75.9	45.1	272.9	348.8	393.9	W
1959	0.0	0.2	18.9	37.5	0.0	0.0	0.0	56.7	56.7	56.7	D
1960	0.0	0.0	1.3	36.5	44.6	0.0	0.0	82.4	82.4	82.4	B
1961	0.5	11.0	9.4	33.9	21.5	0.0	0.0	76.4	76.4	76.4	D
1962	0.0	3.7	0.0	29.1	46.3	0.0	0.0	79.1	79.1	79.1	B
1963	0.9	10.7	3.5	65.5	12.4	87.7	28.5	93.0	180.7	209.2	W
1964	0.1	0.0	0.0	0.0	0.7	0.0	2.0	0.8	0.8	2.8	D
1965	0.0	33.3	94.6	24.2	0.0	23.6	0.0	152.1	175.7	175.7	W
1966	0.1	0.0	17.8	37.8	11.6	8.2	0.0	67.3	75.5	75.5	B
1967	0.6	0.0	35.4	35.0	10.6	33.1	35.1	81.6	114.7	149.8	W
1968	0.8	0.0	0.0	38.4	3.9	0.0	5.9	43.1	43.1	49.0	B
1969	0.0	0.0	64.1	91.5	47.4	18.7	33.4	203.0	221.7	255.0	W
1970	0.3	0.6	72.3	65.5	8.4	0.0	8.8	147.1	147.1	155.8	W
1971	0.0	34.8	55.8	0.0	24.3	0.0	21.7	114.9	114.9	136.6	W
1972	0.3	0.0	0.0	0.0	3.1	0.0	0.0	3.4	3.4	3.4	B
1973	0.0	8.2	64.6	70.0	39.5	11.2	51.6	182.2	193.3	245.0	W
1974	0.4	66.6	86.6	8.5	56.5	67.4	31.0	218.6	286.1	317.0	W
1975	0.0	0.0	0.0	37.7	85.4	22.8	34.8	123.1	145.9	180.7	A
1976	0.1	0.1	0.2	0.0	0.2	1.0	0.0	0.5	1.5	1.5	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	0.0	56.5	66.7	47.2	9.4	50.3	170.5	179.9	230.2	W
1979	0.8	0.0	0.2	3.4	7.7	17.2	6.0	12.2	29.4	35.4	D
1980	0.1	0.0	39.4	44.1	42.9	9.7	15.2	126.6	136.3	151.5	W
1981	0.0	0.0	0.1	17.0	10.1	5.9	0.0	27.1	33.1	33.1	D
1982	17.2	46.2	82.6	35.2	35.0	70.4	64.0	216.3	286.8	350.7	W
1983	3.9	57.2	51.2	91.8	104.1	32.3	86.8	308.1	340.5	427.2	W
1984	38.3	86.7	36.8	1.1	1.0	12.0	11.8	163.8	175.8	187.5	W
1985	7.4	35.1	0.1	0.9	0.4	4.4	0.0	43.9	48.3	48.3	D
1986	0.0	1.8	10.9	82.4	77.2	1.7	3.9	172.3	174.0	177.9	W
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1988	0.0	8.0	75.4	0.0	0.0	0.0	0.0	83.5	83.5	83.5	C
1989	0.0	0.0	0.0	0.0	4.0	6.2	0.0	4.0	10.1	10.1	B
1990	0.0	0.0	4.1	0.0	0.7	0.0	0.0	4.8	4.8	4.8	C
1991	0.0	0.0	0.0	0.0	0.0	0.7	2.8	0.0	0.7	3.5	C
1992	0.0	0.0	0.0	14.4	27.7	0.0	0.0	42.1	42.1	42.1	C
1993	0.0	18.5	90.8	69.1	27.2	31.7	13.0	205.5	237.2	250.2	W
1994	0.0	5.4	0.0	5.7	0.0	14.4	0.0	11.1	25.5	25.5	D
Total								5201.8	6045.3	6726.3	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	38.3	86.7	101.6	94.4	104.1	87.7	86.8	308.1	358.7	427.2	
Average	2.4	14.6	29.8	30.6	26.7	16.9	13.6	104.0	120.9	134.5	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-8. Divertible Flows of Stony Creek to Glenn-Colusa Irrigation Distri -- Grouped by Flow Range
1700 cfs Diversion Capacity (TAF/Month)

Contraints:
Stony Creek below diversion Demand = 50 cfs
Sac. R. @ Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

November through March

	Stony Creek Flow Range (cfs)								Water
	0	500	1000	1500	2000	2500	3000	Nov-Mar	Year
Water Year	500	1000	1500	2000	2500	3000	and above	Total	Class
1945	25.7	17.3	8.6	3.4	0.0	0.0	0.0	55.0	B
1946	34.3	13.3	9.3	19.9	6.7	3.4	33.7	120.6	A
1947	25.9	6.7	8.9	0.0	0.0	0.0	0.0	41.5	D
1948	7.8	1.2	0.0	0.0	0.0	0.0	0.0	9.0	A
1949	11.3	11.7	13.0	6.3	13.5	10.1	13.5	79.5	D
1950	33.0	20.8	4.6	0.0	0.0	0.0	0.0	58.3	B
1951	21.2	63.5	30.8	36.2	27.0	6.7	23.6	209.0	W
1952	15.1	28.1	50.7	65.5	57.3	20.2	60.7	297.7	W
1953	21.0	39.8	24.0	19.2	20.2	10.1	64.1	198.4	W
1954	11.9	53.6	34.8	29.0	23.6	6.7	13.5	173.2	A
1955	27.4	11.6	2.2	0.0	0.0	0.0	0.0	41.2	D
1956	4.3	40.1	45.9	38.4	20.2	43.8	74.2	267.0	W
1957	13.8	17.5	17.1	6.2	0.0	0.0	6.7	61.4	B
1958	7.6	38.8	22.6	31.9	20.2	13.5	138.2	272.9	W
1959	9.2	11.3	9.3	3.3	10.1	10.1	3.4	56.7	D
1960	11.1	18.9	22.1	3.4	10.1	3.4	13.5	82.4	B
1961	16.7	40.1	10.8	0.0	8.8	0.0	0.0	76.4	D
1962	8.0	36.9	4.4	12.9	0.0	6.7	10.1	79.1	B
1963	17.5	12.8	17.8	9.5	3.4	3.4	28.7	93.0	W
1964	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.8	D
1965	0.5	3.9	22.1	41.3	23.6	20.2	40.5	152.1	W
1966	18.3	2.9	2.2	6.7	0.0	10.1	27.0	67.3	B
1967	20.2	4.9	2.6	0.0	3.4	3.4	47.2	81.6	W
1968	6.1	0.9	2.4	6.7	3.4	0.0	23.6	43.1	B
1969	3.0	6.0	25.7	3.0	27.0	6.7	131.5	203.0	W
1970	4.2	8.6	13.0	10.1	20.2	6.7	84.3	147.1	W
1971	7.0	10.9	13.0	3.1	13.5	3.4	64.1	114.9	W
1972	3.4	0.0	0.0	0.0	0.0	0.0	0.0	3.4	B
1973	5.7	25.4	10.2	6.1	13.5	6.7	114.6	182.2	W
1974	9.2	14.2	17.0	36.6	23.6	47.2	70.8	218.6	W
1975	1.2	2.9	5.0	12.8	13.5	16.9	70.8	123.1	A
1976	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	8.4	19.0	5.1	6.5	10.1	6.7	114.6	170.5	W
1979	5.1	4.6	2.4	0.0	0.0	0.0	0.0	12.2	D
1980	3.8	2.9	2.1	9.9	13.5	6.7	87.7	126.6	W
1981	4.6	4.7	4.9	6.1	6.7	0.0	0.0	27.1	D
1982	6.0	26.6	25.9	50.0	6.7	16.9	84.3	216.3	W
1983	11.2	21.8	12.7	6.1	16.9	16.9	222.5	308.1	W
1984	10.4	25.0	20.5	10.1	6.7	6.7	84.3	163.8	W
1985	10.8	12.8	3.8	6.3	10.1	0.0	0.0	43.9	D
1986	8.7	3.7	8.7	29.8	6.7	3.4	111.3	172.3	W
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1988	9.2	6.1	21.7	22.8	10.1	0.0	13.5	83.5	C
1989	3.0	0.9	0.0	0.0	0.0	0.0	0.0	4.0	B
1990	2.2	2.5	0.0	0.0	0.0	0.0	0.0	4.8	C
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1992	5.3	10.8	19.3	3.4	3.4	0.0	0.0	42.1	C
1993	4.7	17.3	31.8	23.6	6.7	6.7	114.6	205.5	W
1994	6.3	4.8	0.0	0.0	0.0	0.0	0.0	11.1	D
Total	502.9	728.3	609.0	586.2	460.6	323.7	1991.1	5201.8	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	34.3	63.5	50.7	65.5	57.3	47.2	222.5	308.1	
Average	10.1	14.6	12.2	11.7	9.2	6.5	39.8	104.0	
% of Total Flow	9.7%	14.0%	11.7%	11.3%	8.9%	6.2%	38.3%	100.0%	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Figure 1-1. Stony Creek below Black Butte Lake
November through March Divertible Flow by Range
1945 - 1994 Analysis Period

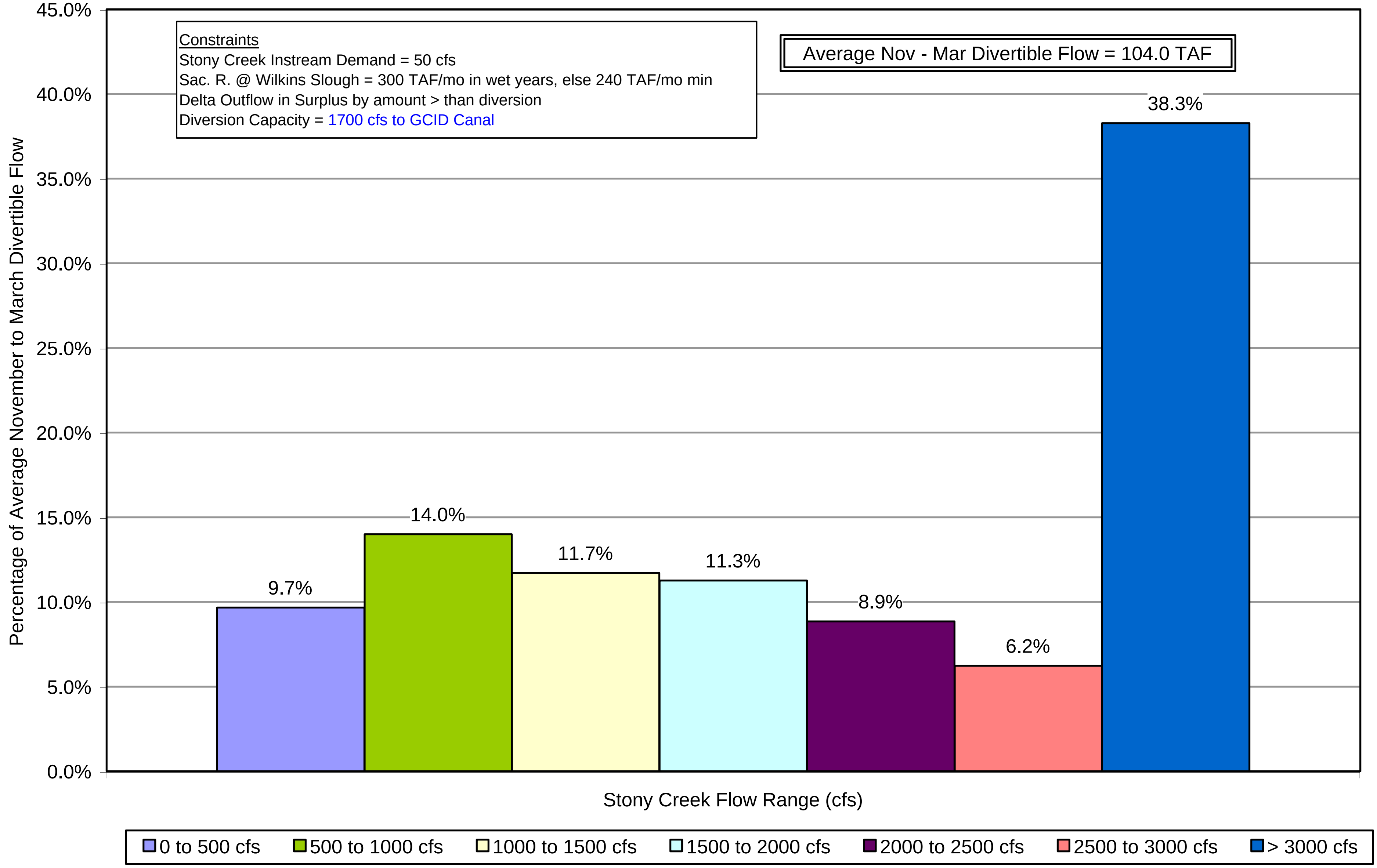


Table 1-9. Estimated Monthly Inflow to East Park Reservoir

Includes diversions from Rainbow Reservoir (TAF/Month)

East Park Reservoir inflow, excluding diversions from Rainbow Reservoir, estimated as 0.31* Stony Gorge Inflow (Area-Precip ratio).
Rainbow Reservoir inflow estimated as 0.45* Stony Gorge inflow (Area-Precip ratio).
Rainbow Reservoir to East Park Reservoir Diversion Capacity = 300 cfs.

Water Year	Nov	Dec	Jan	Feb	Mar	Total	Water Year Class
1945	3.8	6.6	1.6	15.3	4.2	31.5	B
1946	4.6	32.4	22.6	3.8	5.7	69.1	A
1947	3.4	3.2	0.3	6.8	9.6	23.3	D
1948	0.7	0.7	7.1	0.5	2.6	11.5	A
1949	0.4	0.5	0.7	3.3	34.2	39.1	D
1950	0.7	0.4	7.1	9.7	7.4	25.4	B
1951	7.4	21.0	26.5	30.2	17.8	102.9	W
1952	2.4	19.6	35.2	39.6	32.5	129.3	W
1953	2.4	25.5	53.7	12.0	15.4	109.1	W
1954	3.0	0.6	20.1	23.8	24.1	71.5	A
1955	4.9	7.2	1.9	0.5	0.7	15.3	D
1956	0.6	35.9	54.6	41.2	23.3	155.5	W
1957	0.4	0.3	4.5	14.1	15.2	34.5	B
1958	2.1	11.2	24.0	83.0	46.6	166.8	W
1959	1.0	0.7	11.3	18.0	5.6	36.7	D
1960	0.2	0.7	3.3	21.1	18.5	43.8	B
1961	2.7	9.5	5.2	13.1	6.4	36.9	D
1962	1.5	4.9	0.8	17.6	20.4	45.3	B
1963	1.5	4.3	2.2	34.9	13.7	56.6	W
1964	6.5	0.3	5.5	1.1	1.6	14.9	D
1965	4.8	44.2	49.4	17.2	5.9	121.6	W
1966	8.7	2.7	18.0	23.5	14.7	67.6	B
1967	6.3	15.6	27.8	23.3	19.6	92.5	W
1968	1.0	3.6	13.3	32.3	19.7	69.9	B
1969	1.4	11.6	44.4	47.0	38.2	142.7	W
1970	0.8	19.3	67.1	32.1	21.4	140.7	W
1971	5.7	29.4	28.0	6.6	24.9	94.5	W
1972	4.3	4.2	6.1	4.0	11.0	29.5	B
1973	5.9	11.5	35.4	53.4	35.6	141.7	W
1974	21.6	29.7	49.1	19.4	42.2	162.0	W
1975	2.0	2.8	2.5	27.9	46.1	81.3	A
1976	0.8	0.7	0.5	0.9	1.4	4.2	C
1977	0.3	0.2	0.2	0.2	0.3	1.1	C
1978	0.3	10.9	51.2	44.0	35.3	141.8	W
1979	0.2	0.2	5.6	14.9	24.6	45.5	D
1980	3.7	9.9	49.3	53.3	31.5	147.8	W
1981	1.6	2.7	12.1	12.7	14.4	43.4	D
1982	18.2	30.4	37.3	32.2	32.6	150.6	W
1983	9.9	27.8	47.0	63.8	73.3	221.8	W
1984	23.8	56.2	18.4	20.1	18.5	137.0	W
1985	17.6	11.6	0.2	4.5	6.4	40.3	D
1986	1.0	4.2	15.5	91.5	45.9	158.0	W
1987	0.4	0.6	1.0	5.2	15.2	22.5	C
1988	0.4	13.4	30.6	5.0	1.8	51.2	C
1989	1.4	0.2	0.8	0.5	27.9	30.8	B
1990	0.6	0.3	4.5	2.6	6.5	14.4	C
1991	1.0	0.2	0.2	1.1	21.0	23.4	C
1992	0.1	0.4	0.8	22.7	17.9	42.0	C
1993	0.3	14.6	54.4	47.1	33.6	150.0	W
1994	0.5	2.8	1.9	10.3	3.7	19.1	D
Total	195.0	547.2	960.3	1108.7	996.5	3807.6	
Min	0.1	0.2	0.2	0.2	0.3	1.1	
Max	23.8	56.2	67.1	91.5	73.3	221.8	
Average	3.9	10.9	19.2	22.2	19.9	76.2	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-10. Divertible Flows of East Park Inflow

1200 cfs Diversion Capacity (TAF/Month)

Contraints:

Little Stony below East Park Instream Demand = 25 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

Rainbow to East Park Diversion Capacity = 300 cfs
East Park must be full before diverting to Sites Reservoir

Water Year	Nov	Dec	Jan	Feb	Mar	Total	Water Year Class
1945	0.0	0.0	0.0	0.0	0.0	0.0	B
1946	0.0	0.0	7.1	0.0	4.1	11.3	A
1947	0.0	0.0	0.0	0.0	0.0	0.0	D
1948	0.0	0.0	0.0	0.0	0.0	0.0	A
1949	0.0	0.0	0.0	0.0	0.0	0.0	D
1950	0.0	0.0	0.0	0.0	0.0	0.0	B
1951	0.0	0.0	2.6	28.8	16.3	47.6	W
1952	0.0	0.0	5.0	34.2	31.0	70.2	W
1953	0.0	0.0	29.1	10.6	13.9	53.6	W
1954	0.0	0.0	0.0	0.0	16.1	16.1	A
1955	0.0	0.0	0.0	0.0	0.0	0.0	D
1956	0.0	0.0	35.9	32.0	21.7	89.6	W
1957	0.0	0.0	0.0	0.0	0.0	0.0	B
1958	0.0	0.0	0.0	49.2	42.7	91.9	W
1959	0.0	0.0	0.0	0.0	0.0	0.0	D
1960	0.0	0.0	0.0	0.0	0.0	0.0	B
1961	0.0	0.0	0.0	0.0	0.0	0.0	D
1962	0.0	0.0	0.0	0.0	0.0	0.0	B
1963	0.0	0.0	0.0	0.0	0.0	0.0	W
1964	0.0	0.0	0.0	0.0	0.0	0.0	D
1965	0.0	0.0	40.2	15.8	0.0	56.0	W
1966	0.0	0.0	0.0	0.0	12.3	12.3	B
1967	0.0	0.0	0.0	19.5	18.1	37.6	W
1968	0.0	0.0	0.0	0.0	15.1	15.1	B
1969	0.0	0.0	5.1	44.6	36.7	86.4	W
1970	0.0	0.0	22.9	30.7	19.8	73.5	W
1971	0.0	0.0	10.6	0.0	23.4	34.0	W
1972	0.0	0.0	0.0	0.0	0.0	0.0	B
1973	0.0	0.0	0.6	46.3	34.0	80.9	W
1974	0.0	0.4	38.0	18.0	37.4	93.8	W
1975	0.0	0.0	0.0	0.0	24.9	24.9	A
1976	0.0	0.0	0.0	0.0	0.0	0.0	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	0.0	11.7	38.9	33.8	84.4	W
1979	0.0	0.0	0.0	0.0	0.0	0.0	D
1980	0.0	0.0	10.8	35.0	30.0	75.7	W
1981	0.0	0.0	0.0	0.0	0.0	0.0	D
1982	0.0	0.0	33.7	27.8	29.1	90.6	W
1983	0.0	0.0	18.9	50.4	60.2	129.5	W
1984	0.0	18.8	16.9	18.6	17.0	71.3	W
1985	0.0	0.0	0.0	0.0	0.0	0.0	D
1986	0.0	0.0	0.0	28.1	39.4	67.5	W
1987	0.0	0.0	0.0	0.0	0.0	0.0	C
1988	0.0	0.0	0.0	0.0	0.0	0.0	C
1989	0.0	0.0	0.0	0.0	0.0	0.0	B
1990	0.0	0.0	0.0	0.0	0.0	0.0	C
1991	0.0	0.0	0.0	0.0	0.0	0.0	C
1992	0.0	0.0	0.0	0.0	0.0	0.0	C
1993	0.0	0.0	17.4	41.1	32.1	90.5	W
1994	0.0	0.0	0.0	0.0	0.0	0.0	D
Total						1504.0	
Min	0.0	0.0	0.0	0.0	0.0	0.0	
Max	0.0	18.8	40.2	50.4	60.2	129.5	
Average	0.0	0.4	6.1	11.4	12.2	30.1	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-11. Monthly Flows of Thomes Creek at Paskenta
Summarized from daily flows measured at gage (USGS 11382000; 1920 – 1997).

	Thomes Creek at Paskenta (TAF/Month)										
Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
1945	8.3	16.0	9.5	34.2	11.0	24.1	13.7	79.0	103.1	116.8	B
1946	13.5	65.9	37.1	11.4	22.3	28.2	15.9	150.2	178.3	194.3	A
1947	5.3	7.0	2.3	18.0	27.5	12.4	4.2	60.0	72.5	76.6	D
1948	3.4	1.7	32.4	6.1	7.5	39.8	29.9	51.1	91.0	120.8	A
1949	4.2	7.6	3.0	8.4	37.5	47.0	18.7	60.7	107.7	126.4	D
1950	1.1	1.0	16.2	20.3	37.7	33.6	15.8	76.3	109.9	125.7	B
1951	18.1	37.6	42.7	55.2	18.3	16.6	15.7	171.9	188.5	204.2	W
1952	7.2	41.2	27.4	68.0	48.1	72.5	40.6	191.8	264.4	305.0	W
1953	1.3	19.3	100.4	28.5	20.9	35.3	25.3	170.4	205.7	231.0	W
1954	7.5	7.9	40.6	56.3	47.9	52.3	16.0	160.2	212.5	228.5	A
1955	8.6	16.0	11.2	8.8	9.9	12.6	22.4	54.5	67.0	89.4	D
1956	4.6	124.2	98.0	52.8	40.4	51.6	44.4	320.0	371.6	416.1	W
1957	2.2	1.7	3.7	38.5	37.2	20.4	26.3	83.1	103.5	129.8	B
1958	16.0	29.3	51.4	163.7	44.7	67.3	46.7	305.1	372.3	419.0	W
1959	1.6	2.2	32.1	18.3	29.0	19.5	7.7	83.1	102.6	110.3	D
1960	0.3	0.7	4.2	63.2	51.0	16.7	13.5	119.4	136.1	149.5	B
1961	3.0	17.3	12.5	37.0	24.1	22.5	14.6	93.9	116.4	130.9	D
1962	1.6	8.0	5.1	21.6	20.8	41.0	11.7	57.1	98.2	109.8	B
1963	6.9	26.1	20.1	68.0	21.1	63.7	36.5	142.1	205.8	242.3	W
1964	18.6	5.7	12.5	14.1	7.9	9.3	5.8	58.9	68.1	74.0	D
1965	8.9	177.0	74.5	34.0	19.5	55.7	27.2	314.0	369.7	396.9	W
1966	12.3	6.8	35.1	16.5	42.4	48.2	16.2	113.1	161.2	177.4	B
1967	17.1	43.6	51.9	33.6	24.8	21.8	55.9	170.9	192.7	248.6	W
1968	2.0	8.2	51.1	70.1	26.6	17.2	9.1	158.0	175.2	184.3	B
1969	4.1	15.4	103.0	44.1	65.6	111.8	73.6	232.2	344.0	417.6	W
1970	1.7	54.1	178.3	28.8	30.1	10.1	9.3	293.1	303.2	312.5	W
1971	16.9	43.0	82.8	33.0	56.1	36.1	26.2	231.7	267.8	294.0	W
1972	2.5	5.7	23.0	22.8	52.5	16.6	9.2	106.5	123.1	132.4	B
1973	11.4	38.4	59.3	40.1	36.4	43.6	23.8	185.5	229.1	252.9	W
1974	52.1	68.2	140.9	20.8	76.4	52.0	25.0	358.5	410.4	435.4	W
1975	1.1	5.3	11.3	50.6	96.6	42.1	51.4	164.9	207.0	258.5	A
1976	6.7	5.7	2.8	10.6	14.7	11.5	8.3	40.6	52.1	60.4	C
1977	0.8	0.5	1.0	1.3	3.8	4.0	2.7	7.3	11.2	13.9	C
1978	6.7	35.6	97.0	57.7	68.5	34.8	25.9	265.6	300.4	326.3	W
1979	0.7	0.9	9.9	16.7	37.3	20.9	18.7	65.5	86.4	105.1	D
1980	15.2	8.7	106.3	77.6	33.3	27.2	14.8	241.2	268.4	283.2	W
1981	0.8	14.7	20.6	39.1	24.6	16.8	6.4	99.8	116.7	123.1	D
1982	51.6	82.1	33.0	76.0	35.9	69.2	33.3	278.6	347.8	381.1	W
1983	19.2	52.5	75.9	88.0	123.4	62.7	86.4	359.1	421.8	508.2	W
1984	54.5	100.7	30.9	19.8	27.3	15.2	11.2	233.2	248.4	259.6	W
1985	39.7	20.0	9.9	14.8	12.8	26.2	7.0	97.2	123.5	130.4	D
1986	2.0	9.8	31.5	193.4	76.7	21.8	10.4	313.4	335.2	345.6	W
1987	1.3	2.1	7.3	24.5	39.6	17.5	6.7	74.8	92.3	99.0	C
1988	1.4	46.5	31.1	22.6	14.5	9.8	7.1	116.1	126.0	133.1	C
1989	15.3	6.7	13.8	12.3	71.1	27.5	8.1	119.1	146.6	154.7	B
1990	1.9	1.9	15.6	7.6	16.7	5.6	11.1	43.7	49.4	60.4	C
1991	0.3	0.6	2.0	4.6	29.6	25.4	13.9	37.2	62.5	76.4	C
1992	1.9	2.1	5.5	33.4	36.5	28.1	7.3	79.4	107.5	114.9	C
1993	2.9	15.6	51.4	51.7	96.2	40.3	34.0	217.8	258.2	292.2	W
1994	0.6	4.2	7.0	8.2	19.0	8.2	7.4	39.1	47.3	54.7	D
Total	487.0	1313.0	1926.1	1946.5	1873.5	1614.2	1073.2	7546.1	9160.3	10233.5	
Min	0.3	0.5	1.0	1.3	3.8	4.0	2.7	7.3	11.2	13.9	
Max	54.5	177.0	178.3	193.4	123.4	111.8	86.4	359.1	421.8	508.2	
Average	9.7	26.3	38.5	38.9	37.5	32.3	21.5	150.9	183.2	204.7	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-12. Divertible Flows of Thomes Creek at Paskenta to Tehama Colusa Canal
2100 cfs Diversion Capacity (TAF/Month)

Contraints:
Thomes Creek Demand = 50 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
1945	5.4	12.9	0.0	31.4	7.9	20.7	5.8	57.7	78.4	84.2	B
1946	10.6	43.8	33.9	0.0	19.3	0.0	0.0	107.6	107.6	107.6	A
1947	2.6	3.9	0.0	13.2	24.4	8.4	0.0	44.2	52.5	52.5	D
1948	0.0	0.0	18.9	0.0	4.4	36.8	26.8	23.3	60.2	87.0	A
1949	0.0	4.6	0.6	6.0	34.4	44.0	0.0	45.6	89.6	89.6	D
1950	0.0	0.0	13.7	17.5	34.7	30.6	6.0	65.9	96.5	102.5	B
1951	15.1	32.9	34.5	44.6	15.2	13.6	12.6	142.2	155.9	168.5	W
1952	5.0	33.3	24.3	55.4	45.0	69.6	37.6	162.9	232.5	270.0	W
1953	0.2	16.3	71.4	25.8	17.8	32.1	22.2	131.4	163.6	185.8	W
1954	5.3	4.8	33.4	49.8	40.5	48.7	0.0	133.8	182.5	182.5	A
1955	6.1	12.9	8.1	0.0	6.8	8.9	6.0	34.0	42.9	48.9	D
1956	0.0	52.5	75.4	41.8	37.3	48.6	41.4	207.0	255.6	297.0	W
1957	0.2	0.1	1.5	24.4	34.1	0.0	23.2	60.3	60.3	83.5	B
1958	12.7	26.4	41.4	100.1	41.6	64.3	43.6	222.3	286.6	330.2	W
1959	0.3	0.7	27.2	15.5	0.0	0.0	0.0	43.7	43.7	43.7	D
1960	0.0	0.0	2.5	33.0	45.8	0.0	0.0	81.3	81.3	81.3	B
1961	0.9	14.2	5.9	34.2	21.1	0.0	0.0	76.2	76.2	76.2	D
1962	0.0	5.2	0.0	18.9	17.7	0.0	0.0	41.8	41.8	41.8	B
1963	4.7	22.8	5.3	50.4	7.3	53.9	33.4	90.4	144.4	177.7	W
1964	15.9	2.7	9.4	11.2	4.8	0.0	2.7	44.0	44.0	46.7	D
1965	3.3	53.3	70.3	31.2	0.0	49.1	0.0	158.1	207.2	207.2	W
1966	10.0	3.8	30.0	13.7	39.3	45.2	0.0	96.8	142.0	142.0	B
1967	15.0	39.2	35.4	30.8	21.7	18.8	52.8	142.1	160.9	213.8	W
1968	0.2	5.2	39.5	53.7	23.5	0.0	5.0	122.1	122.1	127.1	B
1969	0.6	12.3	70.3	41.3	55.5	94.8	66.0	180.0	274.9	340.8	W
1970	0.3	46.5	82.1	26.1	27.1	0.0	6.2	182.0	182.0	188.2	W
1971	14.2	39.3	56.7	0.0	46.4	0.0	23.1	156.5	156.5	179.6	W
1972	1.0	2.6	18.9	19.3	48.1	0.0	0.0	90.1	90.1	90.1	B
1973	8.6	32.4	46.3	37.3	33.3	40.6	20.8	157.8	198.4	219.2	W
1974	43.6	60.2	62.8	18.1	49.8	43.7	22.0	234.5	278.2	300.2	W
1975	0.0	2.4	8.2	43.5	81.2	39.1	48.4	135.4	174.5	222.8	A
1976	3.8	2.6	0.1	0.0	11.6	8.6	0.0	18.2	26.7	26.7	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	27.1	75.7	53.1	63.0	31.8	22.8	219.0	250.8	273.6	W
1979	0.0	0.0	7.4	14.0	34.3	17.9	5.7	55.7	73.5	79.3	D
1980	12.3	5.7	48.5	56.4	30.3	24.2	11.7	153.1	177.3	189.0	W
1981	0.0	11.1	17.6	32.9	21.6	13.9	0.0	83.1	96.9	96.9	D
1982	39.9	55.9	30.0	49.0	32.8	65.7	30.2	207.5	273.2	303.5	W
1983	16.4	43.9	50.3	77.4	91.7	59.7	83.3	279.7	339.4	422.7	W
1984	48.1	79.3	27.8	17.0	24.2	12.2	8.1	196.4	208.7	216.8	W
1985	36.8	16.9	6.8	12.1	9.7	23.3	0.0	82.3	105.6	105.6	D
1986	0.0	6.7	28.2	77.3	66.0	18.9	7.3	178.2	197.1	204.4	W
1987	0.0	0.2	4.3	21.0	36.0	0.0	0.0	61.4	61.4	61.4	C
1988	0.0	38.8	28.1	0.0	0.0	0.0	0.0	66.8	66.8	66.8	C
1989	0.0	0.0	0.0	0.0	64.7	24.5	0.0	64.7	89.2	89.2	B
1990	0.0	0.0	12.9	0.0	13.7	0.0	0.0	26.6	26.6	26.6	C
1991	0.0	0.0	0.0	0.0	23.4	22.4	5.8	23.4	45.8	51.5	C
1992	0.0	0.0	2.4	30.5	33.4	0.0	0.0	66.4	66.4	66.4	C
1993	0.0	12.7	38.0	48.2	81.1	37.4	31.0	180.0	217.4	248.3	W
1994	0.0	1.9	4.1	5.4	0.0	5.3	0.0	11.4	16.7	16.7	D
Total								5444.7	6622.1	7333.6	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	48.1	79.3	82.1	100.1	91.7	94.8	83.3	279.7	339.4	422.7	
Average	6.8	17.8	26.2	27.6	30.5	23.5	14.2	108.9	132.4	146.7	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-13. Divertible Flows of Thomes Creek at Paskenta to T-C Canal -- Grouped by Flow Range 2100 cfs Diversion Capacity (TAF/Month)

Contraints:

Thomes Creek Demand = 50 cfs

Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo

Delta Outflow in Surplus

November through March

	Thomes Creek Flow Range (cfs)								**Water**
	0	**250**	**500**	**750**	**1000**	**1500**	**2000**	**Nov-Mar**	**Year**
Water Year	**250**	**500**	**750**	**1000**	**1500**	**2000**	**and above**	**Total**	**Class**
1945	13.6	10.4	11.0	11.1	11.6	0.0	0.0	57.7	B
1946	6.1	35.5	7.6	6.6	24.0	6.9	20.8	107.6	A
1947	9.0	11.5	12.1	2.1	2.0	3.2	4.2	44.2	D
1948	4.6	3.5	2.1	5.0	0.0	2.0	6.1	23.3	A
1949	5.5	14.3	9.8	8.4	7.6	0.0	0.0	45.6	D
1950	5.0	21.3	16.2	8.7	10.5	0.0	4.1	65.9	B
1951	12.6	31.3	25.6	10.2	18.5	23.3	20.8	142.2	W
1952	6.7	28.4	26.5	16.2	30.0	34.4	20.8	162.9	W
1953	8.2	26.5	20.7	16.5	19.2	11.1	29.2	131.4	W
1954	5.4	16.1	30.1	17.5	24.9	6.4	33.3	133.8	A
1955	18.8	5.6	3.6	3.1	2.9	0.0	0.0	34.0	D
1956	1.3	16.0	39.8	30.5	31.4	25.5	62.5	207.0	W
1957	3.0	11.1	12.0	6.2	4.9	6.4	16.7	60.3	B
1958	1.6	17.1	35.6	24.7	40.9	23.4	79.0	222.3	W
1959	5.4	14.3	7.8	0.0	9.1	2.9	4.2	43.7	D
1960	4.0	9.5	24.7	9.5	6.9	10.1	16.7	81.3	B
1961	8.9	15.8	21.0	4.5	13.4	10.5	2.1	76.2	D
1962	10.0	9.4	8.9	13.5	0.0	0.0	0.0	41.8	B
1963	10.3	10.4	13.1	4.7	15.5	7.2	29.2	90.4	W
1964	16.2	15.3	5.0	1.5	2.7	3.3	0.0	44.0	D
1965	3.4	17.7	5.7	31.3	48.7	6.0	45.4	158.1	W
1966	12.1	21.6	17.2	12.8	20.9	3.9	8.3	96.8	B
1967	12.6	21.9	30.1	29.6	16.6	6.4	25.0	142.1	W
1968	5.5	24.0	21.7	22.8	12.3	6.7	29.2	122.1	B
1969	4.0	17.2	24.4	30.1	27.6	26.8	50.0	180.0	W
1970	2.5	26.1	26.0	17.9	13.4	17.2	79.0	182.0	W
1971	7.1	14.4	26.3	22.4	30.4	14.3	41.6	156.5	W
1972	11.8	12.1	7.9	6.4	24.0	7.0	20.8	90.1	B
1973	10.2	23.8	32.3	16.1	34.3	3.7	37.3	157.8	W
1974	0.3	23.8	44.3	38.2	40.3	17.0	70.6	234.5	W
1975	5.9	3.6	12.8	20.7	32.1	22.8	37.4	135.4	A
1976	10.1	4.3	2.3	1.4	0.0	0.0	0.0	18.2	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.7	3.2	34.7	49.9	44.5	31.3	54.7	219.0	W
1979	3.4	14.6	11.3	9.4	9.2	3.7	4.0	55.7	D
1980	5.0	32.5	24.7	13.4	25.3	10.6	41.7	153.1	W
1981	8.0	19.5	12.3	6.8	11.9	12.2	12.4	83.1	D
1982	1.0	35.6	42.1	29.0	25.2	16.9	57.8	207.5	W
1983	1.2	22.2	23.4	30.7	47.4	43.1	111.7	279.7	W
1984	6.7	30.2	30.7	19.1	22.5	33.1	54.1	196.4	W
1985	23.6	19.3	12.0	6.0	10.2	7.0	4.1	82.3	D
1986	6.7	7.8	15.1	30.0	33.2	27.0	58.3	178.2	W
1987	6.9	19.5	12.0	3.5	7.2	0.0	12.3	61.4	C
1988	3.3	13.6	12.7	11.0	11.1	6.8	8.3	66.8	C
1989	0.7	1.0	3.6	11.4	24.7	10.8	12.5	64.7	B
1990	9.2	6.4	5.4	1.4	0.0	0.0	4.2	26.6	C
1991	4.0	5.8	1.9	1.4	2.7	3.4	4.2	23.4	C
1992	3.0	13.0	21.0	15.1	4.8	9.5	0.0	66.4	C
1993	5.1	11.2	22.5	26.8	34.2	42.6	37.5	180.0	W
1994	7.0	3.4	1.1	0.0	0.0	0.0	0.0	11.4	D
Total	337.7	792.7	870.7	714.9	890.6	566.3	1271.8	5444.7	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	23.6	35.6	44.3	49.9	48.7	43.1	111.7	279.7	
Average	6.8	15.9	17.4	14.3	17.8	11.3	25.4	108.9	
% of Total Flow	6.2%	14.6%	16.0%	13.1%	16.4%	10.4%	23.4%	100.0%	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Figure 1-2. Thomes Creek at Paskenta
November through March Divertible Flow by Range
1945 - 1994 Analysis Period

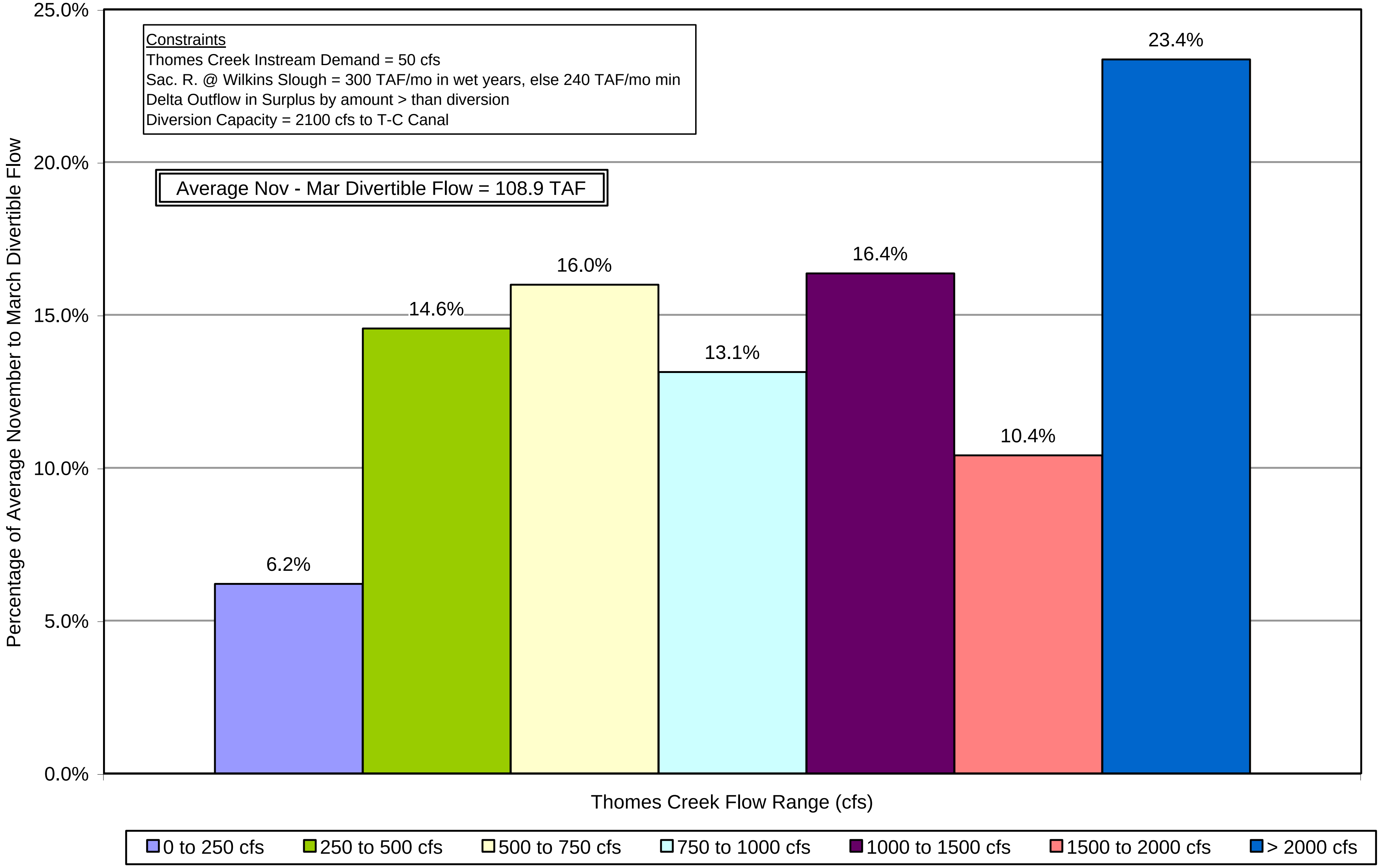
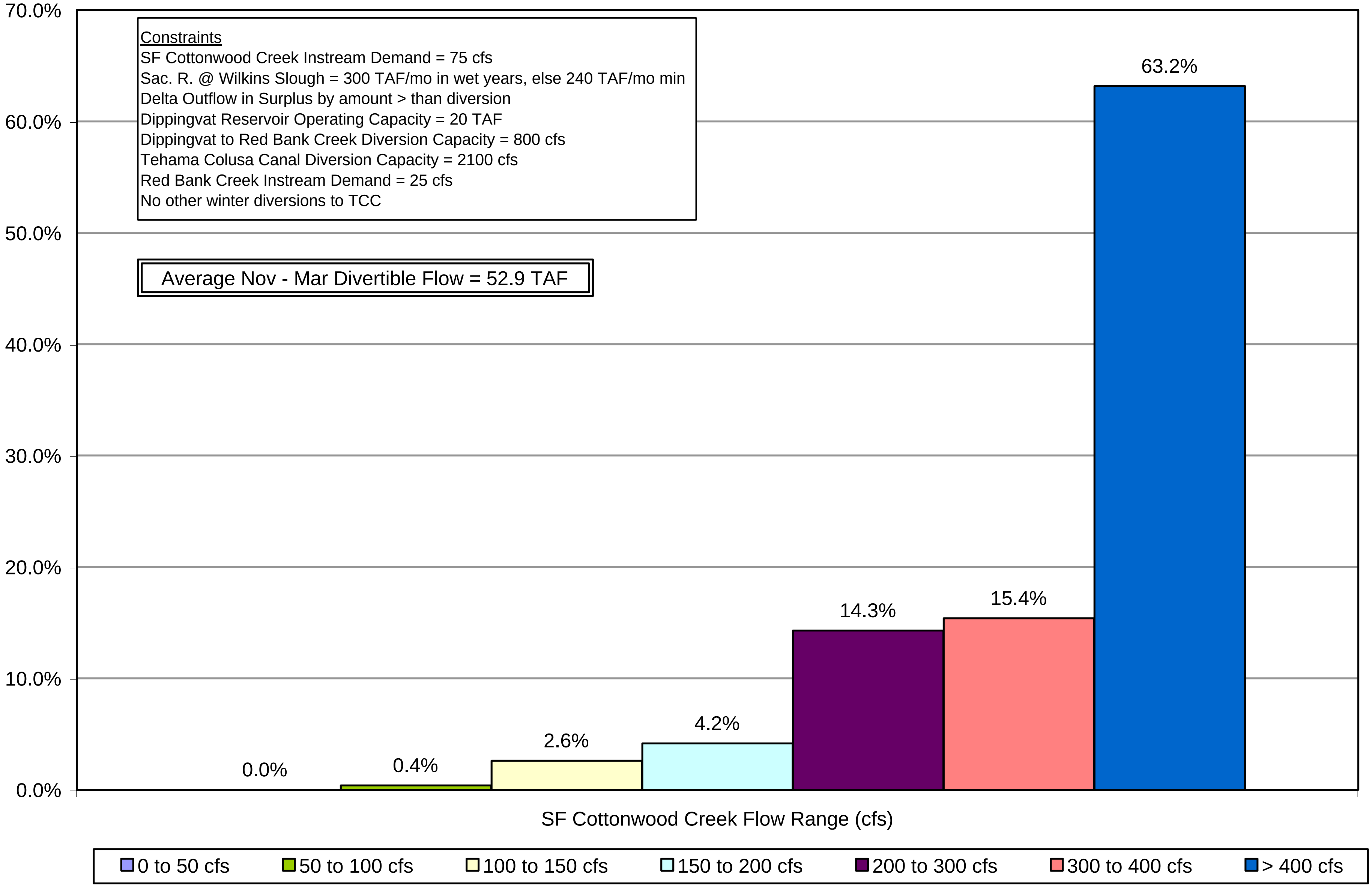


Table 1-14. Estimated Monthly Flows of South Fork Cottonwood Creek at Dippingvat
Flow at Dippingvat = Cottonwood Creek near Cottonwood (USGS 11376000) * 0.1698 (Area-Precip ratio).

