COLUSA BASIN DRAINAGE ACTION GROUP

COLUSA BASIN DRAIN INVESTIGATION

LANDON
ENGINEERING & SURVEYING, INC.

LAUGENOUR AND MEIKLE
CIVIL ENGINEERS

COLUSA BASIN DRAINAGE ACTION GROUP

COLUSA BASIN DRAIN

INVESTIGATION

June 1981

Thomas E. Landon
Landon Engineering & Surveying, Inc.
Willows, California

Kenneth E. Lerch
Laugenour and Meikle
Civil Engineers
Woodland, California

COLUSA BASIN DRAIN ACTION GROUP

June, 1981

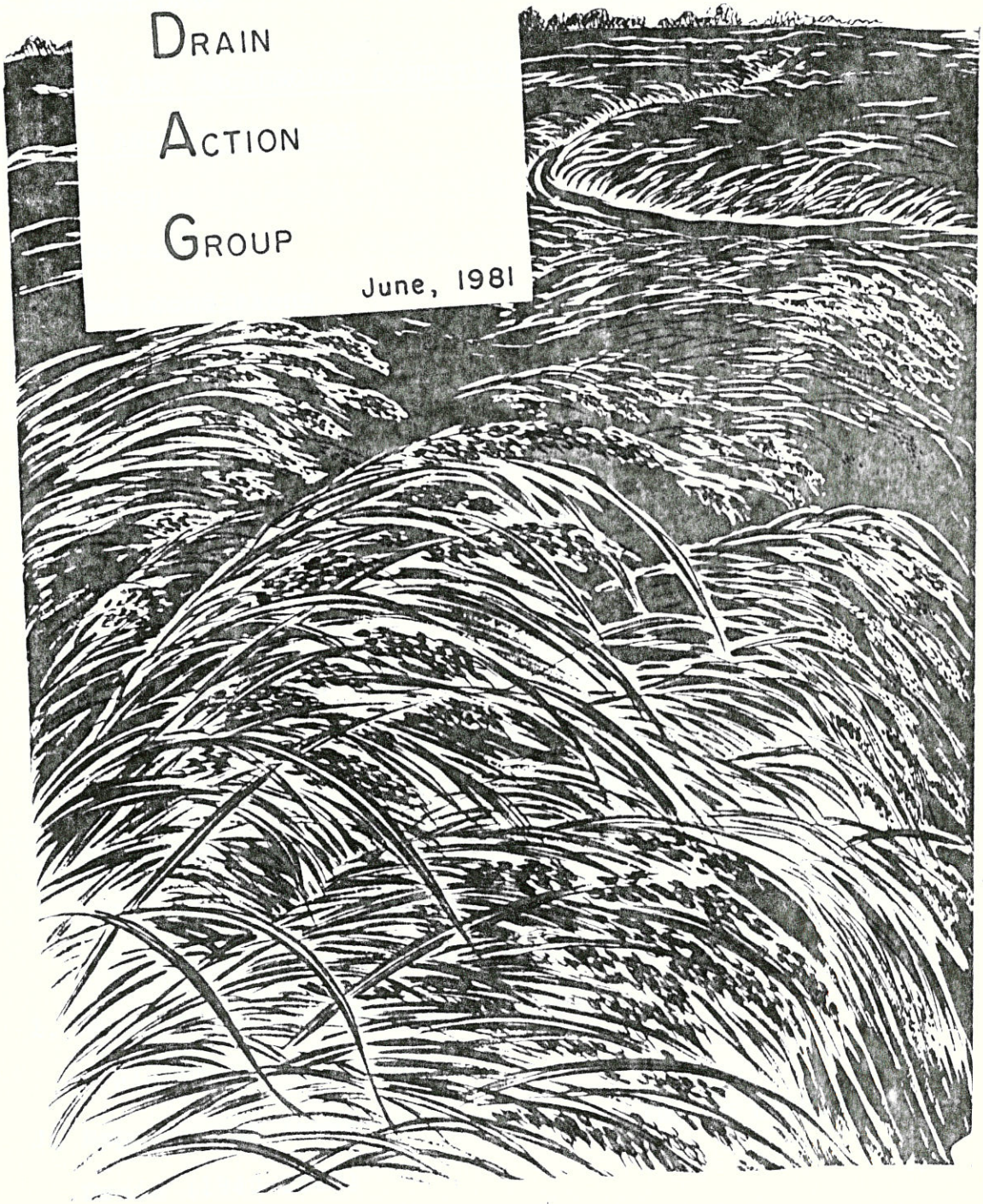


TABLE OF CONTENTS

FIGURES

APPENDIX A PLATES

Plates 7-8	Profiles of U.S.G.S. Level Circuits
Plate 9	Knights Landing Cut Project
Plate 10	Total Agricultural Drainage Outflow Flood Prevention and Drainage Work Team Report, U.S.B.R., October, 1974
Plate 10a & 10b	Tehama Colusa Service Area Land Classification (Drainage Areas)
Plate 11	Runoff Tabulation of Same
Plates 12-14	Alternates, Colusa Drain Flooding Sacramento River Drainage and Seepage Utilization, U.S.B.R., February, 1977
Plate 14	Total Monthly Discharge Drainage Return Flow from Irrigation Flood Prevention and Drainage Work Team Report, U.S.B.R., October, 1974
Plates 15-18	Flow of Colusa Trough, Back Borrow Pit, Colusa Basin Drainage and Ridge Cut Water Supply and Water Rights Work Team Report, U.S.B.R., December, 1973
Plates 19-20	Tables 1 and 2 of Runoff and Sedimentation Study, University of California at Davis, 1980
Plates 21-24	Irrigation Systems, Tailwater Recovery, Water Management and Land Leveling, Recommended Plan of Best Management Practices, Central Valley Region, U.S.D.A., Soil Conservation Service, June, 1979
Plates 25-29	Letters from U. S. Corps of Engineers regarding Potential Drainage Projects in the Colusa Basin
Plates 30-31	Profile of Water Surface in the Colusa Basin Drain and Willow Creek between Tule Road and State Highway 162
Plate 32	Profile of Water Surfaces, Ground Elevations and Drain Thalwed between the Outfall Gates at Knights Landing and Hahn Road
Plates 33-34a	Irrigation Season Weekly Flows for 1978 and 1979, Colusa Basin Drain
Plates 35-38	Colusa Basin Drainage Action Group Investigation Maps

APPENDIX B

References

