Appendix 8A Groundwater Resources Basin Setting

8A.1 Introduction

Groundwater, often stored in aquifers[1] contained within permeable rock or soil material, provides water for humans and the surrounding environment. Groundwater quality refers to the physical, chemical, and biological characteristics of water, which can be degraded by contaminants introduced by domestic, construction, industrial, and agricultural practices. This appendix provides a detailed description of the environmental setting for the groundwater basins and subbasins that may be affected by construction or operation of the Project. It also discusses existing sustainable groundwater management efforts in the study area through implementation of groundwater management plans and the Multi-Benefit Groundwater Recharge Incentive Program.

8A.2 Environmental Setting

Basin boundaries, groundwater storage capacity, groundwater level, groundwater quality, and well yields were summarized using the California Department of Water Resources (DWR) Bulletin 118, 2003 Update (California Department of Water Resources 2003). Colusa and Yolo Subbasin boundaries were updated based on the 2016 DWR Bulletin 118 Interim Update (California Department of Water Resources 2016). In addition, the 2018 DWR Sustainable Groundwater Management Act (SGMA) Basin Prioritization Dashboard (SGMA Basin Dashboard) and SGMA Data Viewer were reviewed for historical and groundwater data within the study area (California Department of Water Resources 2020a, 2020b). A survey of DWR well completion report records was used to determine the number and location of wells near Project facilities (California Department of Water Resources 2020c). Groundwater quality Primary Maximum Contaminant Levels (MCLs) exceedances in the study area during the last 3 years were reviewed using the GAMA Groundwater Information System (California Water Boards 2021).

8A.2.2 Funks and Antelope Creek Groundwater Basins

The study area includes the location for the Sites Reservoir, which would completely inundate both the Funks Creek and Antelope Creek Groundwater Basins (5-090 and 5-091, respectively). Funks Creek is regulated by Glenn and Colusa Counties, which both have adopted water management ordinances. The Funks Creek basin is 3,014 acres (4.7 square miles) north of

[1] An aquifer consists of underground layers saturated with water which can be brought to the surface through natural springs or by pumping.

Antelope Valley in Glenn and Colusa Counties (California Department of Water Resources 2020a, 2004a:1). The Antelope Creek basin is 2,040 acres (3.2 square miles) within Antelope Valley east of the Black Mountain in Colusa County (California Department of Water Resources 2020a, 2004b:1). Funks Creek is regulated by the Colusa County water management ordinance. Groundwater is likely recharged from precipitation and surface water infiltration within Antelope Valley which then drains to the east through Grapevine, Funks, and Antelope Creeks. These groundwater basins, within creek valleys, are largely shallow (generally less than 100 feet below ground surface [bgs]) alluvial deposits consisting of fine-grained sands, silts, and clays occurring within the reservoir footprint (California Department of Water Resources 2003:159). More detailed descriptions of the geologic setting and formations in the Sites Reservoir footprint are included in Chapter 12, *Geology and Soils*.

Groundwater resources from this formation are limited because of poor water-bearing and water quality characteristics (see below for further discussion of groundwater quality). The SGMA Basin Dashboard reported 972 acre-feet (AF) of groundwater was pumped from the Funks Creek basin entirely for agricultural use in 2018 (California Department of Water Resources 2020a). Similarly, 66 AF of groundwater was pumped from the Antelope Creek basin in 2018 and used entirely for agriculture. As described in Appendix 4A, *Regulatory Requirements*, both basins are noted as a low priority by SGMA (California Department of Water Resources 2020a).

8A.2.2.2 Local Groundwater Infrastructure and Use

Groundwater generally moves through the subsurface from a place of groundwater recharge to a place of groundwater discharge. When a pump is operated and lifts water to the land surface (such as for the purposes of dewatering or dust suppression), it is removing groundwater from aquifer storage and intercepts groundwater that would have flowed elsewhere based on hydrologic conditions. Thus, groundwater temporarily discharged from a groundwater well is initially removed from storage in the aquifer, which is eventually balanced by a temporary loss of water from somewhere else. The decline in the water level inside the pumping well creates a hydraulic gradient (slope) toward the well within the surrounding groundwater system outside the well. This slope causes groundwater from the surrounding groundwater system to flow radially (laterally and vertically) to the well, resulting in a declining water table (unconfined aquifer) or potentiometric surface (confined aquifer) in the surrounding aquifer. The feature formed by the decline in surrounding groundwater levels from groundwater pumping is referred to as the cone of depression. Operation of existing production wells located within a cone of depression has the potential to be adversely affected.

There are approximately 30 wells and 1 test hole within an approximately 1-mile radius of the Sites Reservoir inundation area. Of the 30 wells, 13 are constructed to a depth of 100 feet or greater and the deepest well is 201 feet. Well yields in the area are low, ranging from 60 gallon per minute (gpm) to zero or no measurable yield, and averaging approximately 14 gpm. The depth to water in the area, based on well completion reports, ranges from 1 foot to 30 feet bgs, with an average depth of approximately 17 feet (California Department of Water Resources 2011, Sites Project Authority 2017a:10–17). Half of the wells in the area are for domestic use and constructed to depths ranging from approximately 30 to 165 feet, with yields averaging approximately 14 gpm. Stock wells are the second most common well type and constructed to depths ranging from 20 to 200 feet. Well yields from stock wells average approximately 15 gpm.