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
	South Fork Cottonwood Creek at Dippingvat Flow (TAF/Month)										
1945	3.4	7.4	4.4	16.9	9.1	6.3	3.9	41.2	47.4	51.3	B
1946	5.1	37.6	22.4	5.1	6.1	7.0	3.7	76.2	83.2	86.9	A
1947	1.5	3.6	1.2	9.1	13.4	4.2	1.7	28.7	32.9	34.7	D
1948	1.3	1.1	9.1	2.1	4.8	18.8	9.3	18.5	37.3	46.6	A
1949	0.9	1.8	1.5	3.9	39.4	10.5	4.4	47.6	58.1	62.5	D
1950	0.6	0.6	6.5	12.3	9.8	6.0	3.2	29.8	35.8	39.0	B
1951	5.5	24.9	24.4	23.8	7.9	4.1	5.2	86.5	90.6	95.8	W
1952	2.2	30.9	31.4	26.8	24.7	15.9	9.5	116.0	132.0	141.5	W
1953	1.4	30.0	49.6	9.4	8.1	8.1	7.5	98.6	106.7	114.2	W
1954	2.4	2.6	27.8	27.8	26.8	22.0	7.6	87.4	109.4	117.0	A
1955	5.2	10.4	8.8	4.6	3.5	5.7	6.7	32.5	38.2	45.0	D
1956	2.8	50.0	55.1	31.4	18.4	14.2	12.0	157.8	172.0	184.0	W
1957	1.4	1.0	2.9	13.7	16.3	8.0	10.5	35.3	43.3	53.9	B
1958	6.2	13.7	30.7	101.9	37.8	37.3	11.4	190.3	227.5	238.9	W
1959	1.1	1.2	14.5	18.7	9.7	5.4	3.0	45.2	50.7	53.6	D
1960	0.8	0.8	2.1	28.1	15.6	5.5	4.3	47.6	53.0	57.4	B
1961	1.2	8.2	7.4	23.7	11.4	6.5	3.8	51.8	58.3	62.1	D
1962	1.2	6.0	3.2	21.8	15.0	7.8	3.4	47.2	55.0	58.4	B
1963	2.2	7.4	5.6	25.5	10.5	31.5	10.3	51.1	82.6	92.9	W
1964	6.0	2.9	7.7	4.4	2.5	2.3	2.0	23.5	25.8	27.8	D
1965	4.9	49.0	36.4	10.5	5.4	26.5	7.8	106.1	132.6	140.4	W
1966	7.0	3.7	17.4	13.0	14.3	9.6	3.8	55.4	64.9	68.7	B
1967	4.6	15.6	32.6	16.7	11.0	18.7	14.0	80.4	99.1	113.1	W
1968	1.2	3.5	15.0	34.2	11.3	4.9	3.3	65.1	70.0	73.4	B
1969	1.4	14.2	50.4	45.9	28.7	22.7	12.6	140.6	163.3	175.9	W
1970	0.8	17.4	79.3	20.5	19.1	5.8	3.6	137.1	142.9	146.5	W
1971	9.6	27.8	33.5	10.3	20.2	11.5	6.5	101.5	112.9	119.4	W
1972	1.5	3.3	6.4	6.1	10.7	4.6	3.1	27.9	32.5	35.6	B
1973	8.5	13.5	41.0	33.6	25.8	11.5	6.2	122.4	133.9	140.0	W
1974	16.8	30.5	66.3	14.2	43.0	27.1	7.8	170.7	197.8	205.6	W
1975	1.1	2.9	4.2	30.0	56.3	17.1	12.0	94.6	111.7	123.6	A
1976	2.1	2.4	1.4	3.6	5.2	4.0	2.4	14.7	18.7	21.2	C
1977	1.0	0.6	1.0	0.7	1.5	1.4	1.7	4.8	6.2	7.9	C
1978	1.8	14.2	64.5	31.8	39.5	17.6	7.6	151.7	169.4	177.0	W
1979	1.0	0.9	6.2	14.3	16.3	7.9	7.4	38.7	46.5	53.9	D
1980	6.4	9.8	24.5	45.0	20.7	8.6	4.8	106.3	114.9	119.7	W
1981	0.6	5.2	21.1	21.9	17.9	8.0	4.1	66.8	74.8	78.9	D
1982	15.1	41.0	23.2	26.0	24.3	27.5	8.9	129.5	157.0	165.9	W
1983	6.2	25.9	47.1	67.6	112.4	31.1	25.5	259.3	290.4	316.0	W
1984	17.0	56.7	14.9	8.2	8.2	5.8	3.8	105.0	110.8	114.6	W
1985	18.5	11.4	4.4	5.8	4.7	6.4	2.6	44.7	51.0	53.6	D
1986	1.1	4.1	11.7	70.1	36.3	7.6	4.2	123.2	130.8	135.0	W
1987	0.7	0.9	2.7	7.8	14.0	4.4	2.6	26.1	30.5	33.1	C
1988	0.5	13.6	18.5	5.9	3.4	3.2	4.7	41.9	45.1	49.9	C
1989	4.8	2.6	5.9	2.9	27.0	7.8	3.2	43.3	51.1	54.2	B
1990	1.3	1.0	6.2	2.8	4.4	1.7	4.0	15.7	17.4	21.3	C
1991	0.5	0.5	0.6	1.3	17.6	7.8	3.9	20.6	28.4	32.3	C
1992	0.6	1.1	2.8	20.4	17.5	7.8	3.4	42.5	50.2	53.7	C
1993	0.8	6.4	33.9	30.8	29.1	11.1	8.8	101.0	112.1	120.9	W
1994	0.7	1.7	3.0	7.2	5.3	0.0	0.0	18.0	18.0	18.0	D
Total								3768.3	4325.0	4633.0	
Min	0.5	0.5	0.6	0.7	1.5	0.0	0.0	4.8	6.2	7.9	
Max	18.5	56.7	79.3	101.9	112.4	37.3	25.5	259.3	290.4	316.0	
Average	3.8	12.5	19.8	20.4	18.8	11.1	6.2	75.4	86.5	92.7	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Figure 1-3. SF Cottonwood Creek at Dippingvat
November through March Divertible Flow by Range
1945 - 1994 Analysis Period



attach1 tables&graphs.xls, RBDIP20800_SFCDFNov-MarChart

Table 1-15. Divertible Flows of SF Cottonwood Creek to Red Bank Creek to Tehama-Colusa Canal
800 cfs Diversion Capacity (TAF/Month)

Contraints:
SF Cottonwood Creek Instream Demand = 75 cfs
Dippingvat Reservoir Operating Capacity = 20 TAF
Delta Outflow in Surplus by amount > than diversion
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo

Water Year	Nov	Dec	Jan	Feb	Mar	Nov-Mar Total	Water Year Class
1945	0.6	3.7	0.0	12.8	4.6	21.7	B
1946	2.1	22.3	28.5	0.0	1.5	54.4	A
1947	0.3	1.0	0.0	6.1	8.8	16.3	D
1948	0.0	0.0	5.5	0.0	2.0	7.5	A
1949	0.0	0.0	0.0	1.3	34.8	36.1	D
1950	0.0	0.0	3.9	8.3	5.3	17.5	B
1951	1.6	20.3	19.8	19.6	3.3	64.6	W
1952	0.4	16.7	36.4	22.5	20.1	96.1	W
1953	0.0	24.9	44.4	6.5	3.5	79.3	W
1954	0.1	0.0	20.5	27.7	22.2	70.5	A
1955	2.2	5.8	4.3	0.0	0.0	12.3	D
1956	0.0	25.9	49.2	32.5	24.8	132.4	W
1957	0.0	0.0	0.5	8.5	14.3	23.3	B
1958	2.5	9.9	22.8	41.5	49.2	126.0	W
1959	0.0	0.0	10.3	14.6	0.0	25.0	D
1960	0.0	0.0	0.3	23.8	11.0	35.1	B
1961	0.0	4.4	3.6	20.0	6.8	34.8	D
1962	0.0	2.9	0.0	18.0	10.4	31.3	B
1963	0.5	3.2	0.1	24.6	2.4	30.8	W
1964	2.3	0.0	4.5	0.7	0.0	7.5	D
1965	1.5	16.8	47.6	6.9	0.0	72.8	W
1966	3.8	0.5	12.8	8.8	9.6	35.6	B
1967	1.9	11.0	16.4	25.0	6.4	60.6	W
1968	0.0	0.5	11.1	26.3	11.3	49.2	B
1969	0.0	10.5	34.0	42.2	35.4	122.2	W
1970	0.0	14.1	30.4	36.0	14.5	95.0	W
1971	5.7	24.2	28.9	0.0	14.7	73.5	W
1972	0.0	0.3	3.0	1.8	6.1	11.1	B
1973	4.8	9.9	30.1	35.5	21.4	101.7	W
1974	13.0	23.2	35.5	21.8	24.3	117.9	W
1975	0.0	0.5	1.0	25.9	39.9	67.3	A
1976	0.1	0.1	0.0	0.0	1.5	1.7	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	10.8	38.0	37.6	34.9	121.3	W
1979	0.0	0.0	3.6	11.3	11.7	26.6	D
1980	2.7	6.3	19.9	22.7	34.3	85.9	W
1981	0.0	2.7	11.6	24.4	13.3	52.0	D
1982	11.9	26.3	28.6	21.8	19.6	108.3	W
1983	3.4	21.3	15.8	40.9	44.2	125.6	W
1984	13.3	37.9	24.5	3.8	3.6	83.2	W
1985	14.5	6.8	0.2	1.9	0.4	23.7	D
1986	0.0	1.2	7.8	33.3	48.5	90.8	W
1987	0.0	0.0	0.2	3.8	9.5	13.5	C
1988	0.0	9.1	13.9	0.0	0.0	23.0	C
1989	0.0	0.0	0.0	0.0	22.4	22.4	B
1990	0.0	0.0	3.0	0.0	0.6	3.6	C
1991	0.0	0.0	0.0	0.0	13.2	13.2	C
1992	0.0	0.0	0.6	17.0	12.9	30.5	C
1993	0.0	3.6	26.5	29.4	24.5	84.0	W
1994	0.0	0.0	0.8	3.5	0.0	4.2	D
Total						2643.2	
Min	0.0	0.0	0.0	0.0	0.0	0.0	
Max	14.5	37.9	49.2	42.2	49.2	132.4	
Average	1.8	7.6	14.0	15.4	14.1	52.9	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-16. Divertible Flows of SF Cottonwood Creek to Red Bank Creek tc -- Grouped by Flow Range
800 cfs Diversion Capacity (TAF/Month)

Contraints: **November through March**

SF Cottonwood Creek Instream Demand = 75 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo Dippingvat Reservoir Operating Capacity = 20 TAF
Delta Outflow in Surplus

	SF Cottonwood Creek Flow Range (cfs)								Water
	0	50	100	150	200	300	400	Nov-Mar	Year
Water Year	50	100	150	200	300	400	and above	Total	Class
1945	0.0	0.4	1.5	2.8	4.9	3.7	8.4	21.7	B
1946	0.0	0.5	3.1	6.0	6.1	2.2	36.4	54.4	A
1947	0.0	0.3	1.1	2.2	2.4	2.0	8.3	16.3	D
1948	0.0	0.1	0.7	0.7	0.6	1.2	4.3	7.5	A
1949	0.0	0.0	0.5	0.5	2.2	6.9	26.0	36.1	D
1950	0.0	0.1	2.7	1.5	4.7	2.4	6.1	17.5	B
1951	0.0	0.5	3.9	3.4	7.0	6.8	43.0	64.6	W
1952	0.0	0.2	0.5	2.2	16.9	16.6	59.8	96.1	W
1953	0.0	0.4	1.6	3.0	13.3	9.2	51.7	79.3	W
1954	0.0	0.0	0.2	0.7	7.7	12.6	49.2	70.5	A
1955	0.0	0.4	1.2	1.9	1.2	2.1	5.5	12.3	D
1956	0.0	0.2	10.3	5.0	22.5	13.2	81.3	132.4	W
1957	0.0	0.1	1.0	1.0	5.3	4.5	11.3	23.3	B
1958	0.0	0.1	0.7	0.6	9.6	17.2	97.8	126.0	W
1959	0.0	0.2	0.6	1.3	4.0	2.1	16.7	25.0	D
1960	0.0	0.3	1.2	5.2	5.2	5.8	17.4	35.1	B
1961	0.0	0.3	1.5	1.8	6.4	4.9	19.9	34.8	D
1962	0.0	0.1	2.0	2.3	3.1	3.2	20.6	31.3	B
1963	0.0	0.4	1.1	1.2	4.6	4.6	19.0	30.8	W
1964	0.0	0.2	1.9	0.7	0.9	1.0	2.8	7.5	D
1965	0.0	0.1	2.1	1.2	4.3	10.2	54.9	72.8	W
1966	0.0	0.2	2.6	6.0	7.9	8.5	10.3	35.6	B
1967	0.0	0.5	1.8	3.5	13.9	11.9	28.9	60.6	W
1968	0.0	0.0	2.7	2.6	11.7	6.7	25.5	49.2	B
1969	0.0	0.1	0.3	0.4	8.2	24.1	89.1	122.2	W
1970	0.0	0.1	0.9	1.8	12.4	18.3	61.5	95.0	W
1971	0.0	0.4	0.5	3.7	11.1	11.4	46.5	73.5	W
1972	0.0	0.7	1.7	1.5	1.8	2.0	3.4	11.1	B
1973	0.0	0.1	0.9	1.4	15.5	19.0	64.8	101.7	W
1974	0.0	0.1	0.4	6.1	21.1	21.0	69.2	117.9	W
1975	0.0	0.1	0.7	0.9	4.4	9.4	51.8	67.3	A
1976	0.0	0.2	0.2	0.4	0.5	0.5	0.0	1.7	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	0.0	0.2	0.8	21.6	28.7	70.0	121.3	W
1979	0.0	0.0	0.2	1.9	8.5	2.6	13.4	26.6	D
1980	0.0	0.2	2.4	4.5	15.2	11.7	52.0	85.9	W
1981	0.0	0.0	0.5	6.7	13.3	7.4	24.0	52.0	D
1982	0.0	0.0	0.8	2.7	13.5	29.9	61.4	108.3	W
1983	0.0	0.2	1.8	2.3	5.3	2.7	113.4	125.6	W
1984	0.0	0.5	3.0	6.1	11.2	9.7	52.8	83.2	W
1985	0.0	0.6	1.7	1.3	4.7	3.0	12.3	23.7	D
1986	0.0	0.2	0.8	1.0	10.1	16.6	62.2	90.8	W
1987	0.0	0.3	1.1	2.1	1.9	1.1	6.9	13.5	C
1988	0.0	0.1	1.0	2.5	4.2	3.6	11.6	23.0	C
1989	0.0	0.0	0.1	0.2	2.5	3.7	15.9	22.4	B
1990	0.0	0.2	0.9	0.0	0.6	0.4	1.5	3.6	C
1991	0.0	0.1	0.3	0.2	2.9	1.1	8.6	13.2	C
1992	0.0	0.0	0.9	2.1	4.6	4.2	18.6	30.5	C
1993	0.0	0.1	0.4	0.6	14.9	15.1	52.9	84.0	W
1994	0.0	0.1	0.8	1.6	1.1	0.0	0.7	4.2	D
Total	0.0	10.1	69.1	109.8	377.7	406.7	1669.8	2643.2	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	0.0	0.7	10.3	6.7	22.5	29.9	113.4	132.4	
Average	0.0	0.2	1.4	2.2	7.6	8.1	33.4	52.9	
% of Total Flow	0.0%	0.4%	2.6%	4.2%	14.3%	15.4%	63.2%	100.0%	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-17. Monthly Flows of Red Bank Creek near Red Bluff

Summarized from daily flows measured at gage (USGS 11378800; 1960 – 1994).
Data for years 1945-1959 is based on correlation with Elder Creek near Paskenta USGS 11379500.

	Red Bank Creek near Red Bluff Flow (TAF/Month)										Water Year
Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Class
1945	0.5	1.9	0.5	5.6	0.7	3.4	1.3	9.2	12.6	13.9	B
1946	1.6	11.9	6.0	0.9	3.0	4.2	1.7	23.4	27.7	29.4	A
1947	0.5	0.4	0.0	2.5	4.1	1.1	0.0	7.5	8.5	8.5	D
1948	0.0	0.0	5.3	0.2	0.7	1.3	1.0	6.3	7.6	8.6	A
1949	0.0	0.2	0.0	0.7	16.7	3.1	0.3	17.7	20.8	21.1	D
1950	0.0	0.0	1.9	2.8	2.1	0.7	0.0	6.8	7.5	7.5	B
1951	0.7	6.0	7.4	6.9	1.9	0.3	1.6	23.0	23.3	24.9	W
1952	0.0	7.6	18.6	4.5	9.5	1.3	3.4	40.3	41.6	45.0	W
1953	0.0	18.4	17.1	1.8	2.1	2.8	1.7	39.5	42.2	44.0	W
1954	0.2	0.0	10.6	7.1	7.1	8.2	1.2	25.0	33.2	34.4	A
1955	3.3	5.4	1.6	0.5	0.2	2.3	1.5	11.0	13.3	14.9	D
1956	0.4	12.3	17.4	11.6	3.1	6.8	4.7	44.7	51.5	56.1	W
1957	0.0	0.0	1.2	6.8	3.0	2.2	1.5	11.1	13.2	14.7	B
1958	0.4	3.8	12.1	41.7	16.4	10.5	5.1	74.4	84.8	90.0	W
1959	0.0	0.0	5.7	8.8	0.8	1.0	0.0	15.4	16.3	16.3	D
1960	0.0	0.0	0.3	10.8	2.0	0.9	0.2	13.2	14.1	14.2	B
1961	0.0	1.9	3.8	6.6	1.8	0.4	0.1	14.1	14.5	14.6	D
1962	0.0	2.3	0.2	12.4	9.5	0.3	0.1	24.4	24.7	24.8	B
1963	0.1	0.9	5.4	10.8	7.4	9.0	1.1	24.6	33.6	34.7	W
1964	2.7	0.2	1.6	0.2	0.2	0.0	0.0	5.0	5.0	5.0	D
1965	3.4	14.3	17.6	1.3	0.7	13.7	1.3	37.3	51.0	52.3	W
1966	6.5	1.2	12.7	7.8	2.3	0.6	0.1	30.6	31.2	31.3	B
1967	1.6	7.3	19.5	5.0	3.0	7.9	1.7	36.4	44.4	46.0	W
1968	0.0	0.3	6.4	9.0	1.4	0.3	0.1	17.1	17.5	17.5	B
1969	0.0	8.1	29.2	29.0	9.1	2.2	0.4	75.4	77.5	78.0	W
1970	0.0	4.1	33.9	6.8	5.1	0.7	0.2	50.0	50.7	50.9	W
1971	2.9	10.5	6.2	1.1	3.1	1.2	0.3	23.8	24.9	25.2	W
1972	0.0	0.3	0.3	0.4	0.2	0.0	0.0	1.2	1.2	1.2	B
1973	8.3	4.7	22.4	19.7	13.6	2.3	0.4	68.8	71.0	71.5	W
1974	4.3	5.3	20.0	2.5	18.1	7.3	1.1	50.3	57.6	58.7	W
1975	0.0	1.8	0.3	12.1	29.6	2.8	0.6	43.7	46.5	47.1	A
1976	0.0	0.0	0.0	0.1	0.3	0.6	0.0	0.3	1.0	1.0	C
1977	0.0	0.0	0.0	0.0	0.4	0.0	0.5	0.4	0.5	1.0	C
1978	0.0	5.9	42.8	14.5	16.6	7.5	0.9	79.8	87.3	88.3	W
1979	0.0	0.0	2.5	6.4	6.4	1.6	0.5	15.3	16.9	17.4	D
1980	0.8	5.4	8.0	21.0	5.9	1.3	0.3	41.0	42.3	42.6	W
1981	0.0	1.5	19.3	5.3	8.0	1.6	0.3	34.1	35.7	36.0	D
1982	5.8	8.9	8.5	5.7	11.3	7.0	0.8	40.2	47.1	48.0	W
1983	2.0	9.0	25.3	35.8	53.7	8.1	4.3	125.8	133.8	138.1	W
1984	5.2	25.8	5.2	2.0	2.2	0.9	0.0	40.3	41.2	41.3	W
1985	4.7	2.2	0.4	1.0	0.7	0.3	0.1	8.9	9.2	9.3	D
1986	0.0	2.2	5.4	26.1	20.0	4.9	0.6	53.8	58.7	59.3	W
1987	0.0	0.0	0.2	1.6	3.1	0.2	0.0	4.8	5.0	5.0	C
1988	0.0	5.8	12.3	0.9	0.5	2.0	1.8	19.5	21.5	23.3	C
1989	0.2	0.1	0.3	0.1	8.0	0.4	0.1	8.7	9.1	9.2	B
1990	0.1	0.1	1.3	0.3	0.2	0.0	0.4	1.9	2.0	2.4	C
1991	0.0	0.0	0.0	0.0	10.3	0.9	0.2	10.3	11.2	11.3	C
1992	0.0	0.2	0.8	13.1	11.4	1.0	0.1	25.5	26.5	26.6	C
1993	0.0	2.4	17.9	16.8	6.4	1.6	1.1	43.5	45.1	46.1	W
1994	0.0	0.0	0.4	4.2	0.5	0.2	0.2	5.2	5.3	5.5	D
Total								1430.1	1569.1	1614.0	
Min	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.5	1.0	
Max	8.3	25.8	42.8	41.7	53.7	13.7	5.1	125.8	133.8	138.1	
Average	1.1	4.0	8.7	7.9	6.9	2.8	0.9	28.6	31.4	32.3	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-18. Divertible Flows of Red Bank Creek near Red Bluff to Tehama-Colusa Canal
2100 cfs Diversion Capacity (TAF/Month)

Contraints:
Red Bank Creek Instream Demand = 25 cfs
Delta Outflow in Surplus by amount > than diversion
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo

Water Year	Nov	Dec	Jan	Feb	Mar	Nov-Mar Total	Water Year Class
1945	0.1	1.1	0.0	4.3	0.2	5.7	B
1946	1.1	10.6	4.5	0.0	1.5	17.7	A
1947	0.3	0.1	0.0	2.0	2.7	5.1	D
1948	0.0	0.0	4.6	0.0	0.0	4.6	A
1949	0.0	0.1	0.0	0.3	15.2	15.5	D
1950	0.0	0.0	1.3	1.6	1.0	3.8	B
1951	0.3	4.7	6.3	5.5	0.4	17.1	W
1952	0.0	6.9	17.1	3.1	8.0	35.1	W
1953	0.0	16.9	15.6	0.7	1.2	34.4	W
1954	0.1	0.0	9.8	5.7	5.6	21.3	A
1955	2.4	4.1	0.6	0.0	0.0	7.1	D
1956	0.0	11.2	15.8	10.2	1.5	38.7	W
1957	0.0	0.0	0.7	6.4	1.6	8.7	B
1958	0.0	2.9	10.6	40.3	14.8	68.6	W
1959	0.0	0.0	4.5	6.6	0.0	11.1	D
1960	0.0	0.0	0.0	9.7	0.9	10.6	B
1961	0.0	1.3	3.4	5.3	0.8	10.9	D
1962	0.0	1.9	0.0	11.3	8.0	21.1	B
1963	0.0	0.3	4.7	9.5	1.8	16.3	W
1964	2.0	0.0	1.1	0.0	0.0	3.1	D
1965	1.3	11.9	13.8	0.2	0.0	27.2	W
1966	5.8	0.5	11.2	6.4	0.9	24.8	B
1967	1.1	6.1	18.7	3.7	1.7	31.3	W
1968	0.0	0.0	5.6	7.5	0.2	13.3	B
1969	0.0	7.1	25.5	27.6	7.6	67.8	W
1970	0.0	3.2	30.1	5.4	3.6	42.4	W
1971	2.8	9.0	4.6	0.0	2.1	18.4	W
1972	0.0	0.0	0.0	0.0	0.0	0.0	B
1973	7.3	3.5	20.3	18.3	12.1	61.6	W
1974	3.3	3.8	15.7	1.2	16.6	40.6	W
1975	0.0	1.3	0.0	10.7	28.1	40.2	A
1976	0.0	0.0	0.0	0.0	0.0	0.0	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	5.1	33.8	13.6	15.1	67.6	W
1979	0.0	0.0	1.9	5.5	5.0	12.4	D
1980	0.3	4.8	6.5	19.3	4.3	35.2	W
1981	0.0	1.3	16.8	3.9	6.5	28.4	D
1982	4.9	7.5	6.9	4.3	9.8	33.4	W
1983	1.4	7.7	18.7	27.3	39.1	94.2	W
1984	4.1	22.9	3.6	0.7	0.8	32.1	W
1985	3.8	1.3	0.0	0.4	0.1	5.7	D
1986	0.0	1.5	4.4	24.7	18.5	49.1	W
1987	0.0	0.0	0.0	1.0	2.1	3.1	C
1988	0.0	4.7	10.8	0.0	0.0	15.5	C
1989	0.0	0.0	0.0	0.0	6.8	6.8	B
1990	0.0	0.0	0.9	0.0	0.0	0.9	C
1991	0.0	0.0	0.0	0.0	9.2	9.2	C
1992	0.0	0.0	0.5	12.0	9.5	22.0	C
1993	0.0	2.0	13.2	15.4	4.9	35.5	W
1994	0.0	0.0	0.0	3.1	0.0	3.1	D
Total						1178.3	
Min	0.0	0.0	0.0	0.0	0.0	0.0	
Max	7.3	22.9	33.8	40.3	39.1	94.2	
Average	0.8	3.3	7.3	6.7	5.4	23.6	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table. 1-19. Divertible Flows of Red Bank Creek near Red Bluff to TCC -- Grouped by Flow Range 2100 cfs Diversion Capacity (TAF/Month)

Contraints:

Red Bank Creek Instream Demand = 25 cfs

Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo

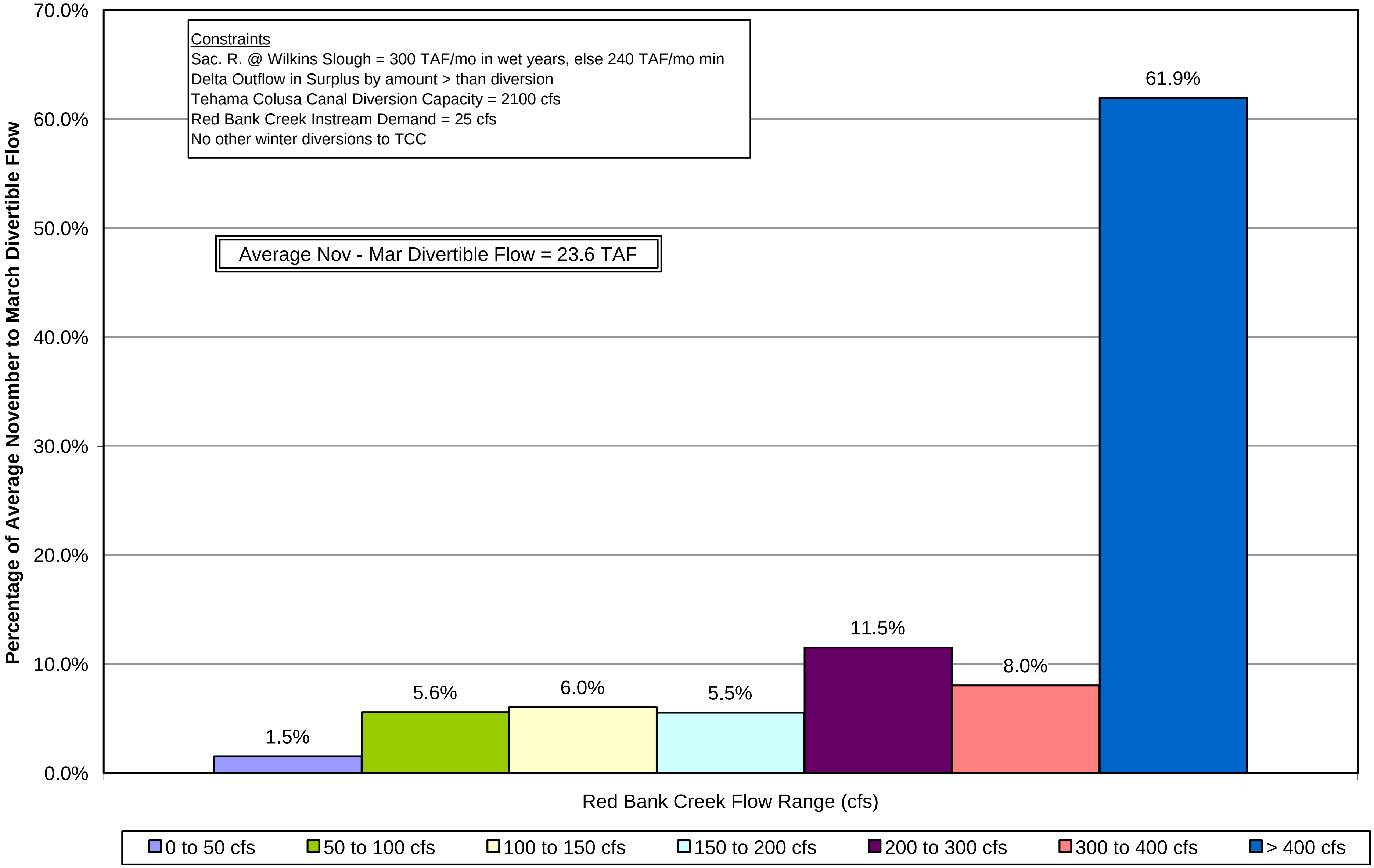
Delta Outflow in Surplus

November through March

	Red Bank Creek Flow Range (cfs)								**Water**
	0	**50**	**100**	**150**	**200**	**300**	**400**	**Nov-Mar**	**Year**
Water Year	**50**	**100**	**150**	**200**	**300**	**400**	**and above**	**Total**	**Class**
1945	0.3	0.9	1.8	1.4	1.3	0.0	0.0	5.7	B
1946	0.8	2.4	0.8	1.3	3.4	1.3	7.7	17.7	A
1947	0.2	1.8	1.1	0.3	0.0	0.6	1.2	5.1	D
1948	0.1	0.3	0.5	0.3	0.0	1.3	2.2	4.6	A
1949	0.1	0.8	0.7	1.5	3.2	4.4	4.7	15.5	D
1950	0.5	1.1	1.1	0.3	0.9	0.0	0.0	3.8	B
1951	0.6	2.2	1.9	2.8	2.4	0.7	6.5	17.1	W
1952	0.5	2.6	2.3	1.8	6.2	4.5	17.2	35.1	W
1953	0.4	1.7	2.0	1.2	5.6	7.8	15.6	34.4	W
1954	0.3	1.7	2.5	1.2	1.8	1.3	12.6	21.3	A
1955	0.6	1.0	0.9	0.3	1.5	0.7	2.1	7.1	D
1956	0.9	2.5	1.7	2.1	5.0	2.5	24.0	38.7	W
1957	0.3	0.8	0.4	0.0	0.5	0.7	6.0	8.7	B
1958	0.2	1.9	1.7	4.0	8.0	4.3	48.5	68.6	W
1959	0.3	1.0	0.4	0.6	1.7	1.3	5.9	11.1	D
1960	0.2	0.6	0.6	0.6	0.9	1.3	6.3	10.6	B
1961	0.3	0.6	0.4	0.8	1.9	1.1	5.8	10.9	D
1962	0.3	1.2	0.5	0.9	2.6	1.8	13.9	21.1	B
1963	0.1	0.6	1.6	0.9	1.8	1.2	10.2	16.3	W
1964	0.1	0.5	0.5	0.3	0.0	0.7	1.0	3.1	D
1965	0.3	0.7	1.8	3.1	2.5	1.6	17.2	27.2	W
1966	0.9	3.3	1.8	1.2	1.1	1.1	15.3	24.8	B
1967	0.6	1.4	1.4	0.9	1.2	2.0	23.9	31.3	W
1968	0.4	0.8	0.7	0.9	2.2	2.7	5.6	13.3	B
1969	0.2	2.9	2.8	3.0	6.4	4.1	48.3	67.8	W
1970	0.6	1.6	3.7	2.9	5.0	3.1	25.6	42.4	W
1971	0.5	1.9	2.2	1.7	2.9	0.7	8.6	18.4	W
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	B
1973	0.2	2.6	6.5	3.6	6.4	4.6	37.7	61.6	W
1974	0.8	3.8	2.3	2.5	4.0	1.3	25.8	40.6	W
1975	0.2	0.6	1.6	1.7	2.2	2.5	31.4	40.2	A
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.4	1.4	2.5	0.9	2.6	1.3	58.6	67.6	W
1979	0.3	0.7	0.8	0.3	2.1	1.2	7.0	12.4	D
1980	0.6	1.4	2.5	1.5	2.8	0.7	25.8	35.2	W
1981	0.8	1.7	1.3	1.2	1.4	1.2	20.9	28.4	D
1982	0.9	3.7	4.8	4.6	1.7	1.7	15.9	33.4	W
1983	0.2	0.7	1.1	1.9	8.0	7.3	74.9	94.2	W
1984	1.0	2.9	2.3	2.0	2.7	1.9	19.4	32.1	W
1985	0.2	1.1	0.7	0.6	2.2	0.0	1.0	5.7	D
1986	0.1	0.7	0.4	1.6	10.9	6.7	28.8	49.1	W
1987	0.1	0.2	0.2	1.2	0.9	0.6	0.0	3.1	C
1988	0.1	0.8	0.8	2.1	6.9	2.0	2.8	15.5	C
1989	0.1	0.1	1.0	0.9	3.1	0.6	0.9	6.8	B
1990	0.0	0.0	0.2	0.0	0.0	0.6	0.0	0.9	C
1991	0.0	0.6	0.2	0.3	2.4	1.2	4.3	9.2	C
1992	0.4	1.2	1.8	0.8	1.3	1.9	14.7	22.0	C
1993	0.6	2.4	1.9	0.9	3.1	3.7	22.9	35.5	W
1994	0.2	0.3	0.2	0.0	0.9	0.6	0.9	3.1	D
Total	17.7	65.4	70.8	65.0	135.5	94.4	729.5	1178.3	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	1.0	3.8	6.5	4.6	10.9	7.8	74.9	94.2	
Average	0.4	1.3	1.4	1.3	2.7	1.9	14.6	23.6	
% of Total Flow	1.5%	5.6%	6.0%	5.5%	11.5%	8.0%	61.9%	100.0%	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Figure 1-4. Red Bank Creek near Red Bluff
November through March Divertible Flow by Range
1945 - 1994 Analysis Period



attach1 tables&graphs.xls, RBDIP20800_RBDFNov-MarChart

Table 1-20. Monthly Flows of Colusa Basin Drain at Highway 20

Summarized from daily flows measured at gage (DWR A0-2976; 1945 – 1994).

	Colusa Basin Drain at Highway 20 (TAF/Month)										Water Year
Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Class
1945	13.8	13.5	12.9	38.1	14.6	13.6	42.9	93.1	106.7	149.6	B
1946	11.5	69.6	32.3	6.8	5.8	19.0	46.6	126.0	144.9	191.6	A
1947	15.8	20.6	7.7	15.1	9.6	8.3	29.2	68.8	77.1	106.3	D
1948	9.0	3.9	6.3	3.2	16.4	31.1	26.3	38.8	70.0	96.2	A
1949	17.2	10.7	11.3	4.8	110.5	17.6	55.0	154.5	172.1	227.1	D
1950	17.1	4.9	18.9	43.6	6.8	15.3	43.4	91.5	106.7	150.1	B
1951	17.5	54.8	40.4	24.7	8.4	26.4	53.4	145.8	172.2	225.6	W
1952	19.0	61.7	162.4	40.4	29.6	23.2	37.4	313.2	336.4	373.8	W
1953	23.2	123.6	115.5	13.8	15.8	28.9	73.2	291.9	320.8	393.9	W
1954	21.7	7.0	12.1	24.3	14.5	17.4	15.6	79.5	96.9	112.5	A
1955	41.5	33.8	18.9	7.7	7.4	29.7	57.0	109.3	139.0	196.0	D
1956	21.9	83.3	146.5	59.9	18.6	37.2	75.9	330.2	367.4	443.3	W
1957	15.4	15.3	16.3	10.0	9.3	30.3	71.9	66.4	96.7	168.5	B
1958	6.6	10.3	49.0	387.0	124.9	96.0	65.0	577.8	673.9	738.9	W
1959	26.1	22.3	38.0	59.1	18.2	24.1	65.3	163.6	187.7	253.0	D
1960	21.4	23.1	19.7	34.9	10.0	25.1	73.9	109.1	134.1	208.1	B
1961	25.8	24.3	23.7	52.5	14.1	23.3	73.1	140.4	163.6	236.7	D
1962	23.1	30.2	10.0	78.3	29.1	25.1	67.5	170.7	195.8	263.3	B
1963	*11.3*	16.6	13.0	59.5	*14.4*	33.8	44.7	*114.8*	*148.6*	*193.3*	W
1964	23.3	12.3	17.6	7.1	20.3	*10.8*	56.3	80.5	*91.3*	*147.6*	D
1965	29.9	20.0	70.6	9.9	16.5	29.4	49.9	146.9	176.3	226.2	W
1966	29.8	*13.3*	*24.4*	32.9	13.2	19.5	53.0	*113.6*	*133.1*	*186.2*	B
1967	31.3	43.3	71.0	60.6	15.3	36.7	27.3	221.6	258.3	285.6	W
1968	24.6	14.0	26.3	88.0	18.0	15.2	65.1	171.0	186.2	251.3	B
1969	24.2	39.5	105.7	149.6	75.3	23.9	59.8	394.3	418.3	478.1	W
1970	14.1	39.0	168.8	51.9	23.5	22.0	58.9	297.4	319.4	378.3	W
1971	24.6	64.4	28.3	9.1	11.6	22.3	81.0	138.0	160.3	241.3	W
1972	16.5	17.5	12.1	7.0	17.5	21.9	59.3	70.6	92.5	151.9	B
1973	46.6	29.9	169.7	191.7	96.1	18.9	44.7	533.9	552.8	597.5	W
1974	40.8	43.0	58.2	12.4	17.7	18.3	46.3	172.1	190.4	236.7	W
1975	12.1	19.9	13.4	56.4	47.7	21.2	56.6	149.4	170.6	227.2	A
1976	14.8	9.9	11.4	10.2	22.8	18.6	41.8	69.1	87.7	129.5	C
1977	15.2	8.5	19.2	10.1	15.8	5.3	39.5	68.7	74.0	113.5	C
1978	16.2	15.6	191.9	118.5	87.8	21.7	42.0	430.0	451.7	493.7	W
1979	18.6	7.0	42.4	52.2	25.0	19.5	49.3	145.1	164.6	213.9	D
1980	33.5	51.5	115.2	166.1	80.2	19.4	64.5	446.5	465.9	530.4	W
1981	19.5	22.1	62.5	46.6	26.6	20.3	63.9	177.3	197.6	261.5	D
1982	52.2	68.6	119.2	26.2	23.6	40.6	45.7	289.7	330.3	376.0	W
1983	46.3	75.3	143.3	168.2	326.1	58.9	*55.4*	759.2	818.1	*873.5*	W
1984	77.5	222.8	93.6	23.2	16.3	32.5	73.2	433.4	465.9	539.1	W
1985	69.0	42.0	17.5	9.5	12.1	24.4	64.4	150.1	174.4	238.9	D
1986	39.5	43.0	46.3	234.0	115.8	26.7	56.6	478.7	505.4	562.0	W
1987	27.3	14.4	15.3	17.7	31.3	29.5	56.1	106.0	135.5	191.7	C
1988	39.8	28.4	83.9	16.5	26.5	39.6	52.2	195.2	234.8	287.0	C
1989	36.7	21.8	21.0	11.8	24.8	26.1	35.2	116.1	142.2	177.4	B
1990	24.4	11.1	21.3	11.3	*13.3*	*18.2*	35.8	*81.4*	*99.5*	*135.4*	C
1991	*22.9*	*9.0*	9.4	12.0	56.3	25.2	29.3	*109.8*	*135.0*	*164.3*	C
1992	19.0	17.9	16.1	53.6	41.2	15.2	10.3	147.8	163.0	173.3	C
1993	15.9	21.3	178.3	169.3	46.9	19.2	17.1	431.7	450.9	468.0	W
1994	24.9	28.7	19.4	41.1	20.4	17.9	11.7	134.4	152.3	164.0	D
Total	1289.9	1704.4	2748.6	2838.3	1863.9	1264.1	2519.6	10445.1	11709.2	14228.8	
Min	6.6	3.9	6.3	3.2	5.8	5.3	10.3	38.8	70.0	96.2	
Max	77.5	222.8	191.9	387.0	326.1	96.0	81.0	759.2	818.1	873.5	
Average	25.8	34.1	55.0	56.8	37.3	25.3	50.4	208.9	234.2	284.6	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

italicized values are estimated - No Record of flow on some days.