APPENDIX C

State of California Reclamation Board Regulations - October, 1973
(Designated Floodway)

APPENDIX D

Written Responses to Basin Problem Inquiries

LANDON
ENGINEERING
and
SURVEYING
INCORPORATED

103 SOUTH PLUMAS STREET
P. O. BOX 1325
(916) 934-7055
WILLOWS, CALIFORNIA 95988

MUNICIPAL • HIGHWAYS • AGRICULTURAL • LAND SURVEYS

June 11, 1981

Mr. Harold L. Peterson, Chairman
Colusa Basin Drainage Action Group
Colusa County Courthouse
546 Jay Street
Colusa, California 95932

Dear Mr. Peterson:

Submitted herewith is our final report on the "Colusa Basin Drain Investigation". This report was prepared in collaboration with Laugenour and Meikle, Civil Engineers of Woodland, California.

We have incorporated the comments and recommendations which the Colusa Basin Drainage Action Group has made in this final report.

It has been a pleasure to work with the members of your Group to complete this investigation. The guidance of the Group in helping to develop a report which provides a comprehensive review of the Colusa Basin Drain problems has been most helpful.

Very truly yours,

Thomas E. Landon

TEL/kjs

T. E. LANDON, C.E. D. J. HOLVIK, C.E: G. W. WHITE, L.S. W. K. JACKSON, C.E:

ACKNOWLEDGEMENT

During the course of this investigation, the assistance of many individuals and agencies proved invaluable in providing data and information to compile the report. We wish to acknowledge the cooperation of the following agencies and entities.

California Department of Fish and Game

California Department of Transportation

California Department of Water Resources

California State Reclamation Board

Colusa County Department of Public Works

Glenn Colusa Irrigation District

Kanawha Water District

Knights Landing Ridge Cut Water Users and Drainage Association

Knights Landing Ridge Drainage District

Reclamation District No. 108

Reclamation District No. 2047

Soil Conservation Service

The University of California at Davis

U. S. Army, Corps of Engineers

U. S. Fish and Wildlife Service

U. S. Geological Survey

Water and Power Resources Service

Woodland Farms Ltd.