8A.2.2.3 Groundwater Quality

Groundwater quality data for the Sites Reservoir area are limited.[2] Fifteen wells were sampled in 2005[3]. Groundwater quality in the inundation area and adjacent area was fair, but high in mineral content. Salinity, measured as specific conductance or electrical conductivity[4] (EC), ranged from 680 to 2,190 micromhos per centimeter (µmhos/cm) and total dissolved solids (TDS) values ranged from 375 to 1,291 milligrams per liter (mg/L). Sampling revealed that no Primary MCLs were exceeded. Of the 15 wells sampled, Secondary MCLs were exceeded for TDS in 14 wells, specific conductance in 12 wells, sulfate in four wells, pH in three wells, manganese and iron in two wells, and aluminum and chloride in one well each. Agricultural Water Quality Goals from the Food and Agriculture Organization of the United Nations (Central Valley Regional Water Quality Control Board 2011) were exceeded for specific conductance and TDS in 14 wells, sodium in 13 wells, chloride in eight wells, boron in six wells, pH in three wells, and selenium in one well (Sites Project Authority 2017b:11-12).

Data from 21 wells near the locations of the roads and Sites Reservoir I/O Works were reviewed for groundwater quality. The groundwater quality was moderately impaired by high mineral content. Specific conductance values ranged from 290 to 2,190 µmhos/cm with 1 well at 38,200 µmhos/cm, and TDS ranged from 169 to 1,291 mg/L with 1 well at 27,400 mg/L. Secondary MCLs were exceeded for TDS in 15 wells; specific conductance in 13 wells; manganese, pH, and sulfate each in three wells; and chloride and iron each in two wells. Agricultural Water Quality Goals were exceeded for specific conductance, sodium, and TDS in 14 wells each, chloride in eight wells, boron in six wells, pH in three wells, and selenium in one well (California Department of Water Resources 2007).

8A.2.3 Sacramento Valley Groundwater Basin

Outside of the Sites Reservoir inundation area, construction and operation of Project components are located in the Sacramento Valley Groundwater Basin. The Sacramento Valley Groundwater Basin is a north-northwestern trending asymmetrical trough composed of marine and continental rocks with sediment layers several miles deep (Page 1986). On the eastern side, the basin overlies basement bedrock that rises relatively gently to form the Sierra Nevada. On the western side, the underlying basement bedrock rises more steeply to form the Coast Ranges. Marine sandstone, shale, and conglomerate rocks that generally contain brackish or saline water overlie the basement bedrock. The more recent continental deposits overlying the marine sediments contain fresh water. These continental deposits are generally 2,000 to 3,000 feet thick (Page

[2] There is a limited number of well logs for wells in the Site Reservoir area. Several of these wells were not in use or were otherwise unable to be sampled. There are also several wells in this area for which no well log was available. Two of these wells were sampled to provide data in areas where no other wells were located and where adequate well construction data were provided by the owner/ranch manager.

[3] Groundwater monitoring data for the Funks Creek and Antelope Creek Basins are not available on GAMA Groundwater Information System online tool nor provided in the DWR Bulletin 118-03.

[4] For water quality purposes electronic conductivity and specific conductance are interchangeable and measure ions in the solution (U.S. Geological Survey 2019:2).

1986). The depth to the base of fresh water typically ranges from 1,000 to 3,000 feet bgs (Berkstresser 1973). Along the edges of the basin, near the base of the mountains, groundwater is produced from limited fractured-rock aquifers. In areas outside of the Sacramento Valley, groundwater occurs in alluvium deposited in smaller valleys and along stream and river channels. Groundwater is also produced from fractured-rock areas and in the Cascade Range from sand and gravel aquifers between ancient lava flows. Groundwater and surface water are hydraulically connected within the Sacramento Valley Groundwater Basin, with generally losing conditions along tributary streams at the basin margin, transitioning to gaining conditions along the major trunk streams draining the valley. However, local conditions may vary depending primarily on groundwater use in particular areas.

Groundwater Quality

From the Shasta County line south, groundwater composition in the subbasins along the Sacramento River is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate (California Department of Water Resources 2006:4). TDS concentrations range from 120 to 558 mg/L (Sites Project Authority 2017b:11-7). Groundwater quality impairments are typically localized and can include boron, chloride, high magnesium, TDS, calcium, and phosphorus. High nitrate concentrations have been noted in the Antelope area near Red Bluff (California Department of Water Resources 1987:54).

Groundwater data from 19 wells in the vicinity of the GCID Main Canal indicate good quality groundwater in this area. Impairments were not noted to be extensive, but some groundwater had high mineral content. Specific conductance values ranged from 223 to 1,950[5] µmhos/cm, and TDS values ranged from 120 to 649 mg/L. Primary MCLs exceeded were for nitrite plus nitrate in two wells, and arsenic in one well. Secondary MCLs were exceeded for iron in four wells, TDS in three wells, and aluminum and specific conductance in two wells each. Agricultural Water Quality Goals were exceeded for specific conductance in eight wells, TDS in five wells, sodium in six wells, and copper in one well (California Department of Water Resources 2007).