Table 1-21. Divertible Flows of Colusa Basin Drain at Highway 20
3000 cfs Diversion Capacity (TAF/Month)

Contraints:
Colusa Basin Drain below Highway 20 Instream Demand = 200 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
1945	3.9	4.6	0.0	27.8	5.7	3.0	6.0	42.0	45.0	51.0	B
1946	1.1	55.3	20.3	0.0	0.1	0.0	0.0	76.7	76.7	76.7	A
1947	4.5	9.2	0.0	6.5	1.0	0.4	0.0	21.2	21.6	21.6	D
1948	0.0	0.0	0.0	0.0	5.6	19.7	15.8	5.6	25.3	41.1	A
1949	0.0	3.9	2.0	0.0	77.8	6.6	0.0	83.6	90.2	90.2	D
1950	0.0	0.0	7.6	32.6	0.0	5.5	5.9	40.2	45.7	51.6	B
1951	5.8	42.6	28.1	13.5	0.4	14.6	41.5	90.6	105.1	146.6	W
1952	8.1	49.4	114.7	28.9	17.3	12.3	25.1	218.5	230.8	256.0	W
1953	11.9	111.3	103.2	2.8	4.7	17.1	60.9	233.9	251.0	311.9	W
1954	9.9	0.0	3.6	14.2	2.7	6.1	0.0	30.5	36.6	36.6	A
1955	29.6	21.6	6.7	0.0	0.7	7.6	6.0	58.6	66.2	72.2	D
1956	0.0	70.8	133.3	48.4	6.6	25.3	63.6	259.1	284.3	348.0	W
1957	2.7	2.8	5.8	3.6	0.2	0.0	59.6	15.1	15.1	74.7	B
1958	0.0	1.6	36.9	159.2	105.4	83.8	52.7	303.1	386.9	439.6	W
1959	14.2	10.0	25.8	47.9	0.0	0.0	0.0	97.9	97.9	97.9	D
1960	0.0	0.0	8.2	24.0	0.7	0.0	0.0	32.9	32.9	32.9	B
1961	5.8	12.1	9.8	41.4	2.1	0.0	0.0	71.1	71.1	71.1	D
1962	0.0	16.0	0.0	64.6	17.3	0.0	0.0	98.0	98.0	98.0	B
1963	1.1	6.7	3.8	48.4	3.0	21.9	32.4	63.0	85.0	117.3	W
1964	11.7	0.9	6.6	0.0	10.5	0.0	6.0	29.6	29.6	35.6	D
1965	5.7	8.9	58.3	1.1	0.0	18.5	0.0	74.0	92.4	92.4	W
1966	17.9	2.1	12.9	21.8	2.4	9.0	0.0	57.2	66.2	66.2	B
1967	19.4	31.0	52.4	41.9	4.0	24.8	16.6	148.6	173.4	190.0	W
1968	12.7	4.8	15.8	76.5	6.5	0.0	6.0	116.3	116.3	122.3	B
1969	1.6	28.3	91.0	121.3	62.7	12.0	47.5	305.0	317.0	364.5	W
1970	4.5	28.8	131.1	40.8	11.6	0.0	44.0	216.8	216.8	260.8	W
1971	14.4	52.1	16.0	0.0	2.9	0.0	68.7	85.4	85.4	154.2	W
1972	4.7	6.5	2.3	0.0	8.1	0.0	0.0	21.6	21.6	21.6	B
1973	35.1	17.8	119.5	131.3	80.0	7.1	32.5	383.7	390.8	423.3	W
1974	28.9	30.7	45.9	2.5	6.3	7.8	34.5	114.2	122.0	156.5	W
1975	3.5	8.4	2.8	45.3	35.6	9.8	44.8	95.6	105.4	150.2	A
1976	3.2	0.5	2.2	0.0	10.5	10.0	0.0	16.4	26.4	26.4	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	5.1	118.9	97.4	73.9	9.8	30.8	295.3	305.1	335.9	W
1979	6.4	0.0	31.6	41.9	13.0	8.8	5.2	92.9	101.7	106.8	D
1980	21.6	39.6	91.5	79.7	65.4	8.4	49.3	297.8	306.2	355.6	W
1981	0.0	9.8	47.2	34.8	14.3	9.1	0.0	106.1	115.2	115.2	D
1982	40.3	52.8	93.3	15.1	11.4	28.7	32.1	212.9	241.5	273.6	W
1983	34.4	61.1	65.8	129.2	182.8	47.0	43.2	473.3	520.3	563.5	W
1984	65.6	139.2	72.4	11.7	4.0	15.7	56.1	292.8	308.5	364.6	W
1985	57.1	29.7	5.6	0.5	0.9	12.6	0.0	93.8	106.4	106.4	D
1986	0.0	30.7	33.8	141.1	99.3	14.8	44.0	304.9	319.7	363.7	W
1987	0.0	2.4	3.3	6.6	19.1	0.0	0.0	31.5	31.5	31.5	C
1988	0.0	16.1	67.5	0.0	0.0	0.0	0.0	83.7	83.7	83.7	C
1989	0.0	0.0	0.0	0.0	12.5	14.2	0.0	12.5	26.7	26.7	B
1990	0.0	0.0	9.5	0.0	1.5	0.0	0.0	11.0	11.0	11.0	C
1991	0.0	0.0	0.0	0.0	44.0	13.3	5.5	44.0	57.3	62.8	C
1992	0.0	0.0	4.3	43.2	28.9	0.0	0.0	76.5	76.5	76.5	C
1993	0.0	9.5	135.9	122.9	34.6	8.3	8.4	302.9	311.2	319.6	W
1994	0.0	16.4	7.1	30.0	0.0	7.7	0.0	53.5	61.2	61.2	D
Total								6291.2	6812.6	7757.1	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	65.6	139.2	135.9	159.2	182.8	83.8	68.7	473.3	520.3	563.5	
Average	9.7	21.0	37.1	36.0	22.0	10.4	18.9	125.8	136.3	155.1	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-22. Divertible Flows of Colusa Basin Drain at Highway 20 -- Grouped by Flow Range
3000 cfs Diversion Capacity (TAF/Month)

Contraints:

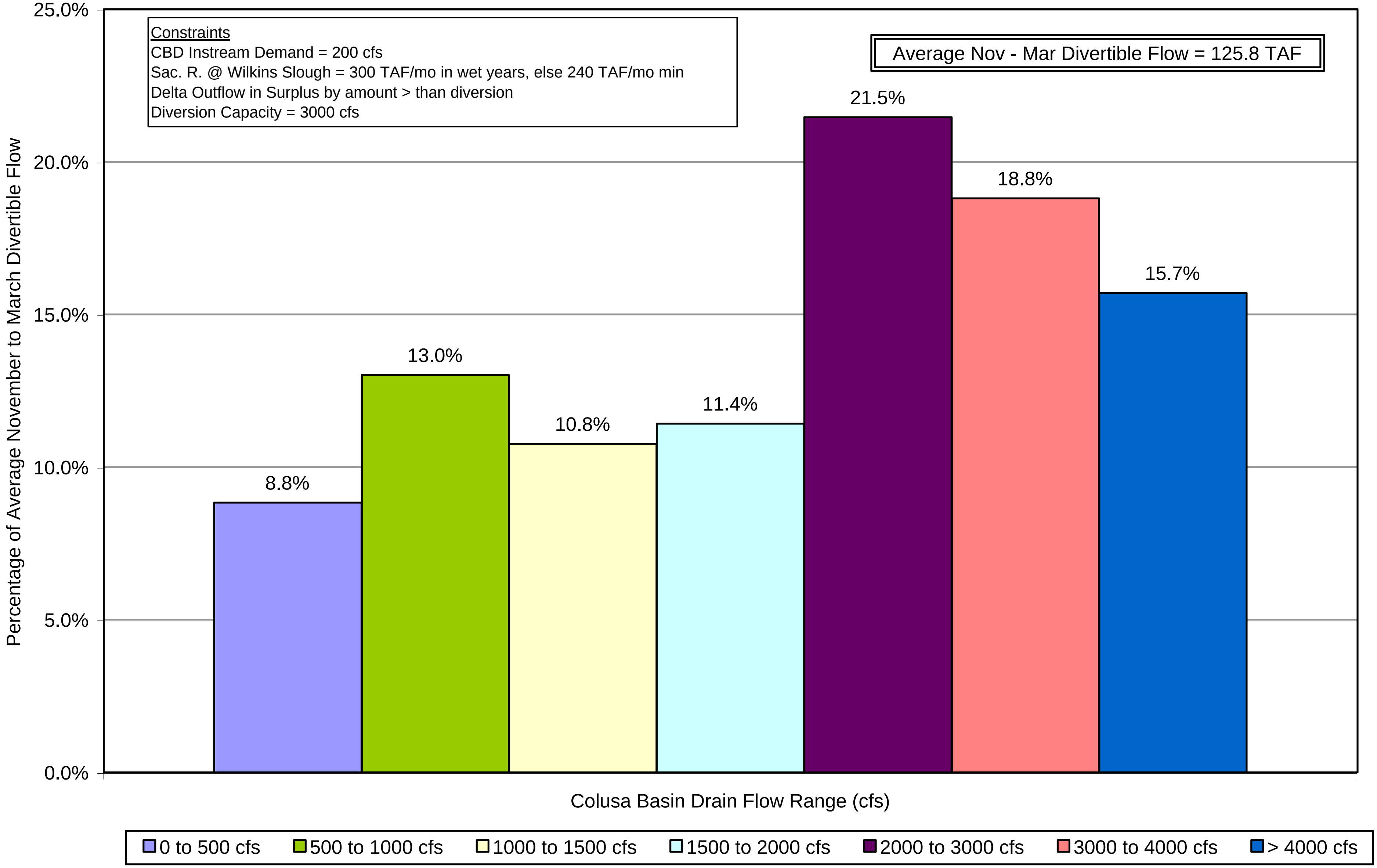
November through March

Colusa Basin Drain below Highway 20 Instream Demand = 200 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

	Colusa Basin Drain Flow Range (cfs)								Water
	0	**500**	**1000**	**1500**	**2000**	**3000**	**4000**	**Nov-Mar**	**Year**
Water Year	**500**	**1000**	**1500**	**2000**	**3000**	**4000**	**and above**	**Total**	**Class**
1945	9.0	9.4	4.4	19.1	0.0	0.0	0.0	42.0	B
1946	6.2	5.1	15.4	9.0	17.3	23.6	0.0	76.7	A
1947	9.6	8.3	3.4	0.0	0.0	0.0	0.0	21.2	D
1948	4.3	1.3	0.0	0.0	0.0	0.0	0.0	5.6	A
1949	3.8	7.8	9.5	24.7	14.0	0.0	23.8	83.6	D
1950	7.8	5.7	13.3	13.4	0.0	0.0	0.0	40.2	B
1951	15.9	16.2	17.3	41.2	0.0	0.0	0.0	90.6	W
1952	17.1	26.6	25.0	31.9	58.6	23.8	35.7	218.5	W
1953	13.7	16.1	17.1	18.9	168.1	0.0	0.0	233.9	W
1954	11.6	12.4	6.5	0.0	0.0	0.0	0.0	30.5	A
1955	13.4	15.7	21.2	8.4	0.0	0.0	0.0	58.6	D
1956	10.0	12.0	8.2	28.4	124.4	76.1	0.0	259.1	W
1957	8.7	6.4	0.0	0.0	0.0	0.0	0.0	15.1	B
1958	6.7	14.4	4.3	9.0	97.1	58.5	113.1	303.1	W
1959	23.4	15.1	15.7	2.6	17.4	23.6	0.0	97.9	D
1960	6.0	9.6	14.4	2.9	0.0	0.0	0.0	32.9	B
1961	11.7	14.5	18.0	10.7	16.2	0.0	0.0	71.1	D
1962	7.7	8.1	12.1	19.2	9.7	35.2	6.0	98.0	B
1963	9.2	7.6	12.4	12.1	21.6	0.0	0.0	63.0	W
1964	11.0	16.8	1.9	0.0	0.0	0.0	0.0	29.6	D
1965	10.3	8.5	6.3	9.8	27.6	11.5	0.0	74.0	W
1966	14.8	14.0	15.9	12.4	0.0	0.0	0.0	57.2	B
1967	12.8	25.7	15.4	19.1	22.3	23.5	29.8	148.6	W
1968	22.7	17.6	4.5	9.3	56.5	5.6	0.0	116.3	B
1969	9.1	26.4	19.5	34.1	109.2	76.8	29.8	305.0	W
1970	15.5	22.6	21.0	14.9	41.7	59.4	41.7	216.8	W
1971	13.2	19.6	17.0	15.6	20.2	0.0	0.0	85.4	W
1972	13.1	8.5	0.0	0.0	0.0	0.0	0.0	21.6	B
1973	6.9	26.7	24.2	42.6	93.0	71.3	119.0	383.7	W
1974	18.3	39.7	33.9	14.9	7.4	0.0	0.0	114.2	W
1975	10.9	25.5	18.3	21.0	19.9	0.0	0.0	95.6	A
1976	12.2	4.2	0.0	0.0	0.0	0.0	0.0	16.4	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	9.5	20.3	21.1	16.0	67.9	107.0	53.6	295.3	W
1979	10.4	22.0	24.9	6.7	29.0	0.0	0.0	92.9	D
1980	13.0	30.4	13.3	28.7	39.9	83.2	89.3	297.8	W
1981	11.1	16.6	13.8	8.2	20.9	35.4	0.0	106.1	D
1982	18.2	37.8	40.3	33.0	24.0	35.7	23.8	212.9	W
1983	11.7	23.8	23.9	30.4	33.3	177.6	172.6	473.3	W
1984	16.2	27.2	32.8	32.8	59.2	53.2	71.4	292.8	W
1985	13.2	16.6	24.4	35.5	4.1	0.0	0.0	93.8	D
1986	10.0	39.1	15.5	27.0	58.9	94.9	59.5	304.9	W
1987	15.9	9.4	6.2	0.0	0.0	0.0	0.0	31.5	C
1988	9.1	22.3	12.8	2.8	12.9	23.7	0.0	83.7	C
1989	7.4	5.2	0.0	0.0	0.0	0.0	0.0	12.5	B
1990	5.0	6.0	0.0	0.0	0.0	0.0	0.0	11.0	C
1991	2.4	14.8	7.9	9.5	9.4	0.0	0.0	44.0	C
1992	11.3	10.6	17.6	20.1	16.9	0.0	0.0	76.5	C
1993	11.1	25.7	15.7	16.5	31.6	83.2	119.0	302.9	W
1994	13.9	22.6	10.8	6.2	0.0	0.0	0.0	53.5	D
Total	556.1	818.6	677.1	718.6	1350.2	1182.9	987.8	6291.2	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	23.4	39.7	40.3	42.6	168.1	177.6	172.6	473.3	
Average	11.1	16.4	13.5	14.4	27.0	23.7	19.8	125.8	
% of Total Flow	8.8%	13.0%	10.8%	11.4%	21.5%	18.8%	15.7%	100.0%	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Figure 1-5. Colusa Basin Drain at Highway 20
November through March Divertible Flow by Range
1945 - 1994 Analysis Period



attach1 tables&graphs.xls, CBD_DF_DFNov-MarChart

Table 1-23. Monthly Flows of Sacramento River at Butte City
Summarized from daily flows measured at gage (USGS 11389000; 1939 – 1995).

	Sacramento River at Butte City Flow (TAF/Month)										
Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
1945	371.1	542.5	471.5	1051.6	696.3	424.6	397.8	3133.1	3557.7	3955.5	B
1946	550.5	1969.3	1944.2	645.3	602.9	553.1	458.6	5712.2	6265.3	6723.8	A
1947	437.8	578.5	428.2	528.2	603.9	435.9	328.4	2576.6	3012.5	3340.8	D
1948	382.7	326.7	670.7	320.1	608.6	1462.1	1325.4	2308.7	3770.8	5096.2	A
1949	401.9	487.4	405.6	376.0	1546.0	490.4	391.1	3216.8	3707.2	4098.3	D
1950	322.0	311.6	603.3	836.4	540.1	401.9	369.3	2613.5	3015.4	3384.7	B
1951	621.5	1906.8	1417.6	1880.9	867.5	370.3	447.7	6694.4	7064.6	7512.4	W
1952	388.7	1229.1	2023.7	2317.9	1593.9	1366.8	1128.6	7553.4	8920.2	10048.8	W
1953	343.8	1440.4	4077.4	812.4	604.9	487.3	647.1	7278.9	7766.2	8413.3	W
1954	478.7	495.1	1501.1	2339.9	1281.5	1088.9	593.0	6096.3	7185.2	7778.2	A
1955	521.2	788.4	710.0	442.2	354.3	423.2	440.2	2816.1	3239.3	3679.5	D
1956	383.3	2407.8	4099.6	2105.1	1155.8	516.4	888.3	10151.6	10668.0	11556.2	W
1957	461.2	428.1	375.2	609.1	1488.8	413.0	769.0	3362.5	3775.5	4544.5	B
1958	710.4	882.5	1648.5	5802.6	2295.3	2636.6	1074.2	11339.2	13975.9	15050.1	W
1959	465.6	429.1	1110.9	1477.5	635.4	371.9	399.9	4118.4	4490.4	4890.3	D
1960	259.3	261.7	391.2	1166.3	738.1	358.5	439.3	2816.6	3175.1	3614.4	B
1961	401.2	687.7	444.7	1470.9	1201.4	524.5	425.8	4205.8	4730.3	5156.1	D
1962	354.7	635.2	385.2	1393.5	1030.9	425.0	419.6	3799.5	4224.6	4644.2	B
1963	432.9	1030.1	640.0	1751.2	703.7	2356.2	888.4	4557.9	6914.1	7802.5	W
1964	705.8	684.9	796.5	650.8	397.3	383.9	420.6	3235.3	3619.2	4039.8	D
1965	492.0	2036.5	2945.3	1098.4	436.3	1000.3	610.5	7008.4	8008.7	8619.2	W
1966	757.1	851.0	1462.8	945.1	719.6	546.5	525.6	4735.5	5282.0	5807.6	B
1967	745.3	1752.8	1404.3	1758.5	818.8	1334.3	1286.9	6479.7	7814.0	9100.9	W
1968	472.4	630.7	958.3	1779.6	1142.3	490.4	482.2	4983.2	5473.6	5955.8	B
1969	512.9	1097.0	3096.4	3118.6	1431.5	886.8	1039.3	9256.4	10143.2	11182.6	W
1970	522.2	1677.7	4420.2	2592.6	1138.5	544.6	491.2	10351.2	10895.8	11387.0	W
1971	1011.3	2511.7	2025.5	957.6	907.5	1054.2	1011.6	7413.6	8467.8	9479.4	W
1972	448.6	613.8	632.4	640.7	1027.3	617.4	599.1	3362.8	3980.1	4579.2	B
1973	866.5	1004.6	2678.9	2374.0	1694.7	685.0	665.5	8618.7	9303.7	9969.2	W
1974	2023.6	2804.2	3944.5	1612.6	2253.4	2753.3	912.8	12638.4	15391.6	16304.4	W
1975	650.7	742.6	565.9	1595.0	2543.6	1011.4	1050.8	6097.9	7109.2	8160.1	A
1976	685.2	749.8	488.8	490.9	582.7	561.0	627.6	2997.3	3558.3	4185.9	C
1977	261.8	260.7	421.8	326.0	343.0	351.0	424.8	1613.4	1964.4	2389.2	C
1978	317.3	566.5	2283.5	1636.1	2373.0	1188.9	686.6	7176.4	8365.3	9051.9	W
1979	391.6	432.7	680.4	881.2	776.9	514.9	501.3	3162.9	3677.8	4179.0	D
1980	471.2	808.4	2327.2	2674.3	1902.3	520.7	414.1	8183.5	8704.2	9118.4	W
1981	366.3	591.4	874.1	710.3	953.0	607.9	530.7	3495.1	4103.0	4633.7	D
1982	1093.0	2459.5	1933.5	2099.5	1731.6	2339.9	951.1	9317.1	11657.0	12608.1	W
1983	850.6	1892.4	1951.5	3931.0	5789.0	1895.8	1646.9	14414.6	16310.4	17957.2	W
1984	1463.0	3641.3	1662.1	761.7	886.7	513.4	483.0	8414.8	8928.2	9411.2	W
1985	1099.0	1108.6	552.0	498.4	466.9	412.2	419.8	3724.8	4137.1	4556.9	D
1986	347.1	489.7	682.2	3785.1	3193.2	509.7	460.3	8497.3	9007.0	9467.3	W
1987	423.2	464.1	489.2	581.5	880.4	514.6	523.4	2838.2	3352.8	3876.2	C
1988	253.9	645.0	965.7	375.1	410.4	637.8	540.8	2650.1	3287.9	3828.7	C
1989	431.4	494.9	467.1	377.5	1240.1	475.0	530.1	3011.0	3486.0	4016.2	B
1990	469.5	357.1	553.2	338.8	403.9	398.3	497.1	2122.4	2520.7	3017.8	C
1991	261.0	292.2	315.0	277.4	830.1	341.7	397.7	1975.7	2317.4	2715.2	C
1992	247.5	299.2	368.4	976.3	725.7	366.7	307.3	2617.1	2983.8	3291.1	C
1993	217.4	466.3	1860.4	1500.2	2068.2	1110.3	582.6	6112.5	7222.8	7805.5	W
1994	309.5	462.3	407.5	599.5	399.7	3.7	3.3	2178.6	2182.3	2185.6	D
Total								273035.1	312713.5	344169.8	
Min	217.4	260.7	315.0	277.4	343.0	3.7	3.3	1613.4	1964.4	2185.6	
Max	2023.6	3641.3	4420.2	5802.6	5789.0	2753.3	1646.9	14414.6	16310.4	17957.2	
Average	549.1	994.5	1351.3	1385.4	1180.3	793.6	629.1	5460.7	6254.3	6883.4	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-24. Divertible Flows of Sacramento River at Butte City
5000 cfs Diversion Capacity (TAF/Month)

Contraints:
Butte City = 10000 cfs
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo
Delta Outflow in Surplus

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Nov-Mar Total	Nov-Apr Total	Nov-May Total	Water Year Class
1945	4.1	49.4	0.0	171.6	33.1	2.0	0.0	258.2	260.2	260.2	B
1946	27.8	178.3	303.3	0.0	13.7	0.0	0.0	523.1	523.1	523.1	A
1947	1.1	43.3	0.0	44.4	56.3	1.8	0.0	145.1	146.9	146.9	D
1948	0.0	0.0	22.7	0.0	51.4	258.6	250.7	74.1	332.7	583.4	A
1949	0.0	0.0	0.0	4.2	256.1	0.6	0.0	260.2	260.8	260.8	D
1950	0.0	0.0	77.8	90.4	54.3	0.0	0.0	222.5	222.5	222.5	B
1951	83.4	287.4	285.2	277.7	174.7	0.0	5.2	1108.5	1108.5	1113.6	W
1952	7.3	122.4	307.4	287.6	307.4	297.5	298.7	1032.2	1329.7	1628.4	W
1953	0.0	241.8	307.4	173.6	47.8	16.4	47.6	770.6	787.0	834.6	W
1954	12.1	0.4	148.8	277.7	293.4	268.0	0.0	732.3	1000.3	1000.3	A
1955	25.9	102.3	91.4	0.0	0.0	1.6	0.0	219.6	221.2	221.2	D
1956	0.0	171.0	307.4	279.3	245.6	3.0	218.6	1003.2	1006.2	1224.8	W
1957	0.2	0.0	5.2	49.6	246.1	0.0	62.6	301.1	301.1	363.7	B
1958	98.6	151.7	307.4	277.7	307.4	297.5	301.9	1142.9	1440.4	1742.3	W
1959	0.0	0.0	240.6	215.0	0.0	0.0	0.0	455.6	455.6	455.6	D
1960	0.0	0.0	6.7	160.1	102.0	0.0	0.0	268.7	268.7	268.7	B
1961	0.5	38.9	4.1	271.7	145.0	0.0	0.0	460.2	460.2	460.2	D
1962	0.0	19.7	0.0	198.3	153.9	0.0	0.0	372.0	372.0	372.0	B
1963	7.9	194.8	59.8	277.7	4.2	284.6	180.3	544.4	829.0	1009.4	W
1964	102.9	38.6	104.9	29.9	0.0	0.0	0.0	276.4	276.4	276.4	D
1965	1.7	123.4	307.4	214.8	0.0	172.8	0.0	647.3	820.1	820.1	W
1966	146.4	205.1	305.3	178.5	110.7	5.2	0.0	945.9	951.1	951.1	B
1967	74.2	300.7	117.4	257.3	163.4	279.3	307.4	913.0	1192.2	1499.7	W
1968	0.0	31.4	122.2	256.9	238.6	0.0	0.0	649.0	649.0	649.0	B
1969	0.1	163.6	238.2	277.7	307.4	247.1	303.5	987.0	1234.2	1537.7	W
1970	0.6	188.4	307.4	277.7	272.5	0.0	2.4	1046.7	1046.7	1049.1	W
1971	156.9	307.4	307.4	0.0	125.6	0.0	293.4	897.3	897.3	1190.7	W
1972	0.0	36.5	56.1	72.4	206.7	0.0	0.0	371.7	371.7	371.7	B
1973	181.3	204.9	305.1	277.7	301.3	95.8	36.4	1270.2	1366.0	1402.4	W
1974	219.2	307.4	307.4	277.7	307.4	297.5	230.9	1419.2	1716.7	1947.6	W
1975	72.0	102.6	28.9	265.0	302.3	286.6	306.0	770.8	1057.4	1363.4	A
1976	107.2	100.0	0.0	0.0	42.6	5.8	0.0	249.9	255.7	255.7	C
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	C
1978	0.0	19.9	240.4	217.6	291.6	288.0	91.9	769.4	1057.4	1149.3	W
1979	0.0	0.0	61.5	136.9	106.3	23.4	0.2	304.7	328.1	328.3	D
1980	17.9	72.2	280.5	220.0	261.2	18.2	0.0	851.8	870.0	870.0	W
1981	0.0	25.2	84.3	100.4	151.5	26.0	0.0	361.4	387.3	387.3	D
1982	157.1	307.4	306.8	243.8	306.4	297.5	67.0	1321.6	1619.1	1686.1	W
1983	126.1	278.7	227.3	277.7	307.4	297.5	305.1	1217.3	1514.8	1819.8	W
1984	207.1	307.4	304.3	158.9	187.4	3.4	0.0	1165.1	1168.5	1168.5	W
1985	190.6	248.9	3.2	22.8	0.0	0.0	0.0	465.5	465.5	465.5	D
1986	0.0	19.1	67.4	241.4	307.0	18.2	4.7	635.0	653.2	657.9	W
1987	0.0	0.0	28.8	64.3	116.8	0.0	0.0	209.9	209.9	209.9	C
1988	0.0	36.7	164.0	0.0	0.0	0.0	0.0	200.7	200.7	200.7	C
1989	0.0	0.0	0.0	0.0	257.7	30.9	0.0	257.7	288.6	288.6	B
1990	0.0	0.0	59.1	0.0	3.2	0.0	0.0	62.3	62.3	62.3	C
1991	0.0	0.0	0.0	0.0	139.8	0.0	0.0	139.8	139.8	139.8	C
1992	0.0	0.0	0.8	162.0	69.8	0.0	0.0	232.6	232.6	232.6	C
1993	0.0	19.6	276.9	207.5	208.5	196.4	16.1	712.5	908.8	924.9	W
1994	0.0	15.0	11.9	91.8	0.0	0.0	0.0	118.7	118.7	118.7	D
Total								29364.6	33386.0	36716.6	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Max	219.2	307.4	307.4	287.6	307.4	297.5	307.4	1419.2	1716.7	1947.6	
Average	40.6	101.2	142.0	151.7	151.7	80.4	66.6	587.3	667.7	734.3	

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Table 1-25. Divertible Flows of Sacramento River at B -- Grouped by Flow Range

5000 cfs Diversion Capacity (TAF/Month)

Contraints: **November through March**

Butte City = 10000 cfs

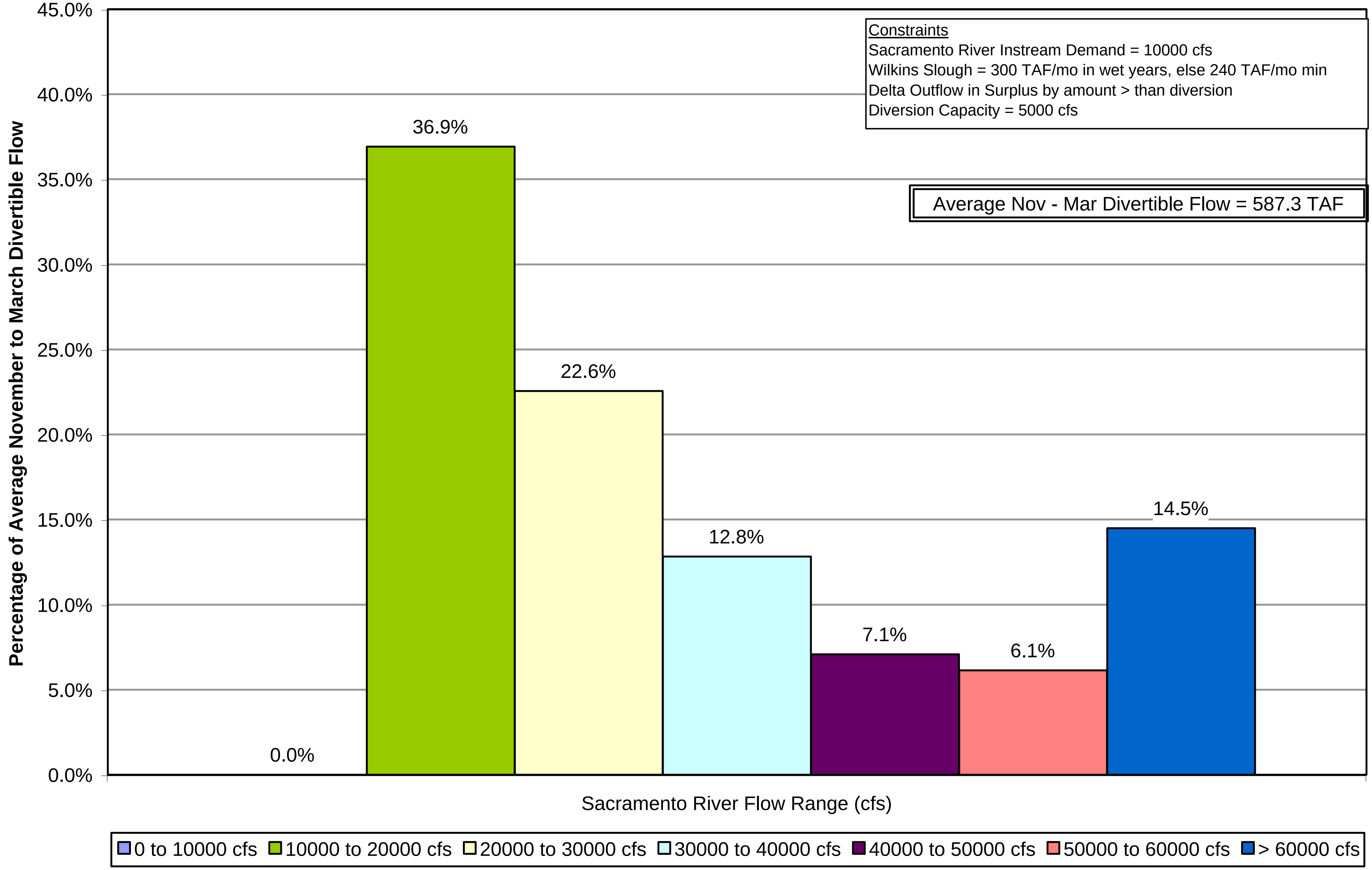
Wilkins Slough = 300 TAF/mo in wet years, else 240 TAF/mo

Delta Outflow in Surplus

	Sacramento River Flow Range (cfs)							
	0	**10000**	**20000**	**30000**	**40000**	**50000**	**60000**	**Nov-Mar**
Water Year	**10000**	**20000**	**30000**	**40000**	**50000**	**60000**	**and above**	**Total**
1945	0.0	167.2	51.3	9.9	19.8	9.9	0.0	258.2
1946	0.0	168.0	117.1	49.6	59.5	59.5	69.4	523.1
1947	0.0	86.4	48.8	0.0	9.9	0.0	0.0	145.1
1948	0.0	36.2	16.0	2.0	19.8	0.0	0.0	74.1
1949	0.0	71.8	128.9	29.8	0.0	9.9	19.8	260.2
1950	0.0	153.1	39.7	0.0	0.0	29.8	0.0	222.5
1951	0.0	464.4	257.3	188.4	128.9	39.7	29.8	1108.5
1952	0.0	90.0	446.3	257.9	89.3	69.4	79.3	1032.2
1953	0.0	314.4	119.0	99.2	29.8	39.7	168.6	770.6
1954	0.0	206.7	218.2	89.3	49.6	59.5	109.1	732.3
1955	0.0	182.7	29.8	7.2	0.0	0.0	0.0	219.6
1956	0.0	328.9	69.4	59.5	69.4	158.7	317.4	1003.2
1957	0.0	122.5	59.5	39.7	39.7	39.7	0.0	301.1
1958	0.0	409.5	207.8	69.4	69.4	39.7	347.1	1142.9
1959	0.0	227.5	99.2	49.6	49.6	9.9	19.8	455.6
1960	0.0	159.6	49.6	29.8	9.9	0.0	19.8	268.7
1961	0.0	213.2	157.4	44.8	19.8	25.0	0.0	460.2
1962	0.0	166.4	81.8	59.5	14.8	9.9	39.7	372.0
1963	0.0	276.0	120.3	88.2	20.3	19.8	19.8	544.4
1964	0.0	226.8	29.8	19.8	0.0	0.0	0.0	276.4
1965	0.0	111.2	119.6	198.3	39.7	39.7	138.8	647.3
1966	0.0	688.1	178.5	39.7	29.8	0.0	9.9	945.9
1967	0.0	432.0	203.3	29.8	79.3	109.1	59.5	913.0
1968	0.0	361.4	109.1	69.4	19.8	59.5	29.8	649.0
1969	0.0	292.8	148.8	109.1	128.9	59.5	247.9	987.0
1970	0.0	233.5	257.9	119.0	79.3	109.1	247.9	1046.7
1971	0.0	242.8	267.8	178.5	59.5	59.5	89.3	897.3
1972	0.0	272.5	99.2	0.0	0.0	0.0	0.0	371.7
1973	0.0	506.6	228.1	208.3	79.3	99.2	148.8	1270.2
1974	0.0	40.7	317.4	446.3	238.0	148.8	228.1	1419.2
1975	0.0	325.9	157.2	99.2	49.6	59.5	79.3	770.8
1976	0.0	239.9	9.9	0.0	0.0	0.0	0.0	249.9
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	246.3	126.5	99.2	59.5	49.6	188.4	769.4
1979	0.0	146.0	99.2	49.6	9.9	0.0	0.0	304.7
1980	0.0	296.4	138.8	79.3	29.8	89.3	218.2	851.8
1981	0.0	181.1	110.8	49.6	0.0	9.9	9.9	361.4
1982	0.0	329.9	386.8	238.0	128.9	59.5	178.5	1321.6
1983	0.0	294.9	109.1	79.3	39.7	49.6	644.6	1217.3
1984	0.0	391.5	307.4	178.5	89.3	79.3	119.0	1165.1
1985	0.0	148.2	297.5	19.8	0.0	0.0	0.0	465.5
1986	0.0	104.8	93.7	79.3	59.5	29.8	267.8	635.0
1987	0.0	110.7	49.6	39.7	9.9	0.0	0.0	209.9
1988	0.0	103.1	87.7	0.0	9.9	0.0	0.0	200.7
1989	0.0	158.5	59.5	9.9	29.8	0.0	0.0	257.7
1990	0.0	32.5	29.8	0.0	0.0	0.0	0.0	62.3
1991	0.0	90.2	39.7	9.9	0.0	0.0	0.0	139.8
1992	0.0	88.5	86.1	48.0	9.9	0.0	0.0	232.6
1993	0.0	202.5	138.3	94.0	99.2	69.4	109.1	712.5
1994	0.0	98.9	19.8	0.0	0.0	0.0	0.0	118.7
Total	0.0	10842.7	6624.0	3765.2	2078.0	1800.2	4254.5	29364.6
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	0.0	688.1	446.3	446.3	238.0	158.7	644.6	1419.2
Average	0.0	216.9	132.5	75.3	41.6	36.0	85.1	587.3
% of Total Flow	0.0%	36.9%	22.6%	12.8%	7.1%	6.1%	14.5%	100.0%

WATER YEAR CLASSIFICATION: W - Wet, A - Above Normal, B - Below Normal, D - Dry, C - Critical

Figure 1-6. Sacramento River at Butte City
November through March Divertible Flow by Range
1945 - 1994 Analysis Period



attach1 tables&graphs.xls, SRatBCop10k_DFDC2Nov-MarChart

ATTACHMENT 2

Standard Assumptions for CALSIM Operation Studies
North of the Delta Offstream Storage Investigation

1. Meet 1995 Water Quality Control Plan Bay-Delta Accord Standards. Minimum flows at Vernalis, including the pulse flows, are not imposed. Instead, alternative flow and export requirements are imposed under CVPIA (b)(2) Delta Action 1.
2. The following Anadromous Fish Restoration Program CVPIA (b)(2) Actions per November 20, 1997 AFRP Document are incorporated as described below.

- AFRP Upstream Flows are imposed at the following locations:

  Clear Creek

  Below Keswick Dam – Sacramento River

  Below Nimbus Dam – American River

- AFRP Delta Actions:

Delta Action 1 Vernalis Adaptive Management Plan (VAMP) flows and export reductions are imposed.
Delta Action 2 Head of Old River barrier (not modeled in CALSIM)
Delta Action 3 Additional X2 days at Chipps Island from March to June.
Delta Action 4 Maintain Sacramento River flows at Freeport from 9,000 to 15,000 cfs in May.
Delta Action 5 Ramping of Delta Exports during May.
Delta Action 6 Close Delta Cross Channel gates in October through January in all water year types.
Delta Action 7 July flows and exports based on X2 position in June.
Delta Action 8 Evaluate effects of exports on smolt survival in December through January (not modeled in CALSIM).

3. According to current regulatory limitations, Banks Pumping Plant capacity is 6,680 cfs and is increased to 8,500 cfs from December 15 to March 15 per USACE October 31, 1981 Public Notice Criteria, except where noted.
4. Stanislaus River operations per USBR's New Melones Interim Operations Plan.
5. According to current requirements, Trinity River minimum fish flows below Lewiston Dam are maintained at 340 taf per year, except where noted.
6. 2020 level hydrology (d09c) with updated American River Water Forum demands.
7. 2020 level of development water demands include:

- Total SWP demand varies from 3.6 maf to 4.2 maf per year.
- Maximum SWP Interruptible Demand is 134 taf per month.
- Total CVP demand is 3.5 maf per year including Level II Refuge demand of 288 taf per year. CVP Unmet Demand of 500 taf per year is to be met by SWP surrogate.

8. JPOD: Full and unlimited joint point of diversion is implemented. SWP wheels for the CVP whenever unused capacity at Banks Pumping Plant is available.

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North of the Delta
Offstream Storage Investigation

Progress Report

Appendix M: Sites Offstream Storage Project, Power Cost Study

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Appendix M: Sites Offstream Storage Project, Power Cost Study

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May 2000

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Objectives

The main objective of the study is to determine the energy costs and revenues associated with the pumping of the scheduled inflows and with power generated by the release of the scheduled outflows at the proposed pumped-storage hydroelectric powerplant between the existing Funks Reservoir and the proposed 1.8 maf Sites Reservoir. The study does not include costs associated with any additional pumping/generating plants required to transport water from the river to Funks Reservoir. The study also does not include the cost of energy consumed during the initial filling of the reservoir. Two alternative operations are considered: (1) an operation with existing storage capability at Funks Reservoir to accommodate water needs only, which will be referred to as minimal operation; and (2) an operation with an enlarged Funks Reservoir to maximize power operations which will be referred to as optimized operation.

The following are the other objectives of the study:

1) Verify if pumpback is economical and requires the expansion of Funks Reservoir.
2) Determine availability and cost of transmission interconnection.
3) Establish additional factors that can affect the feasibility of the proposed pumped-storage project.
4) Summarize information on pumped-storage technology, including projects constructed this decade and current license applications for pumped-storage hydroelectric powerplants.
5) Establish if pumped-storage is competitive in the present state of deregulation of the electric power utility system.

Methods

The study is based on the Division of Planning and Local Assistance's Sites Reservoir Study 656, which consists of 74 years of simulated operation. These data, shown in Tables 4-7 in the Attachment, are based on hydrology for 1921 through 1994 and include monthly inflow from Sacramento River diversion, outflow, reservoir storage, and end-of-month head (difference in elevation between Funks and Sites). The average monthly head shown on Table 8 of the Attachment was calculated and used in the study.

Figure 1 shows the range of the calculated average monthly heads over the study period while Figure 2 shows the variation of the average monthly head used in the study. Based on the available head, the study establishes the amount of power to pump the inflows (in MW) and the power generated when the outflows are released through the generators.

For the minimal operation, the average monthly pumping rates were calculated in cubic feet per second based on the monthly inflow and were used to compute the monthly pumping energies and associated costs. Likewise, the average monthly released flows were calculated based on the monthly outflow and used for computing the monthly generated energies and associated revenues. The plant operates twenty-four hours a day at the average pumping or generating discharge rates computed above, without maximizing off-peak pumping or on-peak generation.

For the optimized operation, the plant is assumed to operate at the rated capacities of 6,800 cfs in the pumping mode and 9,064 cfs in the generating mode. To be able to operate at the rated pumping and generating capacities, Funks Reservoir must be enlarged to accommodate the maximum additional daily storage capacity with the pumps operating at rated capacity (6,800 cfs) during the duration of the off-peak hours (ten hours daily). On pumpback, whatever capacity was pumped into Sites must be the same capacity to be discharged to Funks so as not to affect the scheduled inflows and outflows. Additional assumptions used in the study are shown in the Attachment. The amounts of energy consumed for pumping and produced by generation are then determined for two modes of operation:

1) Seasonal operation – Water is generally pumped into the reservoir in the winter and released from the reservoir in the summer in the amounts indicated by the inflow and outflow data provided by the Division of Planning and Local Assistance. Water is pumped during the off-peak hours at the rated capacities of 6,800 cfs to minimize pumping energy costs unless additional on-peak pumping is required to move the total inflow. Water is released during the on-peak hours to maximize revenue generated unless additional off-peak generation is required to move the total outflow.
2) Daily pumpback operation – After the plant has pumped or released the required amount for seasonal operation, the remaining hours are made available for pumpback operation. During pumpback operation, pumping is scheduled during the off-peak hours to minimize pumping energy costs and generation is scheduled during the on-peak hours to maximize the generated revenues. Since the primary purpose of the plant is to store water during periods of excess inflows and release water during the dry seasons, the daily pumpback operation is optional and used only when economically justified.

The cost of energy consumed for pumping and revenue produced during generation is determined by the projected energy price for 1999 as shown in Table 3 under the Discussion section.

Result

The annual pumping cost and generation income for the minimal operation is shown on Figure 3. Of the 72 years examined, 40 years (55 percent) of the study period resulted in the annual pumping costs exceeding the generation income. Figure 4 shows the average monthly pumping cost and generation income, and Table 1 summarizes the range of annual operation in terms of MWh and dollars, which excludes the first and last years of the study due to incomplete yearly data. The average annual energy cost and revenue are 24.9 and 25.7 $/MWh, respectively.

Table 1. Minimal Operation

72-Year Range	Annual Operation			
	Energy Consumption (MWh)	Energy Production (MWh)	Energy Cost ($)	Energy Revenue ($)
Max	350,462	260,743	8,990,537	6,330,848
Min	0	0	0	0
Avg	106,705	74,961	2,657,206	1,925,370

For the optimized operation with an enlarged Funks Reservoir and no pumpback operation, Figure 5 shows 39 years (53 percent) of the study period resulted in the annual seasonal generation income exceeding the pumping cost. The plant can also generate additional revenue as shown in Figure 6 if pumpback is used. The pumpback analysis shows economical operation for all months of every year; however the benefits are only significant during the summer months when the on-peak and off-peak differentials are large. Incorporating pumpback with the seasonal operation results in 57 years (77 percent) of the time that annual generation exceeded the pumping costs and also results in a more substantial generation revenue over the pumping costs shown in Figure 7. The range of annual operation in terms of MWh and dollars is summarized in Table 2 below for both the seasonal and pumpback modes. Figures 8 and 9 also show the average monthly pumping cost and generation income for the seasonal and pumpback modes. The average combined seasonal and pumpback energy cost and revenue are 17.9 and 29.6 $/MWh, respectively.

Table 2. Optimized Operation

Mode of Operation	72-Year Range	Annual Operation			
		Energy Consumption (MWh)	Energy Production (MWh)	Energy Cost ($)	Energy Revenue ($)
Seasonal Without Pumpback	Max	350,462	260,743	8,437,045	7,889,120
	Min	0	0	0	0
	Avg	106,705	74,961	2,399,642	2,459,610
Pumpback and No Seasonal	Max	691,325	529,807	11,987,731	15,403,745
	Min	217,675	166,819	3,645,719	4,861,268
	Avg	447,204	342,721	7,492,857	9,913,321
Combined Seasonal and Pumpback	Max	799,973	625,161	15,032,086	18,362,605
	Min	223,201	166,819	3,770,901	4,861,268
	Avg	553,909	417,682	9,892,498	12,372,931

The optimized operation maximizes off-peak pumping to operate economically; this often results in operating the plant at maximum capacity for all off-peak hours of the day, especially if pumpback is incorporated. To accommodate such operation, Funks Reservoir needs to be enlarged to have an operating storage of 5.6 taf in addition to any dead-pool storage required.

Additional Cost And Revenue

PG&E performed an Informational Review to determine the transmission interconnection costs of the proposed pumped-storage hydroelectric powerplant at Sites Reservoir. A report is enclosed that includes a map showing the approximate location of the proposed pumped-storage powerplant and the closest 230 kV line. Based on the previously estimated generation capacity of 162 MW, pumping requirement of 200 MW, and allowance for future expansion, PG&E proposes to loop two 230 kV transmission lines to the pumped-storage facility.

The next step is for PG&E to perform either a Preliminary Facilities Study or a Detailed Facilities Study depending on how much detail DWR requires. The cost of the study will depend on the complexity and the number of alternatives to be studied. The Informational Review Report is included in the Attachment. Note that the location of the proposed pumped-storage facility shown on the map provided by PG&E is incorrect. A letter has been sent to PG&E informing them of the discrepancy, which will be corrected when the decision on when and how to proceed with this project is reached.

Also, the previous estimate of a pumped-storage facility with 162 MW of generating capacity and 200 MW of pump load has now been corrected per Division of Engineering's estimated plant ratings of 192 MW in generating mode and 184 MW in pumping mode. Together with the location of the proposed pumped-storage plant, the change in the unit sizes will be corrected after the decision to proceed is made. The corrected plant ratings will not affect the transmission line capacity because the estimated complex capacity is still 300 MW and the length of the line is about one fifth of the PG&E estimate, which will result in a reduction in the transmission line material and construction costs shown in PG&E's Informational Review.

The California Independent System Operator has currently filed an amendment to its tariff with the Federal Energy Regulatory Commission to include requirements for new generation interconnection. The main premise of new generation interconnection is that new generators will be required to eliminate any impact to the local area as the primary condition for interconnection. If system studies indicate inadequacy of the electrical capabilities of any of the electrical equipment (line circuit breakers, substation transformers, voltage transformers, etc.) in the substation or switchyard at the point of interconnection, then replacing them will become part of the interconnection requirements for the new generator.

Transmission congestion resulting from the interconnection must also be solved by the new generator. More costs will be assessed to the new generator if the interconnection studies performed by the participating transmission owner reveal that local transmission congestion is created and/or electrical equipment capabilities are exceeded within the surrounding area at the point of interconnection. These additional technical problems and costs will only be established after the interconnection studies are done. Once transmission is available, the CAISO also charges usage fees, including grid management and access charges. The grid management charge is based on the pump load and for 1999 is $0.7781/MWh. Methodology for calculating the access charge is under development. Additional costs to consider are those involving the terms and conditions associated with the Federal Energy Regulatory Commission Licensing as a result of the generation feature of the facility.

Pumped-Storage Technology Information

Current North American Electric Reliability Council generation resources database shows 40 pumped-storage hydroelectric power plants operating in the NERC region. Of the 40, six were constructed within the last ten years. They range in size from the single unit, 5,000 kW Youghiogheny owned by an independent power producer connected to the Pennsylvania Electric Co. system, to the 4-unit, 1,065,000 kW Bad Creek plant owned and operated by Duke Power Co. The latest pumped-storage plant constructed is the 3-unit (847,800 kW) Rocky Mountain Project which is jointly owned and operated by Oglethorpe Power Corp. and other utilities. The remaining three plants are quite small compared to the Bad Creek and Rocky Mountain Projects, having only a combined capacity of 75,500 kW.

From the same database source, two pumped-storage plants are currently under construction: the NA1 (Union Electric Co. owned) has a single 215,000 kW unit scheduled to be in service by May of this year; and Summit Energy (independently-owned but connected to Ohio Edison, Co.) has six 250,000 kW units, three of which are scheduled to be in service by January 2004 with the remaining three by January of 2005. A third plant, the NA1 Richard Russell (owned by the United States Corps of Engineers – Savannah District), has four 85,000 kW units which were supposedly put into service November of 1998. The December 11, 1998, issue of the California Energy Markets Newsletter also noted that Arizona Independent Power applied in October 1998 to the Federal Energy Regulatory Commission for a preliminary permit to build White Tank Mountain, a project with a 1,250,000 kW pumped-storage hydroelectric power plant.

To improve the range of operation, the current technology in hydraulic machinery uses adjustable-speed generators and motor-generators in conjunction with high current capacity, power electronic devices for conventional and pumped-storage hydroelectric power projects.

Pumped-Storage Role In Deregulation

The deregulation of the electric utility system created a separate market for providing ancillary services to the grid, including the following:

1) regulation
2) voltage support
3) spinning reserves
4) non-spinning reserves
5) replacement reserves
6) black start

Due to the inherent dynamic operating characteristics of hydroelectric generators with motor/generators for pumped-storage, they are excellent participants in the ancillary services market. Their ability to respond to changes in power requirements are steps ahead of the competition and where the ancillary services market puts a premium to this capability. Some of these characteristics include:

1) load following
2) unit commitment
3) reduced system minimum loading
4) voltage and power factor correction (condenser mode)
5) frequency regulation
6) improved system operating reliability
7) black start capability

Therefore, in addition to producing energy, a potentially profitable application of pumped-storage hydroelectric power plants in the deregulated power market is in providing ancillary services such as spinning and non-spinning reserves.

Discussion

The reason for building a reservoir at the Sites location is to store excess winter flows of the Sacramento River and local streams. Water management is the main purpose of the proposed project; however, this study only focuses on power-related aspects of the project. The study estimates the pumping costs incurred to store the inflows during wet months and income from generation when water outflows are released during the dry months. Even without pumpback, minimal operation costs more than optimized operation because of the assumption to not maximize on-peak generation and to not enlarge Funks Reservoir. An enlarged Funks Reservoir allows maximized off-peak pumping when power costs less.