MEMBERS

COLUSA BASIN DRAINAGE ACTION GROUP

Glenn County

Supervisor Keith Hansen
Ron Vickery (Kanawha Water District)
Robert Clark (R.D. No. 2047)

Colusa County

Supervisor H. L. Peterson - Chairman
Eugene Massa (Landowner)
Harold Myers (Westside Water District)
Shirley Griffin (Colusa County Water District) (Alt.)

Yolo County

Supervisor Twyla Thompson
Dave Granicher (Knights Landing Ridge Drainage District)
Secretary/Treasurer
George Youngmark (Knights Landing Ridge Cut Water Users and Drainage Association)

The following individuals and organizations provided financial support for the development of this study:

California Central Valley Flood Control Association
Colusa County
Colusa County Water District
Davis Ranches
Glenn Colusa Irrigation District
Glenn County
Kanawha Water District
Knights Landing Ridge Cut Water Users and Drainage Association
Knights Landing Ridge Drainage District
Reclamation District 108
Reclamation District 2047
Ridge Cut Farms
River Garden Farms
Fred S. Tadlock
Tuttle & Beachamp
Woodland Farms Ltd.
Yolo County

1) INTRODUCTION

A. SPONSORING ORGANIZATIONS

In the fall of 1978, The Board of Trustees of Reclamation District No. 2047 in cooperation with many interested individuals, Drainage Districts, County Representatives, Water Districts and Irrigation Districts sought to define the drainage problems throughout the Colusa Basin Drainage System. The Trustees requested input and comments from local people and entities in order to identify drainage and winter flood problems and requested that Tom Landon of Landon Engineering and Surveying, Inc. and Ken Lerch of Laugenour and Meikle, Civil Engineers, jointly prepare a proposal to prepare a study report.

An Ad-Hoc Advisory Committee was formed with an objective to develop a statement of the problems associated with the drainage and flood control within the overall basin, and to develop a means to fund the study.

The Colusa Basin Drainage Action Group was formally organized out of the Ad-Hoc Committee on August 15, 1979 and a trust fund was established to fund the engineering study.

The Group consists of nine members who are appointed as follows: The Boards of Supervisors of Glenn, Colusa and Yolo Counties each select one of their members to serve. Further, the respective Boards appoint two others who have economic interests in the Colusa Basin or who are connected with a district, water agency, or other organization which makes use of the Drain.

According to the adopted by-laws, the general purpose of the Colusa Basin Drainage Action Group is to promote cooperation between

landowners, districts and others whose lands adjoin or make use of the Colusa Basin Drain and to promote consistent and equitable management of irrigation and drainage facilities in the area to the continuing good and betterment of all local interests.

During the development of this report, Colusa Basin Drainage Action Group members meet periodically and provided review and input.

B. SCOPE OF THE STUDY

In order to comply with the stated objectives of the Colusa Basin Drainage Action Group, the scope of the investigation was formulated. It was the general consensus of the participants that winter drainage and flooding would not be considered, as it would be beyond the scope of this report. Numerous studies and reports on the subject of winter flows are available and many are mentioned in this report. Drainage and runoff problems would be identified and discussed, but solutions to the problems identified in the investigation would not be a part of the study.

In order to make a comprehensive investigation of the drain, the study was segregated into the following work study areas or tasks:

1. Review and analyze existing known studies of the Colusa Basin Drain and Knights Landing Ridge Cut and develop a brief history of the development of the Drain.
2. Inventory existing physical encroachments within the Colusa Basin Drain designated floodway, using data available from existing studies verified by field inspections and an analysis of downstream impediments to outflow.
3. Review existing agency studies and analyze the effect of irrigation outflow and development on the Colusa Basin Drain.

4. Make a reconnaissance analysis of Colusa Drain flow capacity.

5. Make an analysis of factors contributing to flooding problems within the Colusa Basin.

6. Analyze existing management of Colusa Basin and project future management requirements.

7. After input from the Colusa Basin Drainage Action Group, prepare a summary, conclusion and recommendations in a final report form.