Groundwater data from 58 wells sampled along the length of the TC Canal indicate that the quality of the groundwater along the canal is good, with a few impairments. Specific conductance ranged from 138 to 986 µmhos/cm, and TDS values ranged from 112 to 520 mg/L. Nitrate values exceeded the Primary MCL from one well. Secondary MCLs were exceeded for specific conductance, iron, and TDS in three wells each, and pH in one well. Agricultural Water Quality Goals were exceeded for specific conductance in five wells, boron and TDS in three wells each, copper and sodium in two wells each, and pH in one well (California Department of Water Resources 2007).

8A.2.3.2 Red Bluff Subbasin (5-021.50)

Water would be diverted into the TC Canal at the RBPP within the Red Bluff Subbasin. This subbasin is 271,794 acres (424 square miles) in size and is bound by Red Bluff Arch to the north, the Sacramento River to the south, Thomas Creek to the east, and the Coast Range to the west

[5] Upper limit for specific conductance taken from 2015 data reported in shallow wells (less than 20 feet bgs) in Appendix I of *Initial Study/Environmental Assessment: 2020 Tehama-Colusa Canal Authority In-Basin Water Transfers* (Bureau of Reclamation and Tehama-Colusa Canal Authority 2020).

(California Department of Water Resources 2020a, 2004c:1). It is regulated by the Groundwater Sustainable Agency of Tehama County. Hydrostratigraphic units[6] containing fresh water include the Tuscan Formation (derived from a series of volcanic lahars), the Tehama Formation (derived from the Coast Ranges and Klamath Mountains), the Riverbank Formation (alluvial terrace deposits), and the Modesto Formation (more recent alluvial terrace deposits) as well as alluvial fans, basin deposits, and stream deposits (Dudley et al. 2005). The RBPP and diversion dam are within the Modesto Formation which is composed of gravelly sand, silt, and clay alluvial deposits up to 200 feet thick with groundwater stored in the unconsolidated layers (Blake et al. 1999, Dudley et al. 2005).

An estimated 4,208,851 AF of groundwater is stored at a depth of 200 feet within the Red Bluff Subbasin and provides 82% of water use to the subbasin (California Department of Water Resources 2004c:2; California Department of Water Resources, Northern Regional Office 2020). Groundwater flows from north to southeast within the subbasin and is recharged from applied surface water and precipitation to a lower degree. Groundwater recharge was estimated to be approximately 20,000 AF annually (California Department of Water Resources 2020a, 2004c:2). Groundwater discharge is from waterways (rivers and canals), pumping, and to a lesser extent, evapotranspiration. The SGMA Basin Dashboard reports an estimated 92,586 AF of groundwater was pumped in 2018 primarily for agriculture (estimated use 85,310 AF) (California Department of Water Resources 2020a). Groundwater levels within the subbasin generally vary between 5 to 10 feet within a year (California Department of Water Resources 2004c:2). Between fall 2019 and spring 2020 groundwater levels ranged between 110 feet bgs in the north and 30 feet bgs near the southeast margin. From spring 2010 to spring 2020 there has been a decline in groundwater levels throughout the basin, especially in the southern portion which recorded an average bgs decline of 18 feet in the last 10 years (California Department of Water Resources 2020b). As described in Appendix 4A, *Regulatory Requirements*, the SGMA Basin Dashboard also reported a decline in groundwater levels with the Red Bluff Subbasin designated as a medium priority (California Department of Water Resources 2020a).

Local Groundwater Infrastructure and Use

There are approximately 49 wells constructed for domestic, agricultural, industrial, or public use within approximately 1 mile of the RBPP. The well depths range from 45 feet to 600 feet bgs with a static water level of 55 feet bgs. The reported data for well yields ranged between 20 to 2,080 gpm. Of the 49 wells, 32 are used for domestic water supply, nine are used for irrigation water supply, five are used for production, and three for public use (California Department of Water Resources 2020c).

Groundwater Quality

Based on the 2003 DWR Bulletin 118-03, the Red Bluff Subbasin has TDS values ranging from 120 to 500 mg/L and averaging 207 mg/L (California Department of Water Resources 2004c:3). In the last 3 years, there has been one exceedance of thallium MCL near the northeast subbasin boundary, four well exceedances of perfluorooctanoic acid and perfluorooctanoic sulfonate MCLs along the mid-east boundary, and barium and boron MCL exceedances in the southwest

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[6] A body of rock which is distinct in its permeability resulting in differences in the flow of water between units.

region (California Water Boards 2021). Approximately 1 mile from the RBPP, specific conductivity ranges from 158 to 707 µmhos/cm with a TDS range from 70 to 593 mg/L. In the past 3 years, there have been no Primary MCL exceedances within a 1-mile radius of the RBPP. Based on magnitude and prevalence of MCL exceedances in public drinking water the SGMA Basin Dashboard determined this subbasin was mid to low priority for water quality (California Department of Water Resources 2020a).