Pumpback is considered to offset pumping costs; however, with an enlarged Funks Reservoir, net income is generated even without pumpback operation. Pumpback does generate significant additional income, making it logical to incorporate pumpback in between scheduled seasonal operation when the generation revenues are more than the pumping costs. The pumpback operation shown in the study is optimized and requires very efficient scheduling that may be difficult to achieve in actual operations. For the most economic operation, the existing Funks Reservoir must be expanded to accommodate the maximum water that can be stored during the off-peak hours (ten hours per day) at the maximum flow of 6,800 cfs, in addition to any dead-pool storage.

The cost of transmission interconnection will depend on the interconnection studies to be performed by the participating transmission owner, PG&E. PG&E will require a payment to perform the studies and an official request to initiate them. If the interconnection studies indicate that the proposed project will result in local transmission congestion or cause electrical equipment capabilities to be inadequate at the point of interconnection, eliminating the transmission congestion and replacing the affected electrical equipment will certainly add more costs to the project.

Adjustable-speed motor/generator technology is state of the art in pumped-storage hydroelectric powerplant design; it has an advantage over the conventional hydraulic motor/generator because the speed of the unit can be adjusted to allow high turbine efficiency at a wider range of head and flow variations. This technology is suitable for seasonal operation of pumped-storage where the head varies widely as in the case of the Sites Offstream Reservoir Project. If the Sites Offstream Reservoir Project proceeds and the Division of Engineering prepares a specification indicating the ratings (size, operating range, etc.) of the unit, the study will need to be updated to more accurately represent the operation of the plant.

The ancillary services market created by the deregulation of the electric utility industry is an attractive market for hydroelectric power plants due to their inherent operating characteristics, specifically the spinning and supplemental (non-spinning) reserves where their ability to respond quickly to changes and to start and get on line quickly are utilized. Since the project is primarily proposed to store water during the wet months and release the water during the dry months, participation in the ancillary services market will only be employed for as long as the scheduled inflows and outflows are not affected. Even without participation in the ancillary services market, energy revenue is greater than energy cost if pumpback is employed.

The results of the study are based on the projected 1999 energy prices from the December 22, 1998 “1998 Market Clearing Price Forecast for the California Energy Market: Forecast Methodology and Analytical Issues” by the California Energy Commission and are shown on Table 3 below. These prices will fluctuate due to the uncertain conditions resulting from the ongoing developments brought about by deregulation, thus subsequent studies may be more or less favorable depending on the available on-peak and off-peak energy price differentials.

It is often difficult to forecast these differentials. Table 3A below was taken from the CEC report and shows a comparison of the forecasted 1998 energy prices to the actual 1998 energy prices. Only the actual energy prices for the months of April to November of 1998 are available for comparison with the forecasted data, limiting the comparison to that time frame only. There are considerable differences in the forecasted to the actual energy prices, especially during the months of May through August where they ranged from a low of 16 percent to a high of 71 percent. Among the reasons for these variation in prices are fuel prices, CEC staffs’ modeling of the California Power Exchange market, hydro availability, CEC staffs’ modeling reliance on historical utility load shapes, transmission congestion, summer peak temperatures, and the future pace and extent of deregulation for states outside of California. The prices shown are average prices only; hourly prices fluctuate much more and range from practically nothing to hundreds of dollars per MWh.

Table 3. 1999 Projected Energy Prices

Month	On-peak $/MWh	Off-peak $/MWh
Jan	30.60	22.36
Feb	27.55	20.13
Mar	26.29	19.21
Apr	24.43	16.10
May	26.44	8.92
Jun	25.56	6.43
Jul	30.77	14.83
Aug	41.10	19.71
Sep	35.01	21.11
Oct	25.53	18.08
Nov	26.40	19.29
Dec	29.72	21.72
Avg	29.12	17.32

Table 3A. Comparison of Forecasted to Actual CalPX Energy Prices

Mo./Year	Projected On-Peak ($/MWh)	Actual On-Peak ($/MWh)	% Diff.	Projected Off-Peak ($/MWh)	Actual Off-Peak ($/MWh)	% Diff.
Apr-98	24.1	25.9	7	15.9	17.0	6
May-98	26.6	15.6	-71	9.0	5.8	-55
Jun-98	26.6	16.7	-59	6.7	4.0	-68
Jul-98	33.9	40.3	16	16.3	19.7	17
Aug-98	37.4	49.6	25	17.9	23.8	25
Sep-98	35.9	39.6	9	21.6	23.8	9
Oct-98	27.8	29.8	7	19.7	21.5	8
Nov-98	28.9	28.5	-1	21.1	21.3	1

The study only addresses power-related costs and does not include costs for construction, O&M, environmental studies, etc. A complete economic analysis would require cost projections from other DWR divisions. A time frame of when the plant would be constructed and operated would also be necessary to project and present the costs and revenues. In addition, as the electric power industry gains experience with deregulation, projections for the price for energy, ancillary services, and transmission will be more accurate and should be updated as more information on this project becomes available**.** Currently few projections even exist for beyond ten years.

final draft

Figure 1 - SITES RESERVOIR STUDY 656
RANGE OF AVERAGE MONTHLY HEAD
(difference between Funks & Sites)

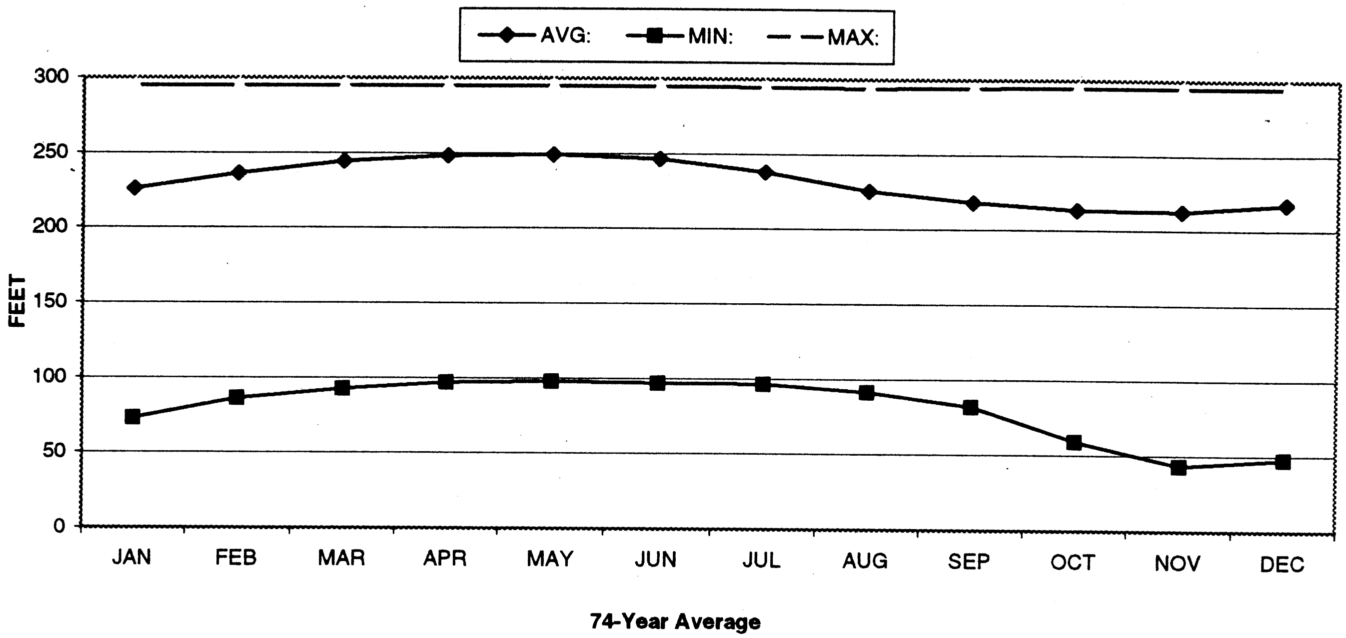

Figure 2 - SITES RESERVOIR STUDY 656
AVERAGE MONTHLY HEAD
(difference between Funks & Sites)

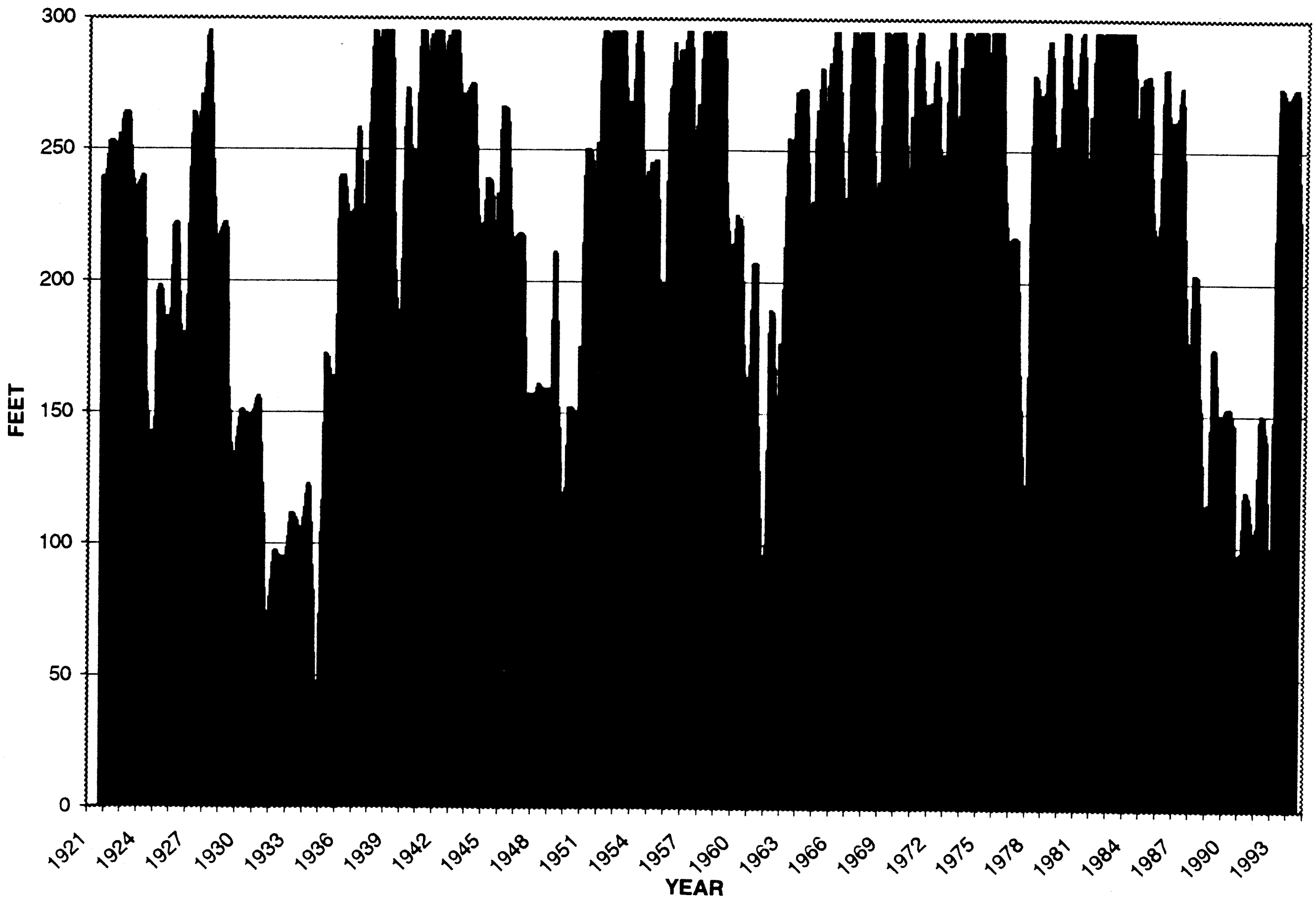

Figure 3 - Annual Pumping Cost/Generation Income
Minimal Operation

final draft

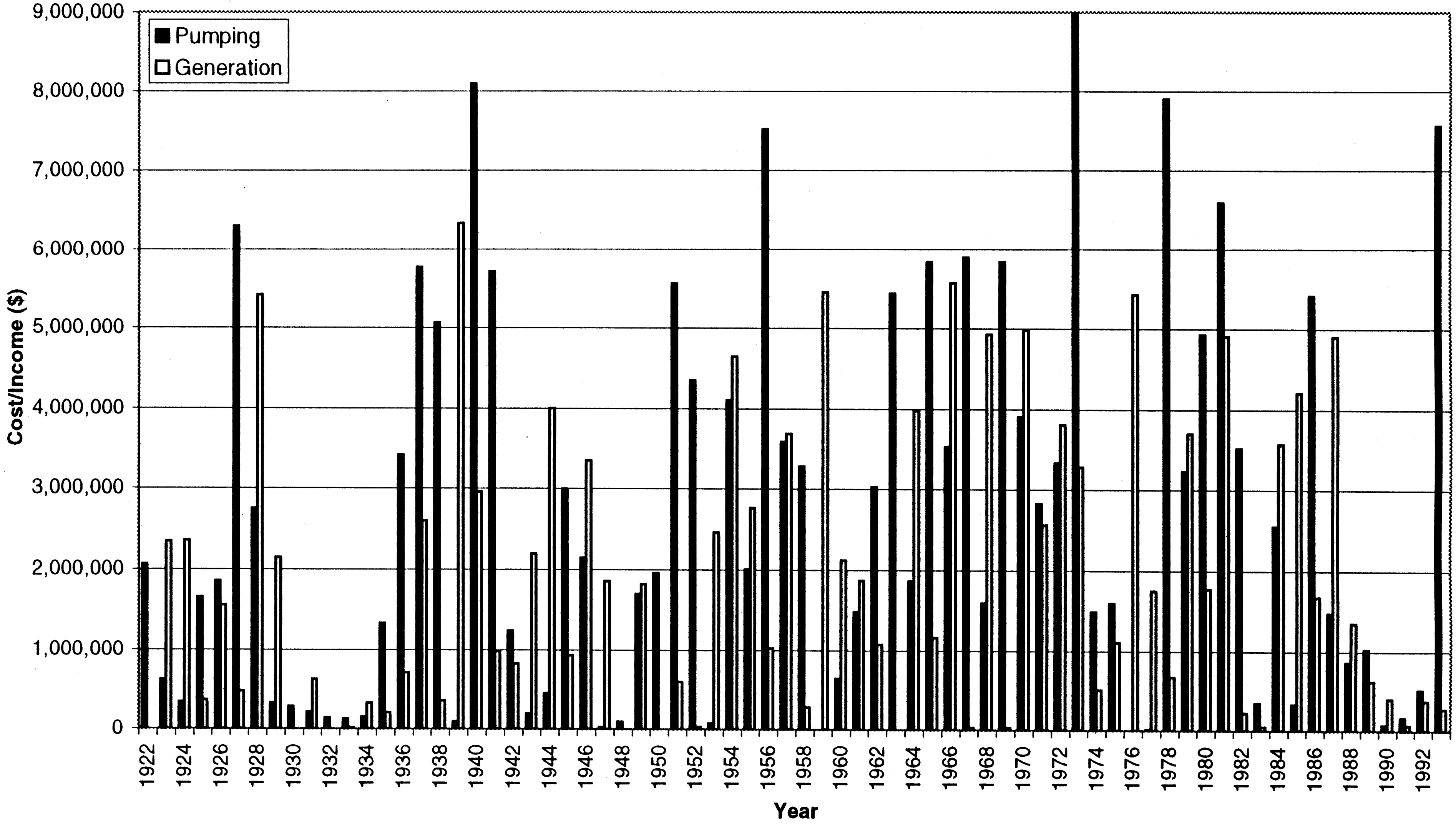

Figure 4 - Average Monthly Pumping Cost/Generation Income
Minimal Operation

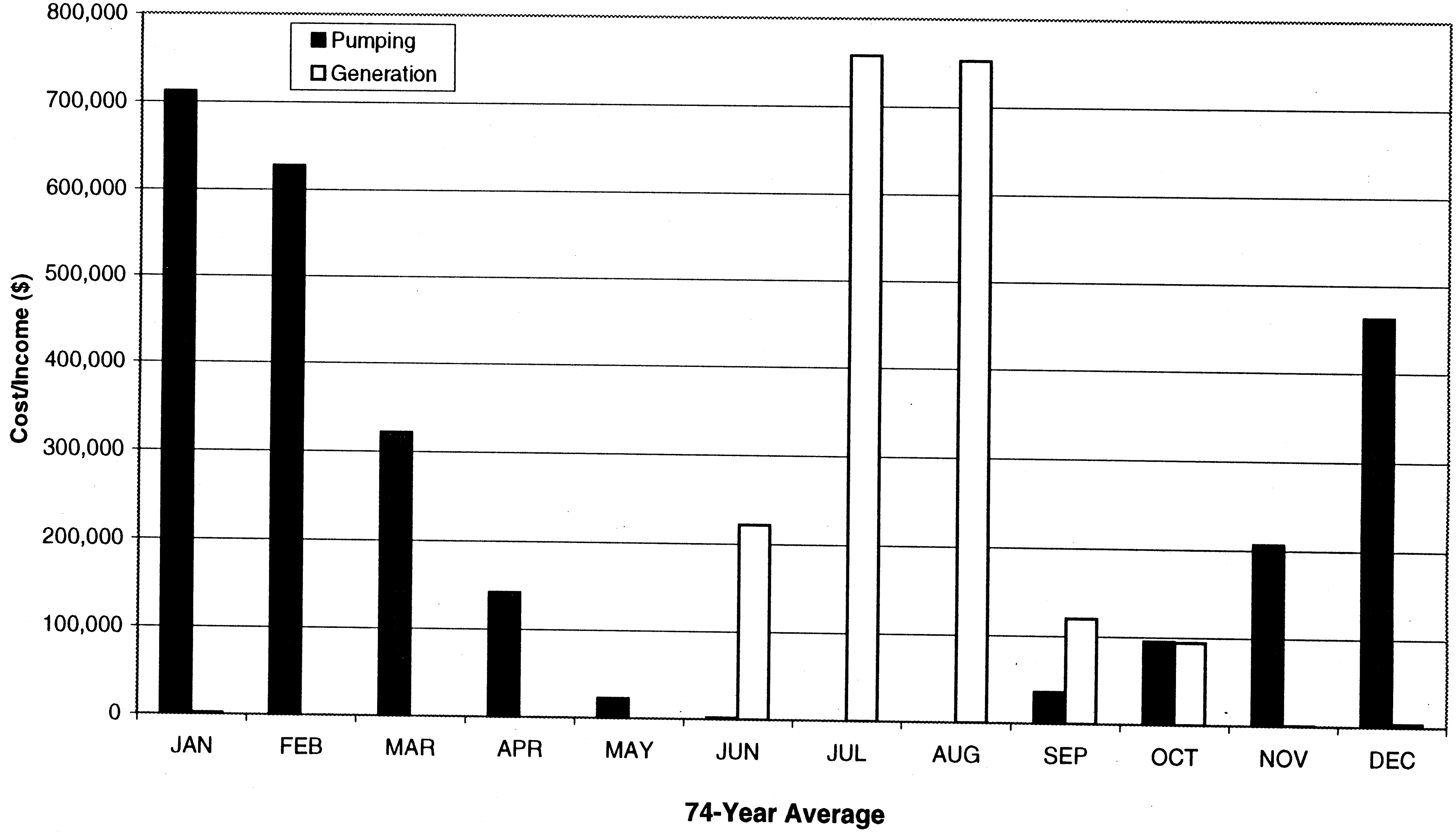

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Figure 6 - ANNUAL PUMPING COST/GENERATION INCOME
Optimized Operation (Pumpback)

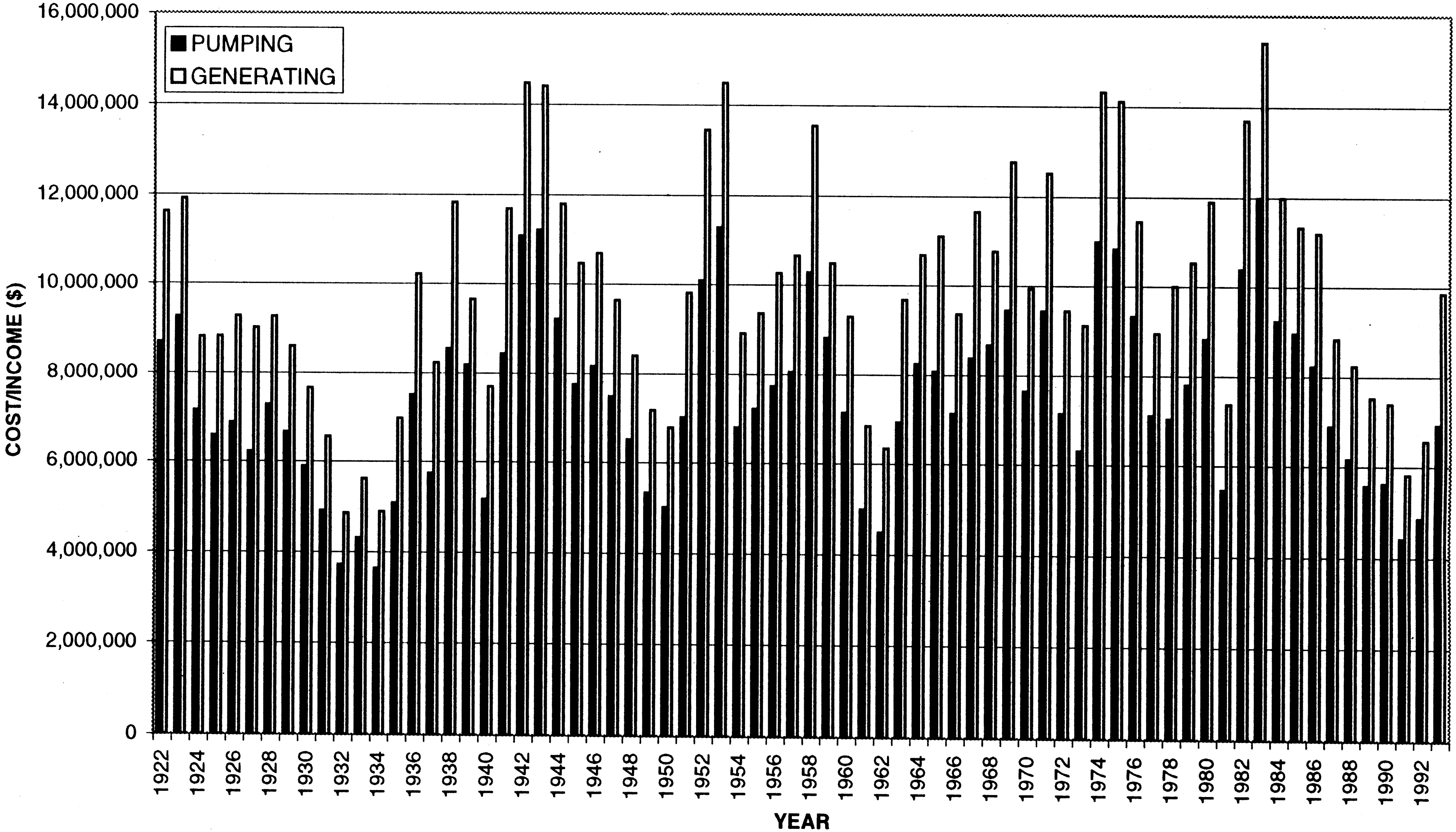

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Figure 7 - ANNUAL PUMPING COST/GENERATION INCOME
Optimized Operation (Seasonal & Pumpback)

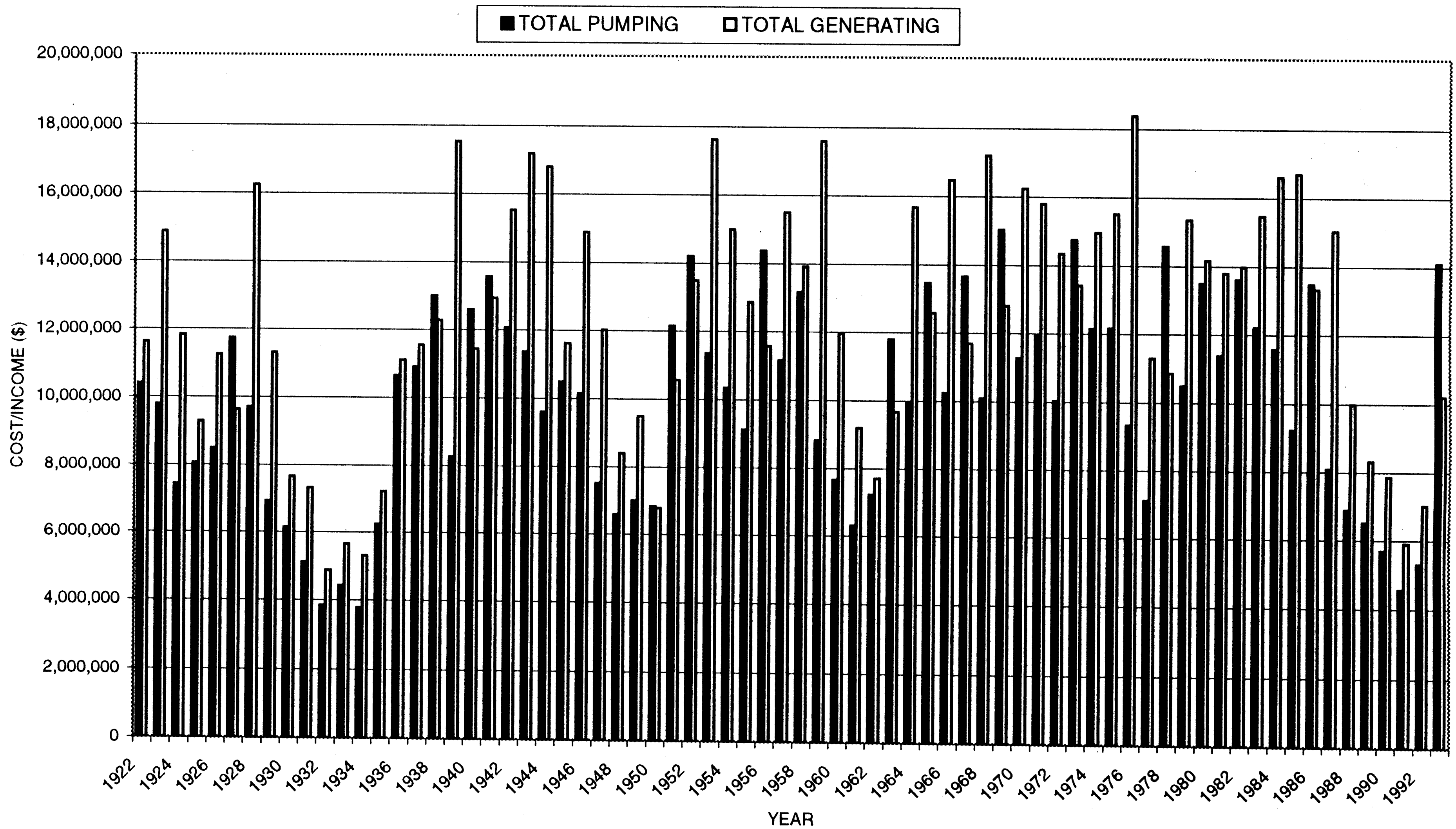

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Figure 8 - Average Monthly Pumping Cost & Generation Income
Optimized Operation (Seasonal)

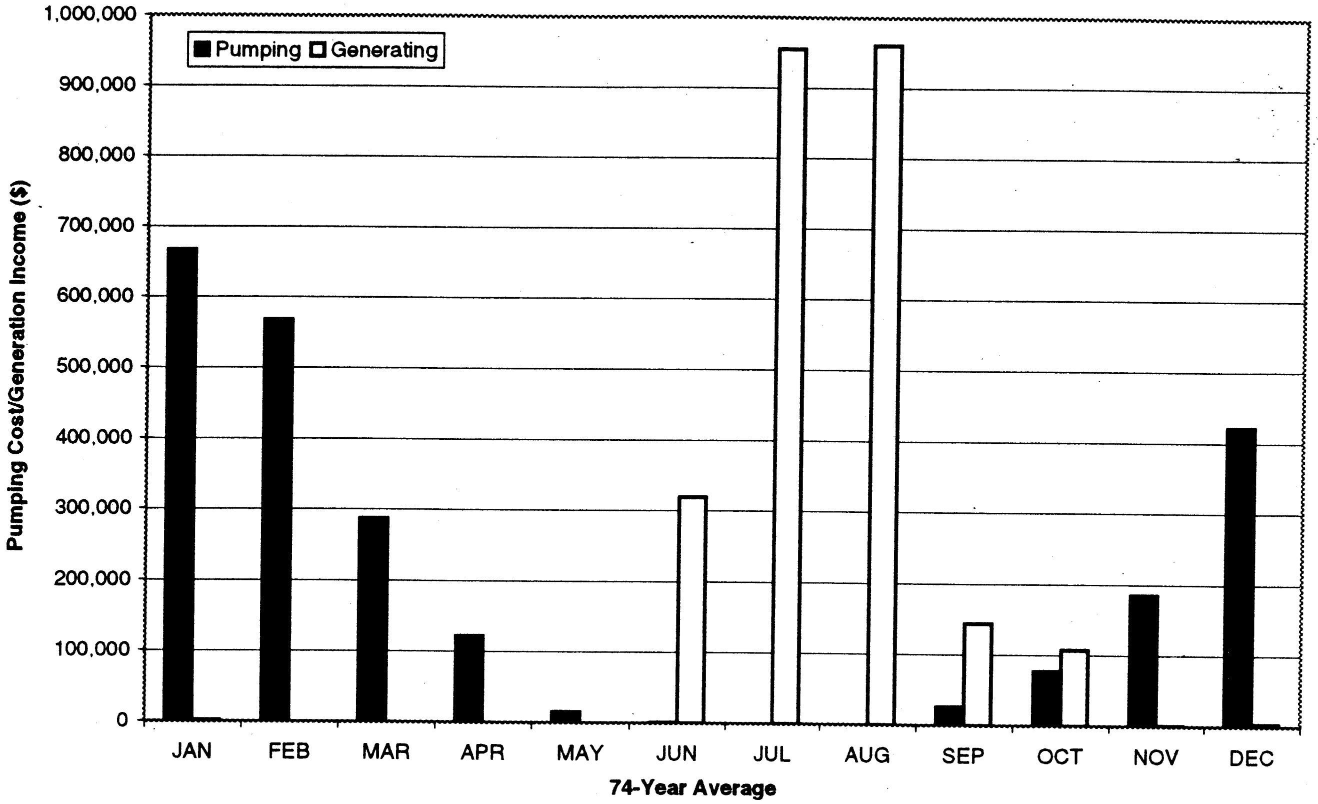
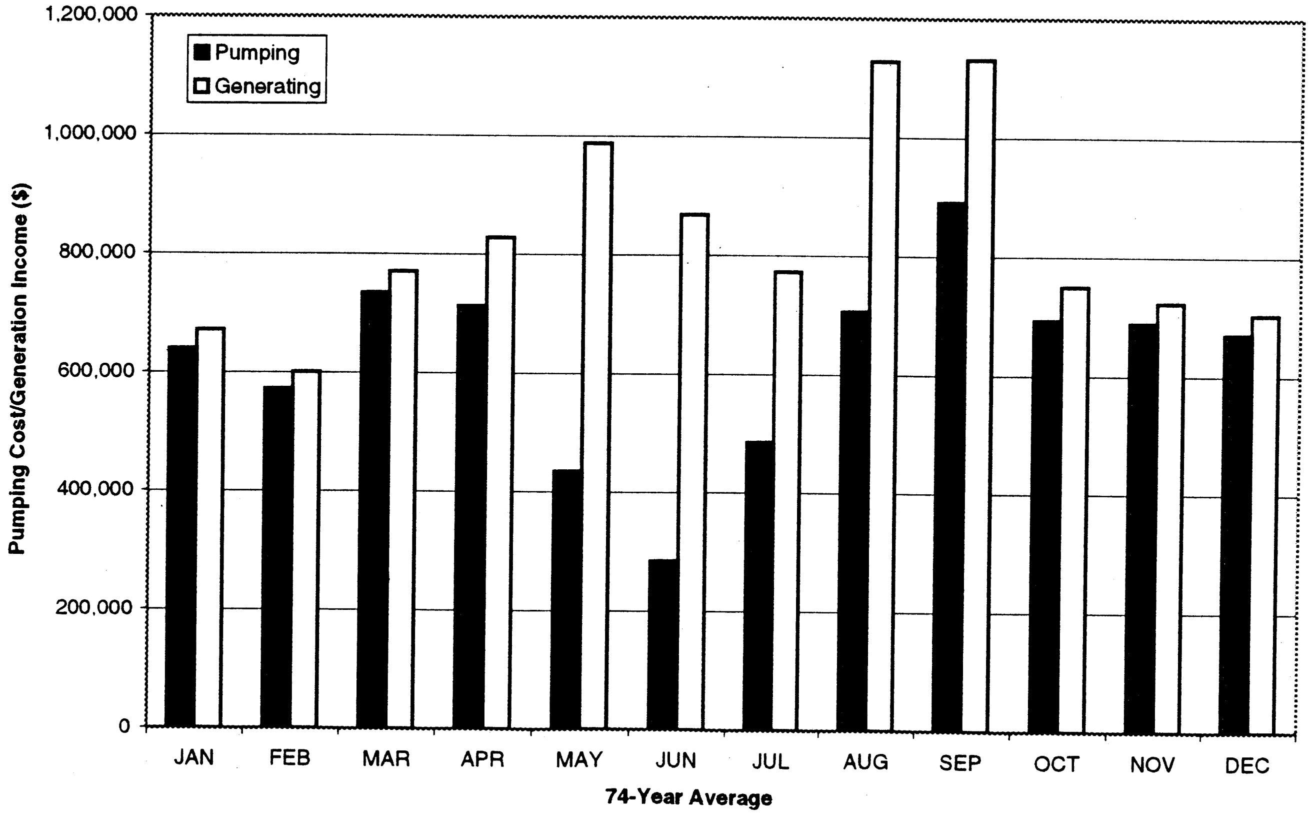


Figure 9 - Average Monthly Pumping Cost & Generation Income
Optimized Operation (Pumpback)



Attachments

Table 4 - Study 656: Sites Reservoir monthly inflow in TAF

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1921	----	----	----	----	----	----	----	----	----	0	2	15	17
1922	37	123	15	8	0	0	0	0	0	0	4	93	280
1923	44	24	5	3	0	0	0	0	0	0	0	3	79
1924	13	7	16	3	0	0	0	0	0	0	2	15	56
1925	37	254	15	8	0	0	0	0	0	0	13	9	336
1926	16	224	16	6	0	0	0	0	0	0	15	45	322
1927	128	280	115	244	0	0	0	0	0	0	186	15	968
1928	37	233	67	0	0	0	0	0	0	0	0	3	340
1929	13	7	16	3	0	0	0	0	0	0	13	9	61
1930	16	13	31	6	0	0	0	0	0	0	0	3	69
1931	13	7	16	3	0	0	0	0	0	0	13	9	61
1932	16	13	16	6	0	0	0	0	0	0	0	3	54
1933	13	7	16	3	0	0	0	0	0	0	0	3	42
1934	13	7	16	3	0	0	0	0	0	0	2	15	56
1935	104	43	15	234	0	0	0	0	0	0	2	15	413
1936	271	254	15	8	0	0	0	0	0	0	4	4	556
1937	6	125	239	3	0	0	0	0	0	0	189	278	840
1938	88	280	189	2	4	0	0	0	0	84	0	0	647
1939	0	0	0	0	0	0	0	0	0	0	2	15	17
1940	271	254	249	92	0	0	0	0	0	0	15	278	1159
1941	322	188	0	2	4	0	0	0	0	122	15	36	689
1942	0	0	0	3	4	0	0	0	0	88	15	45	155
1943	1	0	0	2	0	0	0	0	0	0	13	9	25
1944	16	13	16	6	0	0	0	0	0	0	0	8	59
1945	0	135	2	1	0	0	0	0	0	0	0	291	429
1946	254	0	0	0	0	0	0	0	0	0	4	8	266
1947	0	4	0	0	0	0	0	0	0	0	0	0	4
1948	0	0	4	19	0	0	0	0	0	0	0	0	23
1949	0	0	332	5	0	0	0	0	0	0	0	0	337
1950	7	104	0	3	0	0	0	0	0	0	6	276	396
1951	262	224	0	0	0	0	0	0	0	0	7	283	776
1952	384	80	0	2	4	0	0	0	13	20	0	0	503
1953	0	0	0	0	0	0	0	0	0	0	10	0	10
1954	234	146	0	2	0	0	0	0	0	0	30	86	498
1955	7	0	0	14	0	0	0	0	0	0	0	305	326
1956	368	259	6	25	234	0	0	0	0	140	4	3	1039
1957	4	92	0	0	0	0	0	0	0	129	0	234	459
1958	270	14	0	2	4	8	0	0	61	3	0	0	362
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	7	80	0	0	0	0	0	0	0	0	7	12	106
1961	40	214	11	0	0	0	0	0	0	0	0	18	283
1962	0	278	96	0	0	0	0	0	0	46	0	238	658
1963	1	259	56	248	0	0	0	0	0	44	238	0	846
1964	5	0	8	0	0	0	0	0	0	0	9	241	263
1965	292	0	0	243	0	0	0	0	0	0	244	3	782
1966	166	0	0	0	0	0	0	0	0	0	19	265	450
1967	292	235	176	2	4	8	0	0	0	26	0	0	743
1968	0	0	0	0	0	0	0	0	0	0	2	216	218
1969	327	345	0	2	4	0	0	0	30	3	0	0	711
1970	0	0	0	0	0	0	0	0	0	0	239	286	525
1971	250	0	65	0	0	0	0	0	0	0	5	5	325
1972	0	0	239	0	0	0	0	0	0	0	35	170	444
1973	391	187	0	0	0	0	0	0	0	0	255	264	1097
1974	51	0	0	2	0	0	0	0	63	49	0	0	165
1975	0	0	0	0	0	0	0	0	12	196	0	0	208
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	3	3
1978	413	318	309	236	0	0	0	0	0	0	7	0	1283
1979	30	181	81	7	0	0	0	0	0	0	22	89	410
1980	337	244	0	0	0	0	0	0	0	0	0	10	591
1981	123	132	40	0	0	0	0	0	0	0	266	290	851
1982	315	0	0	2	0	0	0	0	64	3	0	0	384
1983	0	0	0	2	4	8	0	0	23	3	0	0	40
1984	0	0	0	0	0	0	0	0	0	0	283	61	344
1985	5	0	0	12	0	0	0	0	0	0	0	31	48
1986	34	378	337	14	0	0	0	0	0	0	0	2	765
1987	3	22	164	0	0	0	0	0	0	0	0	16	205
1988	142	0	0	0	0	0	0	0	0	0	0	0	142
1989	0	0	245	14	0	0	0	0	0	0	0	0	259
1990	9	0	8	0	0	0	0	0	0	0	0	0	17
1991	0	0	44	13	0	0	0	0	0	0	0	0	57
1992	4	99	29	0	0	0	0	0	0	0	0	9	141
1993	400	369	268	225	0	0	0	0	0	0	0	16	1278
1994	7	30	0	6	0	0	0	0	0	----	----	----	43
AVG:	95	93	49	24	4	0	0	0	4	13	30	64	380
MIN:	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX:	413	378	337	248	234	8	0	0	64	196	283	305	1283

Table 5 - Study 656: Sites Reservoir monthly outflow in TAF

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1921	----	----	----	----	----	----	----	----	----	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	33	263	0	56	0	0	352
1924	0	0	0	0	0	375	189	19	60	18	0	0	661
1925	0	0	0	0	0	0	4	59	0	7	0	0	70
1926	0	0	0	0	0	0	114	152	0	50	0	0	316
1927	0	0	0	0	0	0	0	64	0	0	0	0	64
1928	0	0	0	0	0	231	329	237	81	72	0	0	950
1929	0	0	0	0	0	35	330	90	8	79	0	0	542
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	10	109	0	49	79	0	0	247
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	6	0	0	6
1934	0	0	0	0	0	0	62	10	31	75	0	0	178
1935	0	0	0	0	0	0	0	0	48	0	0	0	48
1936	0	0	0	0	0	0	0	63	40	10	0	0	113
1937	0	0	0	0	0	31	237	121	75	0	0	0	464
1938	0	0	0	0	0	0	51	0	0	0	1	4	56
1939	2	0	0	0	0	305	418	308	69	68	0	0	1170
1940	0	0	0	0	0	0	180	217	32	33	0	0	462
1941	0	0	0	0	0	0	107	38	0	0	0	0	145
1942	2	0	0	0	0	0	103	20	0	0	0	0	125
1943	0	0	0	0	0	0	220	92	16	0	0	0	328
1944	0	0	0	0	0	0	189	267	116	59	0	0	631
1945	0	0	0	0	0	0	0	80	68	0	0	0	148
1946	0	0	0	0	0	0	137	283	54	65	0	0	539
1947	0	0	0	0	0	0	144	236	0	0	0	0	380
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	14	306	89	0	63	0	0	472
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	84	0	0	0	0	84
1952	0	0	0	0	0	0	0	0	0	0	1	4	5
1953	2	0	0	0	0	0	216	142	0	0	0	0	360
1954	0	0	0	0	0	222	313	203	39	29	0	0	806
1955	0	0	0	0	0	0	274	217	0	40	0	0	531
1956	0	0	0	0	0	0	138	22	0	0	0	0	160
1957	0	0	0	0	0	175	254	189	0	0	0	0	618
1958	0	0	0	0	0	0	39	0	0	0	1	4	44
1959	2	0	0	0	0	279	324	291	0	82	0	0	978
1960	0	0	0	0	0	0	31	268	52	57	0	0	408
1961	0	0	0	0	0	0	267	150	0	83	0	0	500
1962	0	0	0	0	0	0	5	219	0	0	0	0	224
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	240	255	91	62	0	0	648
1965	0	0	0	0	0	0	148	37	0	0	0	0	185
1966	0	0	0	0	0	179	260	277	74	166	0	0	956
1967	0	0	0	0	0	0	0	0	0	0	1	4	5
1968	2	0	0	0	0	260	281	215	75	30	0	0	863
1969	0	0	0	0	0	0	0	0	0	0	1	4	5
1970	2	0	0	0	0	114	344	265	53	34	0	0	812
1971	0	0	0	0	0	0	212	160	0	0	0	0	372
1972	0	0	0	0	0	52	262	284	0	0	0	0	598
1973	0	0	0	0	0	145	230	166	0	0	0	0	541
1974	0	0	0	0	0	0	76	0	0	0	1	4	81
1975	2	0	0	0	0	0	170	0	0	0	1	4	177
1976	2	0	0	0	0	226	347	230	71	80	0	0	956
1977	0	0	0	0	0	264	25	86	64	68	0	0	507
1978	0	0	0	0	0	0	23	68	0	0	0	0	91
1979	0	0	0	0	0	153	252	174	39	0	0	0	618
1980	0	0	0	0	0	0	225	49	0	0	0	0	274
1981	0	0	0	0	0	241	285	252	57	9	0	0	844
1982	0	0	0	0	0	0	30	0	0	0	1	4	35
1983	2	0	0	0	0	0	0	0	0	0	1	4	7
1984	2	0	0	0	0	107	249	208	0	0	0	0	566
1985	0	0	0	0	0	84	295	241	32	73	0	0	725
1986	0	0	0	0	0	0	203	63	0	0	0	0	266
1987	0	0	0	0	0	180	355	262	74	66	0	0	937
1988	0	0	0	0	0	111	148	8	47	94	0	0	408
1989	0	0	0	0	0	0	0	134	0	0	0	0	134
1990	0	0	0	0	0	0	27	0	0	129	0	0	156
1991	0	0	0	0	0	0	0	0	7	21	0	0	28
1992	0	0	0	0	0	0	30	0	17	93	0	0	140
1993	0	0	0	0	0	0	0	35	0	0	0	0	35
1994	0	0	0	0	0	48	290	224	72	----	----	----	634
AVG:	0	0	0	0	0	53	139	112	22	27	0	0	349
MIN:	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX:	2	0	0	0	0	375	418	308	116	166	1	4	1170