C. REPORT DATA

Excerpts of existing reports and studies have been included in the text and appendix along with a complete list of reference information sources. The studies and reports reviewed provided much of the background data needed to investigate the drain system. Many cost and design studies have been presented in the past, all of which show that construction of physical flood improvements are not substantially cost effective or feasible at this time. Better regulation of spring and summer flows by way of cooperative management of irrigation outflows by the various entities is considered. A discussion of these items and ways to alleviate local drainage problems caused in part by encroachments is included in the study.

2) HISTORY AND BACKGROUND OF THE COLUSA TROUGH AND ADJACENT RIVER AREAS

In order that a proper background may be obtained for an areal view of the problems encountered and the extensive development work accomplished in the Colusa Trough region, it has been deemed necessary to present a brief description of the major factors affecting development and reclamation in the area. This is done in the following section.

Among the more important background conditions that have influenced agricultural development and reclamation of the Colusa Trough and River Area are the geology and topography of the region, flood conditions, soils, early reclamation laws and valley flood control projects.

A. GEOLOGY

Since early geologic time, some 181 to 135 million years ago, the great Central Valley of California has been a depression or structural trough, which has generally been sinking as the bordering mountain ranges have been rising and into which streams have carried and dropped the sediments brought down from adjacent mountains. This has resulted in a valley fill several thousand feet thick.

The Sacramento Valley occupies approximately the northern 40 per cent of the great Central Valley of California. Its enclosure, except at its southern end, was accomplished at the close of Cretaceous time (135 to 63 million years ago) by the folding and uplifting of the earths surface that resulted in the Coast Range. The sediments carried into the gulf-like depression during Tertiary

time (63 to 1 million years ago) consisted of fine grained tuffs, sands and clays.

During the early period of valley sedimentation, the Sierra Nevada and Klamath Mountains had a low relief. Their streams deposited much of their coarse sediments in channels now found at elevations above the present mountain stream channels. It is these coarse sediment deposits that constitute the auferous gravels of the early mining days in California. The era of sedimentation was brought to a close by a period of intense volcanic activity, which produced the great lava and ash fields of the Lassen region.

This period of intense volcanic eruption was followed by a period of crustal adjustment which resulted in the uplift of the Sierra Nevada and Coast Range Mountains to their present elevations. This adjustment brought about a rejuvenation of drainage along new lines, with heavy erosion in the mountain areas and along the borders of the valley. It also caused the building up, during Pliocene and Pleistocene time, of great stream fans and a valley plain through deposition similar to that now being carried on over the valley depression.

Continued uplift of the Coast Range caused a warping of the valley region in adjustment. The older alluvium is found as great alluvial fans uplifted and dipping slightly toward the valley from the east and plunging rapidly below the younger alluvium from the west, due to faulting south of Stony Creek.

The modern or recent period of alluviation has resulted in the physiographic condition previously described. Within recent geologic time, continued volcanism (the last being the 1915 eruption of Mount Lassen), crustal adjustment, and climatic changes resulted

in glacial periods. These periods have influenced the character of the sediments deposited and the topographic form of the present valley plain, which were quite important in the development of effective reclamation works.

B. TOPOGRAPHY

The Sacramento Valley is a great plain formed by vast quantities of sediments washed down from the adjacent mountains during the millions of years since the mountains were first uplifted. Part of these sediments were deposited in still back-water at various times when the valley was below sea level, and part were deposited in alluvial fans when the valley floor was above sea level. The valley has a length of about 150 miles, extending from the vicinity of Red Bluff on the north to Suisun Bay on the south. It has a maximum width of approximately 40 miles and an area of about 4,500 square miles.

In recent geologic time the present alluvial fans have become more defined and have formed a more or less continuous plain sloping gradually from the base of the foothills toward the axis of the valley. While these fans were being formed, the Sacramento River was building up its banks by the deposit of sediments during the almost yearly and often protracted periods when stream flow exceeded the natural river channel's capacity and overflowed its banks. The slope away from the river was quite rapid at first, often as much as ten feet in a one-half of a mile, but flattened to practically nothing as it met the alluvial plains extending out from the foothills. The meeting of these two slopes resulted in troughs, one on each side of the river. The troughs generally parallel the river at a distance of two to eight miles and at elevation from

four to twenty feet lower than the river banks.