8A.2.3.3 Colusa Subbasin (5-021.52)

Quarries, GCID system upgrades, and construction and operation of the conveyance complex (i.e., Funks Reservoir, TRR) would be located within the Colusa Subbasin (5-021.52). This subbasin is regulated by the Colusa Groundwater and Glenn Groundwater Authorities (CGA and GGA, respectively) with groundwater accounting for 37% of total water use (California Department of Water Resources, Northern Regional Office 2020). The Colusa Subbasin is approximately 723,824 acres (1,130 square miles) and defined by the Sacramento River to the east, Stony Creek to the north, the Coast Range and foothills to the west, and the Colusa/Yolo County Line to the south (California Department of Water Resources 2020a, 2006:1). Hydrostratigraphic units containing fresh water within the Colusa Subbasin include the Tuscan Formation, the Tehama Formation, the Riverbank Formation, and the Modesto Formation as well as alluvial fans, basin deposits, and stream deposits. Funks Reservoir is within the bedrock of Great Valley Sequence which consists of interbedded marine sandstone, siltstone, shale, and conglomerate. Groundwater within this formation is typically saline except for some valley margins which may have been flushed with fresh water (California Department of Water Resources, Northern Regional Office 2014). The TRR East and West and GCID system upgrades are largely within the Riverbank Formation. The Riverbank Formation is composed of terrace deposits that consist of poorly consolidated gravel, sand, and silt. These water-bearing deposits are found throughout the Sacramento Valley and reach a maximum thickness of 200 feet; this depositional thickness limits the formation's water-bearing capacity. The Riverbank Formation has moderate water yields for domestic and shallow irrigation wells and does provide some groundwater at deeper irrigation wells (California Department of Water Resources 2006:1).

Approximately 13,025,887 AF of groundwater is stored within the Colusa Subbasin at a depth up to 200 feet bgs. Groundwater generally flows from the western basin margin to the east/southeast toward the Sacramento River. There are localized areas of groundwater flow to the west/southwest in the northern portion of the subbasin (Stony Creek Fan). The aquifer is recharged from irrigation canals, stream infiltration, and to a lesser extent, precipitation. Deep percolation groundwater recharge is estimated to be 64,000 AF annually (California Department of Water Resources 2006:4). Groundwater is lost due to streams, pumping, and evapotranspiration. Between spring 1980 and spring 2021, groundwater storage has decreased an estimated 1,120 AF (Davids Engineering and West Yost 2022:6). The *Colusa Subbasin Groundwater Sustainability Plan 2022 Annual Report* reports an estimated 977,000 AF of groundwater is pumped mainly for agriculture (estimated agriculture use approximately 933,000 AF; Davids Engineering and West Yost 2022:5). Groundwater levels within the subbasin generally vary by 5 feet between Wet and Dry Water Years (Central Valley Regional Water Quality Control Board 2008:25). Figure 8A-1 depicts groundwater elevation contours as inferred from groundwater level data collected in spring 2020. Recent depth to groundwater was between 10 and 20 feet bgs across the central-west portion of the subbasin during fall 2019 and spring

2020. Greater depths to groundwater (roughly 200 feet bgs) are found along the northwestern and southwestern basin margins. A comparison of spring 2010 and spring 2020 groundwater elevations shows a decline of approximately 40 to 50 feet along the western basin margins (Figure 8A-2) (California Department of Water Resources 2020b). This decline in groundwater levels is likely related to a combination of recent multi-year drought conditions (decreasing groundwater recharge) and an increase in permanent, groundwater-supplied agricultural areas (increasing groundwater extraction) (Davids Engineering 2016). The 2018 SGMA Basin Dashboard also reported a decline in groundwater levels in the subbasin (California Department of Water Resources 2020a). Additionally, seasonal groundwater flow through the Colusa Subbasin in 2021 was in the same direction as previous years but with lower groundwater gradients, and the overall depth to groundwater increased (Davids Engineering and West Yost 2022:3). Between 2008 and 2017, land subsidence has been documented in the north and southern portions of the Colusa Subbasin with over 2 feet of subsidence noted near Arbuckle (Colusa and Glenn Groundwater Authorities 2020:22). The greater Arbuckle and Orland areas have reported failed or failing wells due to lower groundwater levels (Davids Engineering and West Yost 2022:6). As described in Appendix 4A, *Regulatory Requirements,* the Colusa Subbasin was designated as a high priority under the SGMA (California Department of Water Resources 2020a).

Local Groundwater Infrastructure and Use

There are approximately 13 wells that have been constructed for domestic, agricultural, or other use within an approximately 1-mile radius of TRR East and West (California Department of Water Resources 2020c). The well depths range from 70 feet to 400 feet. The reported data for well yields were limited but ranged between 70 and 200 gpm. The depth to static water ranged between 4 and 20 feet bgs, with an average depth of 13 feet (California Department of Water Resources 2011; Sites Project Authority 2017a). Of the 13 wells, nine are used for domestic water supply, three are used for irrigation water supply, and one has an unknown use. In addition, there are approximately 18 domestic or agricultural groundwater wells within approximately 1 mile of the TRR East and West pipelines. Well depths ranged from 64 feet to 380 feet with a wide range of reported data for well yields (between 12 and 200 gpm). The depth to static water was between 15 and 18 feet bgs. Of the 18 wells, 16 are used for domestic water supply and two are used for irrigation (California Department of Water Resources 2020c).