Table 6 - Study 656: Sites Reservoir end of month storage in TAF

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1921	----	----	----	----	----	----	----	----	----	998	1,000	1,018
1922	1,057	1,180	1,195	1,201	1,198	1,192	1,185	1,179	1,174	1,172	1,177	1,273
1923	1,319	1,343	1,348	1,349	1,345	1,339	1,299	1,029	1,025	967	968	973
1924	987	995	1,010	1,011	1,008	627	434	412	350	330	332	349
1925	387	641	656	663	661	657	648	585	582	573	587	598
1926	615	839	855	860	857	852	733	576	573	521	537	584
1927	713	993	1,108	1,351	1,347	1,341	1,334	1,264	1,259	1,256	1,442	1,461
1928	1,500	1,733	1,800	1,798	1,794	1,555	1,219	976	891	817	818	823
1929	836	844	859	861	858	818	483	389	380	300	313	323
1930	340	354	385	390	388	385	382	379	377	376	377	381
1931	394	401	416	418	417	404	291	289	238	158	171	181
1932	197	211	226	232	231	229	227	225	224	223	223	227
1933	240	247	263	265	264	262	259	257	256	249	249	253
1934	266	273	288	291	289	287	222	210	178	102	104	120
1935	224	267	282	516	514	511	507	503	453	451	454	470
1936	742	997	1,011	1,018	1,015	1,010	1,003	935	891	879	884	890
1937	898	1,024	1,262	1,263	1,260	1,223	978	851	773	771	960	1,241
1938	1,331	1,612	1,800	1,800	1,800	1,792	1,732	1,725	1,719	1,800	1,800	1,800
1939	1,800	1,800	1,800	1,797	1,793	1,481	1,055	741	669	599	601	618
1940	890	1,145	1,393	1,484	1,480	1,474	1,285	1,062	1,026	991	1,007	1,288
1941	1,611	1,800	1,800	1,800	1,800	1,792	1,676	1,630	1,625	1,744	1,760	1,800
1942	1,800	1,800	1,800	1,800	1,800	1,792	1,681	1,653	1,647	1,732	1,748	1,797
1943	1,800	1,800	1,800	1,800	1,796	1,788	1,559	1,460	1,439	1,436	1,450	1,462
1944	1,480	1,494	1,509	1,513	1,509	1,503	1,306	1,032	912	851	852	862
1945	863	998	1,000	1,000	997	992	986	900	828	827	827	1,120
1946	1,376	1,376	1,376	1,374	1,370	1,364	1,220	931	872	805	810	820
1947	822	826	826	824	822	817	668	428	426	425	425	426
1948	427	427	431	449	447	444	441	438	435	434	434	436
1949	437	437	769	773	770	752	440	348	346	282	282	283
1950	290	395	395	397	395	392	389	386	384	383	389	666
1951	929	1,154	1,154	1,152	1,149	1,143	1,137	1,047	1,043	1,040	1,048	1,334
1952	1,719	1,800	1,800	1,800	1,800	1,792	1,784	1,776	1,783	1,800	1,800	1,800
1953	1,800	1,800	1,800	1,797	1,793	1,786	1,561	1,412	1,407	1,404	1,415	1,418
1954	1,653	1,800	1,800	1,800	1,796	1,566	1,246	1,036	993	963	993	1,081
1955	1,089	1,090	1,089	1,102	1,099	1,093	812	591	588	546	546	853
1956	1,222	1,482	1,488	1,511	1,741	1,734	1,587	1,558	1,553	1,690	1,695	1,701
1957	1,707	1,800	1,800	1,798	1,794	1,612	1,350	1,154	1,150	1,276	1,277	1,513
1958	1,786	1,800	1,800	1,800	1,800	1,800	1,753	1,745	1,800	1,800	1,800	1,800
1959	1,800	1,800	1,800	1,797	1,793	1,507	1,175	878	874	790	790	793
1960	801	882	882	880	878	873	836	563	508	450	457	471
1961	512	726	737	736	733	729	457	304	302	218	218	237
1962	237	516	612	611	608	605	596	373	371	416	417	656
1963	658	917	973	1,219	1,216	1,210	1,203	1,197	1,192	1,234	1,472	1,475
1964	1,482	1,483	1,490	1,488	1,485	1,478	1,231	970	875	812	821	1,065
1965	1,358	1,359	1,358	1,599	1,596	1,589	1,433	1,389	1,384	1,381	1,626	1,632
1966	1,800	1,800	1,800	1,798	1,794	1,607	1,339	1,056	977	809	829	1,096
1967	1,390	1,625	1,800	1,800	1,800	1,800	1,791	1,783	1,777	1,800	1,800	1,800
1968	1,800	1,800	1,800	1,798	1,794	1,526	1,237	1,016	936	905	907	1,126
1969	1,455	1,800	1,800	1,800	1,800	1,792	1,784	1,776	1,800	1,800	1,800	1,800
1970	1,800	1,800	1,800	1,798	1,794	1,672	1,321	1,049	992	956	1,195	1,484
1971	1,735	1,736	1,800	1,798	1,794	1,786	1,565	1,398	1,393	1,391	1,396	1,404
1972	1,406	1,406	1,645	1,643	1,639	1,580	1,309	1,019	1,015	1,012	1,047	1,220
1973	1,613	1,800	1,800	1,798	1,794	1,641	1,403	1,230	1,226	1,223	1,479	1,746
1974	1,800	1,800	1,800	1,800	1,796	1,788	1,704	1,696	1,754	1,800	1,800	1,800
1975	1,800	1,800	1,800	1,798	1,794	1,786	1,608	1,600	1,607	1,800	1,800	1,800
1976	1,800	1,800	1,800	1,797	1,793	1,560	1,205	969	893	811	812	814
1977	815	816	815	814	811	543	514	424	358	288	289	293
1978	707	1,026	1,335	1,568	1,565	1,558	1,527	1,452	1,447	1,444	1,451	1,454
1979	1,486	1,668	1,749	1,754	1,750	1,589	1,329	1,148	1,105	1,103	1,125	1,217
1980	1,556	1,800	1,800	1,798	1,794	1,786	1,553	1,497	1,492	1,489	1,490	1,503
1981	1,628	1,760	1,800	1,798	1,794	1,546	1,253	995	934	923	1,190	1,483
1982	1,800	1,800	1,800	1,800	1,796	1,788	1,749	1,742	1,800	1,800	1,800	1,800
1983	1,800	1,800	1,800	1,800	1,800	1,800	1,791	1,783	1,800	1,800	1,800	1,800
1984	1,800	1,800	1,800	1,798	1,794	1,680	1,423	1,208	1,203	1,201	1,485	1,549
1985	1,556	1,556	1,556	1,566	1,562	1,471	1,168	921	884	810	810	843
1986	879	1,257	1,593	1,606	1,602	1,595	1,384	1,314	1,309	1,307	1,307	1,312
1987	1,317	1,340	1,504	1,502	1,498	1,312	949	682	605	537	538	555
1988	699	699	699	697	695	580	428	416	367	273	273	274
1989	274	275	519	532	530	527	523	385	383	382	382	383
1990	393	393	401	400	398	395	365	362	360	229	230	230
1991	231	231	275	287	286	284	281	279	271	249	249	250
1992	255	354	383	382	380	378	345	342	323	229	229	239
1993	639	1,009	1,277	1,500	1,496	1,489	1,481	1,439	1,434	1,432	1,432	1,452
1994	1,461	1,491	1,491	1,494	1,491	1,436	1,138	908	832	----	----	----
AVG:	1,125	1,218	1,267	1,289	1,290	1,231	1,086	968	946	933	963	1,029
MIN:	197	211	226	232	231	229	222	210	178	102	104	120
MAX:	1,800	1,800	1,800	1,800	1,800	1,800	1,791	1,783	1,800	1,800	1,800	1,800

Table 7 - Study 656: Sites Reservoir head in FEET
(originally titled by Planning as end-of-month elevation)

NOTE: Per Division of Planning and Local Assistance, this will be used as head (difference in elevation between Funks & Sites) in the calculations.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1921	---	---	---	---	---	---	---	---	---	239	239	240
1922	243	252	253	253	253	253	252	252	251	251	252	259
1923	262	264	264	264	264	263	260	241	241	235	235	236
1924	237	238	240	240	239	192	159	155	144	140	141	144
1925	151	194	197	198	198	197	195	184	184	182	185	187
1926	190	220	221	222	222	221	207	183	182	173	176	184
1927	204	238	247	264	264	263	263	258	258	257	270	271
1928	274	290	295	295	295	278	255	236	226	217	217	217
1929	219	220	222	222	222	217	167	151	149	127	132	137
1930	143	145	150	151	151	150	150	149	149	149	149	149
1931	152	153	156	156	156	153	123	122	100	67	72	76
1932	83	89	96	98	97	97	96	95	95	94	94	96
1933	101	104	111	112	111	111	110	109	108	105	105	107
1934	112	115	122	123	122	121	94	89	75	43	44	51
1935	95	113	119	172	172	171	171	170	162	161	162	165
1936	208	238	240	240	240	240	239	231	226	224	225	226
1937	227	241	258	258	258	255	236	221	211	211	234	256
1938	263	282	295	295	295	294	290	290	289	295	295	295
1939	295	295	295	295	295	273	243	208	199	187	187	190
1940	226	249	267	273	273	272	259	243	241	238	239	260
1941	282	295	295	295	295	294	286	283	283	291	292	295
1942	295	295	295	295	295	294	287	285	284	290	291	295
1943	295	295	295	295	295	294	278	271	270	270	271	271
1944	273	273	275	275	275	274	261	241	228	221	221	222
1945	222	239	239	239	238	238	237	227	218	218	218	248
1946	266	266	266	266	265	265	255	230	223	215	216	217
1947	217	218	218	218	217	217	199	157	157	157	157	157
1948	157	157	158	161	161	160	160	159	159	158	159	159
1949	159	159	211	211	211	209	160	144	144	119	119	120
1950	123	152	152	152	152	151	151	150	150	150	151	199
1951	230	250	250	250	250	249	249	242	242	242	242	263
1952	289	295	295	295	295	294	294	293	294	295	295	295
1953	295	295	295	295	295	294	278	268	268	268	268	268
1954	285	295	295	295	295	279	257	241	238	234	238	245
1955	245	245	245	246	246	246	216	185	185	178	178	221
1956	255	273	273	275	291	290	280	278	278	287	288	288
1957	288	295	295	295	295	282	264	250	250	259	259	275
1958	294	295	295	295	295	295	292	291	295	295	295	295
1959	295	295	295	295	295	274	251	224	224	214	214	214
1960	215	225	225	224	224	223	219	181	171	161	162	165
1961	172	206	207	207	207	206	162	128	128	92	92	100
1962	100	172	189	189	188	188	186	148	148	156	156	197
1963	197	229	236	255	254	254	254	253	253	256	272	272
1964	273	273	273	273	273	272	255	235	224	216	217	244
1965	265	265	265	281	281	280	269	267	266	266	283	283
1966	295	295	295	295	295	281	263	243	236	216	218	246
1967	267	283	295	295	295	295	294	294	293	295	295	295
1968	295	295	295	295	295	276	256	240	231	227	228	248
1969	271	295	295	295	295	294	294	293	295	295	295	295
1970	295	295	295	295	295	286	262	242	238	233	253	273
1971	290	290	295	295	295	294	278	267	267	267	267	268
1972	268	268	284	284	284	280	261	240	240	240	242	255
1973	282	295	295	295	295	284	268	255	255	255	272	291
1974	295	295	295	295	295	294	288	288	292	295	295	295
1975	295	295	295	295	295	294	281	281	281	295	295	295
1976	295	295	295	295	295	278	254	235	226	216	216	216
1977	217	217	217	216	216	177	172	157	146	122	122	124
1978	204	241	263	279	278	278	276	271	270	270	271	271
1979	273	286	291	292	291	280	263	250	246	246	248	255
1980	278	295	295	295	295	294	278	274	273	273	273	274
1981	283	292	295	295	295	277	257	238	231	230	253	273
1982	295	295	295	295	295	294	291	291	295	295	295	295
1983	295	295	295	295	295	295	294	294	295	295	295	295
1984	295	295	295	295	295	287	269	254	254	253	273	277
1985	278	278	278	279	278	272	251	229	225	216	216	220
1986	224	257	280	281	281	281	266	261	261	261	261	261
1987	262	263	274	274	274	261	233	201	188	176	176	179
1988	203	203	203	202	202	184	157	156	147	115	115	116
1989	116	116	173	175	175	174	173	150	150	150	150	150
1990	152	152	153	153	152	152	147	146	146	97	97	97
1991	98	98	116	121	121	120	119	118	114	105	105	106
1992	108	145	150	150	149	149	143	143	137	97	97	101
1993	194	239	259	274	274	273	273	270	270	269	269	271
1994	271	273	273	274	273	270	249	228	219	---	---	---
AVG:	231	242	247	249	249	244	231	220	216	211	214	220
MIN:	83	89	96	98	97	97	94	89	75	43	44	51
MAX:	295	295	295	295	295	295	294	294	295	295	295	295

Table 8 - Average monthly head (difference in elevation between Funks & Sites) used in the study, FEET

NOTE: The current monthly average head is the sum of the previous and current end-of-the-month's elevation divided by two.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1921	0	0	0	0	0	0	0	0	0	0	239	239.5
1922	241.5	247.5	252.5	253	253	253	252.5	252	251.5	251	251.5	255.5
1923	260.5	263	264	264	264	263.5	261.5	250.5	241	238	235	235.5
1924	236.5	237.5	239	240	239.5	215.5	175.5	157	149.5	142	140.5	142.5
1925	147.5	172.5	195.5	197.5	198	197.5	196	189.5	184	183	183.5	186
1926	188.5	205	220.5	221.5	222	221.5	214	195	182.5	177.5	174.5	180
1927	194	221	242.5	255.5	264	263.5	263	260.5	258	257.5	263.5	270.5
1928	272.5	282	292.5	295	295	286.5	266.5	245.5	231	221.5	217	217
1929	218	219.5	221	222	222	219.5	192	159	150	138	129.5	134.5
1930	140	144	147.5	150.5	151	150.5	150	149.5	149	149	149	149
1931	150.5	152.5	154.5	156	156	154.5	138	122.5	111	83.5	69.5	74
1932	79.5	86	92.5	97	97.5	97	96.5	95.5	95	94.5	94	95
1933	98.5	102.5	107.5	111.5	111.5	111	110.5	109.5	108.5	106.5	105	106
1934	109.5	113.5	118.5	122.5	122.5	121.5	107.5	91.5	82	59	43.5	47.5
1935	73	104	116	145.5	172	171.5	171	170.5	166	161.5	161.5	163.5
1936	186.5	223	239	240	240	240	239.5	235	228.5	225	224.5	225.5
1937	226.5	234	249.5	258	258	256.5	245.5	228.5	216	211	222.5	245
1938	259.5	272.5	288.5	295	295	294.5	292	290	289.5	292	295	295
1939	295	295	295	295	295	284	258	225.5	203.5	193	187	188.5
1940	208	237.5	258	270	273	272.5	265.5	251	242	239.5	238.5	249.5
1941	271	288.5	295	295	295	294.5	290	284.5	283	287	291.5	293.5
1942	295	295	295	295	295	294.5	290.5	286	284.5	287	290.5	293
1943	295	295	295	295	295	294.5	286	274.5	270.5	270	270.5	271
1944	272	273	274	275	275	274.5	267.5	251	234.5	224.5	221	221.5
1945	222	230.5	239	239	238.5	238	237.5	232	222.5	218	218	233
1946	257	266	266	266	265.5	265	260	242.5	226.5	219	215.5	216.5
1947	217	217.5	218	218	217.5	217	208	178	157	157	157	157
1948	157	157	157.5	159.5	161	160.5	160	159.5	159	158.5	158.5	159
1949	159	159	185	211	211	210	184.5	152	144	131.5	119	119.5
1950	121.5	137.5	152	152	152	151.5	151	150.5	150	150	150.5	175
1951	214.5	240	250	250	250	249.5	249	245.5	242	242	242	252.5
1952	276	292	295	295	295	294.5	294	293.5	293.5	294.5	295	295
1953	295	295	295	295	295	294.5	286	273	268	268	268	268
1954	276.5	290	295	295	295	287	268	249	239.5	236	236	241.5
1955	245	245	245	245.5	246	246	231	200.5	185	181.5	178	199.5
1956	238	264	273	274	283	290.5	285	279	278	282.5	287.5	288
1957	288	291.5	295	295	295	288.5	273	257	250	254.5	259	267
1958	284.5	294.5	295	295	295	295	293.5	291.5	293	295	295	295
1959	295	295	295	295	295	284.5	262.5	237.5	224	219	214	214
1960	214.5	220	225	224.5	224	223.5	221	200	176	166	161.5	163.5
1961	168.5	189	206.5	207	207	206.5	184	145	128	110	92	96
1962	100	136	180.5	189	188.5	188	187	167	148	152	156	176.5
1963	197	213	232.5	245.5	254.5	254	254	253.5	253	254.5	264	272
1964	272.5	273	273	273	273	272.5	263.5	245	229.5	220	216.5	230.5
1965	254.5	265	265	273	281	280.5	274.5	268	266.5	266	274.5	283
1966	289	295	295	295	295	288	272	253	239.5	226	217	232
1967	256.5	275	289	295	295	295	294.5	294	293.5	294	295	295
1968	295	295	295	295	295	285.5	266	248	235.5	229	227.5	238
1969	259.5	283	295	295	295	294.5	294	293.5	294	295	295	295
1970	295	295	295	295	295	290.5	274	252	240	235.5	243	263
1971	281.5	290	292.5	295	295	294.5	286	272.5	267	267	267	267.5
1972	268	268	276	284	284	282	270.5	250.5	240	240	241	248.5
1973	268.5	288.5	295	295	295	289.5	276	261.5	255	255	263.5	281.5
1974	293	295	295	295	295	294.5	291	288	290	293.5	295	295
1975	295	295	295	295	295	294.5	287.5	281	281	288	295	295
1976	295	295	295	295	295	286.5	266	244.5	230.5	221	216	216
1977	216.5	217	217	216.5	216	196.5	174.5	164.5	151.5	134	122	123
1978	164	222.5	252	271	278.5	278	277	273.5	270.5	270	270.5	271
1979	272	279.5	288.5	291.5	291.5	285.5	271.5	256.5	248	246	247	251.5
1980	266.5	286.5	295	295	295	294.5	286	276	273.5	273	273	273.5
1981	278.5	287.5	293.5	295	295	286	267	247.5	234.5	230.5	241.5	263
1982	284	295	295	295	295	294.5	292.5	291	293	295	295	295
1983	295	295	295	295	295	295	294.5	294	294.5	295	295	295
1984	295	295	295	295	295	291	278	261.5	254	253.5	263	275
1985	277.5	278	278	278.5	278.5	275	261.5	240	227	220.5	216	218
1986	222	240.5	268.5	280.5	281	281	273.5	263.5	261	261	261	261
1987	261.5	262.5	268.5	274	274	267.5	247	217	194.5	182	176	177.5
1988	191	203	203	202.5	202	193	170.5	156.5	151.5	131	115	115.5
1989	116	116	144.5	174	175	174.5	173.5	161.5	150	150	150	150
1990	151	152	152.5	153	152.5	152	149.5	146.5	146	121.5	97	97
1991	97.5	98	107	118.5	121	120.5	119.5	118.5	116	109.5	105	105.5
1992	107	126.5	147.5	150	149.5	149	146	143	140	117	97	99
1993	147.5	216.5	249	266.5	274	273.5	273	271.5	270	269.5	269	270
1994	271	272	273	273.5	273.5	271.5	259.5	238.5	223.5	0	0	0
AVG:	225.8	236.3	244.3	248.0	249.1	246.6	237.6	225.4	217.9	213.5	212.4	217.1
MIN:	73	86	92.5	97	97.5	97	96.5	91.5	82	59	43.5	47.5
MAX:	295	295	295	295	295	295	294.5	294	294.5	295	295	295

April 27, 1999

Mr. Frank Tsai
Pacific Gas and Electric Company
Electric Transmission Services
77 Beale Street
San Francisco, California 94105

Dear Mr. Tsai:

We received your letter regarding the informational review of the proposed Sites Offstream Reservoir Pumped-Storage Hydroelectric Project transmission interconnection. Your letter will be part of an overall report on the proposed Sites Offstream Reservoir Project.

The report will be submitted to our Northern District in Red Bluff which is leading the study on the proposed project. After Northern District's review, a decision will be made on how to proceed with the proposed project, including the transmission interconnection for the pumped-storage and probable additional pumping or pumped-storage plants. You will then receive a letter on whether to proceed with the preliminary facilities study or a detailed facilities study.

For your information, the location of the proposed pumped-storage shown in Figure 1 of your informational review is incorrect. A copy of Figure 1 marked with the correct approximate location of the proposed pumped-storage plant and a map of the proposed Sites Offstream Reservoir is enclosed.

If you should have any questions or require further information on this matter, please call me at (916) 653-6271 or Sonny Punzalan at (916) 653-9551.

Sincerely,

ORIGINAL SIGNED BY

Chi Doan
Power Supply
and Transmission Planning

SPunzalan:rm
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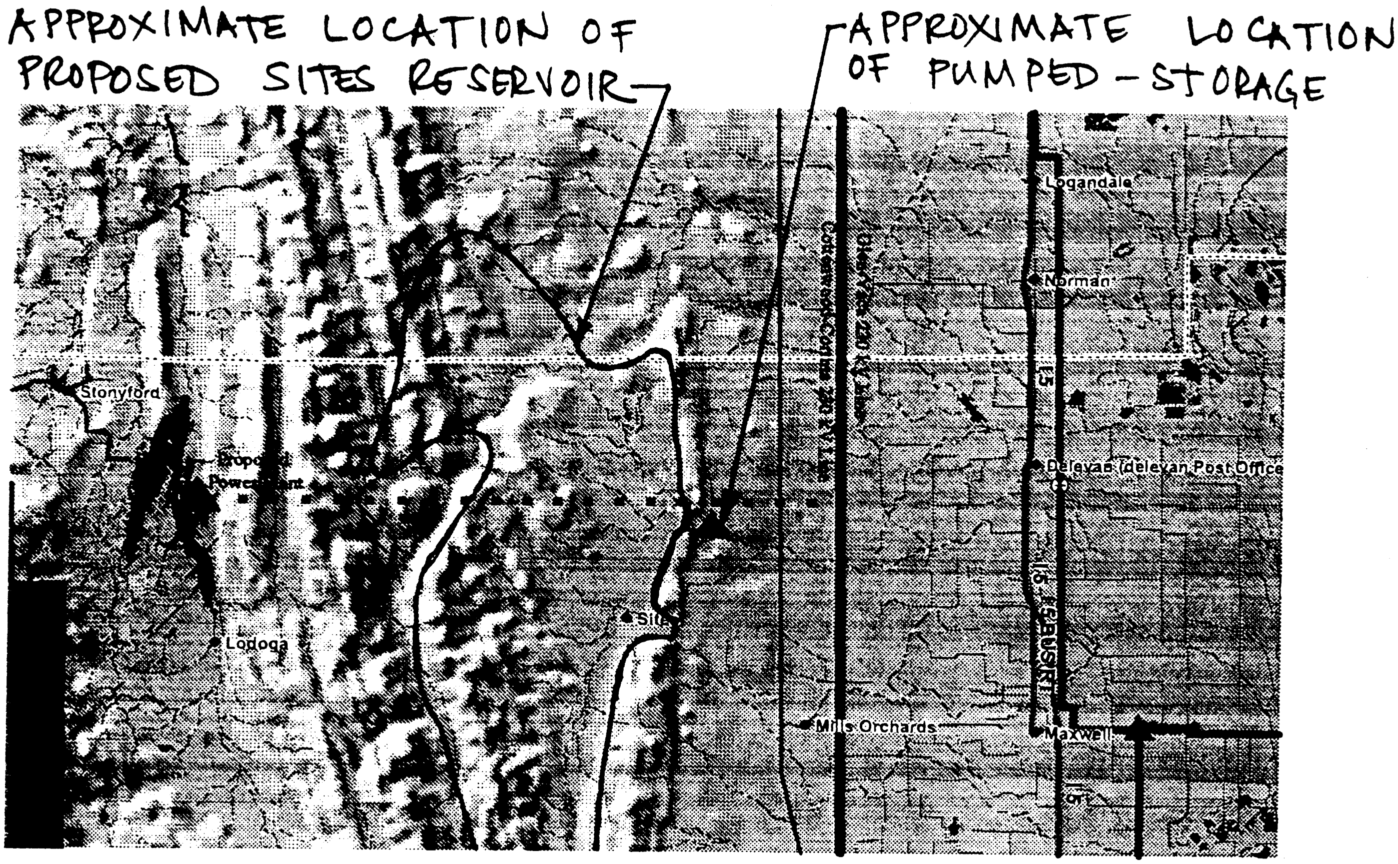


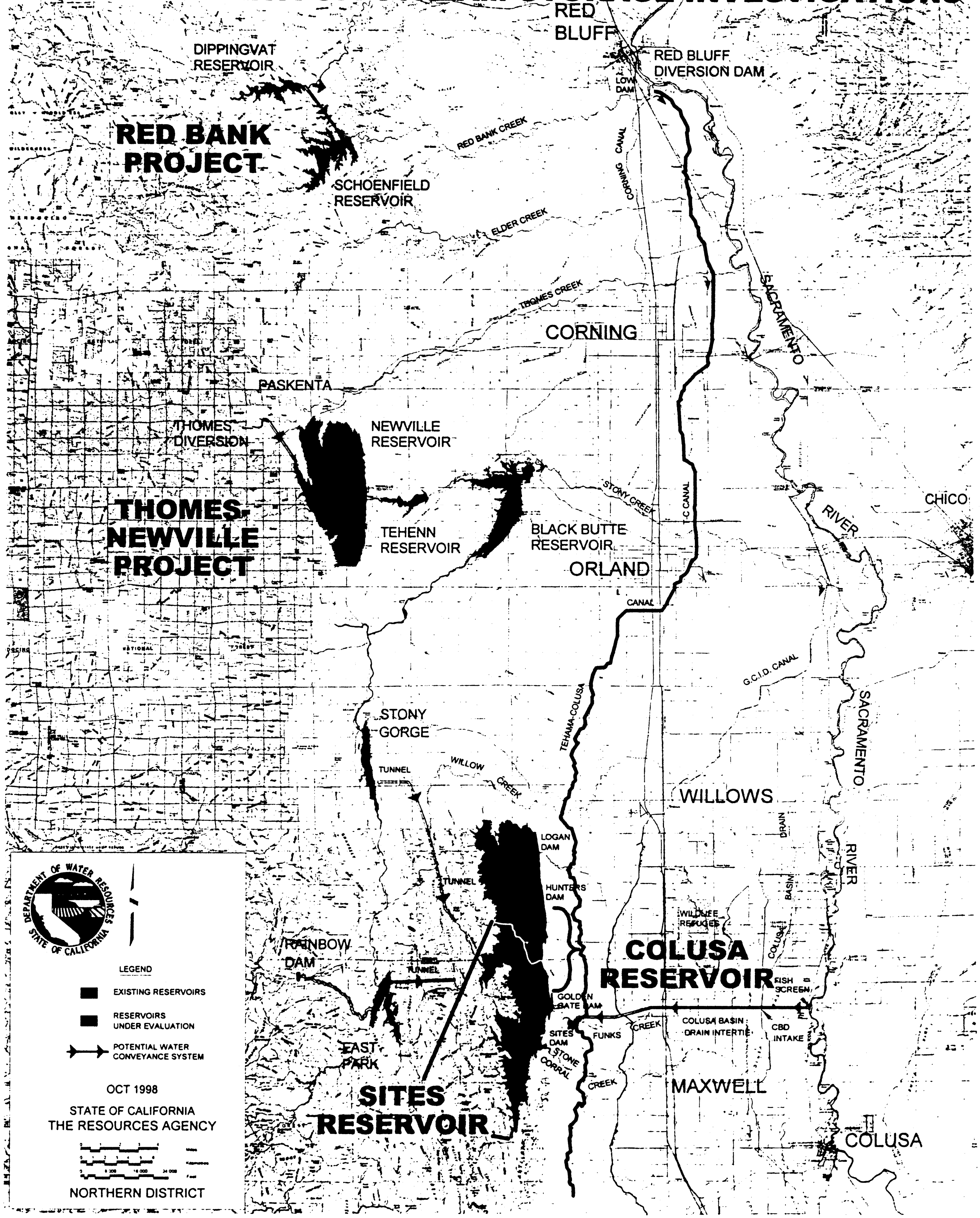
Figure 1 - Proposed Pump Storage Hydroelectric Facility

	Proposed Work	Rough Cost ($000)
1	Loop Cottonwood-Cortina 230 kV line into CDWR's facility (approx. 15 miles each way)	$ 5,000
2	Loop Glenn-Vaca 230 kV line into CDWR's facility (approx. 15 miles each way)	$ 5,000
3	Protection Upgrades on the Cottonwood-Cortina 230 kV line	$ 400
3	Protection Upgrades on the Glenn-Vaca 230 kV line	$ 400
4	Construct a 6-breaker ring bus Switching Station on CDWR's facility	$ 6,000
	TOTAL	**$16,800**

Table 1 - Proposed Interconnection Facilities

Figure 1

NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATIONS



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Pacific Gas and
Electric Company

Electric Transmission Services

77 Beale Street
San Francisco, CA 94105

Mailing Address
Mail Code B23A
P.O. Box 770000
San Francisco, CA 94177

415.973.7000

April 12, 1999

Mr. Arsenio F. Punzalan
California Department of Water Resources
Power Supply and Transmission Planning - Room 1655
1416 Ninth Street
Sacramento, CA 95814

Subject: Informational Review - Sites Offstream Pump Storage Hydro Project

Dear Sonny:

As CDWR requested, PG&E has performed an Informational Review for the proposal to interconnect a pump storage hydroelectric generating facility under consideration near Maxwell to PG&E's transmission grid. This review is based on the assumption that the proposed generating facility is capable of producing a maximum of 162 MW of power in the generating mode and requires a demand of 300 MW in the pumping mode.

As part of our effort to provide an Informational Review, we have reviewed our existing studies, used engineering judgment and performed a few preliminary powerflow analysis using standard base cases under normal and emergency conditions. Review conclusions and a non-binding indication of the order-of-magnitude cost estimate for the interconnection option considered are summarized in the attached report. The review results must be validated by an interconnection study and the costs to perform either a Preliminary Facilities Study or a Detailed Facilities Study will be provided upon request when you are ready to proceed further.

Should you have any questions, please do not hesitate to call me at (415) 973-0437.

Sincerely,

Frank Tsai

Attachment

Informational Review

Sites Offstream Pump Storage Hydroelectric Project

PG&E

Pacific Gas and Electric Company

April 12, 1999

INFORMATIONAL REVIEW
(Confidential)

Background

As requested by California Department of Water Resources (CDWR), PG&E has completed an Informational Review for CDWR's proposed pump storage hydroelectric facility located in Sites Reservoir in Colusa County. In the generating mode, the facility would have a capability of 162 MW and in the pumping mode a demand of 200 MW. CDWR also indicated that the ultimate demand of the facility in the pumping mode would be about 300 MW. This report summaries PG&E's Informational Review using screening level information to provide a non-binding rough cost estimate for the interconnection facilities.

Please also note that this review only addresses the transmission interconnection and substation aspect for the proposed project.

Objective of Information Review

This Informational Review gives CDWR a quick, no cost, non-binding indication of the order-of-magnitude cost for service connection to the PG&E's transmission grid. This review, on which typically a maximum of two days of study time is spent, is based on past experience with similar requests and previously conducted studies, where available. This approach can save both CDWR and PG&E time and resources when CDWR is considering its own options and is only seeking general feasibility information. A request for an Informational Review is not considered a formal request for interconnection.

All costs provided in this Information Review have no intended degree of accuracy and are based on typical per unit cost. The costs does not include the cost of land right-of-way, income tax component of contribution (ITCC) tax or cost of ownership (COC) charges. ITCC and COC typically add approximately 75% to the cost. Cost of facilities to be constructed, owned and maintained by the customer is also not included.

Information and findings stated in this review must be validated by a PG&E interconnection study if CDWR decides to proceed further.

Interconnection Facilities

Based on the information provided by CDWR, it appears that the proposed project site would be located about 15 miles west of PG&E's Cottonwood-Cortina and Glenn-Vaca 230 kV transmission lines. (Figure 1) To accommodate the ultimate project size of 300 MW, PG&E explored the option of looping both the Cottonwood-Cortina and Glenn-Vaca 230 kV lines into a proposed switchyard to be located on the project site. The rough cost of the required interconnection facilities are tabulated in Table 1.

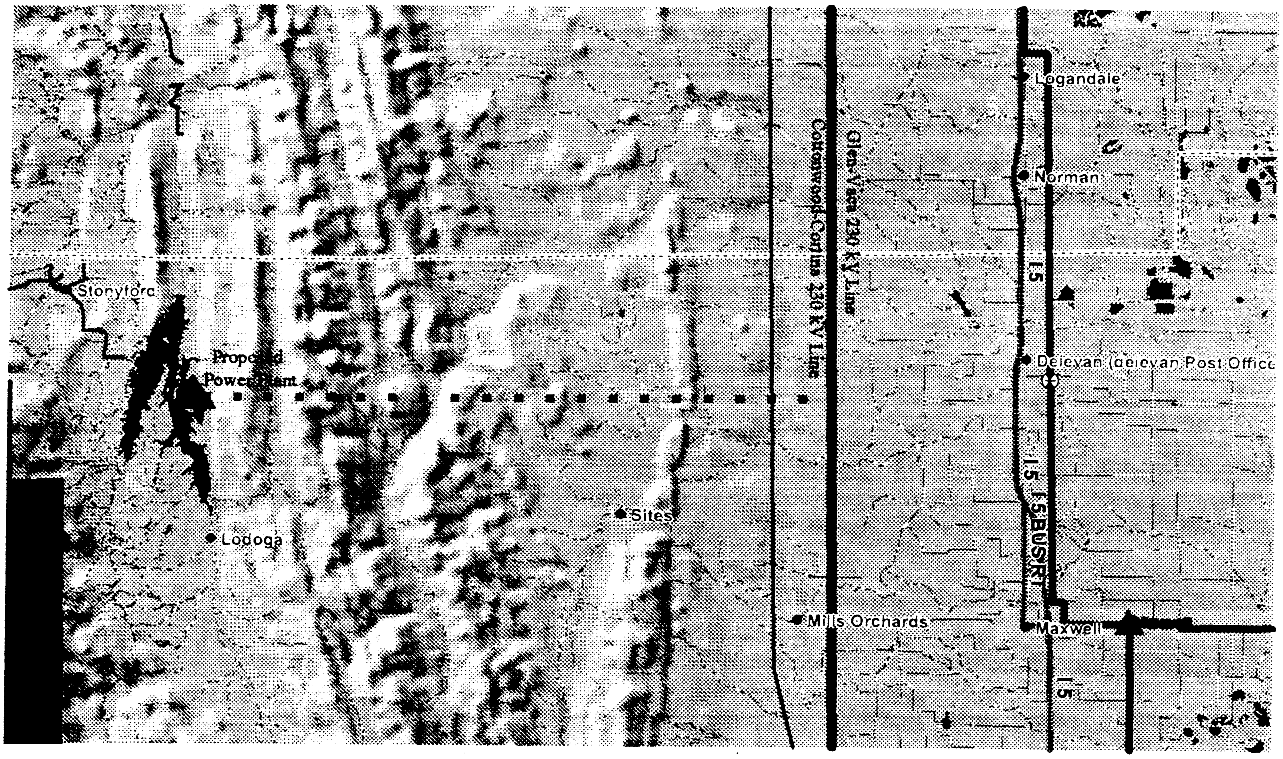

Figure 1 - Proposed Pump Storage Hydroelectric Facility

	Proposed Work	Rough Cost ($000)
1	Loop Cottonwood-Cortina 230 kV line into CDWR's facility (approx. 15 miles each way)	$ 5,000
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3	Protection Upgrades on the Cottonwood-Cortina 230 kV line	$ 400
3	Protection Upgrades on the Glenn-Vaca 230 kV line	$ 400
4	Construct a 6-breaker ring bus Switching Station on CDWR's facility	$ 6,000
	TOTAL	**$16,800**

Table 1 - Proposed Interconnection Facilities

Transmission System Upgrade

On a screening analysis basis, we do not anticipate any need for major transmission system upgrades. System analyses such as power flow, short circuit and stability studies would have to be performed as part of the interconnection study.

Next Step - System Impact Study

To continue with this proposed transmission interconnection, PG&E will perform either a Preliminary Facilities Study (PFS) or a Detailed Facilities Study (DFS), depending on the desired degree of the cost estimate accuracy. This work is necessary to determine specifically what interconnection facilities will be required to provide the proposed service and their associated cost estimates.

The optional PFS will study multiple interconnection alternatives and will provide non-binding cost estimates for the required interconnection facilities with an intended ±50 % accuracy. The PFS results are intended to help the customer gain information about the available alternatives and eventually select a preferred alternative for a DFS. The charge for the PFS will be based on the complexity and the number of alternatives to be studied. In most cases, a PFS will take 90 days to complete.

The DFS is required for any request for interconnection. It will provide a cost estimate, binding for 60 days from the date the DFS report is issued for a single interconnection alternative chosen by the customer and/or the associated system reinforcements. The charge for the DFS will be based on the complexity of the alternative. In most cases, a DFS will take 120 days to complete.

ASSUMPTIONS & FORMULAS

Plant Capacity =	6800 cfs (P)			9064 cfs (G)
Plant MW (Generate) =	Head * flow * Eff.*		0.746	
	1000	8.815		
Plant MW (Pump) =	Head * flow * .		11.3333	0.746
	Eff.	100000		

Efficiency (Generate) =	87.30%	- from EPRI GS-6669 (Jan. 1990) - Pumped-Storage Planning & Evaluation Guide
Efficiency (Pump) =	87.70%	- from EPRI GS-6669 (Jan. 1990) - Pumped-Storage Planning & Evaluation Guide
Onpk Hours/Month =	426	
Offpk Hours/Month =	304	
Max. Onpk TAF through plant /month =	319	
Max. Offpk TAF through plant /month =	171	

tate of California DEPARTMENT OF WATER RESOURCES The Resources Agency

FFICE MEMO

TO: Chi Doan	DATE: May 11, 1999
FROM: Farshid Falaki	SUBJECT: Efficiency Assumption of the Proposed Pumped-Storage Hydroelectric Power Plant for Site Reservoir Project

In reference to your office memo of May 5, 1999, my comments based on the plant flow capacity of 6,800 cfs during power generation and 280 feet head are as following:

1- Your assumption on turbine efficiency of 90 percent is reasonable.
2- The assumption on pump efficiency should be revised from 70 percent to 89 percent.

The above assumptions are made for a plant with six pump-turbines with following characteristics:

N = 400 rpm	(Unit Speed)
Q_T = 1,133 cfs	(Turbine Rated Flow)
P_T = 31,700 hp	(Generator Output based on 98% generator eff.)
n_{ST} = 63	(Turbine Specific Speed)
Q_P = 850 cfs	(Pump Rated Flow)
P_P = 30,950 hp	(Motor Input)
n_{SP} = 3,609	(Pump Specific Speed)

Presently, Mechanical and Electrical Engineering Branch is not authorized to work on this project; however, Please do not hesitate to call me at 653-9848 if you have any further questions.

FROM EPRI GS-6669 (JAN. 1990) - PUMPED-STORAGE PLANNING & EVALUATION GUIDE

Efficiency

The modern pumped-storage plant has become quite efficient, where the term efficiency denotes cycle efficiency (ratio of energy output to energy input). Cycle efficiency has improved from under 65% for the early plants of the 1960's to over 75% for the newer plants. The overall efficiency includes the efficiencies of the water conductors, pump/turbines, generator/motors and transformers (if energy input and output are measured at the high side of the main transformers). For most pumped-storage plants, the efficiency is often determined from its energy production and consumption over a year. In that case, the overall operation such as unit startup, turn-around, part-load, and seal-ring losses in the pump/turbine would be factored in. In addition, losses in the reservoirs due to evaporation and seepage as well as gains due to local inflow are accounted for.

Efficiency is controlled to some extent by the plant design. For example, more elaborate design of the water conductors and intake/outlets reduces the hydraulic losses, and hence increases the cycle efficiency. A modern large pumped-storage plant is expected to have a cycle efficiency in the range of 72 to 80% depending on unit size, head variation, length of water conductors relative to head, design refinements, and how the plant is operated. Table 2-2 illustrates the individual component efficiencies for a typical plant having a cycle efficiency of about 75 %.

Table 2-2

COMPOSITION OF CYCLE EFFICIENCY - %

GENERATING	
Water Conductors	97.4
Pump/Turbine	91.5
Generator/Motor	98.5
Transformer	99.5
Subtotal - Generating	87.3
PUMPING	
Water Conductors	97.6
Pump/Turbine	91.5
Generator/Motor	98.7
Transformer	99.5
Subtotal - Pumping	87.7
OPERATIONAL	
Losses/Leakage	98.0
TOTAL	75.0

State of California
The Resources Agency
Department of Water Resources
Division of Planning and Local Assistance

Attachment A. Formulation of Alternatives

The formulation of alternatives was an iterative process consisting of brainstorming, fatal flaw analysis, initial cost comparisons, and screening criteria. The process involved meetings with interdisciplinary staff from ND, CD, ESO, and CALFED. The alternatives were also discussed with the Tehama-Colusa Canal Authority and USBR during Technical Advisory Group meetings.

The objective of the formulation process was to identify a reasonable number of alternatives that would be retained for further study. In selecting alternatives for this study, the goal was to provide the decision-makers with an array of alternatives. As such, each alternative can be viewed as representing a reasonable design configuration for that type of alternative.

In general, the screening process considered criteria that tended to make one alternative more or less favorable when compared to another alternative. However, as mentioned above, the process attempted to retain at least one alternative of each type for comparison. The following factors were primary considerations for deferral or retention of an alternative:

Engineering feasibility. Site conditions were assessed to determine the feasibility of constructing a new diversion along the Sacramento River. A stable bank or "hardened point" was considered a minimum requirement for the location to be deemed feasible. Although a difficult site could be made feasible, it was deferred under these criteria if costly measures would be required.

Capital cost. While all costs should be included when making comparisons, the initial screening process compared only capital or construction costs. The operations and maintenance costs are not included in the comparison nor are the costs annualized over the life of the project. During the screening process, costs were compared between alternatives in order to defer alternatives whose costs were significantly higher than the costs of the retained alternatives.

Environmental issues. The initial screening process considered known environmental impacts that would make the alternative very unlikely to be implemented. Examples of such "fatal flaws" would be potential impacts to endangered species. Staff from ESO is studying fishery, plant, wildlife, archeological and related impacts of the conveyance alternatives.

Institutional issues. Would there be significant public opposition to the alternative? By itself this factor would not cause an alternative to be deferred but combined with other unfavorable factors could provide adequate justification for deferral. Institutional issues would also include those related to the operation or implementation of an alternative. Such issues could limit the flexibility of operations.

Representative alternative. An alternative may be deferred if it is similar to another alternative that will be retained for further study. An alternative may be retained in order to provide a comparison of different types of alternatives.

Other factors not considered during the initial screening process but necessary for future comparisons include operational flexibility, land acquisition and operations and maintenance costs, site limitations, drainage issues, and mitigation costs.

During the initial brainstorming process, a number of alternatives were eliminated for not meeting the initial scope of this study although they could potentially provide water to an offstream storage reservoir at Sites. Other alternatives were eliminated later during the screening process when they were determined to have unacceptable high costs or had unstable site conditions at the diversion location. At various times during the formulation process, the number of alternatives would fluctuate as ones were eliminated while new ones were added. Ultimately, five primary alternatives were identified for this study and described in the main report. Three of the alternatives have options or variations based on different components.

The following list describes alternatives that were considered for study during the formulation process and the reason(s) for deferral in this study.

Alternatives considered outside the scope of this study:

- Diversion from existing Black Butte Reservoir to enlarged Tehama-Colusa Canal between Stony Creek near Orland and Funks Reservoir.
- New 5,000 cfs canal flowing south from Black Butte Reservoir to Funks Reservoir.
- New 5,000 cfs canal flowing north from Berryessa Reservoir to Funks Reservoir.
- New 5,000 cfs tunnel and canal system flowing northeasterly from Clear Lake to Funks Reservoir.
- Butte Sink or other diversions from east of the Sacramento River.

Alternatives deferred for engineering reasons:

- New Sacramento River diversion and intertie north of Chico Landing to enlarged 5,000 cfs Tehama-Colusa Canal (similar to Chico Landing Intertie).
- New Sacramento River diversion and intertie north of Chico Landing to enlarged 5,000 cfs Glenn-Colusa Canal, then to Funks Reservoir.
- Sacramento River diversion and intertie south of Maxwell Road back northwesterly to Funks Reservoir.

Alternatives deferred because of high costs:

- Divert from an enlarged Colusa Basin Drain to a new canal (near Maxwell Road) to Funks Reservoir.

Alternatives deferred for institutional reasons:

- Series of interconnections from Sacramento River to Colusa Basin Drain, CBD to Glenn-Colusa Canal, and Glenn-Colusa Canal to Tehama-Colusa Canal and Funks Reservoir.

Alternatives deferred for environmental reasons:

- Divert from Sacramento River near Highway 162 and Butte City to an enlarged Colusa Basin Drain to a new canal (near Delevan Road) to Funks Reservoir.

Alternatives represented by other alternatives to be studied:

- Divert from Sacramento River to a new canal (near Maxwell Road) to Funks Reservoir.
- Use existing Tehama-Colusa Canal with a diversion from an enlarged Colusa Basin Drain to a new canal (near Delevan Road) to Funks Reservoir.
- Use existing Tehama-Colusa and Glenn-Colusa Canals and Colusa Basin Drain to Funks Reservoir.

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Attachment B. Design Assumptions and Criteria

The conveyance alternatives design assumptions and criteria describe pre-feasibility level studies of alternatives for diverting and conveying 5,000 cfs to existing Tehama-Colusa Canal/Funks Reservoir for the proposed Sites Reservoir offstream storage project.

General:

- The level of study for this report is pre-feasibility for general alternative conveyance facility comparison and selection purposes.
- The four alternative water sources for offstream reservoir storage are the Tehama-Colusa Canal, Glenn-Colusa Canal, Colusa Basin Drain, and new Sacramento River diversion at, or downstream of, Chico Landing.
- No boundary or topographic survey work has been performed. All work is based on U.S. Geological Survey quad maps, existing reports, data and visual field observations.
- No field geologic observations, borings, soil tests, or detailed research has been performed. Limited geologic data was obtained from existing reports and discussions with various agency geologists, soil scientists, and other technical staff.
- No Sacramento River, Colusa Basin Drain, Tehama-Colusa Canal, or Glenn-Colusa Canal hydrology, operations, routing, or other studies are included in the study scope.
- ND is doing reservoir sizing, hydrology, operation analysis, pre-design, and other related storage facility work.
- Environmental research, assessment, evaluations, and similar work are being done by ESO. Environmental considerations are being discussed between ND, CD, and ESO.
- Several of the alternatives could be modified or utilized in the larger Colusa/Sites offstream water storage reservoir alternative.
- Pumping works necessary to lift diverted water from Funks Reservoir into Sites Reservoir will be studied by ND.
- Preliminary right of way ownership, where available, is based on the latest available property ownership maps.
- Preliminary conveyance design is based on DWR design manuals and CALFED facility descriptions for Chico Landing Intertie and Tehama-Colusa Canal Enlargement.
- Preliminary alternative conveyance facility costs are based on CALFED cost criteria and recently constructed comparable facilities.
- Institutional constraints, interagency agreements and cost sharing are beyond the scope of this report at this time.