These troughs were not continuous, but were separated into basins by ridges usually built up by the larger tributaries of the main river. On the east side of the river are located the Butte, Sutter, American and Sacramento Basins and some smaller ones to the south. On the west side, there are only the Colusa Basin in the north and the Yolo Basin in the south. The latter two basins are separated by the broad flat ridge built up by deposits from a former channel of Cache Creek, upon which the town of Knights Landing is located.

Colusa Basin is divided into an upper and a lower basin by the broad flat ridge built up some six to eight feet above the adjacent lands by deposits during periods of overflow of Upper Sycamore Slough. This slough was a major overflow channel of the Sacramento River. It left the river at the former town of Sycamore and ran southwesterly for about five miles to the vicinity of Wallace Crossing (near the north boundary of Reclamation District No. 479), then turned south for some four miles and then east for about a mile, and finally disappeared in the bottom of the trough east of College City. Only a narrow channel was left between the north-south section of the ridge and the higher ground of the alluvial plain extending out from the Coast Range Mountains to connect the upper and lower basins.

Upper Colusa Basin is a long, narrow tract of land about four miles wide and 25 miles long, with a longitudinal slope of one to two feet per mile. The trough of this basin is quite narrow and is depressed about ten to fifteen feet below the banks of the Sacramento River. It drains winter flood waters quite rapidly into the lower basin through the narrow straight channel described above. Lower Colusa Basin is