There are 15 groundwater wells within approximately 1 mile of the transition manifold and Funks Reservoir. Ten are domestic use wells, three are industrial wells, and two are wells for stock use. Well depths ranged from 22 feet to 440 feet with poor well yields ranging between 3 and 75 gpm. The depth to static water ranged between 15 and 207 feet bgs with an average depth of 98 feet. The three quarries immediately to the east of Sites Reservoir (SD1,2,3-Z3 Quarry 2, GG-Z3 Quarry 2, and Sites-Z3 Quarry) have 10 domestic wells and 2 industrial wells within approximately 1 mile. Well depths range from 28 to 300 feet bgs with well yields between 2 to 50 gpm (California Department of Water Resources 2020c).

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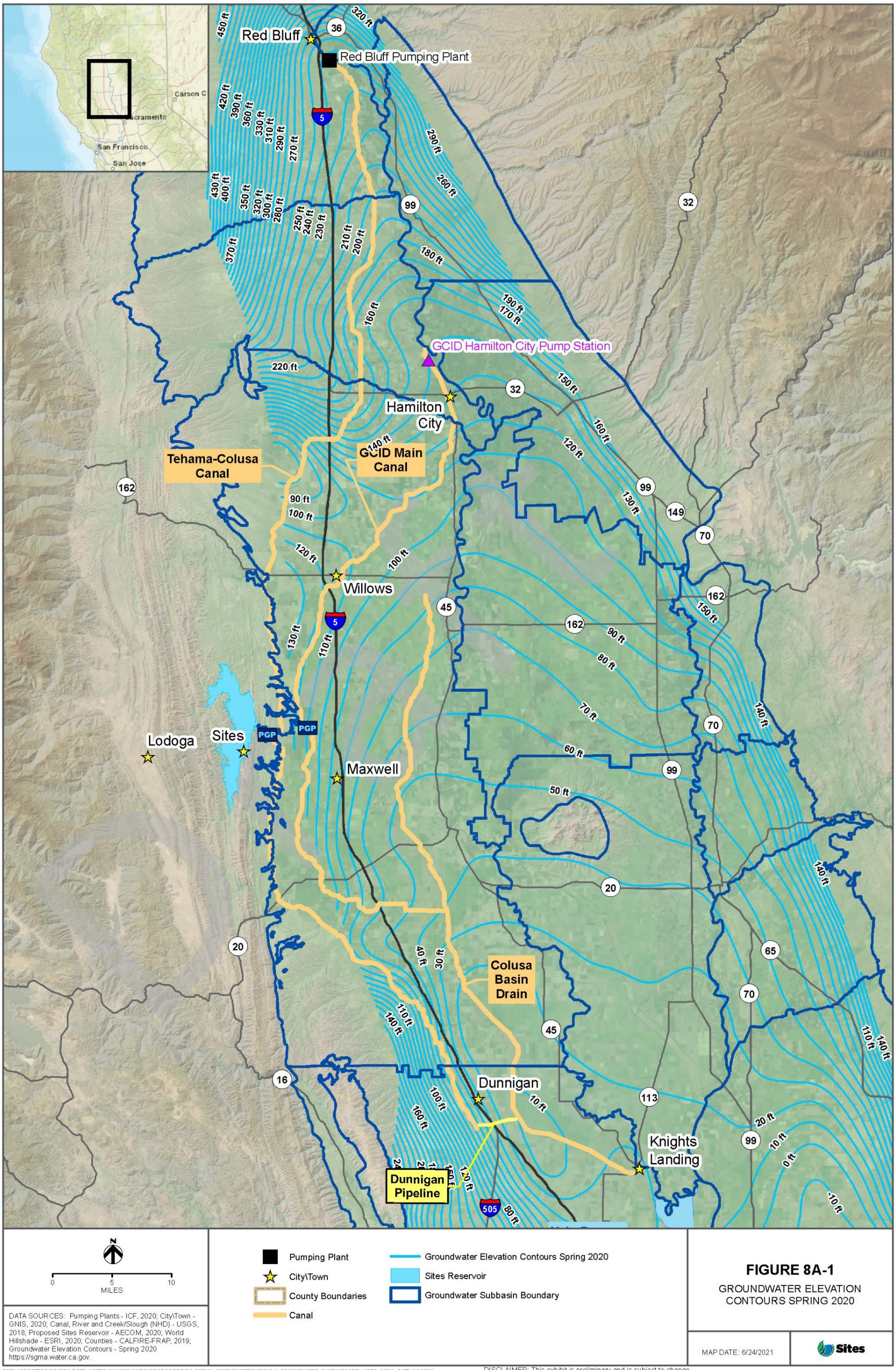

FIGURE 8A-1
GROUNDWATER ELEVATION CONTOURS SPRING 2020

PATH: \\PDCCITRDSGIS1\PROJECTS_1\SITES_PA\00528_20\FIGURES\DOC\EIREIS\1_DEIR\01_ADEIR\CHAPTER8\FIG8A_1_GROUNDWATER_CONTOURS.MXD - USER: 24991 - DATE: 6/24/2021

DISCLAIMER: This exhibit is preliminary and is subject to change.