- Detailed planning, design, and construction scheduling are beyond the scope of this report at this time.

Preliminary capital and construction costs are the only costs included in the alternative screening process. Annual operations and maintenance costs, which vary depending on the pumping head, type of canal lining, length of canal, and other factors, will be developed for the alternatives selected for further study.

The initial 12 conveyance alternatives were screened down to three or four alternatives for further study between March and September 1998.

Tehama-Colusa Canal:

- Existing Tehama-Colusa Canal plans and data were furnished by USBR; and related information was gathered from existing reports, visual observation, and discussions.
- Facility descriptions and preliminary costs for the Tehama-Colusa Canal are based on, and described in, the CALFED Tehama-Colusa Canal enlargement report.
- Chico Landing Intertie and Tehama-Colusa Canal facility descriptions and preliminary costs for the CL/TC intertie and enlargement are based on, and described in, the CALFED Chico Landing Intertie and Tehama-Colusa Canal enlargement reports.
- Alternatives involving the Tehama-Colusa Canal are assumed not to adversely affect existing delivery capability or schedules, cross drainage, institutional constraints, or other existing factors.

Glenn-Colusa Canal:

- Glenn-Colusa Canal data was furnished by GCID and gathered from existing reports, visual observations, and discussions.
- Alternatives involving the Glenn-Colusa Canal are assumed not to adversely affect existing delivery capability or schedules, cross drainage, institutional constraints, or other existing factors.
- GCID is presently planning to expand the existing 450-foot-long fish screen to approximately 1,000 feet. The extension would not provide additional capacity beyond existing capability.

Colusa Basin Drain:

- Funks Reservoir is the terminal point for CD conveyance study alternatives.
- Colusa Basin Drain data was gathered from existing reports, observations, and discussions.
- Alternatives involving the Colusa Basin Drain are assumed not to adversely affect existing delivery capability or schedules, agricultural return flows, cross drainage, institutional constraints or other existing factors.
- No fish screen requirement is assumed for the Colusa Basin Drain.

Sacramento River:

- CALFED's Chico Landing diversion facility and fish screens descriptions and costs are assumed applicable to other alternative Sacramento River diversions points.
- Sacramento River water rights and diversions are assumed not a factor (for winter period peak flood flow diversions to Funks Reservoir) for this study.
- Sacramento River data was gathered from DWR Flood Operations Center reports, USGS water resources data reports, ND observations, and discussions.
- Alternatives involving Sacramento River diversions are assumed not to adversely affect existing delivery capability or schedules, institutional constraints, or other existing factors.
- For preliminary screening purposes, diversion from the river is assumed to be allowed above a minimum flood flow of 20,000 cfs. (This may be revised because of environmental, water surface elevation, or other reasons.)
- For preliminary screening purposes, diversion from the river is assumed to be allowed up to the maximum river flow following 24-hour 60,000 cfs flushing period. (This may be revised because of environmental, water surface elevation, or other reasons.)

Attachment C. Unit Costs

(Tables C-1 through C-4)

Table C-1. Funks Reservoir Diversions Canal Reaches/Alternatives Matrix, Proposition 204 North of the Delta Storage Facility Studies

No.	Alternative	Diversion to Funks (cfs)	Canal	Canal Reaches: No.	Q(max) (cfs)	Length: Station (1000 ft) (a)	Length: Distance (unit cost) (b)	Length: Distance (Miles)	Status	From	To	Canal Lined	Pumping Plants	Canal Costs (a x b)
I A	TC+GC/NC4A	3,900	TC	all	2,100	350.02	0	66.29	Existing	RBPP	Funks	Yes	0	0.0
	Includes existing		GC	all	1,800	212.00	0	40.15	Existing	HCPP	NC	No	0	0.0
	2,100 cfs TC and		NC	all	1,800	10.60	0.50	2.01	New	GC	TC	Yes	2	5.3
	1,800 cfs GC		TC	last	3,900	2.50	0.35	0.47	Enlarge	NC	Funks	Yes	0	0.9
	Total													**$6.2**
B	TC+GC/NC4B	3,900	TC	all	2,100	352.52	0	66.77	Existing	RBPP	Funks	Yes	0	0.0
	Includes existing		GC	all	1,800	212.00	0	40.15	Existing	HCPP	NC	No	0	0.0
	2,100 cfs TC and		NC	all	1,800	14.00	0.50	2.65	New	GC	Funks	Yes	2	7.0
	1,800 cfs GC													
	Total													**$7.0**
II A	TC+GC/NC4A	5,000	TC	all	2,500	350.02	0.05	66.29	Enlarge	RBPP	NC	Yes	0	17.5
	Includes enlarging		GC	all	2,500	148.11	0.00	28.05	Existing	HCPP	I5	Yes	0	0.0
	existing TC and GC		GC	all	2,500	63.89	0.35	12.10	Enlarge	I5	NC	Yes	0	22.4
	to 2,500 cfs each		NC	all	2,500	10.60	0.65	2.01	New	GC	TC	Yes	2	6.9
			TC	last	5,000	2.50	0.44	0.47	Enlarge	NC	Funks	Yes	0	1.1
	Total													**$47.9**

No.	Alternative	Diversion to Funks *(cfs)*	Canal	No.	Q(max) *(cfs)*	Length: Station *(1000 ft)* (a)	Length: Distance *(unit cost)* (b)	Length: Distance *(Miles)*	Status	From	To	Canal Lined	Pumping Plants	Canal Costs (a x b)
B	TC+GC/NC4B	5,000	TC	all	2,500	352.52	0.05	66.77	Enlarge	RBPP	NC	Yes	0	17.6
	Includes enlarging		GC	all	2,500	63.89	0.35	12.10	Enlarge	I5	NC	Yes	0	22.4
	existing TC and GC		NC	all	2,500	14.00	0.65	2.65	New	GC	Funks	Yes	2	9.1
	to 2,500 cfs each													
	Total													**$49.1**
III	TC+GC+CD/NC	8,000	TC	all	2,100	352.52	0	66.77	Existing	RBPP	Funks	Yes	1	0
	Utilizes 2,100 cfs		GC	1	2,900	72.60	0	13.75	Existing	HCPP	JC	No	0	0
	from existing		GC	2	2,900	139.40	0.04	26.4	Enlarge	JC	NC	No	0	5.6
	RBPP Diversion		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No	0	6.1
	Facilities		NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes	1	9.1
			NC	3	5,900	2.50	0.69	0.47	New	PP2	PP3	Yes	1	1.7
			NC	4	5,900	11.00	0.69	2.65	New	PP3	Funks	Yes	1	7.6
	Total													**$30.1**
IV A	GC+CD/NC	8,000	GC	all	5,000	212.00	0.13	40.15	Enlarge	HCPP	NC	No	1	27.6
	Includes new		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No	0	6.1
	2,000 cfs HCPP		NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes	1	9.1
	Diversion		NC	3	8,000	2.50	0.76	0.47	New	PP2	PP3	Yes	1	1.9
	Facilities		NC	4	8,000	11.00	0.76	2.08	New	PP3	Funks	Yes	1	8.4
	Total													**$53.0**
B	GC/CLI+CD/NC	8,000	CLI	1	2,000	7.20	0.46	1.40	New	SR	GC	No	1	3.3
	Includes new		GC	1	2,900	56.00	0	10.61	Existing	HCPP	CLI	No	0	0
	2,100 cfs CLI		GC	2	5,000	16.60	0.17	3.14	Enlarge	CLI	JC	No	0	2.8
	Diversion		GC	3	5,000	139.40	0.17	26.40	Enlarge	JC	NC	No	0	23.7
	Facilities		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No	0	6.1
			NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes	1	9.1
			NC	3	8,000	2.50	0.76	0.47	New	PP2	PP3	Yes	1	1.9
			NC	4	8,000	11.00	0.76	2.08	New	PP3	Funks	Yes	1	8.4
	Total													**$55.3**

No.	Alternative	Diversion to Funks *(cfs)*	Canal	Canal Reaches No.	Q(max) *(cfs)*	Length: Station *(1000 ft)* (a)	Length: Distance *(unit cost)* (b)	Length: Distance *(Miles)*	Status	From	To	Canal Lined	Pumping Plants	Canal Costs (a x b)
V	NC/SR+CD/NC	8,000	NC	1A	5,000	15.20	0.28	2.88	New	SR	CD	No	0	4.3
	Includes new		NC	1	8,000	30.40	0.36	5.76	New	CD	PP1	No	0	10.9
	5,000 cfs NC		NC	2	8,000	17.00	0.76	3.22	New	PP1	PP2	Yes	1	12.9
	Diversion		NC	3	8,000	2.50	0.76	0.47	New	PP2	PP3	Yes	1	1.9
	Facilities		NC	4	8,000	11.00	0.76	2.08	New	PP3	Funks	Yes	1	8.4
	Total													**$38.4**
VI A	TC+NC/SR+CD/NC	8,000	TC	all	2,100	352.52	0	66.77	Existing	RBPP	Funks	Yes	0	0
	Utilize 2,100 cfs from		NC	1A	2,900	15.20	0.20	2.88	New	SR	CD	No	0	3.0
	existing RBPP & new		NC	1	5,900	30.40	0.31	5.76	New	CD	PP1	No	0	9.4
	2,900 cfs Diversion		NC	2	5,900	17.00	0.69	3.22	New	PP1	PP2	Yes	1	11.7
	Facilities opposite		NC	3	5,900	2.50	0.69	0.47	New	PP2	PP3	Yes	1	1.7
	Moulton Weir		NC	4	5,900	11.00	0.69	2.65	New	PP3	Funks	Yes	1	7.6
	Total													**$33.4**
B	GC+NC/SR+CD/NC	8,000	GC	all	1,800	212.00	0	40.15	Existing	HCPP	NC	No	0	0
	Includes 3,200 cfs		NC	1A	3,200	15.20	0.21	2.88	New	SR	CD	No	0	3.1
	new Diversion		NC	1	6,200	30.40	0.32	5.76	New	CD	PP1	No	0	9.7
	Facilities opposite		NC	2	6,200	17.00	0.70	3.22	New	PP1	PP2	Yes	1	11.9
	Moulton Weir		NC	3	6,200	2.50	0.70	0.47	New	PP2	PP3	Yes	1	1.8
			NC	4	6,200	11.00	0.70	2.08	New	PP3	Funks	Yes	1	7.7
	Total													**$34.2**

No.	Alternative	Diversion to Funks *(cfs)*	Canal	No.	Q(max) *(cfs)*	Canal Reaches: Length: Station *(1000 ft)* (a)	Length: Distance *(unit cost)* (b)	Length: Distance *(Miles)*	Status	From	To	Canal Lined	Pumping Plants	Canal Costs (a x b)
VII A	TC+CD/NC	8,000	TC	all	5,000	352.52	0.44	66.77	Enlarge	RBPP	Funks	Yes	1	155.1
	Includes new		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No	0	6.1
	5,000 cfs RBPP		NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes	1	9.1
	Diversion		NC	3	3,000	2.50	0.69	0.47	New	PP2	PP3	Yes	1	1.7
	Facilities		NC	4	3,000	11.00	0.69	2.65	New	PP3	Funks	Yes	1	7.6
	Total													**$179.6**
B	TC/CLI+CD/NC	8,000	CLI	1	5,000	6.00	0.64	1.14	New	SR	PP1	Yes	1	3.8
	Includes new		CLI	2	5,000	22.20	0.64	4.20	New	PP1	PP2	Yes	1	14.2
	5000 cfs CLI		CLI	3	5,000	22.00	0.64	4.17	New	PP2	PP3	Yes	1	14.1
	Diversion		CLI	4	5,000	7.40	0.64	1.40	New	PP3	TC	Yes	1	4.7
	Facilities		TC	2	5,000	169.83	0.44	32.17	Enlarge	CLI	Funks	Yes	0	74.7
			NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No	0	6.1
			NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes	1	9.1
			NC	3	3,000	2.50	0.69	0.47	New	PP2	PP3	Yes	1	1.7
			NC	4	3,000	11.00	0.69	2.08	New	PP3	Funks	Yes	1	7.6
	Total													**$136.1**

Abbreviations

CD Colusa Basin Drain	MW Moulton Weir	RB Red Bluff Diversion Dam	Funks Funks Reservior
CLI Chico Landing Intertie	NC New Canal	SR Sacramento River	
PP Pumping Plant	GC Glenn-Colusa Canal	JC Jacinto Check	
HC Hamilton City	TC Tehama-Colusa Canal	DP Direct Payment to Contractor	

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Table C-2. Funks Reservoir Conveyance Canal Major Feature Costs, Proposition 204 North of the Delta Storage Facility Studies ($ millions DP only)

Alt. No.		Alternative	New Major Structure			Enlarged Major Structure			TOTAL COST
			Quantity	Avg. Unit Cost	Total Cost	Quantity	Avg. Unit Cost	Total Cost	
I	**A**	TC+GC/NC4A							
		Check Structure	2	4.3	8.6	0	0	0	8.6
		Canal Siphon	0	0	0.0	0	0	0	0.0
		Highway Bridge	0	0	0.0	0	0	0	0.0
		County Road Bridge	2	2.5	5.0	0	0	0	5.0
		Railroad Siphon	0	0	0.0	0	0	0	0.0
		Drainage Crossing	2	0.5	1.0	0	0	0	1.0
		Total [1]			**14.6**			**$0.0**	**$14.6**
	B	TC+GC/NC4B							
		Check Structure	2	4.3	8.6	0	0	0	8.6
		Canal Siphon	1	0	0.0	0	0	0	0.0
		Highway Bridge	0	0	0.0	0	0	0	0.0
		County Road Bridge	2	2.5	5.0	0	0	0	5.0
		Railroad Siphon	0	0	0.0	0	0	0	0.0
		Drainage Crossing	2	0.5	1.0	0	0	0	1.0
		Total [1]			**14.6**			**$0.0**	**$14.6**
II	**A**	TC+GC/NC4A							
		Check Structure	2	4.7	9.4	0	0	0.0	9.4
		Canal Siphon	0	0	0.0	0	0	0.0	0.0
		Highway Bridge	0	0	0.0	0	0	0.0	0.0
		County Road Bridge	2	2.7	5.4	0	0	0.0	5.4
		Railroad Siphon	0	0	0.0	0	0	0.0	0.0
		Drainage Crossing	2	0.5	1.0	0	0	0.0	1.0
		Total [1]			**15.8**			**$0.0**	**$15.8**

Alt. No.		Alternative	New Major Structure			Enlarged Major Structure			TOTAL COST
			Quantity	Avg. Unit Cost	Total Cost	Quantity	Avg. Unit Cost	Total Cost	
	B	TC+GC/NC4B							
		Check Structure	2	4.7	9.4	0	0	0	9.4
		Canal Siphon	1	0	0.0	0	0	0	0.0
		Highway Bridge	0	0	0.0	0	0	0	0.0
		County Road Bridge	2	2.7	5.4	0	0	0	5.4
		Railroad Siphon	0	0	0.0	0	0	0	0.0
		Drainage Crossing	2	0.5	1.0	0	0	0	1.0
		Total [1]			**15.8**			**$0.0**	**$15.8**
III		**TC+GC+CD/NC**							
		Check Structure	6	4.5	27.0	6	1.6	9.5	36.5
		Canal Siphon	1	18.8	18.8	2	6.6	13.2	32.0
		Highway Bridge	3	6.3	18.9	3	2.2	6.6	25.5
		County Road Bridge	6	2.7	16.2	12	0.9	10.8	27.0
		Railroad Siphon	1	19	18.8	1	6.6	6.6	25.4
		Drainage Crossing	8	0.6	4.8	21	0.2	4.2	9.0
		Total [1]			**$ 104.5**			**$ 50.8**	**$155.3**
IV	**A**	**GC+CD/NC**							
		Check Structure	6	4.5	27.0	6	1.6	9.6	36.6
		Canal Siphon	1	18.8	18.8	3	6.6	19.8	38.6
		Highway Bridge	3	6.3	18.9	3	2.2	6.6	25.5
		County Road Bridge	6	2.7	16.2	17	0.9	16.1	32.3
		Railroad Siphon	1	18.8	18.8	1	6.6	6.6	25.4
		Drainage Crossing	8	0.6	4.8	26	0.2	5.2	10.0
		Total [1]			**$ 104.6**			**$ 63.8**	**$168.4**

Alt. No.		Alternative	New Major Structure Quantity	Avg. Unit Cost	Total Cost	Enlarged Major Structure Quantity	Avg. Unit Cost	Total Cost	TOTAL COST
	B	**GC/CLI+CD/NC**							
		Check Structure	7	4.5	31.5	5	1.6	7.9	39.4
		Canal Siphon	2	18.8	37.7	0	6.6	0.0	37.7
		Highway Bridge	3	6.3	18.9	2	2.2	4.4	23.3
		County Road Bridge	7	2.7	18.9	13	0.9	12.3	31.2
		Railroad Siphon	1	18.8	18.8	1	6.6	6.6	25.4
		Drainage Crossing	8	0.6	4.8	23	0.2	4.6	9.4
		Total [1]			**$ 130.6**			**$ 35.8**	**$166.4**
V		**NC/SR+CD/NC**							
		Check Structure	7	4.5	31.5	0	1.6	0.0	31.5
		Canal Siphon	2	18.8	37.7	0	6.6	0.0	37.7
		Highway Bridge	4	6.3	25.2	0	2.2	0.0	25.2
		County Road Bridge	6	2.7	16.2	0	0.9	0.0	16.2
		Railroad Siphon	1	18.8	18.8	0	6.6	0.0	18.8
		Drainage Crossing	9	0.6	5.4	0	0.2	0.0	5.4
		Total [1]			**$ 134.8**			**$0.0**	**$134.8**
VI	**A**	**TC+NC/SR+CD/NC**							
		Check Structure	7	4.5	31.5	0	1.6	0.0	31.5
		Canal Siphon	2	18.8	37.7	0	6.6	0.0	37.7
		Highway Bridge	4	6.3	25.2	0	2.2	0.0	25.2
		County Road Bridge	6	2.7	16.2	0	0.9	0.0	16.2
		Railroad Siphon	1	18.8	18.8	0	6.6	0.0	18.8
		Drainage Crossing	9	0.6	5.4	0	0.2	0.0	5.4
		Total [1]			**$ 134.8**			**$0.0**	**$134.8**
	B	**GC+NC/SR+CD/NC**							
		Check Structure	7	4.5	31.5	0	1.6	0.0	31.5
		Canal Siphon	2	18.8	37.7	0	6.6	0.0	37.7
		Highway Bridge	4	6.3	25.2	0	2.2	0.0	25.2
		County Road Bridge	6	2.7	16.2	0	0.9	0.0	16.2
		Railroad Siphon	1	18.8	18.8	0	6.6	0.0	18.8
		Drainage Crossing	9	0.6	5.4	0	0.2	0.0	5.4
		Total [1]			**$ 134.8**			**$0.0**	**$134.8**

Alt. No.	Alternative	New Major Structure Quantity	New Major Structure Avg. Unit Cost	New Major Structure Total Cost	Enlarged Major Structure Quantity	Enlarged Major Structure Avg. Unit Cost	Enlarged Major Structure Total Cost	TOTAL COST
VII	**TC+CD/NC**							
	Check Structure	6	4.5	27.0	17	1.6	26.8	53.8
	Canal Siphon	1	18.8	18.8	4	6.6	26.4	45.2
	Highway Bridge	3	6.3	18.9	3	2.2	6.6	25.5
	County Road Bridge	6	2.7	16.2	31	0.9	29.3	45.5
	Railroad Siphon	1	18.8	18.8	4	6.6	26.4	45.2
	Drainage Crossing	8	0.6	4.8	15	0.2	3.0	7.8
	Total [1]			**$ 104.6**			**$ 118.4**	**$223.0**
B	**TC/CLI+CD/NC**							
	Check Structure	7	4.5	31.5	5	1.6	7.9	39.4
	Canal Siphon	3	18.8	56.5	0	6.6	0.0	56.5
	Highway Bridge	3	6.3	18.9	3	2.2	6.6	25.5
	County Road Bridge	15	2.7	40.5	4	0.9	3.8	44.3
	Railroad Siphon	1	18.8	18.8	1	6.6	6.6	25.4
	Drainage Crossing	17	0.6	10.2	4	0.2	0.8	11.0
	Total [1]			**$ 176.4**			**$ 25.7**	**$202.1**

Abbreviations

CD Colusa Basin Drain
CLI Chico Landing Intertie
PP Pumping Plant
HC Hamiltion City
MW Moulton Weir
NC New Canal
GC Glenn-Colusa Canal
TC Tehama-Colusa Canal
Funks Funks Reservior
SR Sacramento River
DP Direct Payment to Contractor
RB Red Bluff Diversion Dam
JC Jacinto Check

Footnotes [1] This total is included in the total cost summary, Table 2

Table C-3. Funks Reservoir Diversions Pumping Plants, Proposition 204 North of the Delta storage Facility Studies ($ millions DP only)

No.		Alternative	Diversion to Funks *(cfs)*	Pumping Plants						
				Canal	Plant Name	Status	Q(max) *(cfs)*	H(net) *(ft)*	Power *(mw)*	Cost
I	**A**	TC+GC/NC4A	3,900	TC	RBPP	Existing	2,100	25	0	0
		Includes existing		GC	HCPP	Existing	2,900	0	0	0.0
		2100 cfs TC and		NC1	NC PP1	New	1,800	35	5.9	21.8
		1800 cfs GC		NC2	NC PP2	New	1,800	100	16.9	27.0
		Total [1]								**$48.8**
	B	TC+GC/NC4B	3,900	TC	RBPP	Existing	2,100	25	0	0
		Includes existing		GC	HCPP	Existing	2,900	0	0	0.0
		2100 cfs TC and		NC1	NC PP1	New	1,800	35	5.9	21.8
		1800 cfs GC		NC2	NC PP2	New	1,800	100	16.9	27.0
		Total [1]								**$48.8**
II	**A**	TC+GC/NC4A	5,000	TC	RBPP	Replacement	2,500	25	5.8	0
		Includes enlarging		GC	HCPP	Existing	2,900	0	0	0.0
		existing TC and GC		NC1	NC PP1	New	2,500	35	8.2	23.0
		to 2500 cfs each		NC2	NC PP2	New	2,500	100	23.4	28.0
		Total [1]								**$51.0**

No.		Alternative	Diversion to Funks *(cfs)*	Pumping Plants: Canal	Plant Name	Status	Q(max) *(cfs)*	H(net) *(ft)*	Power *(mw)*	Cost
	B	TC+GC/NC4B	5,000	TC	RBPP	Replacement	2,500	25	5.8	0
		Includes enlarging		GC	HCPP	Existing	2,900	0	0	0.0
		existing TC & GC		NC1	NC PP1	New	2,500	35	8.2	23.0
		to 2,500 cfs each		NC2	NC PP2	New	2,500	100	23.4	28.0
		Total [1]								**$51.0**
III		TC+GC+CD/NC	8,000	TC	RBPP	Replacement	2,100	25	4.9	0.0
		Utilizes 2,100 cfs		GC	HCPP	Existing	2,900	0	0	0.0
		from existing		NC	NC PP1	New	3,000	45	12.7	25.0
		RBPP Diversion		NC	NC PP2	New	46,000	35	19.4	26.3
		Facilities		NC	NC PP3	New	5,900	100	55.5	31.5
		Total [1]								**$82.8**
IV	**A**	GC+CD/NC	8,000	GC	HCPP	Existing	3,000	0	0	0.0
		Includes new		GC	HCPP	Enlarge	2,000	20	3.8	19.2
		2,000 cfs HCPP		NC	NC PP1	New	3,000	45	12.7	25.0
		Diversion		NC	NC PP2	New	8,000	35	26.3	28.0
		Facilities		NC	NC PP3	New	8,000	100	75.2	33.5
		Total [1]								**$105.7**
	B	GC/CLI+CD/NC	8,000	GC	HCPP	Existing	3,000	0	0	0.0
		Includes new		CLI	CL PP1	New	2,000	30	5.6	21.0
		2,100 cfs CLI		NC	NC PP1	New	3,000	45	12.7	25.0
		Diversion		NC	NC PP2	New	8,000	35	26.3	23.8
		Facilities		NC	NC PP3	New	8,000	100	75.2	28.7
		Total [1]								**$98.5**

No.	Alternative	Diversion to Funks *(cfs)*	Pumping Plants						
			Canal	Plant Name	Status	Q(max) *(cfs)*	H(net) *(ft)*	Power *(mw)*	Cost
V	NC/SR+CD/NC	8,000	NC	NC PP1	New	8,000	45	33.9	29.0
	Includes new		NC	NC PP2	New	8,000	35	26.3	28.0
	5,000 cfs NC		NC	NC PP3	New	8,000	100	75.2	33.5
	Diversion Facilities								
	Total [1]								**$90.5**
VI A	TC+NC/SR+CD/NC	8,000	TC	RBPP	Replacement	2,100	25	4.9	0.0
	Includes 2,100 cfs new		NC	NC PP1	New	5,900	45	25.0	27.7
	Diversion Facilities		NC	NC PP2	New	5,900	35	19.4	26.3
	opposite MW		NC	NC PP3	New	5,900	100	55.5	31.5
	Total [1]								**$85.5**
B	GC+NC/SR+CD/NC	8,000	GC	HCPP	Existing	1,800	0	0	0
	Includes 3,200 cfs new		NC	NC PP1	New	6,200	45	26.3	28.0
	Diversion Facilities		NC	NC PP2	New	8,000	35	26.3	28.0
	opposite MW		NC	NC PP3	New	8,000	100	75.2	33.5
	Total [1]						66.77		**$89.5**
VII A	TC+CD/NC	8,000	TC	RBPP	Replacement	5,000	25	11.8	24.7
	Includes new		NC	NC PP1	New	3,000	45	12.7	25.0
	5,000 cfs RBPP		NC	NC PP2	New	3,000	35	9.8	23.8
	Diversion Facilities		NC	NC PP3	New	3,000	100	28.2	28.7
	Total [1]								**$102.2**

No.	Alternative	Diversion to Funks *(cfs)*	Pumping Plants						
			Canal	Plant Name	Status	Q(max) *(cfs)*	H(net) *(ft)*	Power *(mw)*	Cost
VII	B TC/CLI+CD/NC	8,000	CLI	CL PP1	New	5,000	35	16.5	25.2
	Includes new		CLI	CL PP2	New	5,000	40	18.8	26.0
	5000 cfs CLI		CLI	CL PP3	New	5,000	40	18.8	26.0
	Diversion		NC	NC PP1	New	3,000	45	12.7	25.0
	Facilities		NC	NC PP2	New	3,000	35	9.8	23.8
			NC	NC PP3	New	3,000	100	28.2	28.7
	Total [1]								**$154.7**

Abbreviations

CD Colusa Basin Drain
CLI Chico Landing Intertie
PP Pumping Plant
NC New Canal
Funks Funks Reservior
SR Sacramento River
GC Glenn-Colusa Canal
HC Hamiltion City
JC Jacinto Check
DP Direct Payment to Contractor
RB Red Bluff Diversion Dam
TC Tehama-Colusa Canal
MW Moulton Weir

Footnotes [1] This total is included in the total cost summary, Table 2.

Table C-4 Funks Reservoir Diversions Canal Right of Way/Alternatives Matrix
Proposition 204 North of the Delta Storage Facility Studies

No.		Alternative	Diversion to Funks *(cfs)*	Canal	Canal Reaches: No.	Q(max) *(cfs)*	Area to be Acquired: Length *(1000 ft)* (a)	Width *(feet)* (b)	Area *(acres)* (c)	Status	From	To	Canal Lined	Unit Cost *($millions/ac)* (d)	Right of Way Costs *(millions)* (c x d)
I	**A**	TC+GC/NC4A	3,900	TC	all	2,100	0	0	0	Existing	RBPP	NC	Yes	0	0
		Includes existing		GC	all	1,800	0	0	0	Existing	HCPP	NC	No	0	0
		2,100 cfs TC &		NC	1	1,800	3.00	275	19	New	GC/PP1	PP2	Yes	0.0005	0.0
		1,800 cfs GC		NC	2	1,800	7.60	275	48	New	PP2	TC	Yes	0.0005	0.0
				TC	last	3,900	2.50	30	2	Enlarge	NC	Funks	Yes	0.0005	0.0
		Total [1]													**$0.0**
	B	TC+GC/NC4B	3,900	TC	all	2,100	0	0	0	Existing	RBPP	Funks	Yes	0	0
		Includes existing		GC	all	1,800	0	0	0	Existing	HCPP	NC	No	0	0
		2,100 cfs TC &		NC	1	1,800	3.00	275	19	New	GC/PP1	PP2	Yes	0.0005	0.0
		1,800 cfs GC		NC	2	1,800	11.00	275	69	New	PP2	Funks	Yes	0.0005	0.0
		Total [1]										TC			**$0.0**
II	**A**	TC+GC/NC4A	5,000	TC	all	2,500	350.02	0	0	Enlarge	RBPP	NC	Yes	0	0
		Includes enlarging		GC	all	2,500	63.36	40	58	Enlarge	HCPP	NC	No	0.0030	0.2
		existing TC & GC		NC	1	2,500	3.00	300	21	New	GC/PP1	PP2	Yes	0.0005	0.0
		to 2,500 cfs each		NC	2	2,500	7.60	300	52	New	PP2	TC	Yes	0.0005	0.0
				TC	last	5,000	2.50	50	3	Enlarge	NC	Funks	Yes	0.0005	0.0
		Total [1]													**$0.2**
	B	TC+GC/NC4B	5,000	TC	all	2,500	352.52	0	0	Enlarge	RBPP	NC	Yes	0	0
		Includes enlarging		GC	all	2,500	63.36	40	58	Enlarge	HCPP	NC	No	0.0030	0.2
		existing TC & GC		NC	3	2,500	3.00	300	21	New	GC/PP1	PP2	Yes	0.0005	0.0
		to 2,500 cfs each		NC	2	2,500	11.00	300	76	New	PP2	Funks	Yes	0.0005	0.0
		Total [1]													**$0.2**

No.		Alternative	Diversion to Funks *(cfs)*	Canal	Canal Reaches: No.	Q(max) *(cfs)*	Area to be Acquired: Length *(1000 ft)* (a)	Width *(feet)* (b)	Area *(acres)* (c)	Status	From	To	Canal Lined	Unit Cost *($millions/ac)* (d)	Right of Way Costs *(millions)* (c x d)
III		TC+GC+CD/NC	8,000	TC	all	2,100	352.52	0	0	Existing	RBPP	Funks	Yes	0.0030	0
		Utilizes 2,100 cfs		GC	1	2,900	72.60	0	0	Existing	HCPP	JC	No	0	0
		from existing		GC	2	2,900	139.40	2,460	7,883	Enlarge	JC	NC	No	0.0030	23.6
		RBPP Diversion		NC	1	3,000	30.40	300	210	New	CD	PP1	No	0.0030	0.6
		Facilities		NC	2	3,000	17.00	300	117	New	PP1	PP2	Yes	0.0030	0.4
				NC	3	5,900	2.50	400	23	New	PP2	PP3	Yes	0.0005	0.0
				NC	4	5,900	11.00	400	101	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$24.7**
IV	**A**	GC+CD/NC	8,000	GC	all	5,000	212.00	200	975	Enlarge	HCPP	NC	No	0.0030	2.9
		Includes new		NC	1	3,000	30.40	300	210	New	CD	PP1	No	0.0030	0.6
		2,000 cfs HCPP		NC	2	3,000	17.00	300	117	New	PP1	PP2	Yes	0.0030	0.4
		Diversion		NC	3	8,000	2.50	500	29	New	PP2	PP3	Yes	0.0005	0.0
		Facilities		NC	4	8,000	11.00	500	126	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$4.0**
	B	GC/CLI+CD/NC	8,000	CLI	1	2,000	7.20	260	43	New	SR	GC	No	0.0030	0.1
		Includes new		GC	1	2,900	56.00	0	0	Existing	HCPP	CLI	No	0	0
		2,100 cfs CLI		GC	2	5,000	16.60	200	76	Enlarge	CLI	JC	No	0.0030	0.2
		Diversion		GC	3	5,000	139.40	200	641	Enlarge	JC	NC	No	0.0030	1.9
		Facilities		NC	1	3,000	30.40	300	210	New	CD	PP1	No	0.0030	0.6
				NC	2	3,000	17.00	300	117	New	PP1	PP2	Yes	0.0030	0.4
				NC	3	8,000	2.50	500	29	New	PP2	PP3	Yes	0.0005	0.0
				NC	4	8,000	11.00	500	126	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$3.3**

No.		Alternative	Diversion to Funks *(cfs)*	Canal	Canal Reaches: No.	Q(max) *(cfs)*	Area to be Acquired: Length *(1000 ft)* (a)	Width *(feet)* (b)	Area *(acres)* (c)	Status	From	To	Canal Lined	Unit Cost *($millions/ac)* (d)	Right of Way Costs *(millions)* (c x d)
V		NC/SR+CD/NC	8,000	NC	1A	5,000	15.20	375	131	New	SR	CD	No	0.0030	0.4
		Includes new		NC	1	8,000	30.40	500	349	New	CD	PP1	No	0.0030	1.0
		5,000 cfs NC		NC	2	8,000	17.00	500	195	New	PP1	PP2	Yes	0.0030	0.6
		Diversion		NC	3	8,000	2.50	500	29	New	PP2	PP3	Yes	0.0005	0.0
		Facilities		NC	4	8,000	11.00	500	126	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$2.1**
									67						
VI	**A**	TC+NC/SR+CD/NC	8,000	TC	all	2,100	352.52	0	0	Existing	RBPP	Funks	Yes	0	0
		Utilize 2,100 cfs from		NC	1A	2,900	15.20	300	105	New	SR	CD	No	0.0030	0.3
		existing RBPP & new		NC	1	5,900	30.40	400	280	New	CD	PP1	No	0.0030	0.8
		2,900 cfs Diversion		NC	2	5,900	17.00	400	156	New	PP1	PP2	Yes	0.0030	0.5
		Facilities opposite		NC	3	5,900	2.50	400	23	New	PP2	PP3	Yes	0.0005	0.0
		Moulton Weir		NC	4	5,900	11.00	400	101	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$1.7**
	B	GC+NC/SR+CD/NC	8,000	GC	all	1,800	212.00	0	0	Existing	HCPP	NC	No	0	0
		Includes 3,200 cfs		NC	1A	3,200	15.20	300	105	New	SR	CD	No	0.0030	0.3
		new Diversion		NC	1	6,200	30.40	400	280	New	CD	PP1	No	0.0030	0.8
		Facilities opposite		NC	2	6,200	17.00	400	156	New	PP1	PP2	Yes	0.0030	0.5
		Moulton Weir		NC	3	6,200	2.50	400	23	New	PP2	PP3	Yes	0.0005	0.0
				NC	4	6,200	11.00	400	101	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$1.7**

No.		Alternative	Diversion to Funks *(cfs)*	Canal	Canal Reaches: No.	Q(max) *(cfs)*	Area to be Acquired: Length *(1000 ft)* (a)	Width *(feet)* (b)	Area *(acres)* (c)	Status	From	To	Canal Lined	Unit Cost *($millions/ac)* (d)	Right of Way Costs *(millions)* (c x d)
VII	**A**	TC+CD/NC	8,000	TC	all	5,000	352.52	125	1,013	Enlarge	RBPP	Funks	Yes	0.0030	3.0
		Includes new		NC	1	3,000	30.40	300	210	New	CD	PP1	No	0.0030	0.6
		5,000 cfs RBPP		NC	2	3,000	17.00	300	117	New	PP1	PP2	Yes	0.0030	0.4
		Diversion		NC	3	3,000	2.50	300	17	New	PP2	PP3	Yes	0.0005	0.0
		Facilities		NC	4	3,000	11.00	300	76	New	PP3	Funks	Yes	0.0005	0.0
		Total [1]													**$4.1**
	B	TC/CLI+CD/NC	8,000	CLI	1	5,000	6.00	360	50	New	SR	PP1	Yes	0.0030	0.1
		Includes new		CLI	2	5,000	22.20	360	184	New	PP1	PP2	Yes	0.0030	0.6
		5,000 cfs CLI		CLI	3	5,000	22.00	360	182	New	PP2	PP3	Yes	0.0030	0.5
		Diversion		CLI	4	5,000	7.40	360	61	New	PP3	TC	Yes	0.0030	0.2
		Facilities		TC	2	5,000	169.83	125	488	Enlarge	CLI	Funks	Yes	0.0030	1.5
				NC	1	3,000	30.40	300	210	New	CD	PP1	No	0.0030	0.6
				NC	2	3,000	17.00	300	117	New	PP1	PP2	Yes	0.0030	0.4
				NC	3	3,000	2.50	400	23	New	PP2	PP3	Yes	0.0005	0.0
				NC	4	3,000	11.00	400	101	New	PP3	Funks	Yes	0.0005	0.1
		Total [1]													**$3.9**

Abbreviations

CD Colusa Basin Drain
Funks Funks Reservior
CLI Chico Landing Intertie
RB Red Bluff Diversion Dam
NC New Canal
SR Sacramento River
DP Direct Payment to Contractor
PP Pumping Plant
GC Glenn-Colusa Canal
MW Moulton Weir
JC Jacinto Check
HC Hamiltion City

Footnotes [1] This total is included in the total cost summary, Table 2.

Attachment D. Documentation Data Index

A. Design Assumptions and Criteria

- Canal Design Criteria
- Criteria for Evaluation of Sacramento River Diversion Facilities for Offstream Storage
- Design of Hydraulic Structures

B. Formulation of Alternatives

- Maps for Alternatives I - VII

1. ND 1498 and CD Work Plan
    - Sites Work Plan, Draft – November 18, 1998
    - Proposition 204 – January 22, 1998
    - Work Plan – December 10, 1997
2. List of Detailed Assumptions
3. Initial List of Alternatives
    - TAG meeting – July 22, 1998
    - CD Office Memo – Meeting July 7, 1998
    - CD Office Memo – Cost Requests July 15, 1998
    - ND Office Memo – Offstream Storage Operation Studies July 7, 1998
    - Miscellaneous Tables
    - Miscellaneous Maps
4. USGS Quad Sheets
    - Tehama-Colusa Canal Service Area Map
    - Dams
    - Black Butte Reservoir
    - Sites Reservoir
    - Alternatives I-VII Breakdown Map
5. Survey Data
6. Geologic Data
    - Soil Types – North Canal, Chico Landing Intertie, South Canal
    - Soil Descriptions
7. Hydrology and Hydraulic Data
    - Daily Flow Frequency Sacramento River at Colusa
    - Daily Flow Frequency Sacramento River at Butte City
    - Daily Flow Frequency Sacramento River at Bend Bridge
    - Excavation Quantities
    - Glenn-Colusa Canal
    - Integrated Resource Management Pamphlet
    - Comparison Map – Funks and Sites Reservoir
    - Projected Statistics – Small Sites, Large Sites, Colusa, Funks Reservoirs

State of California, Gray Davis, Governor
The Resources Agency, Mary D. Nichols, Secretary for Resources
Department of Water Resources, Thomas M. Hannigan, Director

Steve Macaulay, Chief Deputy Director
Raymond D. Hart, Deputy Director
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Conveyance Study A – Sacramento Valley

Central District has assisted Northern District in a Proposition 204-funded study of alternative diversion points and conveyance routes for delivery of diverted water from the Sacramento River to the Sites offstream storage option. CD's task was to examine the feasibility of providing up to 8,000 cfs total conveyance capacity from one or more diversion locations.

The alternatives include the potential use of existing facilities such as the Tehama-Colusa Canal, Glenn-Colusa Canal and Colusa Basin Drain; the construction of new conveyance facilities; or combinations of new and existing facilities. The Colusa Basin Drain flow is estimated at 3,000 cfs maximum and, when added to the 5,000 cfs Sacramento River diversions, could allow up to 8,000 cfs to be diverted to Funks Reservoir for lifting to the proposed Sites Reservoir.

Funks Reservoir on the Tehama-Colusa Canal would become the forebay for a large or small Sites Reservoir storage option. Funks Reservoir would also be the terminal point for the Sacramento River conveyance alternatives and water diverted from the Colusa Basin Drain.

Study Area

The location of the Sites Reservoir offstream storage option is shown on a map of the study area (see Figure 1). The conveyance alternatives for the reservoir are located partially or entirely within Tehama, Glenn, and Colusa Counties.

Description of Alternatives

General Design Assumptions

- The following general assumptions were used to guide the development of alternatives:
- Divert up to 5,000 cfs surplus or flood water from the Sacramento River to existing canal(s), enlarged existing canal(s) and/or new canal(s).
- Alternatives I and II utilize existing canals or enlarged existing canals and do not include any diversion from the Colusa Basin Drain.
- The current diversion facilities at Red Bluff and Hamilton City are operated primarily during the irrigation season. The facilities are being modified or being studied by other agencies to reduce adverse impacts to fish during diversions. The design and costs of the modifications are not included in this study. However, the costs of new facilities that would increase the existing capacities are included in the alternatives.
- A new Sacramento River diversion, if proposed, would be located below River Mile 200.5, with a fish screen and pumping plant facilities to raise water to Funks Reservoir. A new canal would connect any new diversion to an existing canal or directly to Funks Reservoir.

- Divert up to 3,000 cfs of surplus or floodwater from the Colusa Basin Drain to Funks Reservoir. This water would be in addition to the water diverted from the Sacramento River and is included in Alternatives III through VII. The conveyance capacities would be enlarged above 5,000 cfs, wherever needed, to accommodate additional water from the Colusa Basin Drain.
- The new diverting canals will be concrete-lined, and diverted flows will be controlled by existing or new pumping plants and canal checks. The new canals will require several pumping plants to lift the existing canal flows to the higher elevation of Funks Forebay.
- The new canals are assumed to have zero slopes to allow pump-storage capability between the existing canals and Funks Reservoir. Pumping plants would have generating equipment to allow power recovery when water is delivered back to the existing canals for irrigation or back to the Sacramento River for environmental purposes.
- The alternatives include a conveyance system with a diversion facility, canals, pumping plants, penstocks, and appurtenant works necessary to deliver the water to Funks Reservoir for subsequent lifting into Sites Reservoir. The alternatives utilize existing canal systems, enlarged systems or new systems that will require modifications to existing or new diversion and fish facilities on the Sacramento River.
- CALFED staff recommended that diversion structures have the ability to divert water from the Sacramento River when flows are as low as 15,000 cfs.

A detailed list of design assumptions is included in Attachment B.

FIGURE 1

PROPOSED CONVEYANCE ALTERNATIVES

ALTERNATIVE I (A): TC + GC/ NC4A
Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to TC just upstream of Funks Reservoir.

ALTERNATIVE I(B): TC + GC /NC4B
Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

ALTERNATIVE II(A): TC + GC/NC4A
Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to TC Canal just upstream of Funks Reservoir.

ALTERNATIVE II(B): TC + GC/NC4B
Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

ALTERNATIVE III: TC + GC + CD/NC
Existing 2100 cfs TC Canal and enlarged 2900 cfs GC Canal, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE IV(A): GC + CD/NC
Enlarge existing 3000 cfs GC Canal diversion at Hamilton City to 5000 cfs, 5000 cfs GC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE IV(B): GC/CLI + CD/NC
New 2100 cfs SR diversion near Chico Landing, 5000 cfs GC Canal enlargement below Chico Landing Intertie, plus added 3000 cfs from Colusa Basin Drain to New Canal.

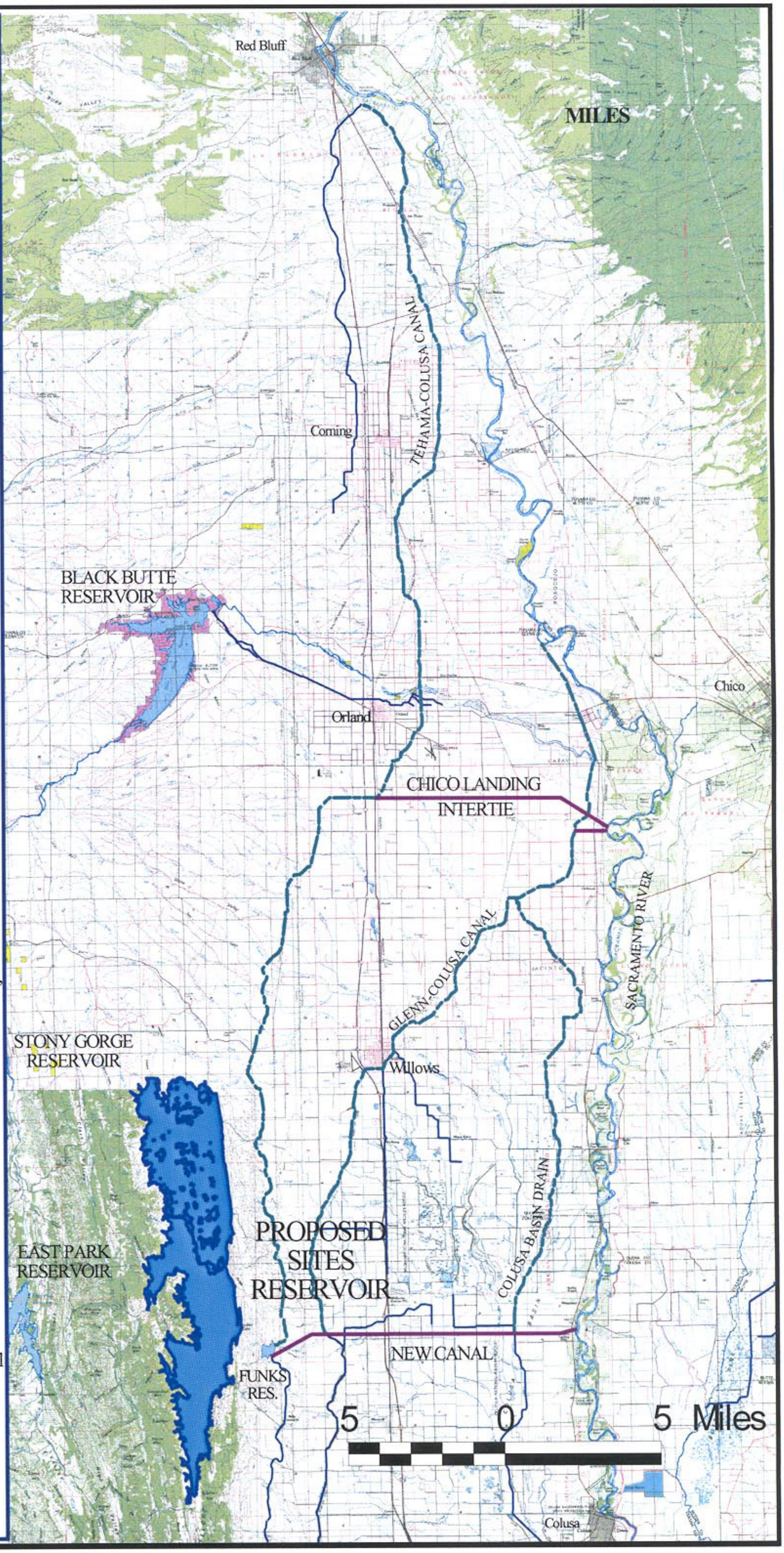
ALTERNATIVE V: NC/SR +CD/NC
New 5000 cfs SR diversion opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VI(A): TC + NC/SR + CD/NC
Existing 2100 cfs TC Canal, new 2900 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VI(B): GC + NC/SR + CD/NC
Existing 1800 cfs GC Canal, new 3200 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VII(A): TC + CD/NC
New 5000 cfs TC diversion dam, 5000cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VII(B): TC/CLI + CD /NC
New 5000 cfs SR diversion near Chico Landing, 5000 cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.