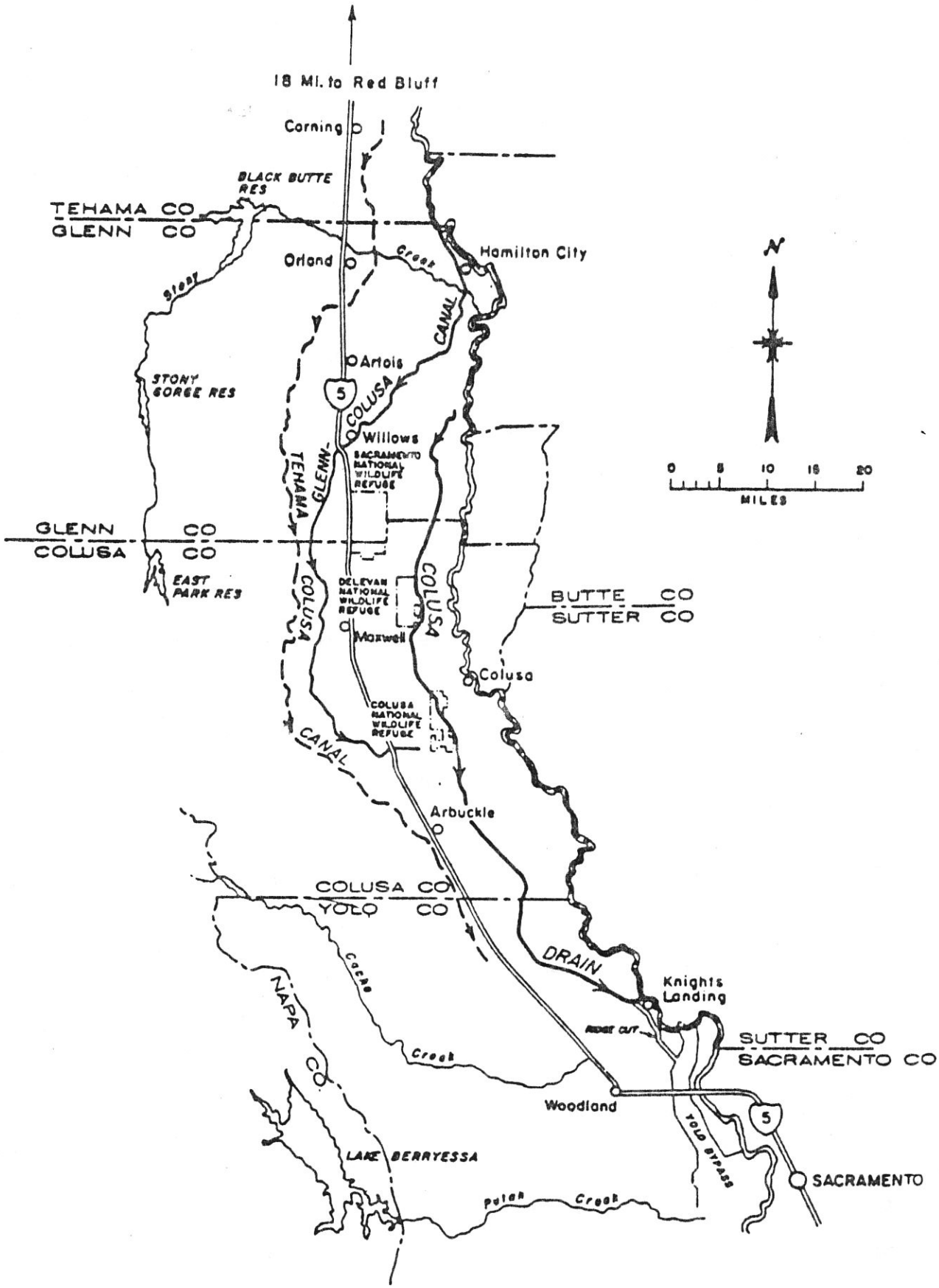


Figure 1. Location map of the Colusa Basin Drain in relation to the Sacramento River and Glenn-Colusa and Tehema-Colusa Canals (USBR, 1974).

also about 25 miles long, but has an average width of approximately 7-1/2 miles. It has a very flat longitudinal slope, averaging scarcely 2-1/2 inches per mile. Its trough is two to three miles wide and near its center is more than 15 feet below the present banks of the Sacramento River.

The bottom of the trough in Lower Colusa Basin is relatively flat and regular. There were, however, several landlocked, shallow depressions that could not be drained by gravity and only dried up by evaporation and/or transpiration through the tules that covered the lower ground. As mentioned, the slope near the river was quite steep, being more than ten feet in a half mile at a few places. This slope was not uniform along all the river frontage but was broken by numerous flat ridges of various sizes. Lower Sycamore Slough, the natural drainage channel for the lower Colusa Basin, had built up its banks only to a slight extent.

C. FLOOD CONDITIONS

The Sacramento River drains a total area of approximately 26,500 square miles. Of this total, about 80 percent is mountainous and the balance is the valley floor. At times there is heavy and prolonged precipitation on the entire watershed that results in severe flood conditions. The peak flood discharge during the 1907 and 1909 floods was determined to be in the neighborhood of 600,000 cubic feet per second.

The actual flood volume of the Sacramento River is exceeded by three rivers in the United States: the Mississippi below its confluence with the Missouri, the Ohio River, and the Columbia River. Taking into consideration the relative areas of drainage

basins, the flood volume of the Sacramento is fifteen times as great as that of the Mississippi and four times as great as that of the Ohio or the Columbia.

In general, the passage of storms over the Sacramento River Basin is in a direction favoring low values of concentration at all points in the lower valley. The order of concentration of the major tributaries at the edge of the valley floor is usually from south to north. The distribution, duration and varying intensities of the storms are such that all the streams rarely experience flood peaks at the same time. Were the reverse true, floods greater than have been experienced could be expected.

In seasons of heavy rainfall, the flood basins were filled by runoff from the adjacent plains and hills and by water from the Sacramento River and its tributaries flowing over their banks, or through crevasses or overflow channels. The basins discharged into the next lower basin, or more often back into the main river through sloughs as the flood level lowered. This drainage of the flood basins frequently took several months to accomplish.

In times of great and prolonged floods, these basins performed a dual function, acting both as large shallow flood channels and as temporary equalizing reservoirs that absorbed the peak of the floods. The great flood plain during these major flood seasons was practically continuous and varied in width from two to thirty miles. It extended from the mouth of the Sacramento River almost to Red Bluff, a distance of about 150 miles, and at times occupied an area in excess of one million acres.