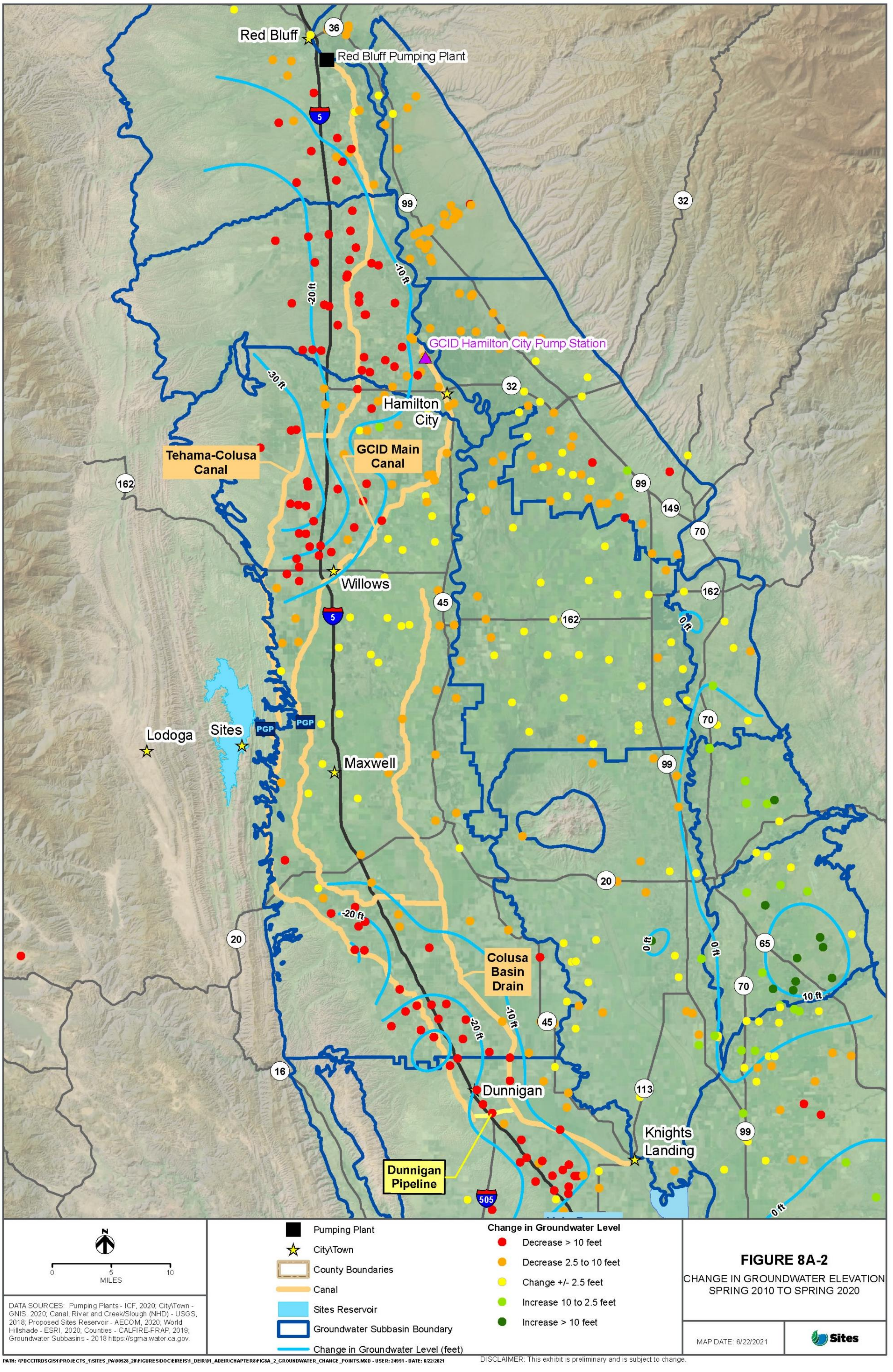

FIGURE 8A-2
CHANGE IN GROUNDWATER ELEVATION SPRING 2010 TO SPRING 2020

Groundwater Quality

Within the Colusa Subbasin, TDS values range from 120 to 1,220 mg/L with an average of 391 mg/L. Impairments in this subbasin include high electric conductivity (EC), TDS, and nitrate, and manganese impairments occur near Colusa (California Department of Water Resources 2006:4). From January 2016 to August 2017, 62 wells were monitored at varying depths in 26 locations. Shallow wells (up to 225 feet bgs) showed MCL exceedances for nitrate, and intermediately deep to deep wells (starting at 430 feet bgs) exceeded MCL levels for arsenic. When compared to other subbasins in the northern region it had the highest sodium levels. This is likely partially due to the subbasin’s sodium bicarbonate and magnesium bicarbonate water type, which produces sodium chloride at greater depths (California Department of Water Resources, Northern Regional Office 2020). In the last 3 years, high nitrates were documented in and near Arbuckle and Willows. Other documented, localized areas of MCL exceedances were high manganese, fluoride, magnesium, sodium, iron, arsenic, and chromium hexavalent (California Water Boards 2021). The SGMA Basin Dashboard designated this subbasin as a high priority for water quality (California Department of Water Resources 2020a).