Winter Operation Issues

All the conveyance alternatives would be operated to divert surplus flows, primarily occurring during the winter or non-irrigation season. Operating during this period requires accommodations for fish passage. There may also be other, yet to be determined, criteria related to operations addressed in future studies. Significant operational and environmental issues will need to be addressed in detailed studies. Issues include agency delivery priorities, interagency agreements, river diversion criteria and other factors.

Modifications to the Red Bluff Diversion Dam

The U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Department of Fish and Game, and the Tehama-Colusa Canal Authority are continuing to investigate alternative diversion methods to improve fish passage at the diversion dam during the irrigation season. Fish passage problems occur whenever the gates are lowered to divert water into the canal headgates. Similar problems would occur if diversions were continued in the same manner during the winter or non-irrigation season to divert surplus flows.

CALFED investigated two alternatives that would increase diversions over a longer diversion period. A fish ladder alternative would improve fish passage on the left abutment of the dam when the gates are lowered during diversions. A pumping plant alternative would install a pumping plant downstream of the dam that could be used to divert water in lieu of lowering the gates. While it may be possible to divert surplus flows during the non-irrigation season with these or other alternatives, the cost of these alternatives for operating at the existing capacity is not included in the cost of the conveyance alternatives.

It is also assumed under this study that efforts to resolve fish passage problems would continue under existing conditions.

Modifications to the Hamilton City Pumping Plant

The Glenn-Colusa Irrigation District and federal and State agencies have been investigating alternatives to improve the fish screens at the Hamilton City Pumping Plant. The purpose is to minimize losses of fish near the pumping plant diversion while maximizing GCID's capability to meet water supply delivery obligations by diverting the full quantity of water it is entitled to divert.

The alternatives being considered are designed to stabilize the hydraulic gradient of the channel adjacent to the pumping plant and to meet DFG and NMFS fish screen criteria to the fullest extent possible all year round. Improvements are currently being made to the fish screens, such as extending the length of the screen and raising the height of the headwall above the screen.

It is assumed that improvements will be implemented to allow the Hamilton City Pumping Plant to divert up to 2,900 cfs of surplus flows during the non-irrigation season and such costs are not included in the alternatives. Costs are included for diversions above the existing capacity of 2,900 cfs.

Diversions from the Colusa Basin Drain

Alternatives III through VII include diversion and conveyance facilities to divert water from the Colusa Basin Drain that would supplement diversions from the Sacramento River. Based on limited hydrological information, it is estimated that a 3,000 cfs diversion near Delevan Road would be required to divert surplus flows from the drain. The new conveyance facilities required to divert water from the Sacramento River would be enlarged to accommodate diversions from the drain.

An important cost issue to be resolved in future studies will be the design of a fish screen, if required, for a diversion from the Colusa Basin Drain. It is assumed for this study that a control gate or turnout type structure without a screen component would be used in the alternatives. A fish screen component, similar to the inclined flat plate design used for a new diversion on the Sacramento River, would add significant cost to the alternatives.

Formulation of Alternatives

The formulation of alternatives was an iterative process consisting of brainstorming, fatal flaw analysis, initial cost comparisons, and screening criteria. The process involved meetings with interdisciplinary staff from DWR's ND, CD, and Environmental Services Office, and CALFED. The alternatives were also discussed with the Tehama-Colusa Canal Authority and USBR during Technical Advisory Group meetings.

The objective of the formulation process was to identify a reasonable number of alternatives that would be retained for further study. In selecting alternatives for this study, the goal was to provide the decision-makers with an array of alternatives. As such, each alternative can be viewed as representing a reasonable design configuration for that type of alternative. See Attachment A for a further discussion of the formulation and screening process.

After several iterations of formulating and screening alternatives, five basic alternatives were initially identified for this study. Three of the alternatives have options based on different diversion locations or use of existing facilities.

In addition to the five basic alternatives (Alternatives III through VII) which are all capable of delivering 8,000 cfs maximum to Funks Reservoir, a sixth and seventh alternative were added after interim studies were completed. Alternative I utilizes the existing capacities of the Tehama-Colusa and Glenn-Colusa Canals' conveyance facilities but is only capable of delivering 3,900 cfs maximum to Funks Reservoir. Alternative II is similar to Alternative I but proposes only minor modifications to increase the capacity of the conveyance facilities. Alternatives I and II include two alignment options that connect the Glenn-Colusa Canal to Funks Reservoir.

The alternatives are described on the next pages and shown on Figure 1.

Common Elements

Funks Reservoir

Local Funks Creek inflow and the Tehama-Colusa Canal fill Funks Reservoir. The canal extends southerly from the reservoir to serve customers as far south as Yolo County. Funks Reservoir is being proposed as a forebay for the Sites Reservoir offstream storage option. Operational studies will determine if modifications to Funks Reservoir are required for use as a forebay. For this study, it is assumed that Funks Reservoir will not require modifications to increase its capacity.

Reach 4 – New Canal from Glenn-Colusa Canal to Funks Reservoir

The approximate 2-mile long reach connecting the Glenn-Colusa Canal to Funks Reservoir was previously identified as Reach 4 of the new canal. The design flows range from approximately 1,800 cfs (existing Glenn-Colusa Canal flow only) to 8,000 cfs (enlarged 5,000 cfs Glenn-Colusa Canal or 5,000 cfs new Sacramento River diversion, plus 3,000 cfs Colusa Basin Drain diversion). The conveyance sizes of Reach 4 for different alternatives are shown below:

Alt. No.	Q (cfs) Reach 4	Q (cfs) Diversion Sources
I	1,800	1,800 Canal (existing canal capacity)
IIA&IIB	2,500	2,500 Glenn-Colusa (line or widen existing canal)
III	5,900	2,900 Glenn-Colusa Canal+3,000 Colusa Basin Drain
IVA & IVB	8,000	5,000 Glenn-Colusa Canal+3,000 Colusa Basin Drain
V	8,000	5,000 New Diversion+3,000 Colusa Basin Drain
VIA	5,900	2,900 New Diversion+3,000 Colusa Basin Drain
VIB	6,200	3,200 New Diversion+3,000 Colusa Basin Drain
VIIA&VIIB	3,000	3,000 Colusa Basin Drain

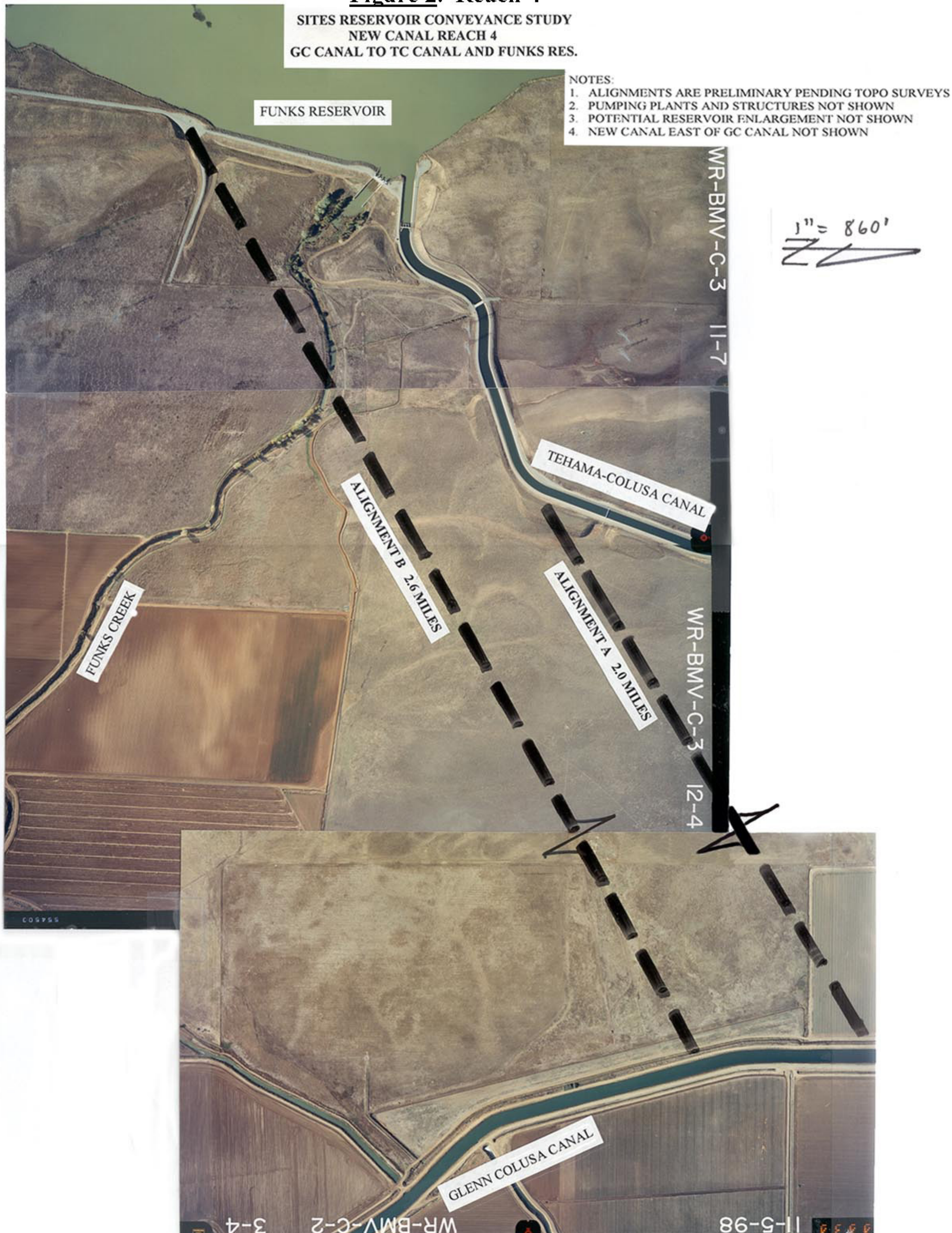
Bottom widths for the lined canal vary from 20 feet for 1,800 cfs to 32 feet for 8,000 cfs. Canal depths vary from 12.7 feet for 1,800 cfs to 22.8 feet for 8,000 cfs. Side slopes are at 1.5 H:V.

Reach 4 Alignment Alternatives

Two possible alignments were considered for Reach 4 as shown in Figure 2. Alignment A would begin at the Glenn-Colusa Canal, approximately one-eighth mile south of Delevan Road. The alignment would proceed west, then southwesterly, connecting to the Tehama-Colusa Canal at the last bend before entering Funks Reservoir. Two pumping plants are assumed in order to lift the water from Glenn-Colusa to Tehama-Colusa Canals, approximately 82 feet (static). Preliminary pumping plant locations will need to be determined based on topographical data.

Alignment B would begin at the Glenn-Colusa Canal, approximately one-quarter mile south of Delevan Road. The alignment would proceed west, then southwesterly, crossing Funks Creek and connecting to the south abutment of Funks Reservoir. The alignment will not affect the existing Funks Dam embankment or southerly outlet to the Tehama-Colusa Canal. It may be

Figure 2. Reach 4



necessary to realign an existing farm road at the south abutment and cut into the hillside for the discharge line construction. Similar to Alignment A, two pumping plants are assumed to lift the water from Glenn-Colusa to Funks Reservoir, approximately 82 feet (static).

If further studies indicate that more capacity is required in Funks Reservoir for use as a forebay, enlargement may be accomplished by moving Funks Dam and spillway easterly down Funks Creek. This would change the proposed Alternative Reach 4 Alignment B connection to the south abutment of the existing dam. Moving the dam would not change the proposed Alternative Reach 4, Alignment A, connection to the existing Tehama-Colusa Canal. A new dam and spillway would be longer, higher, and require more embankment material. Raising the existing dam and water surface would require pumping from the existing Tehama-Colusa Canal inlet and dropping water at the outlet, assuming no Tehama-Colusa Canal water surface changes. A greater lift from the Glenn-Colusa Canal would also be required. Deepening and enlarging the existing reservoir would require dewatering the reservoir, constructing a temporary canal through the reservoir area and extensive earthwork.

Alternative I. Use the existing Tehama-Colusa and Glenn-Colusa Canals facilities

Alternative I utilizes the existing capacities of the Tehama-Colusa and Glenn-Colusa Canals to convey water to Funks Reservoir (see Figure 3). The canals' delivery capacities are limited by the sections of the canal at the downstream end of the system. The present Tehama-Colusa and Glenn-Colusa Canals' capacities are 2,100 cfs and 1,800 cfs, respectively. Neither the Tehama-Colusa nor Glenn-Colusa Canals would be improved in this alternative. A new 1,800 cfs canal for Reach 4, Alignment 4, will be required from the Glenn-Colusa Canal to Funks Reservoir.

Alternative I does not propose modifications to the existing Tehama-Colusa diversion facility at Red Bluff or make any changes to the existing Tehama-Colusa Canal and facilities; however, it assumes that such modifications will be implemented to accommodate diversions during winter periods and meet standards required by the fishery agencies. Alternative I does not propose to divert any water from the Colusa Basin Drain to Funks Reservoir. Under both options, the total delivery capacity to Funks Reservoir is 3,900 cfs.

Alternative II. Modify existing Tehama-Colusa and Glenn-Colusa Canals facilities with minor changes to increase capacity

Alternative II (see Figure 4) proposes to make minor changes to the Tehama-Colusa and Glenn-Colusa Canals' facilities described in Alternative I. The Glenn-Colusa Canal would be upsized to 2,500 cfs by lining or widening the existing sections, where needed, to provide for a flow of 2,500 cfs into a new canal, Reach 4. Reach 4 would extend from the Glenn-Colusa Canal to the Tehama-Colusa Canal (Alignment A) or directly to the south abutment of Funks Dam (Alignment B). Either increasing the freeboard lining or encroaching on the existing freeboard would increase the minimum capacity of the Tehama-Colusa Canal from 2,100 cfs to 2,500 cfs. The new canal would require two pumping plants to lift the water from the Glenn-Colusa Canal to the Tehama-Colusa Canal or to Funks Reservoir.

Like Alternative I above, Alternative II does not propose to divert any water from the Colusa Basin Drain to Funks Reservoir. Under both options, the total delivery capacity to Funks Reservoir is 5,000 cfs.

Figure 3

NORTHERN DISTRICT
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ALTERNATIVE I (A): TC + GC/ NC4A

Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to TC just upstream of Funks Reservoir.

ALTERNATIVE I(B): TC + GC /NC4B

Existing 2100 cfs TC and 1800 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

5 0 5 10
Miles

No.	Alternative	Diversion to Funks (cfs)	Canal Reaches									
			Canal	No.	Q(max) (cfs)	Length: Station (1000 ft) (a)	Length: Distance (unit cost) (b)	Length: Distance (Miles)	Status	From	To	Canal Lined
I A	TC+GC/NC4A	3,900	TC	all	2,100	350.02	0	66.29	Existing	RBPP	Funks	Yes
	Includes existing		GC	all	1,800	212.00	0	40.15	Existing	HCPP	NC	No
	2100 cfs TC and		NC	all	1,800	10.60	0.50	2.01	New	GC	TC	Yes
	1800 cfs GC		TC	last	3,900	2.50	0.35	0.47	Enlarge	NC	Funks	Yes
	Total											
B	TC+GC/NC4B	3,900	TC	all	2,100	352.52	0	66.77	Existing	RBPP	Funks	Yes
	Includes existing		GC	all	1,800	212.00	0	40.15	Existing	HCPP	NC	No
	2100 cfs TC and		NC	all	1,800	14.00	0.50	2.65	New	GC	Funks	Yes
	1800 cfs GC											
	Total											

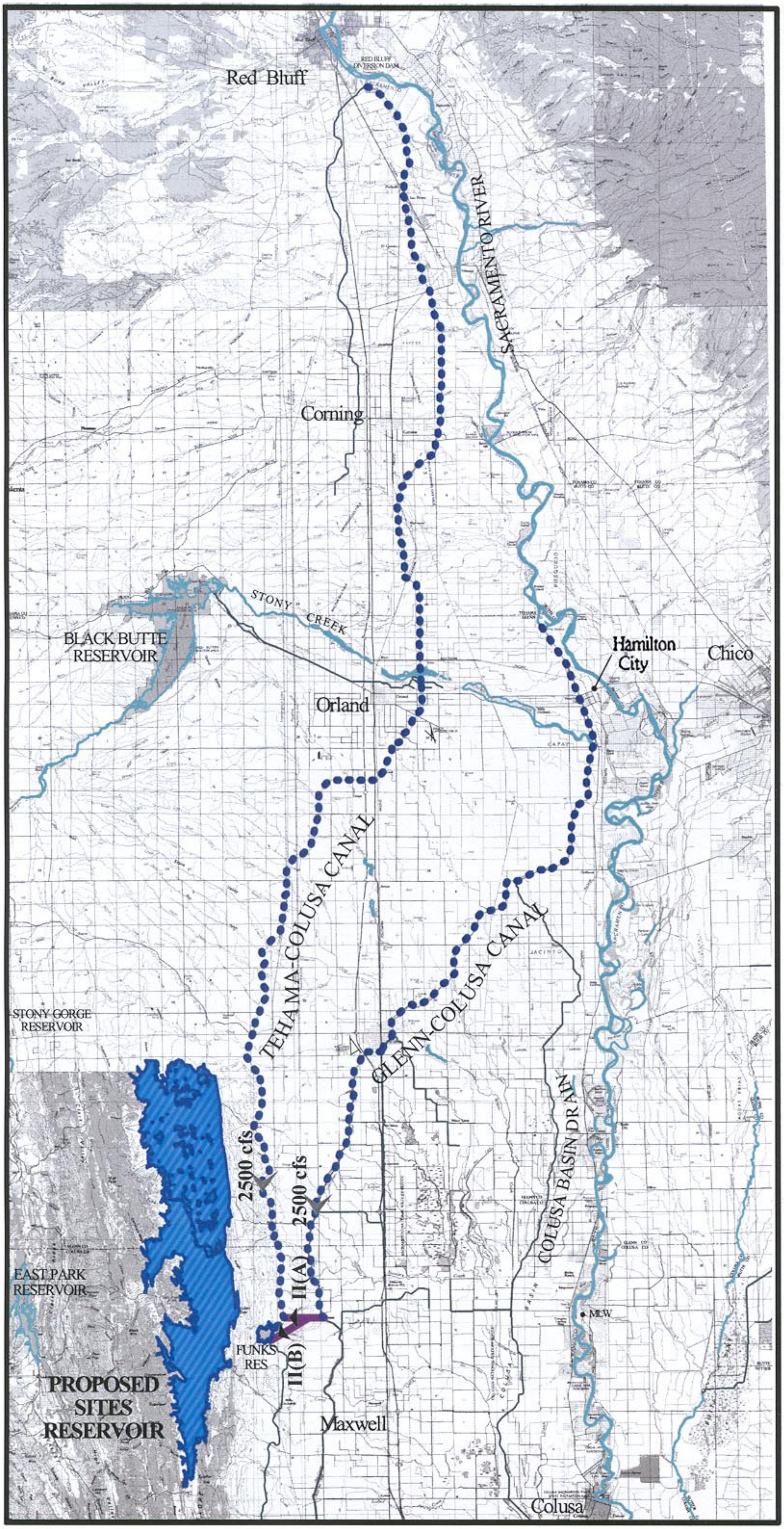

Figure 4

NORTHERN DISTRICT
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ALTERNATIVE II(A): TC + GC/NC4A

Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to TC Canal just upstream of Funks Reservoir.

ALTERNATIVE II(B): TC + GC/NC4B

Enlarged 2500 cfs TC and 2500 cfs GC Canals, with diversion from GC Canal to south abutment of Funks Reservoir.

5 0 5 10

Miles

No.	Alternative	Diversion to Funks (cfs)	Canal Reaches: Canal	No.	Q(max) (cfs)	Length: Station (1000 ft) (a)	Distance (unit cost) (b)	Distance (Miles)	Status	From	To	Canal Lined
II A	TC+GC/NC4A	5,000	TC	all	2,500	350.02	0.05	66.29	Enlarge	RBPP	NC	Yes
	Includes enlarging		GC	all	2,500	148.11	0.00	28.05	Existing	HCPP	I5	Yes
	existing TC and GC		GC	all	2,500	63.89	0.35	12.10	Enlarge	I5	NC	Yes
	to 2500 cfs each		NC	all	2,500	10.60	0.65	2.01	New	GC	TC	Yes
	Total		TC	last	5,000	2.50	0.44	0.47	Enlarge	NC	Funks	Yes
B	TC+GC/NC4B	5,000	TC	all	2,500	352.52	0.05	66.77	Enlarge	RBPP	NC	Yes
	Includes enlarging		GC	all	2,500	63.89	0.35	12.10	Enlarge	I5	NC	Yes
	existing TC and GC		NC	all	2,500	14.00	0.65	2.65	New	GC	Funks	Yes
	to 2500 cfs each											
	Total											

Modifications to the Tehama-Colusa Canal

Increasing Tehama-Colusa Canal Capacity to 2,500 cfs. The design objective of increasing to 2,500 cfs would not require major modifications to the existing Tehama-Colusa Canal. The study considered two options for increasing the capacity of the Tehama-Colusa Canal: (1) raise the 67-mile long concrete lining by 1.25 feet to maintain the existing 2-foot minimum freeboard condition or (2) allow the existing freeboard to be encroached up to 1.25 feet, leaving a 0.75-foot minimum of concrete-lined freeboard. Both alternatives assume that the existing lined canal will continue to function at the 2,500 cfs flow without adversely affecting major structures such as siphons, checks, bridges, and drainage crossings. It may be necessary to modify some turnouts, but all structures should be investigated under potential higher flow conditions.

Minimum Clearances. Existing clearances at bridges, irrigation pipes and other crossings were checked for minimum clearance. The minimum clearance is 2.33 feet at several irrigation pipe crossings. If the existing canal were optimized to 2,500 cfs flow, then the minimum clearance would be reduced to 1.08 feet. Wind and wave action would further reduce the clearance depending on the crossing location, fetch and other factors.

Encroaching on Existing Freeboard. It was determined that raising the water surface 1.25 feet would increase the flow from approximately 2,100 cfs to 2,500 cfs and still reserve 0.75 feet of freeboard on the concrete lining. The feasibility of running the canal at 2,500 cfs, with reduced freeboard and clearance, should be checked with the Tehama-Colusa Canal Authority. Based on DWR design recommendations, it is assumed that encroachment on existing freeboard to increase capacity is not feasible.

Increasing Freeboard. Increasing the concrete lining by 1.25 feet would preserve the existing freeboard. However, the amount of unlined canal above the lined section would be reduced by the same amount. This method of increasing the capacity to 2,500 cfs is assumed for Alternative II.

Modifications to the Glenn-Colusa Canal

Increasing Glenn-Colusa Canal Capacity to 2,500 cfs. Two basic options were considered for increasing the capacity of the Glenn-Colusa Canal to 2,500 cfs: 1) lining the existing unlined section and 2) widening the existing section.

1. **Lining the Existing Unlined Section.** Lining the existing 12-mile canal from Interstate 5 south of Willows to Reach 4 would allow a flow in excess of 2,500 cfs without widening or deepening the canal. The existing upstream flow limitation is approximately 2,500 cfs near Bayliss Road, although several reaches of the canal have capacities in excess of 3,400 cfs and the diversion capacity is approximately 2,900 cfs.
2. **Widening the Existing Section.** Widening the existing unlined canal from Interstate 5 will require extending the bottom width from 60 feet to 85-90 feet in order to obtain a diversion capacity of 2,500 cfs to Reach 4. The net increase in right of way will average approximately 30-50 feet for approximately 12 miles.

Alternative III. Use the existing Tehama-Colusa Canal and enlarge the Glenn-Colusa Canal facilities.

Alternative III would utilize the existing capacity of the Tehama-Colusa Canal and enlarge the lower reaches of the Glenn-Colusa Canal to convey water to Funks Reservoir (see Figure 5). The canals' delivery capacities are currently limited by canal sections at the downstream end of the system. The present Tehama-Colusa and Glenn-Colusa Canals' capacities are 2,100 cfs and 1,800 cfs, respectively near Funks Reservoir for a combined capacity of 3,900 cfs. The Glenn-Colusa Canal is unlined and its capacity would be increased to 2,900 cfs for a total combined capacity of 5,000 cfs. A new canal reach will be required from the Glenn-Colusa Canal to Funks Reservoir. Since no changes to the Tehama-Colusa Canal are proposed under Alternative III, Reach 4 follows Alignment B for this alternative.

Colusa Basin Drain Connection. Water from the Colusa Basin Drain would be diverted into a new canal and conveyed along an alignment for delivery to Funks Reservoir. It is assumed that the design capacity of a diversion and conveyance structure for water from the Colusa Basin Drain is 3,000 cfs. The design capacity of Reach 4 under Alternative III is 8,000 cfs. Three pumping plants will be required to lift the water from the Colusa Basin Drain up to Funks Reservoir. The total pumping lift is approximately 180 feet.

Enlargement of the Glenn-Colusa Canal. The existing canal would be enlarged to 2,900 cfs beginning near the check structure at Jacinto Road by widening and deepening the existing section or by trimming and lining the existing section. The canal would be enlarged for about 13.75 miles downstream to where the water would be diverted into a new canal (to Sites) at Delevan Road. The existing canal capacity at Delevan Road is about 1,780 cfs. It is assumed that the enlarged canal will remain unlined, although it may be necessary to line or pipe the canal in restricted urban areas. At the junction of the Glenn-Colusa Canal and NC (from the Colusa Basin Drain), it will be necessary to provide control gates to allow operational flexibility for (1) continued Glenn-Colusa flow south of NC, (2) Glenn-Colusa diversions to Funks Reservoir, and (3) NC diversions from the Colusa Basin Drain to Funks Reservoir. Enlargement of the Glenn-Colusa Canal will also require enlargement or replacement of existing check structures, siphons, bridges, drainage structures, and other facilities. No modifications to the Hamilton City Pumping Plant are proposed under this alternative.

Alternative IV. Enlarge the capacity of the Glenn-Colusa Canal system

Alternative IV would enlarge the Glenn-Colusa Canal system to deliver 5,000 cfs and would require a new 8,000 cfs canal reach from the Glenn-Colusa Canal to Funks Reservoir (see Figure 6). Additionally, Alternative IV would either require major improvements to the existing diversion facility at Hamilton City from 3,000 cfs to 5,000 cfs (Option A) or the construction of a new diversion facility on the Sacramento River downstream from the existing facility. A new diversion facility and intertie to the Glenn-Colusa Canal would be located near Sacramento River Mile 188 with a capacity of 2,000 cfs (Option B). Under Option B, the combined capacity of the existing Glenn-Colusa diversion and a new diversion is 5,000 cfs.

Figure 5

NORTHERN DISTRICT
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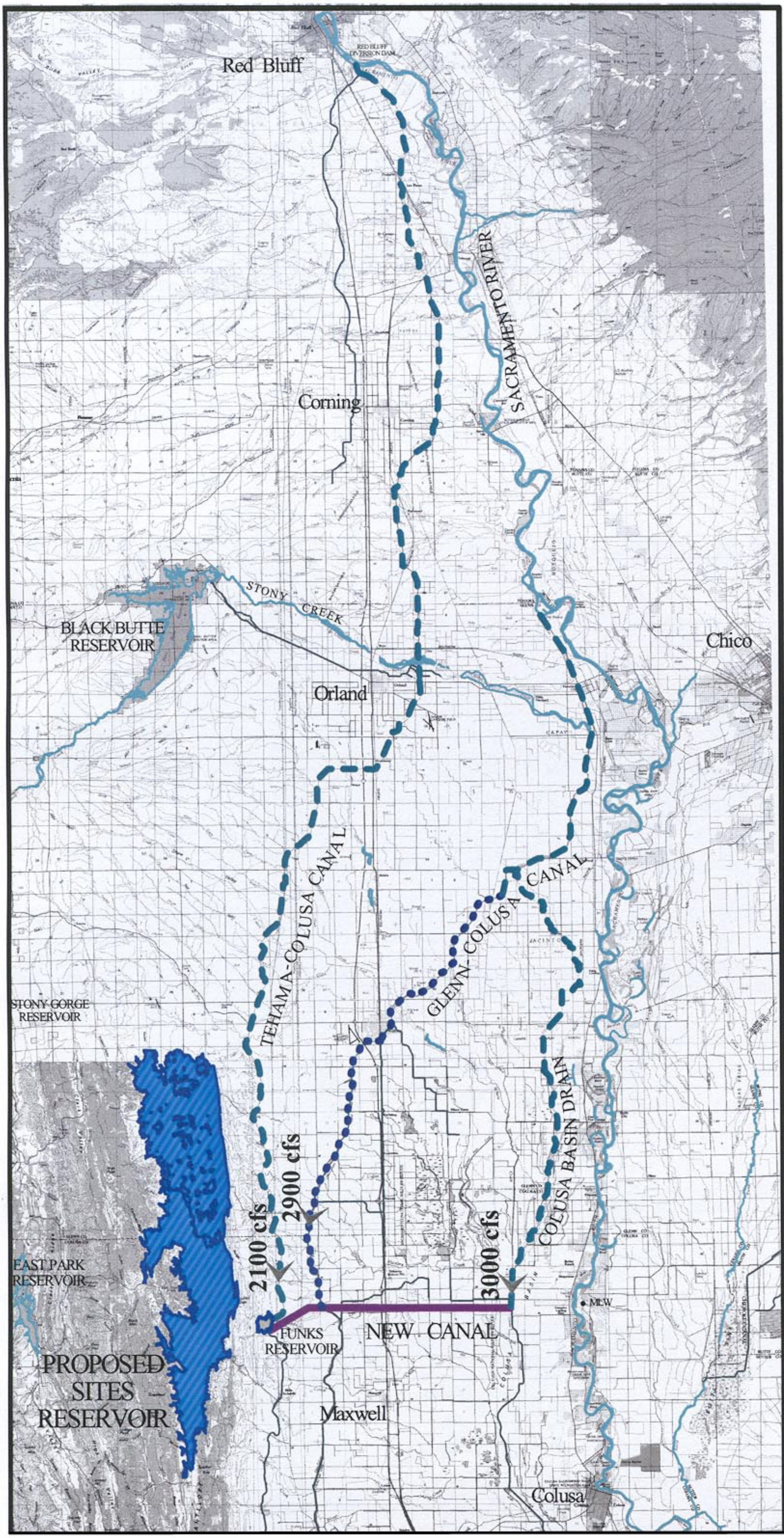
ALTERNATIVE III: TC + GC + CD/NC

Existing 2100 cfs TC Canal and enlarged 2900 cfs GC Canal, plus added 3000 cfs from Colusa Basin Drain to New Canal.

Scale: 5 0 5 10 Miles



No.	Alternative	Diversion to Funks	Canal Reaches									
			Canal	No.	Q(max)	Length			Status	From	To	Canal Lined
						Station	Distance	Distance				
		(cfs)			(cfs)	(1000 ft)	(unit cost)	(Miles)				
III	TC+GC+CD/NC	8,000	TC	all	2,100	352.52	0	66.77	Existing	RBPP	Funks	Yes
	Utilizes 2100cfs		GC	1	2,900	72.60	0	13.75	Existing	HCPP	JC	No
	from existing		GC	2	2,900	139.40	0.04	26.4	Enlarge	JC	NC	No
	RBPP Diversion		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No
	Facilities		NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes
			NC	3	5,900	2.50	0.69	0.47	New	PP2	PP3	Yes
			NC	4	5,900	11.00	0.69	2.65	New	PP3	Funks	Yes
	Total											

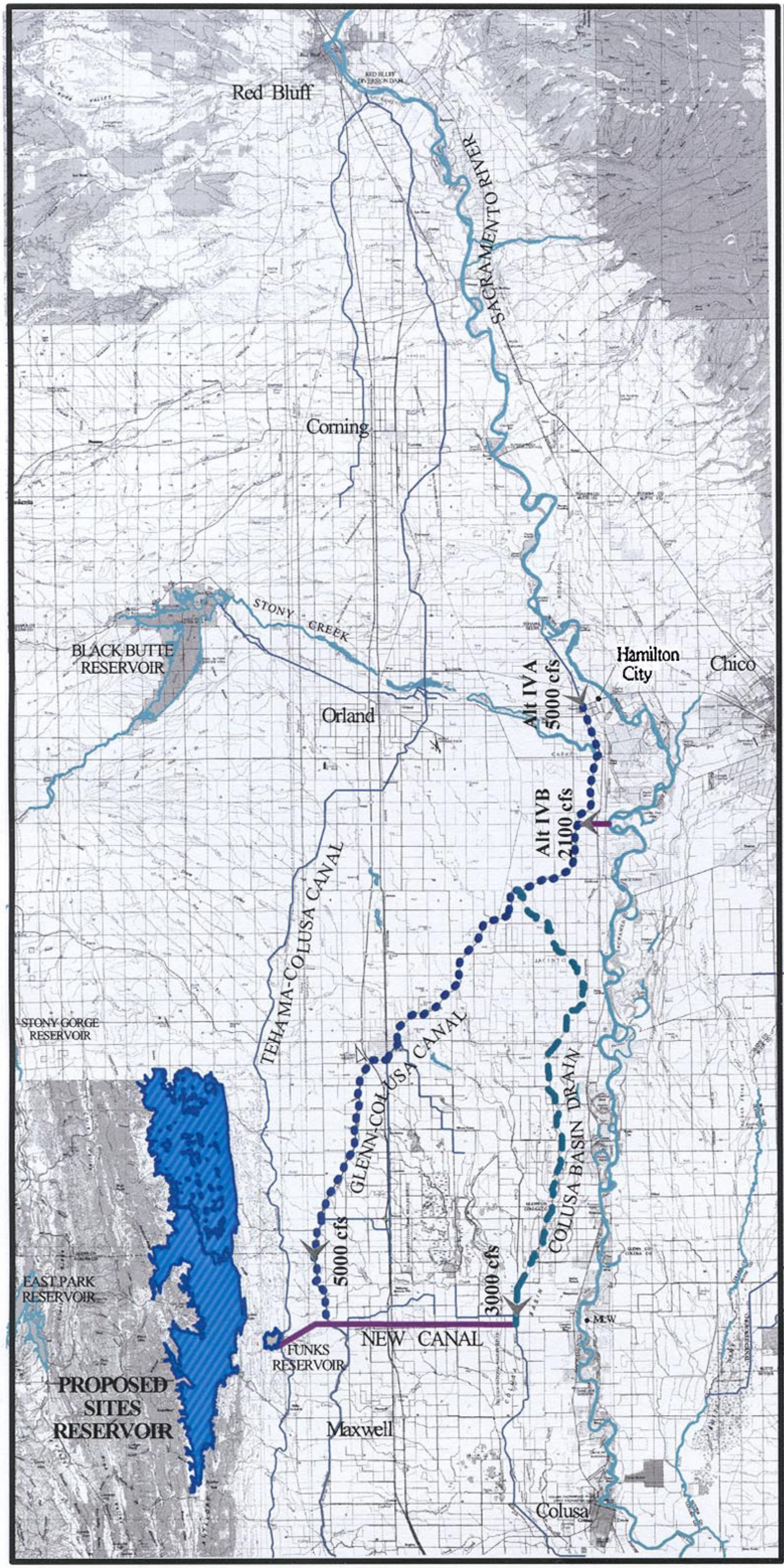


Figure 6

NORTHERN DISTRICT
OCT 1999

ALTERNATIVE IV(A): GC + CD/NC

Enlarge existing 3000 cfs GC Canal diversion at Hamilton City to 5000 cfs, 5000 cfs GC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE IV(B): GC/CLI + CD/NC

New 2100 cfs SR diversion near Chico Landing, 5000 cfs GC Canal enlargement below Chico Landing Intertie, plus added 3000 cfs from Colusa Drain to New Canal.

5 0 5 10

Miles

No.	Alternative	Diversion to Funks	Canal Reaches									
			Canal	No.	Q(max)	Length			Status	From	To	Canal Lined
						Station	Distance	Distance				
		(cfs)			(cfs)	(1000 ft)	(unit cost)	(Miles)				
						(a)	(b)					
IV A	GC+CD/NC	8,000	GC	all	5,000	212.00	0.13	40.15	Enlarge	HCPP	NC	No
	Includes new		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No
	2000 cfs HCPP		NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes
	Diversion		NC	3	8,000	2.50	0.76	0.47	New	PP2	PP3	Yes
	Facilities		NC	4	8,000	11.00	0.76	2.08	New	PP3	Funks	Yes
	Total											
B	GC/CLI+CD/NC	8,000	CLI	1	2,000	7.20	0.46	1.40	New	SR	GC	No
	Includes new		GC	1	2,900	56.00	0	10.61	Existing	HCPP	CLI	No
	2100 cfs CLI		GC	2	5,000	16.60	0.17	3.14	Enlarge	CLI	JC	No
	Diversion		GC	3	5,000	139.40	0.17	26.40	Enlarge	JC	NC	No
	Facilities		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No
			NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes
			NC	3	8,000	2.50	0.76	0.47	New	PP2	PP3	Yes
			NC	4	8,000	11.00	0.76	2.08	New	PP3	Funks	Yes
	Total											

The Glenn-Colusa Canal would be enlarged to 5,000 cfs from the Hamilton City Pumping Plant to NC via the Colusa Basin Drain (Option A) or from near Sacramento River Mile 188 intertie to NC (Option B). Alternative IV will require modifications to the existing Glenn-Colusa Canal structures to accommodate the enlarged capacity.

Water from the Colusa Basin Drain would be diverted into NC as described in Alternative III. However, the capacity of the combined diversion of the Colusa Basin Drain and the Glenn-Colusa Canal would be 8,000 cfs for NC and conveyed along an alignment for delivery to Funks Reservoir. Reach 4 from the Glenn-Colusa Canal to Funks Reservoir would follow Alignment B. Alternative IV does not include any water delivered to Funks Reservoir by the existing Tehama-Colusa Canal.

Option A

Modifications to the Hamilton City Pumping Plant. As mentioned earlier, GCID and federal and State agencies have been investigating alternatives to improve the fish screens at the Hamilton City Pumping Plant. Under this alternative, increasing the capacity from 3,000 cfs to 5,000 cfs would require major design changes to the diversion facility and fish screens. Because of the uncertainty of being able to increase the capacity of the existing facility, it is assumed that such a modification would involve increasing the length of the diversion inlet and fish screen after they have been modified to meet DFG and NMFS fish screen criteria. Additional pumps would also be required to lift the water into the Glenn-Colusa Canal.

Enlargement of the Glenn-Colusa Canal. The engineering issues are similar to those identified under Alternative III except that a larger cross section is required to increase the capacity of the canal to 5,000 cfs from the HCPP to NC at Delevan Road.

Option B

A New Diversion Facility. Similar to Alternative VII, Option B, Alternative IV assumes a new diversion facility would be located about 4 miles south of Hamilton City. This facility would have a diversion capacity of 2,000 cfs and limit the velocity through the fish screen to no more than 0.4 feet per second. A detailed site investigation will need to be conducted to determine the feasibility of the proposed location.

Intertie. Under this alternative, an intertie similar to the one described under Alternative VII, Option B would convey water from the new diversion facility to the Glenn-Colusa Canal. However, the capacity would be less at 2,000 cfs and length about 1.4 miles. The reach would be unlined and would not require pumping plants. The major design components for the intertie include siphons under the Southern Pacific Railroad and Highway 45. A proposed outlet structure connects the intertie to the Glenn-Colusa Canal.

Enlargement of the Glenn-Colusa Canal. Option B is similar to Option A except that enlargement of the Glenn-Colusa Canal to 5,000 cfs would occur from where the intertie connects with the Glenn-Colusa Canal to where water would be diverted into the new canal at Delevan Road.

Alternative V. A new diversion and conveyance facility from the Sacramento River

The new diversion would have a capacity of 5,000 cfs and be located across from the Moulton Weir on the Sacramento River (see Figure 7). Water would be conveyed west to Funks Reservoir in an open channel along an alignment that is located between the Delevan and Sacramento National Wildlife Refuges. NC also follows the same alignment as in Alternatives III and IV from where it diverts water from the Colusa Basin Drain to Funks Reservoir. The conveyance facility from this location to Funks Reservoir would have a design capacity of 8,000 cfs. Alternative V does not include any water delivered directly to Funks Reservoir by the existing Tehama-Colusa Canal.

A New Diversion Facility

Several potential locations for a new diversion (see Figure 8) along the Sacramento River were investigated for Alternative V. In addition to being a stable site, the diversion was located as near as possible to the potential offstream storage reservoir at Sites. A location opposite the Moulton Weir through an existing levee provides control of the maximum water surface level in the vicinity of the diversion structure.

The type of diversion structure is significantly affected by the design of the fish screen components. It is assumed that detailed planning studies will determine the preferred configuration for the diversion and fish screen if Alternative V is selected. ESO developed conceptual designs of alternative fish screens for a new diversion on the Sacramento River.

The land adjacent to the diversion that would be displaced by the structure and sedimentation pond is currently farmed in orchards and other crops.

A New Canal

The alignment of the new canal was chosen to minimize environmental impacts and to minimize the length required to convey water from the Sacramento River to Sites Reservoir. The affected area is currently used for agriculture. The alignment is located just south of Delevan Road and follows parcel boundaries as much as possible; however, future designs should consider adjustments to the alignment where it may cause unacceptable disruption to farm operations.