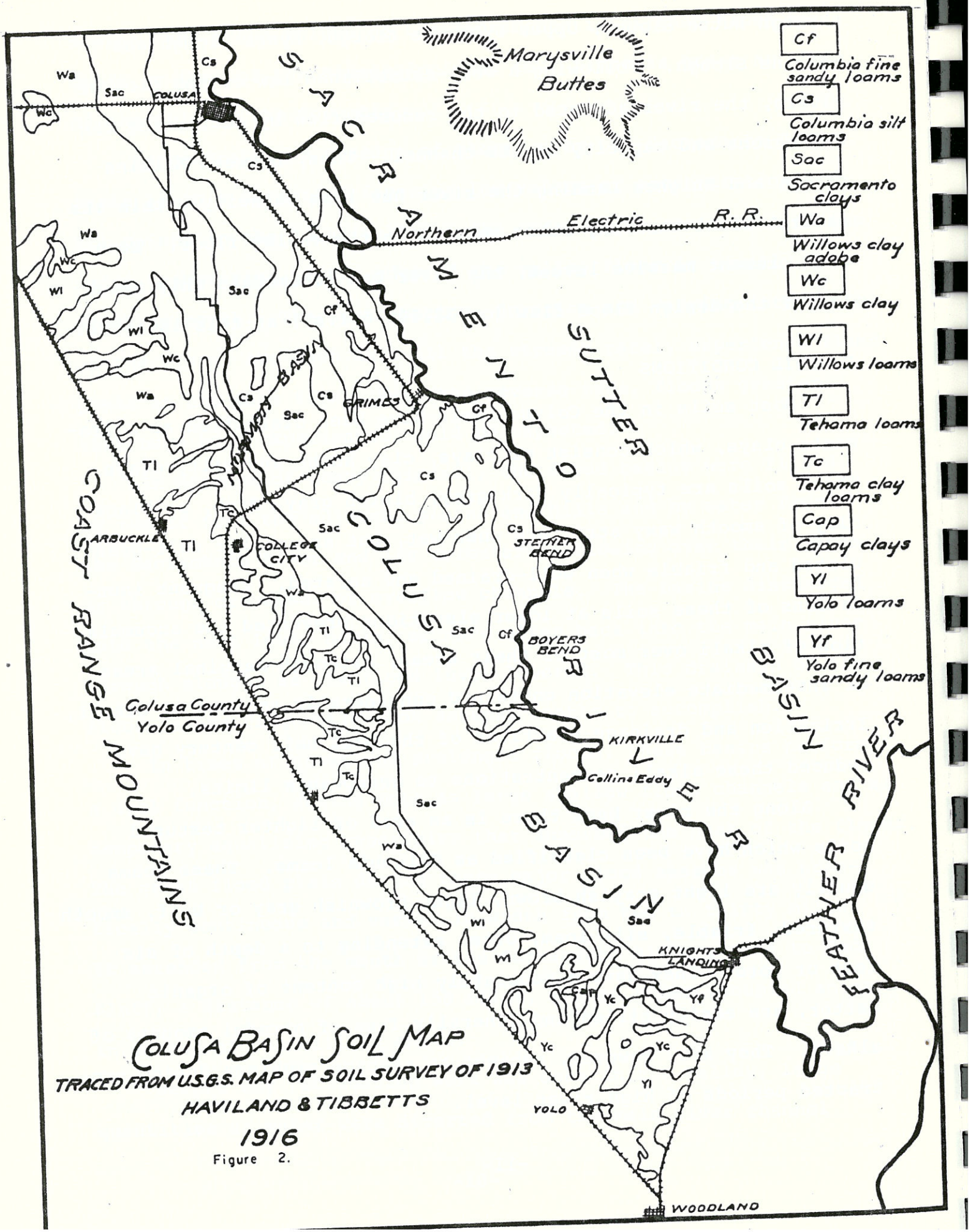
Before any reclamation work was done in the valley, large quantities of water were diverted from the main river channel

through Butte Slough, Upper Sycamore Slough, Byers Slough and Wilkins Slough. Following a well-established law of the flow of rivers, the river adjusted to the reduced flow by decreasing the dimensions and capacity of its channel. Thus, between Wilkins Slough and Knights Landing the river has less capacity within its natural banks than any other section in the valley floor. Even with present massive levees, the river can accomodate only about 1/7 of the design flood flow (or 33,500 c.f.s.) at this latitude.