Data from four wells near the locations of the TRR East and West complex and the TRR East and West pipelines indicate that groundwater quality in this area is fairly good, but high in mineral content. The EC values ranged from 444 to 1,104 µmhos/cm, and TDS ranged from 259 to 608 mg/L. No Primary MCLs were exceeded. Secondary MCLs were exceeded for specific conductance and TDS in two wells each. Agricultural Water Quality Goals were exceeded for sodium in three wells, specific conductance and TDS in two wells each, and chloride in one well (California Department of Water Resource 2007).

8A.2.3.4 Yolo Subbasin (5-021.67)

Facilities to convey water from Sites Reservoir to the Sacramento River (e.g., TC Canal intake, CBD outlet, and Dunnigan Pipeline) would be located in the Yolo Subbasin. The Yolo Subbasin is regulated by the Yolo Subbasin Groundwater Agency and encompasses 540,693 acres (884.83 square miles) in the southern portion of the Sacramento Valley Groundwater Basin (California Department of Water Resources 2020a). This subbasin is bordered by Colusa, Sacramento, and Solano Counties to the north, east, and south, respectively, and by the Coast Range to the west. The Capay Valley is interconnected with the Yolo Subbasin, but the Capay Hills are not (California Department of Water Resources 2018:1). The subbasin aquifer primarily consists of the Tehama Formation overlaid by younger sediments deposited from drainages running in and through the Sacramento Valley during the Quaternary period (Yolo County 2005). The Tehama Formation is the principal water-bearing unit in the Sacramento Valley and was formed by fluvial deposition during large flooding events. This process resulted in noncontiguous layers up to 2,000 feet deep of metamorphic sandstone and siltstone with lenses of pebble and cobble conglomerates (California Department of Water Resources, Northern Regional Office 2014). Groundwater generally occurs within mixed gravel and sand layers of this formation, with reported well yields up to several thousand gpm (California Department of Water Resources 2004d:1). The Dunnigan Pipeline will run through the Modesto Formation, which overlays the

Tehama Formation in this area with groundwater stored in the unconsolidated material (California Department of Water Resources, Northern Regional Office 2014).

Approximately 6,456,000 AF of groundwater is stored within the Yolo Subbasin at depths between 20 and 420 feet bgs; this accounts for 39% of the basin's water use (Yolo County 2005; Groundwater Exchange 2019). In general, groundwater flows from east to south following the natural topography of the region. However, in some areas, this gradient has been disrupted by groundwater pumping that has resulted in areas of localized water table depressions, as well as land subsidence (Water Resources Association of Yolo County 2005). Groundwater is recharged primarily from irrigation, then surface water infiltration from creeks, and to a lesser extent from precipitation occurring more in the west (Central Valley Regional Water Quality Control Board 2008:93). Flooding from the Sacramento and Feather Rivers, which is then diverted into the Yolo Bypass, has also been shown to be a recharge element (Water Resources Association of Yolo County 2005). Groundwater loss occurs from stream discharge, evapotranspiration, and pumping (Central Valley Regional Water Quality Control Board 2008:93). Groundwater levels tend to decrease during dry years, due to increased pumping, but generally quickly recover in Wet Water Years (California Department of Water Resources 2004d:2). Depth to groundwater was between 10 to 250 feet bgs across the northern portion of the subbasin during fall 2019 and spring 2020. Greater depths to groundwater are found along the eastern foothills of the Capay Hills and becomes shallower towards the east boundary of the subbasin. A comparison of spring 2010 and spring 2020 groundwater elevations shows a decline of up to 30 feet bgs within the top half of the subbasin, especially bordering Interstate 5 (California Department of Water Resources 2020b). The SGMA Basin Dashboard recorded 327,195 AF of groundwater pumped from the Yolo Subbasin in 2018 that was primarily for agricultural use (approximately 286,479 AF). The SGMA Basin Dashboard also noted overdrafts in the Yolo Subbasin, largely occurring in Lower Cache-Putah and western Colusa Subbasins and resulting in land subsidence and reduced water quality near the Yolo-Woodland area (additional discussion on water quality below). As described in Appendix 4A, *Regulatory Requirements*, the Yolo Subbasin is designated as a high priority under the SGMA (California Department of Water Resources 2020a).

Local Groundwater Infrastructure and Use

There are 48 domestic, irrigation, industrial, and public wells within an approximately 1-mile radius of the TC Canal intake, Dunnigan Pipeline, and the CBD outlet. Well depths ranged from 51 feet to 1,00 feet. The reported data for well yields were limited but ranged between 30 and 3,000 gpm. The depth to static groundwater was between 52 to 109 feet bgs. Of the 48 wells, 40 are for irrigation, five are for domestic use, two are for industrial use, and one is for public use (California Department of Water Resources 2020c).

If the Dunnigan Pipeline extends to the Sacramento River, there would be 90 wells within an approximately 1-mile radius. These would be 20 domestic wells, 65 irrigation wells, two industrial wells, two public wells, and one stock well. Well depths ranged also from 51 feet to

1,00 feet bgs, with depth to static water between 20 to 293 feet bgs and reported yields ranging from 4 to 5,467 gpm. (California Department of Water Resources 2020c).