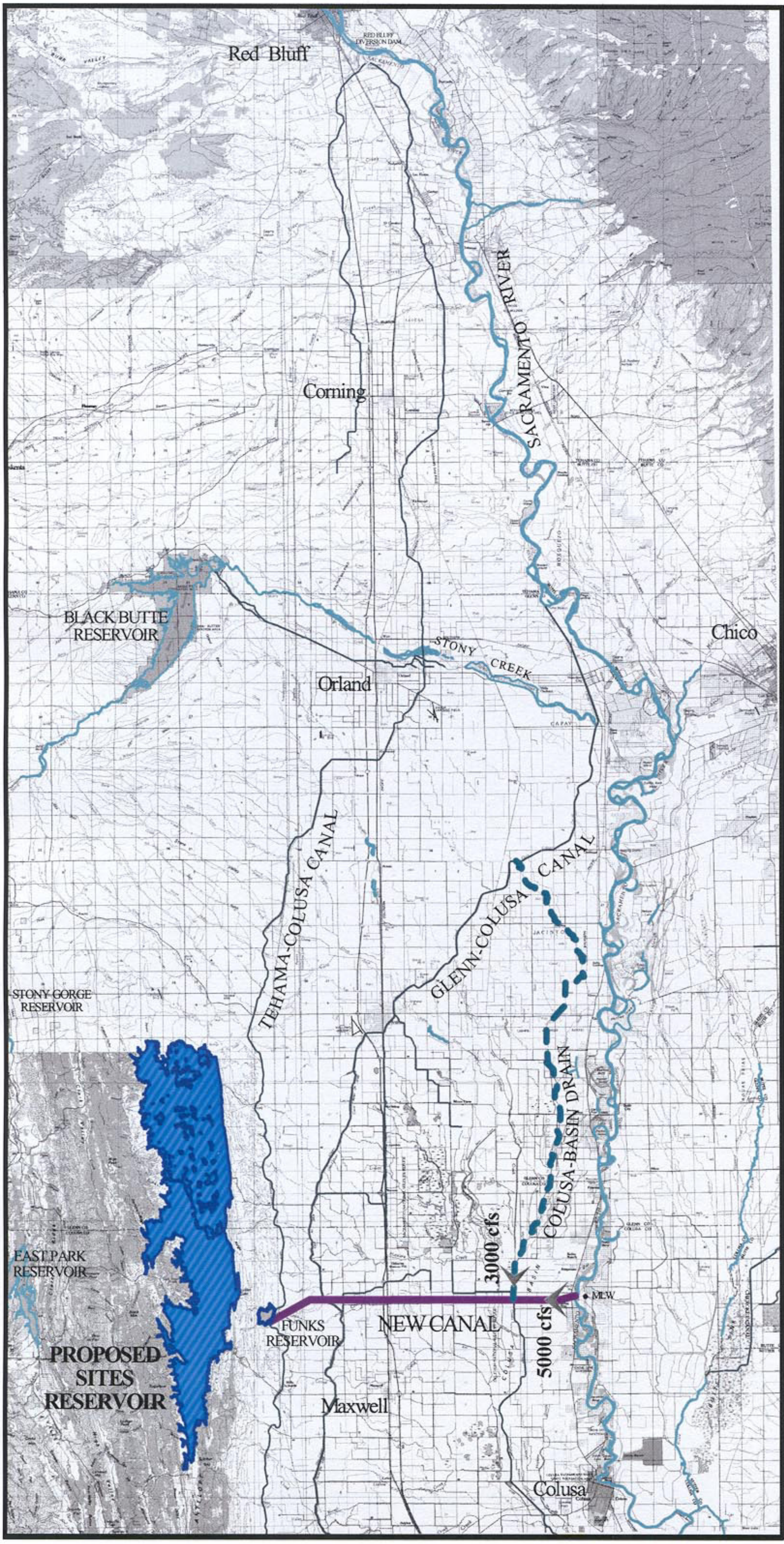


Figure 7

NORTHERN DISTRICT
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N W E S

ALTERNATIVE V: NC/SR +CD/NC

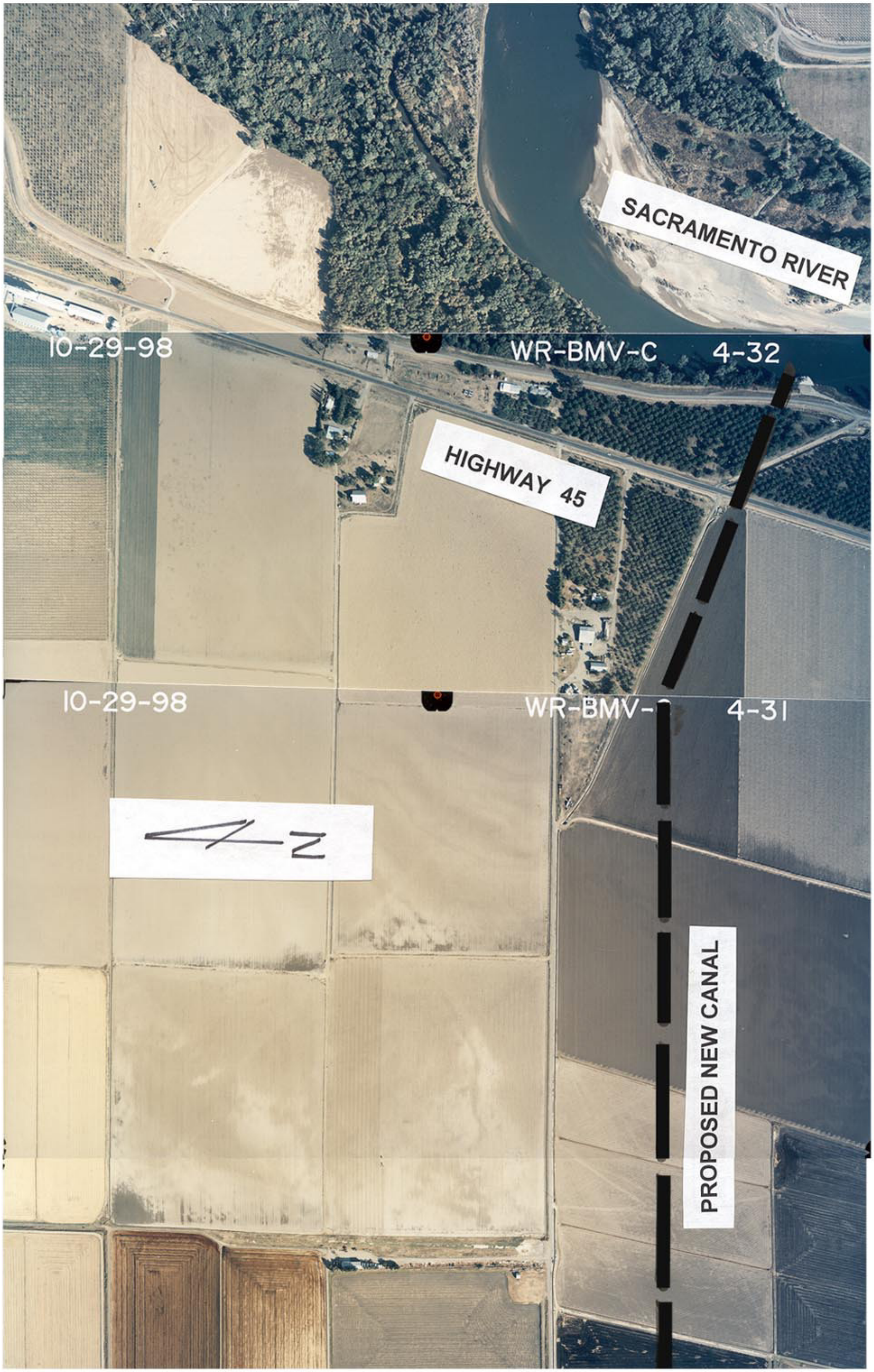
New 5000 cfs SR diversion opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10

Miles

			Canal Reaches									
						Length						
No.	Alternative	Diversion to Funks	Canal	No.	Q(max)	Station	Distance	Distance	Status	From	To	Canal Lined
		(cfs)			(cfs)	(1000 ft)	(unit cost)	(Miles)				
						(a)	(b)					
V	NC/SR+CD/NC	8000	NC	1A	5,000	15.20	0.28	2.88	New	SR	CD	No
	Includes new		NC	1	8,000	30.40	0.36	5.76	New	CD	PP1	No
	5000 cfs NC		NC	2	8,000	17.00	0.76	3.22	New	PP1	PP2	Yes
	Diversion		NC	3	8,000	2.50	0.76	0.47	New	PP2	PP3	Yes
	Facilities		NC	4	8,000	11.00	0.76	2.08	New	PP3	Funks	Yes
	Total											

Figure 8. Sacramento River Diversion



The canal section is unlined to the first of three pumping plants, located about 8-½ miles from the Sacramento River. A 5,000 cfs discharge would require a water depth of about 19-½ feet, bottom width of 45 feet, and a top width of 103 feet. The right of way is about 300 feet.

The capacity of the unlined canal section would be increased to 8,000 cfs to divert water from the Colusa Basin Drain. An 8,000 cfs discharge would require a water depth of about 20 feet, bottom width of 75 feet, and a top width of 135 feet. The right of way is about 350 feet.

An 8,000 cfs concrete-lined canal, beginning at the first pumping plant, would require a water depth of about 22 feet, bottom width of 40 feet, and a top width of 105 feet. The right of way is about 310 feet.

A pipeline design was considered in lieu of an open channel. However, preliminary cost estimates indicate that Alternative V is more expensive than a channel design.

Major crossings include Interstate 5, two Southern Pacific railroads (one near Sacramento River is abandoned), and State Highway 45 (see Figure 10). Minor crossings include county roads, farm roads, irrigation crossings, and utilities.

Colusa Basin Drain Connection

Additional water would be made available from the Colusa Basin Drain by constructing a turnout where the new canal would cross the drain (see Figure 9). The drain turnout is assumed to have a capacity of 3,000 cfs, which would occur during wet years. It is also assumed that this could occur while a maximum of 5,000 cfs is being diverted from the Sacramento River. Therefore, the capacity of the canal is enlarged to 8,000 cfs downstream from this diversion.

<u>Figure 9</u>. Colusa Basin Drain

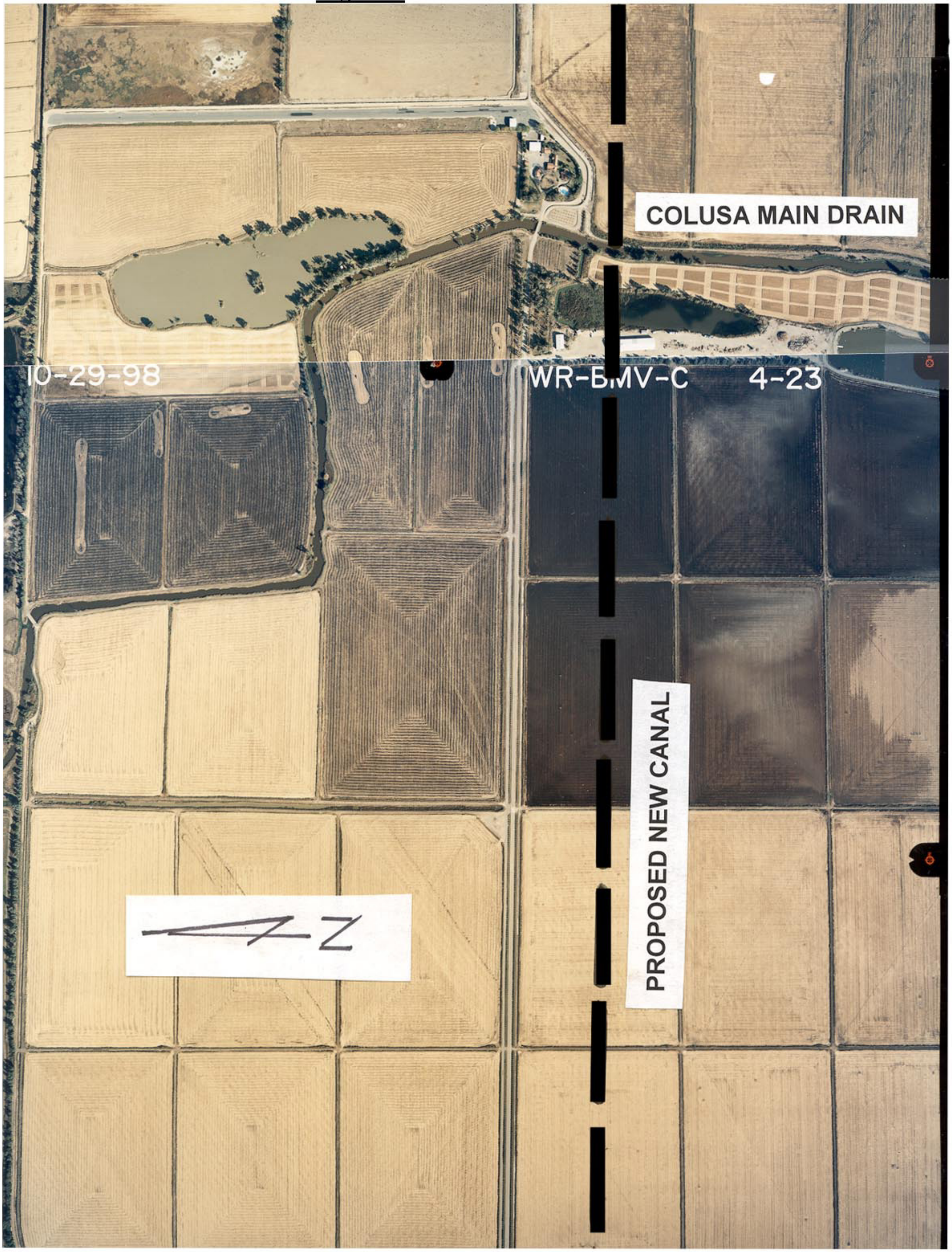
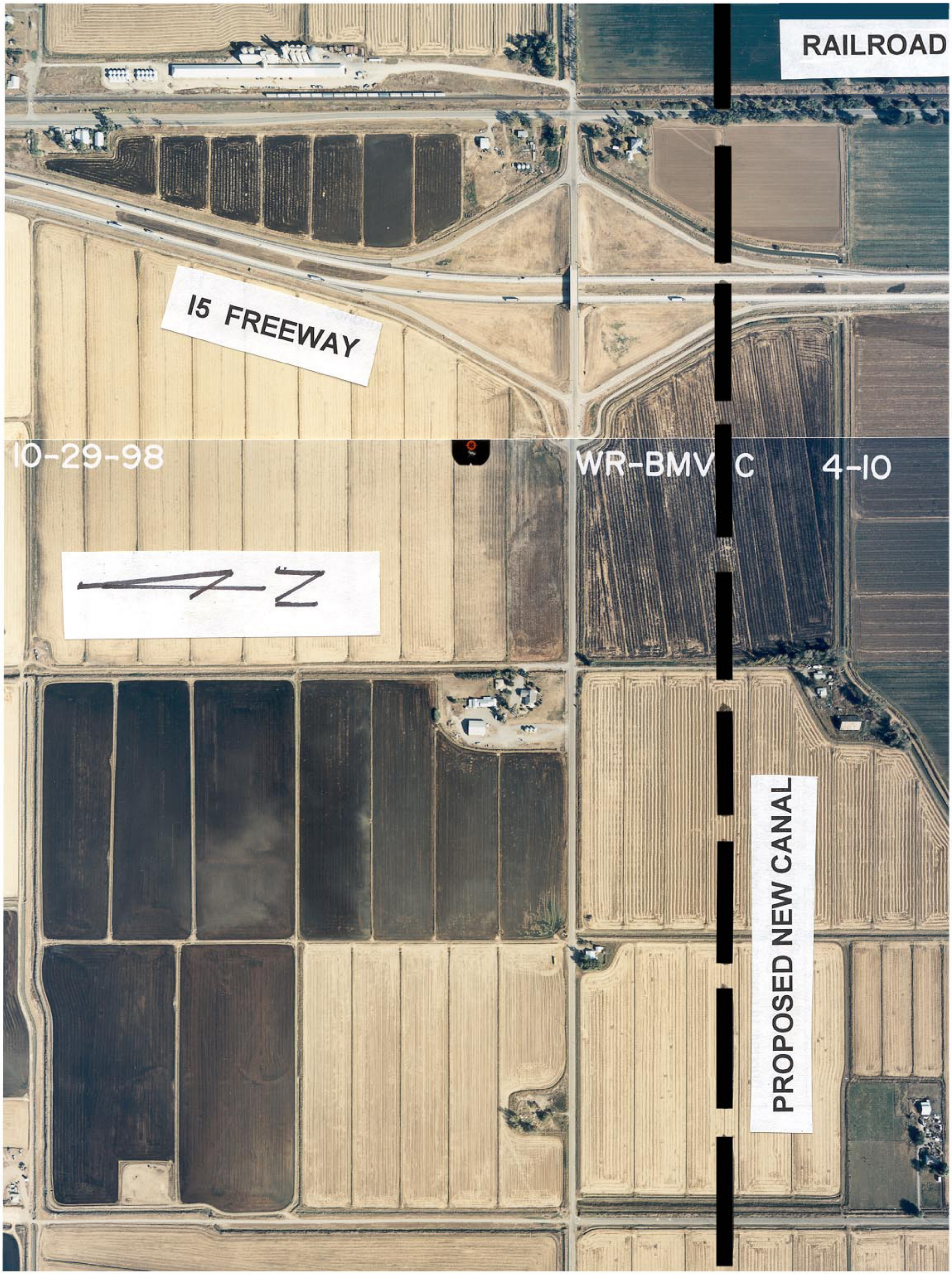


Figure 10. Interstate 5 Crossing



Alternative VI. Use either the Tehama-Colusa or Glenn-Colusa Canal's existing facilities with a new smaller diversion on the Sacramento River.

Alternative VI (see Figure 11) would use either one of the Tehama-Colusa or Glenn-Colusa Canal's existing facilities with a smaller new diversion from the Sacramento River for a total capacity of 5,000 cfs. The two options would be as follows:

Option A: Use existing Tehama-Colusa Canal's capacity of 2,100 cfs along with a new diversion (or new canal) on the Sacramento River that has a capacity of 2,900 cfs.

Option B: Use existing Glenn-Colusa Canal's capacity of 1,800 cfs along with a new diversion (or new canal) on the Sacramento River that has a capacity of 3,200 cfs.

For both options, the use of existing diversion facilities would be the same as described in Alternative I. In addition, the location of a new diversion and canal is the same as described in Alternative V. The capacity of the new canal would be increased to accommodate a 3,000 cfs diversion from the Colusa Basin Drain. Under Option B, the new canal would also be designed to receive water from the Glenn-Colusa Canal. Alignment B is assumed to connect the Reach 4 to Funks Reservoir. Under both options, the total delivery capacity at Funks Reservoir, including water from the Colusa Basin Drain, is 8,000 cfs.

Options A and B

New Diversion, Canal Facilities, Colusa Basin Drain Connection, and Pumping Plants. A new diversion would be similar to the one described in Alternative V, but have a lower capacity. The new canal alignment would follow the same alignment as described in Alternative V, including an increase in canal capacity to accommodate 3,000 cfs from the Colusa Basin Drain. The canal would also be enlarged to receive water diverted from the Tehama-Colusa Canal (Option A) or Glenn-Colusa Canal (Option B).

Alternative VII. Enlarge the capacity of the Tehama-Colusa Canal system. (See *CALFED* report.)

Alternative VII (see Figure 12) would enlarge the Tehama-Colusa Canal system to deliver 5,000 cfs at Funks Reservoir, plus 3,000 cfs from the Colusa Basin Drain. It would either require major improvements (or a new structure) to the existing diversion facility at Red Bluff (Option A) or the construction of a new facility on the Sacramento River (Option B). A new facility under Option B would be located near Sacramento River Mile 188 (between Chico Landing and Old Ferry) with a diversion capacity of 5,000 cfs. An intertie would deliver water from the new diversion near Sacramento River Mile 188 to an enlarged Tehama-Colusa Canal.

Under Option B, the Tehama-Colusa Canal would be enlarged to 5,000 cfs capacity from the Sacramento River Mile 188 intertie to Funks Reservoir. The enlargement would be accomplished by widening the existing concrete-lined section. Alternative VII will also require enlargement or replacement of existing check structures, siphons, bridges, drainage structures, and other facilities. Three pumping plants will be required to lift the water from the Sacramento River up to the beginning of the enlarged Tehama-Colusa Canal. The total pumping lift is approximately 115 feet.

Up to 3,000 cfs of water from the Colusa Basin Drain would be diverted to Funks Reservoir similar to Alternative III and connected directly to Funks Reservoir using Alignment B for Reach 4. The total design capacity at Funks Reservoir under Alternative VII from the Tehama-Colusa and Colusa Basin Drain is 8,000 cfs. Alternative VII does not include any potential water that could be delivered to Funks Reservoir by the existing Glenn-Colusa Canal.

Option A

Modifications to the Red Bluff Diversion Dam. As stated earlier, current fish passage problems at the dam would have to be resolved in order to divert water during the non-irrigation season. The October 1997 CALFED *Facility Descriptions and Cost Estimates* report concluded that increasing the diversion capacity would likely compound fish passage problems if the current fish passage facilities were not improved. Option A assumes the alternatives identified in the CALFED report could be implemented for improving the fish passage conditions and increasing the capacity of the diversion dam.

Modifications to the Tehama-Colusa Canal. The CALFED report contains estimated costs to increase the capacity of the Tehama-Colusa Canal from the diversion dam to Funks Reservoir. Under Alternative VII, the CALFED costs are assumed reasonable for comparison purposes.

Option B

A New Diversion Facility. Under Option B, the CALFED report assumes a new diversion facility would be located about 4 miles south of Hamilton City. This facility would have a diversion capacity of 5,000 cfs and limit the velocity through the fish screen to no more than 0.4 feet per second. A detailed site investigation will need to be conducted to determine the feasibility of the proposed location.

Intertie. The CALFED report assumes an intertie from the new diversion structure consisting of three pumping plants and about 10 miles of concrete-lined conveyance canals. The major design components for the new canal would include siphons under the Southern Pacific Railroad and Glenn-Colusa Canal, nine county road bridges, and nine irrigation crossings. A proposed outlet structure connects the intertie to the Tehama-Colusa Canal.

Modifications to the Tehama-Colusa Canal. A similar estimate was made for Option B except that enlargement of the Tehama-Colusa Canal would occur from where the intertie connects with the Tehama-Colusa Canal to Funks Reservoir. CALFED estimates were assumed for this option.

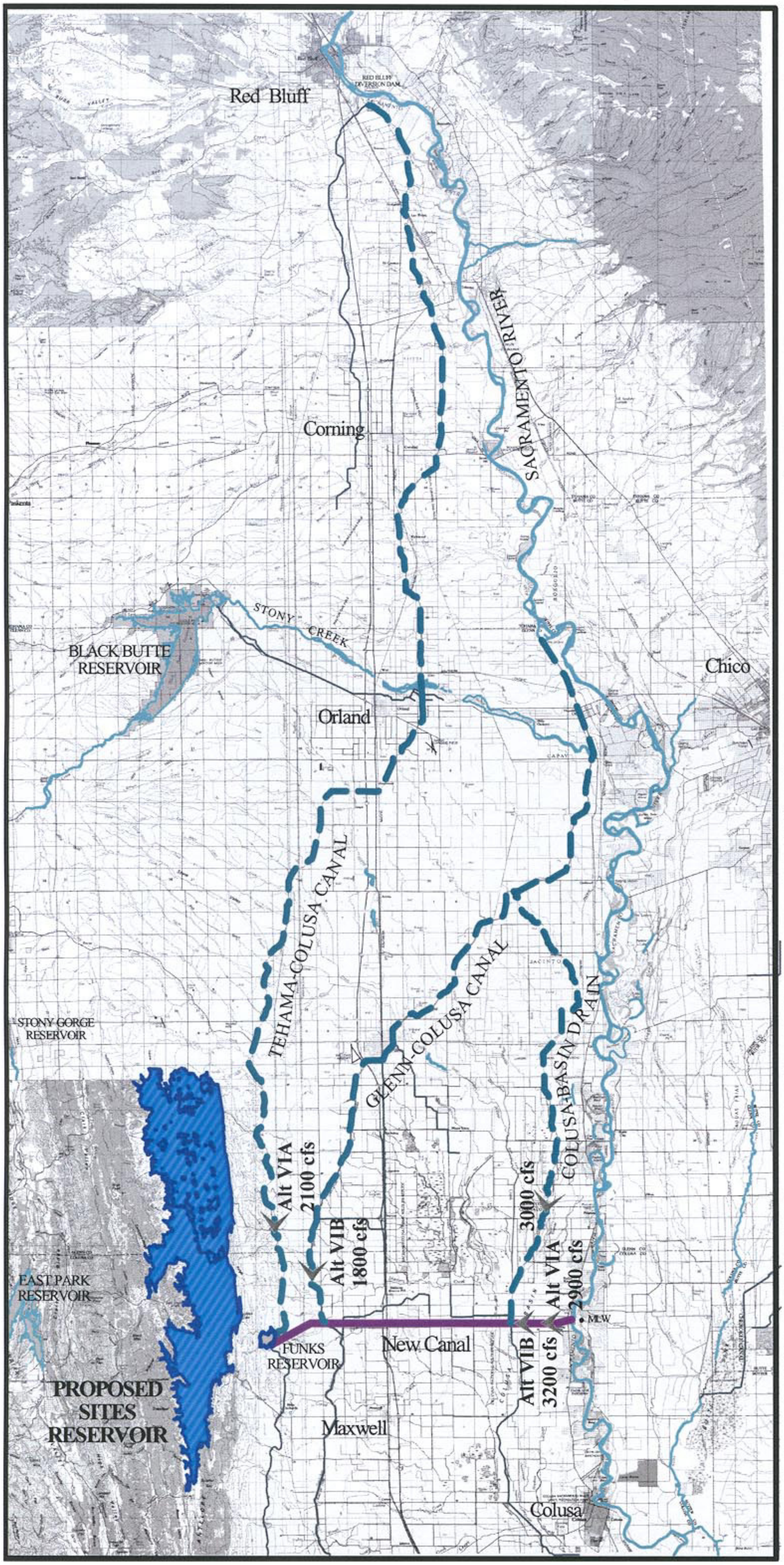


Figure 11

NORTHERN DISTRICT
OCT 1999

N W E S

ALTERNATIVE VI(A): TC + NC/SR + CD/NC

Existing 2100 cfs TC Canal, new 2900 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VI(B): GC + NC/SR + CD/NC

Existing 1800 cfs GC Canal, new 3200 cfs SR diversion and canal opposite Moulton Weir, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10

Miles

No.	Alternative	Diversion to Funks	Canal Reaches									
			Canal	No.	Q(max)	Length			Status	From	To	Canal Lined
						Station	Distance	Distance				
		(cfs)			(cfs)	(1000 ft)	(unit cost)	(Miles)				
						(a)	(b)					
VI A	TC+NC/SR+CD/NC	8,000	TC	all	2,100	352.52	0	66.77	Existing	RBPP	Funks	Yes
	Utilize 2100cfs from		NC	1A	2,900	15.20	0.20	2.88	New	SR	CD	No
	existing RBPP & new		NC	1	5,900	30.40	0.31	5.76	New	CD	PP1	No
	2900cfs Diversion		NC	2	5,900	17.00	0.69	3.22	New	PP1	PP2	Yes
	Facilities opposite		NC	3	5,900	2.50	0.69	0.47	New	PP2	PP3	Yes
	Moulton Weir		NC	4	5,900	11.00	0.69	2.65	New	PP3	Funks	Yes
	Total											
B	GC+NC/SR+CD/NC	8,000	GC	all	1,800	212.00	0	40.15	Existing	HCPP	NC	No
	Includes 3200 cfs		NC	1A	3,200	15.20	0.21	2.88	New	SR	CD	No
	new Diversion		NC	1	6,200	30.40	0.32	5.76	New	CD	PP1	No
	Facilities opposite		NC	2	6,200	17.00	0.70	3.22	New	PP1	PP2	Yes
	Moulton Weir		NC	3	6,200	2.50	0.70	0.47	New	PP2	PP3	Yes
			NC	4	6,200	11.00	0.70	2.08	New	PP3	Funks	Yes
	Total											

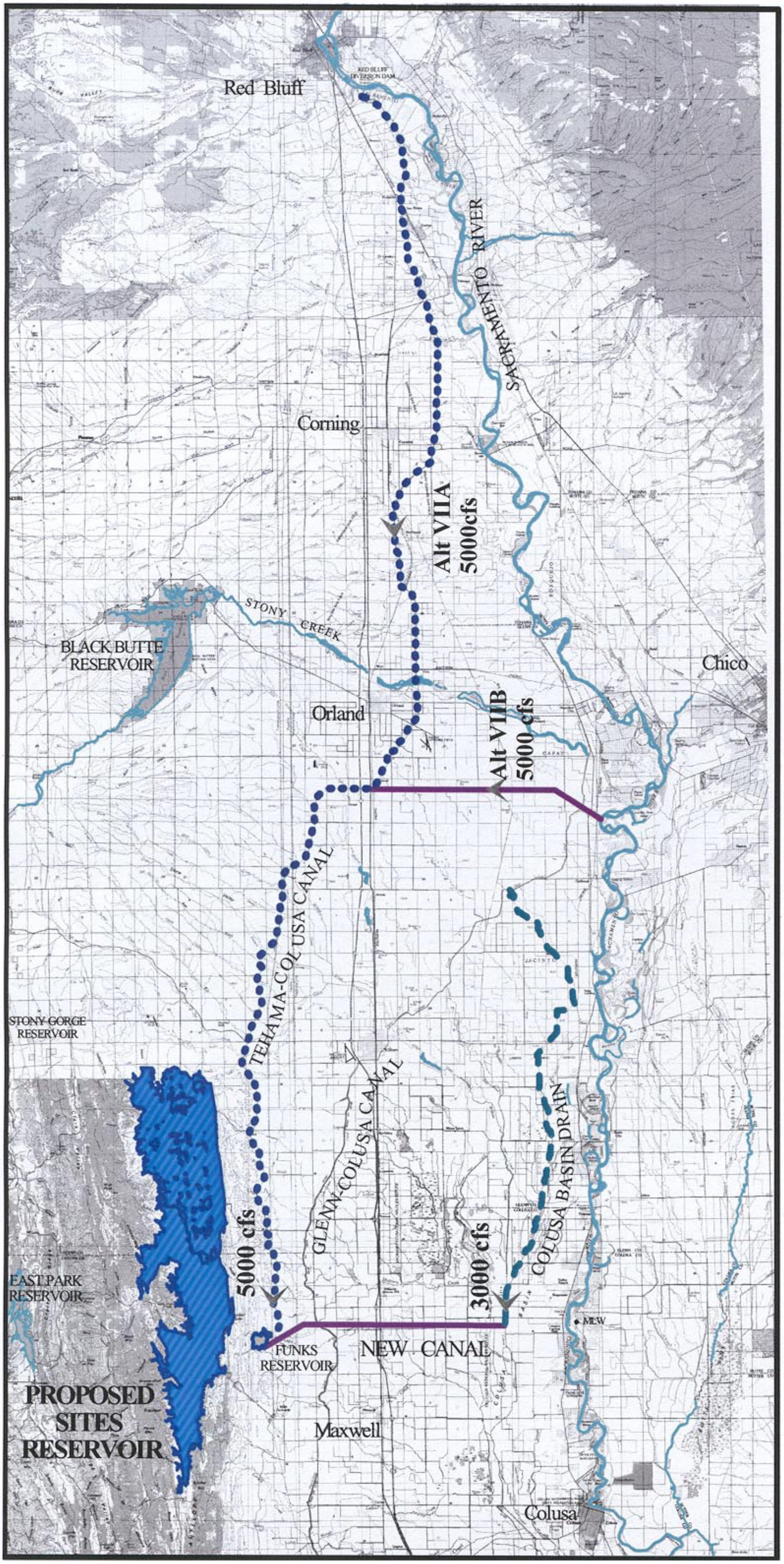


Figure 12

NORTHERN DISTRICT
OCT 1999

N W E S

ALTERNATIVE VII(A): TC + CD/NC

New 5000 cfs TC diversion dam, 5000cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

ALTERNATIVE VII(B): TC/CLI + CD /NC

New 5000 cfs SR diversion near Chico Landing, 5000 cfs TC Canal enlargement, plus added 3000 cfs from Colusa Basin Drain to New Canal.

5 0 5 10

Miles

No.	Alternative	Diversion to Funks (cfs)	Canal Reaches: Canal	No.	Q(max) (cfs)	Length: Station (1000 ft) (a)	Distance (unit cost) (b)	Distance (Miles)	Status	From	To	Canal Lined
VII A	TC+CD/NC	8,000	TC	all	5,000	352.52	0.44	66.77	Enlarge	RBPP	Funks	Yes
	Includes new		NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No
	5000 cfs RBPP		NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes
	Diversion		NC	3	3,000	2.50	0.69	0.47	New	PP2	PP3	Yes
	Facilities		NC	4	3,000	11.00	0.69	2.65	New	PP3	Funks	Yes
	Total											
B	TC/CLI+CD/NC	8,000	CLI	1	5,000	6.00	0.64	1.14	New	SR	PP1	Yes
	Includes new		CLI	2	5,000	22.20	0.64	4.20	New	PP1	PP2	Yes
	5000 cfs CLI		CLI	3	5,000	22.00	0.64	4.17	New	PP2	PP3	Yes
	Diversion		CLI	4	5,000	7.40	0.64	1.40	New	PP3	TC	Yes
	Facilities		TC	2	5,000	169.83	0.44	32.17	Enlarge	CLI	Funks	Yes
			NC	1	3,000	30.40	0.20	5.76	New	CD	PP1	No
			NC	2	3,000	17.00	0.54	3.22	New	PP1	PP2	Yes
			NC	3	3,000	2.50	0.69	0.47	New	PP2	PP3	Yes
			NC	4	3,000	11.00	0.69	2.08	New	PP3	Funks	Yes
	Total											

Preliminary Cost Estimates

Cost Estimate Methodology

Developing cost estimates for this study provides a reasonable estimate of each alternative's costs but more importantly allows for the comparison of alternatives. A comparison of costs seeks to identify any large differences in the cost of alternatives at the earliest point in the decision process. Such information is useful in determining whether to proceed with or defer an alternative.

Initial cost estimates were based on the October 1997 *CALFED Facility Descriptions and Cost Estimates* for: 1) the Red Bluff Diversion and Tehama-Colusa Canal Enlargement and 2) near the Sacramento River Mile 188 Intertie. The initial costs were modified by CD and DWR's Division of Engineering for the preliminary conceptual designs and facility quantity estimates.

Several types of costs are not included in the cost tables. They include environmental documentation, construction mitigation, and agency permit processing and fees. Alternatives involving a new or enlarged diversion from the Sacramento River would have a relatively higher additional cost than alternatives not diverting from the Sacramento River. Future studies should identify and include all project-related costs for a realistic comparison of alternatives.

Component Costs

Preliminary component costs for each alternative include river diversion, conveyance canal, major structures and pumping plant direct payment (DP) construction costs. DP is the product of quantities times unit price or lump sum amount where quantities are not defined. In addition to the DP costs, it is necessary to add construction contingencies, right of way and state operation (SO) costs in order to arrive at the total construction cost for each alternative. SO is estimated at 35 percent and is the sum of planning, design, contract administration, legal, and other project related costs. Operation and maintenance costs are not included in the total construction costs. Unit costs are included in Attachment C.

Diversion Facilities

New diversion structures that included fish screen, bypass, gates, sedimentation basin, pumps, and related works descriptions and costs were developed by DWR's ESO and DOE. Detailed design and cost estimates for 3,000 cfs and 5,000 cfs diversions were developed and used to estimate other size diversions.

Conveyance Canals

Enlarged and/or new trapezoidal canal costs are based on quantities developed for each alternative. Unit costs for unlined and lined canals were developed from existing studies, past projects, CALFED and USBR data and engineering judgment. DOE provided unit costs for generic design criteria and CD staff modified the estimates for the specific pre-design conditions for each alternative canal reach and facility.

Major Features

Enlarged and/or new major features costs are based on quantities as noted above for canals. Major features include canal check structures, highway and county road bridges, railroad siphons, and major drainage crossings. Unit costs for specific pre-design conditions for each alternative were derived as noted above for canals.

Pumping Plants

Enlarged, replacement or new pumping plant costs are based on generic cost curves provided by DOE. The cost curve relates plant cost to the pumping power (in megawatts) required for lifting a given flow to a calculated total dynamic head. Plant cost for specific pre-design conditions for each alternative were derived from the curve.

Right of Way

Enlarged and/or new right of way width is based on canal conditions. The width of the right of way varied from 300 to 350 feet. Predominately agricultural land to be acquired by right of way was calculated for each alternative and multiplied by the estimated cost per acre. Right of way for the river diversion facilities, major features and pumping plants is included in the canal right of way costs. Land and right of way costs are estimated at $3,000 per acre and based on recent land sales for similar lands.

Construction Contingencies

The purpose of the contingency is to provide monies for unexpected construction costs such as change orders, additional work, unforeseen conditions or other justified or negotiated contractor expenses. Construction contingencies are estimated at 25 percent average, and are usually 15 and 45 percent of DP depending upon the estimator level of comfort, cost sensitivity, agency policy, and recent experience.

Cost Sensitivity

The cost of alternatives is based on feasibility or near-feasibility estimates of unit and component costs using the most current data available. The accuracy of cost estimates is affected by the level of design, site conditions, quantity calculations, and the cost of material and labor. Table 1 displays the cost of major components for each of the alternatives. Each of the component categories contributes a significant cost to the total cost of the alternative.

The diversion works are subject to a high level of uncertainty because of questions about the effectiveness of a fish screen that will reduce adverse impacts to fish. The type of fish screen selected will also determine the design for the remainder of the diversion structure. An accurate cost estimate of this structure will not be known until an acceptable fish screen design is completed.

The design of pump stations is affected by site conditions and proposed operations; both are currently unknown. Site conditions such as unfavorable soils, high groundwater, and utilities will increase construction costs. If proposed operations become known, an optimal pumping system can be designed to reduce costs.

At the time of this study, survey data was not available to determine an accurate cost of a new canal or enlarge an existing one. Surveys along the proposed alignment will result in more accurate designs and cost estimates.

The cost of major features, such as check structures and crossings, represent almost half the total cost for some of the alternatives. Similar to the other components, the cost is subject to significant change pending more detailed information on site conditions and design.

Cost of Alternatives

Table 1 summarizes the cost of major components and the total capital cost for each of the alternatives. The alternatives range from $115 million to $651 million in capital costs. As expected, Alternative I is the least costly alternative but is limited by capacity. Alternative VI is the least costly alternative that meets the flow requirements at Funks Reservoir by supplementing the capacity of existing systems.

Table 1. Funks Reservoir Diversion Alternatives Costs Proposition 204 North of the Delta Storage Facility Studies ($ millions)

Alt. No.		Alternative Name	Diversion to Funks *(cfs)*	Cost Item	DP % Add	Diversion Works [5]	Trapezoidal Canal [1]	Major Features [2]	Pumping Plants [3]	Total Costs
I	**A**	TC+GC/NC4A	3,900	Direct Payment		0.0	6.2	14.6	48.8	69.6
		Includes existing		Constr. Contgcy.	25%	0.0	1.5	3.7	12.2	17.4
		2,100 cfs TC and		Right of Way [4]		--	0.0	--	--	0.0
		1,800 cfs GC		State Operations	35%	0.0	2.2	5.1	17.1	24.4
		Total		***TOTAL ALT COST***		**0.0**	**9.9**	**23.4**	**78.1**	***$111.3***
	B	TC+GC/NC4B		Direct Payment		0.0	7.0	14.6	48.8	70.4
		Includes existing		Constr. Contgcy.	25%	0.0	1.8	3.7	12.2	17.6
		2,100 cfs TC and		Right of Way [4]		--	0.0	--	--	0.0
		1,800 cfs GC		State Operations	35%	0.0	2.5	5.1	17.1	24.6
		Total		***TOTAL ALT COST***		**0.0**	**11.2**	**23.4**	**78.1**	***$112.7***
II	**A**	TC+GC/NC4A	5,000	Direct Payment		0.0	47.9	15.8	51.0	114.7
		Includes enlarging		Constr. Contgcy.	25%	0.0	12.0	4.0	12.8	28.7
		existing TC and GC		Right of Way [4]		--	0.2	--	--	0.2
		to 2,500 cfs each		State Operations	35%	0.0	16.7	5.5	17.9	40.1
		Total		***TOTAL ALT COST***		**0.0**	**76.8**	**25.3**	**81.6**	***$183.7***
	B	TC+GC/NC4B		Direct Payment		0.0	49.1	15.8	51.0	115.9
		Includes enlarging		Constr. Contgcy.	25%	0.0	12.3	4.0	12.8	29.0
		existing TC and GC		Right of Way [4]		--	0.2	--	--	0.2
		to 2,500 cfs each		State Operations	35%	0.0	17.2	5.5	17.9	40.6
		Total		***TOTAL ALT COST***		**0.0**	**78.8**	**25.3**	**81.6**	***$185.6***
III		TC+GC+CD/NC	8,000	Direct Payment		0.0	30.1	155.3	82.8	268.2
		Utilizes 2,100cfs		Constr. Contgcy.	25%	0.0	7.5	38.8	20.7	67.1
		from existing RBPP		Right of Way [4]		--	24.7	--	--	24.7
		Diversion Facilities		State Operations	35%	0.0	10.5	54.4	29.0	93.9
				TOTAL ALT COST		**0.0**	**72.8**	**248.5**	**132.5**	***$453.8***
IV	**A**	GC+CD/NC	8,000	Direct Payment		13.5	53.0	168.4	105.7	340.6
		Includes new		Constr. Contgcy.	25%	3.4	13.2	42.1	26.4	85.1
		2,000 cfs HCPP		Right of Way [4]		--	4.0	--	--	4.0
		Diversion Facilities		State Operations	35%	4.7	18.5	58.9	37.0	119.2
				TOTAL ALT COST		**21.6**	**88.8**	**269.5**	**169.1**	***$548.9***
	B	GC/CLI+CD/NC	8,000	Direct Payment		13.5	55.3	166.4	98.5	333.6
		Includes new		Constr. Contgcy.	25%	3.4	13.8	41.6	24.6	83.4
		2100 cfs CLI		Right of Way [4]		--	3.3	--	--	3.3
		Diversion Facilities		State Operations	35%	4.7	19.3	58.2	34.5	116.8
				TOTAL ALT COST		**21.6**	**91.8**	**266.2**	**157.6**	***$537.1***

Table 1. (continued from previous page) ($ millions)

Alt. No.		Alternative Name	Diversion to Funks *(cfs)*	Cost Item	DP% Add	Diversion Works [5]	Trapezoidal Canal [1]	Major Features [2]	Pumping Plants [3]	Total Costs
V		NC/SR+CD/NC	8,000	Direct Payment		33.7	38.4	134.8	90.5	297.4
		Includes new		Constr. Contgcy.	25%	8.4	9.6	33.7	22.6	74.3
		5,000 cfs NC		Right of Way [4]			2.1			2.1
		Diversion Facilities		*State Operations*	35%	11.8	13.4	47.2	31.7	104.1
				TOTAL ALT COST		**53.9**	**63.5**	**215.7**	**144.8**	***$477.9***
VI	**A**	TC+NC/SR+CD/NC	8,000	Direct Payment		19.6	33.4	134.8	85.5	273.3
		Utilize 2,100cfs of		Constr. Contgcy.	25%	4.9	8.4	33.7	21.4	68.3
		existing RBPP &		Right of Way [4]		--	1.7	--	--	1.7
		new 2,900cfs		State Operations	35%	6.9	11.7	47.2	29.9	95.7
		Diversion Facilities		***TOTAL ALT COST***		**31.4**	**55.2**	**215.7**	**136.8**	***$439.0***
		opposite MW								
	B	GC+NC/SR+CD/NC	8,000	Direct Payment		21.6	34.2	134.8	89.5	280.1
		Includes 3,200 cfs		Constr. Contgcy.	25%	5.4	8.5	33.7	22.4	70.0
		new Diversion		Right of Way [4]		--	1.7	--	--	1.7
		Facilities opposite		State Operations	35%	7.6	12.0	47.2	31.3	98.0
		Moulton Weir		***TOTAL ALT COST***		**34.6**	**56.4**	**215.7**	**143.2**	***$449.8***
VII	**A**	TC+CD/NC	8,000	Direct Payment		33.7	179.6	223.0	102.2	538.5
		Includes new		Constr. Contgcy.	25%	8.4	44.9	55.7	25.6	134.6
		5,000 cfs RBPP		Right of Way [4]		--	4.1	--	--	4.1
		Diversion Facilities		State Operations	35%	11.8	62.9	78.0	35.8	188.5
				TOTAL ALT COST		**53.9**	**291.4**	**356.8**	**163.5**	***$865.6***
	B	TC/CLI+CD/NC	8,000	Direct Payment		33.7	136.1	202.1	154.7	526.6
		Includes new		Constr. Contgcy.	25%	8.4	34.0	50.5	38.7	131.6
		5,000 cfs CLI		Right of Way [4]		--	3.9	--	--	3.9
		Diversion Facilities		State Operations	35%	11.8	47.6	70.7	54.1	184.3
				TOTAL ALT COST		**53.9**	**221.7**	**323.3**	**247.5**	***$846.4***

Abbreviations

CD Colusa Basin Drain
CLI Chico Landing Intertie
PP Pumping Plant
HC Hamilton City
RB Red Bluff Diversion Dam
DP Direct Payment to Contractor
MW Moulton Weir
NC New Canal
GC Glenn -Colusa Canal
TC Tehama-Colusa Canal
SR Sacramento River
JC Jacinto Check
Funks Funks Reservior

Footnotes

1. Totals from Table 1.
2. Totals from Table 3.
3. Totals from Table 4.
4. Totals from Table 5.
5. No cost shown for utilization of existing headworks on TC canal.

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Discussion

Alternative I

As expected, utilizing the existing capacities of the Tehama-Colusa and Glenn-Colusa Canal systems would be the least costly alternative; however, it does not meet the general design objective of delivering 5,000 cfs to Funks Reservoir. The most costly elements are the new canal and pumping plants associated with diverting water from the Glenn-Colusa Canal to Funks Reservoir. Option B, which would divert water from the Glenn-Colusa Canal to the south abutment of Funks Reservoir, would cost about $1.4 million more than Option A.

Alternative II

Alternative II estimates an additional cost of $72 million to Alternative I for modifying existing canals to deliver 5,000 cfs to Funks Reservoir. Most of the additional cost is attributed to the construction of the larger new canal from the Glenn-Colusa Canal to Funks Reservoir. It would cost about $1.9 million more under Option B to connect new canal to the south abutment of Funks Reservoir than connecting it to the Tehama-Colusa Canal under Option A.

Alternative III

Alternative III is significantly costlier than the first two alternatives because of the extended NC coming from the Colusa Basin Drain. A 3,000 cfs NC from the Colusa Drain represents about 75 percent of the total cost of the alternative. The remaining costs are the enlargement of the existing Glenn-Colusa Canal and enlargement of the canal structures.

Alternative IV

Alternative IV estimates $83 million to $95 million more than the cost of Alternative III to increase the capacity of the Glenn-Colusa Canal and not utilize the Tehama-Colusa Canal. Option B would supplement the existing diversion capacity at Hamilton City Pumping Plant with a new diversion and intertie near Chico Landing. It is about $12 million less than enlarging the pumping plant canal under Option A. Option B is less costly due to the cost of building a short intertie near Chico Landing while not having to enlarge the Glenn-Colusa Canal reach from Hamilton City to the intertie connection point. Alternative IV would also not require modifications to the siphon at Stony Creek to increase its capacity to 5,000 cfs.

Alternative V

The cost to build a new conveyance system to deliver 8,000 cfs at Funks Reservoir without utilizing existing diversion and canal facilities is close to the cost of Alternatives III, IV, and VI that utilize existing facilities. While it is costly to build new facilities under Alternative V, the additional length of the new canal is much less than the cost of enlarging existing canals in the other alternatives. In addition, most of the cost for Alternatives III, IV, V, and VI is from common elements that would divert water from the Glenn-Colusa Canal and/or Sacramento River, and the Colusa Basin Drain. Alternative V, however, would provide greater flexibility in operating and maintaining the system when compared to the other alternatives. Detailed investigations may result in a more efficient and less costly design of Alternative V, but may incur additional costs associated with right of way acquisition and mitigation of adverse impacts.

Alternative VI

Supplementing the existing capacities of the Tehama-Colusa or Glenn-Colusa Canal systems with a new diversion on the Sacramento River is a compromise between Alternatives III, IV, and Alternative V. Alternative VI combines the cost of Alternative I with a lower capacity design of Alternative V. As expected, it is about $28 million to $39 million less than Alternative V because of its reliance on using the existing Tehama-Colusa and Glenn-Colusa systems. It also has the least cost for an alternative that would convey 8,000 cfs to Funks Reservoir. Using existing facilities reduces the size and cost of a new canal while providing some operational flexibility.

Alternative VII

Alternative VII indicates a substantial cost to increase the deliverable capacity of the Tehama-Colusa Canal system to Funks Reservoir for Options A and B. It is highest in terms of total cost because it is equal to or more costly than the other alternatives for all the major cost components shown in Table 1.

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