Groundwater Quality

Groundwater quality in the Yolo Subbasin is considered good for both agricultural and municipal uses, even though the water is considered hard to very hard (typically over 180 mg/L calcium carbonate). Selenium and boron are found in higher concentrations locally. TDS concentrations range from 107 to 1,300 mg/L, and average 574 mg/L noted in a 2000 report by California Department of Health Services (California Department of Water Resources 2004d:4). Electrical conductivity in the north Yolo Subbasin ranged from 361 to 781 µmhos/cm. In the last 3 years, MCL exceedance of TDS and nitrates have been documented approximately one mile from the Dunnigan Pipeline (California Water Boards 2021). The SGMA Basin Dashboard has designated this subbasin as a high priority for water quality (California Department of Water Resources 2020a).

8A.3 Sustainable Groundwater Management

In 2014, California passed the SGMA, which requires a plan to be developed at the basin or subbasin level that outlines existing groundwater conditions and measurable objectives for sustainability. Under California Code of Regulations, title 23, division 2, subchapter 2, article 5, section 354.24 requirements, Groundwater Sustainability Plans must include minimum thresholds and undesirable results determinations for chronic lowering of groundwater levels, reduction in groundwater storage, degradation of groundwater quality, depletion of surface water connections, and land subsidence.[7] Table 8A-1 provides a summary of the minimum thresholds and undesirable results for subbasins in the study area.

Table 8A-1. Minimum Thresholds and Undesirable Results for Subbasins in the Study Area.

Sustainability Criteria	Subbasin	Minimum Threshold	Undesirable Result
Chronic lowering of groundwater levels and reduction of storage	Red Bluff	Upper Aquifer: Spring groundwater elevation with less than between 10% and 20% of domestic wells could be affected Lower Aquifer: Upper aquifer spring elevation plus 20 to 120 feet	25% exceedance of minimum threshold over two consecutive measurements at the same monitoring well
	Colusa	The lower of the 50% historical groundwater elevation and 20th percentile of domestic well depths in the monitoring well's Thiessen polygon	25% exceedance of the minimum threshold at the same monitoring well for 24 months

[7] Seawater intrusion is also a listed goal criterion but is not applicable to basins or subbasins in the study area.

Sustainability Criteria	Subbasin	Minimum Threshold	Undesirable Result
	Yolo	Varies based on management area. In general, the minimum threshold is at least the 2016 groundwater elevation	51% of monitoring wells exceed the minimum threshold in two of the six management areas
Groundwater quality degradation	Red Bluff	TDS of 750 mg/L	25% exceedance of minimum threshold over two consecutive measurements where it can be established the GSP is the cause of the exceedance
	Colusa	EC of 900 µS/cm or pre-2015 historical maximum observation	25% of monitoring wells exceed the minimum threshold for 2 consecutive years
	Yolo	TDS of greater than 1,000 ppm over a 3-year rolling average	50% of monitoring wells exceed the minimum threshold
Depletion of surface water connections	Red Bluff	Same as chronic lowering of groundwater levels	25% of monitoring wells drop below the minimum threshold for 2 consecutive years in the Upper Aquifer
	Colusa	10 feet below the 2015 groundwater level	25% of monitoring wells exceed the minimum threshold for 24 consecutive months
	Yolo	Minimum thresholds vary by management area, with each well having a unique threshold for depth to water and elevation	50% of interconnected monitoring wells exceed minimum thresholds in two or more interconnected management areas in the same reporting year
Land subsidence	Red Bluff	2 feet subsidence over 20 years solely due to lowering groundwater	50% exceedance of minimum thresholds at monitoring wells over a 5-year period
	Colusa	0.5 foot subsidence per 5 years	20% or more monitoring wells exceed the minimum threshold
	Yolo	25% of the area; averaging 1.5 cm/year (Capay Valley minimum threshold still to be determined)	25% exceedance over minimum threshold in three or more management or sub-management areas in the same year

Source: GEI Consultants, Inc. 2022; Davids Engineering et al. 2021; Luhdorff & Scalmanini Consulting Engineers 2022.
Notes: cm/year = centimeters per year; EC = electrical conductivity; GSP = groundwater sustainability plan; µS/cm = microsiemens per centimeter; mg/L = milligrams per liter; ppm = parts per million; TDS = total dissolved solids.

Project management actions implemented for long-term sustainability include monitoring groundwater levels, monitoring water quality, airborne electromagnetic surveys, increasing groundwater recharge through stormwater retention or surface water storage, increasing and improving surface water use, reducing groundwater demand through removal of nonnative plants along riparian corridors, and conducting public outreach on water conservation practices.

The Multi-Benefit Groundwater Recharge Incentive Program is an example of a potential future Project management action. Under this program, the CGA, in partnership with The Nature Conservancy, has been working with local farmers who own land identified as priority managed aquifer recharge areas or areas with excellent to good recharge potential since 2018. Farmers in these areas flood fallowed agricultural land for 4 to 6 weeks in the fall to create “pop up” wetlands for migratory birds while also acting as a groundwater recharge source. The program compensates farmers based on the area and duration of inundation and has been expanded to farmland near Arbuckle and Williams (The Nature Conservancy 2018; Colusa Groundwater Authority 2021).

8A.4 References

8A.4.2 Printed References

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