D. SOIL CONDITIONS

Most soils in the Colusa Basin have been classified as Sacramento clays, which consist of clays, clay adobe and silty clays. These soils are typically dark gray, bluish gray, drab, or black clay of smooth waxy structure when wet, but are rather well-granulated and friable when well-drained and aerated. Frequent inundations of these soils at lower elevations prevented the accumulation of alkali over most of their areas, although marginal areas of intermediate elevation contained considerable amounts of alkali. Irrigation and drainage practices of the past half century have reduced these alkali concentrations to acceptable limits.

Along the river bank there is an area of lighter textured soils which have been classified as Columbia loams. These loams usually are light grayish brown, light brownish gray or buff, smooth textured, friable, silt loam, often extending to a depth of six feet or more. They have a moderately high content of organic matter, are easily tilled and generally free of harmful amounts of alkali. They are, however, subject to seepage problems during protracted periods of high river level.



COLUSA BASIN SOIL MAP

TRACED FROM U.S.G.S. MAP OF SOIL SURVEY OF 1913

HAVILAND & TIBBETTS

1916

Figure 2.

of $1.00 per acre. By an act of 1862 supplementing the 1861 act, the levying of assessments by a county Board of Supervisors for reclamation works was authorized if requested by a petition signed by the owners of one-third the land in the district. This provision for assessment was not successful due to disagreement among the landowners in the districts.

The Board of Swamp Land Commissioners was abolished in 1866 and its powers and duties were transferred to the Board of Supervisors of the county in which each district was principally located. In 1868, all existing reclamation laws were repealed by the State Legislature and a new act was passed. In addition to reenacting the general provisions of the former laws, the new act introduced several important new features.

The Boards of Supervisors of the various counties remained in direct charge of the reclamation districts and of general reclamation work under the provisions of the 1868 Act. However, a method of organizing districts was prescribed, as well as a method of electing trustees and of levying and collecting assessments. No limit whatever was placed on the amount of land that might be taken up by an individual. As a result of this provision, hundreds of reclamation districts were formed after the passage of the Act, and the state sold about one million acres of the best swamp and overflowed lands in a few years.

No general scheme of reclamation or flood control was followed by the various Boards of Supervisors, so reclamation districts of all sizes and shapes were formed, many overlapping others. As a consequence of this lack of a general reclamation and flood control plan, it became the general practice for reclamation districts to

establish their boundaries and construct their works without any regard for other neighboring districts.

The effect of this lack of cooperation among reclamation districts was to increase the flood hazard to adjacent reclaimed lands each time a new area was leveed, since each additional reclamation project eliminated a portion of the storage capacity of the overflow basins and tended to obstruct and reduce their channel capacity. The ultimate effect of all such reclamation was to raise the flood plain and produce higher flood stages in the river.

Although a number of amendments and modifications were made from time to time, the main principles of the 1868 Act remained in effect until 1911. At that time the State Reclamation Board was created and charged with the supervision of all reclamation works along or near the banks of the Sacramento River and its tributaries. During the period from 1867 to 1911, a total of 772 reclamation districts were formed, but only about eleven per cent of them are still active.

Of the many districts formed during this period, a considerable number were organized merely to qualify for the collection of the per acre allowance for completed reclamation from the swamp land fund. This qualification was often accomplished by the simple expedient of ploughing a furrow around the designated boundaries. Many other districts proved to be infeasible or uneconomic on further study. Considerable numbers of districts were organized for the sole purpose of avoiding inclusion in major districts and the responsibility of paying assessments, even though reclaimed and benefited by the works constructed.

F. VALLEY FLOOD CONTROL SCHEMES

Ever since the settlement of the Sacramento Valley, the floods of the Sacramento River and its tributaries have been the cause of much apprehension and damage to the inhabitants. As the agricultural lands came more and more under cultivation, the damage done by floods caused a greater and greater monetary loss. The best method of securing protection against such damage has been the subject of extensive study, investigation and controversy.

Many of the earlier plans were intended to provide relief only to a portion of the valley. Among these were the diversion of Cache and Putah Creeks to Suisun Bay by a high-line canal through the Montezuma Ridge; the diversion of the Yuba, Bear, and American Rivers into the American Basin; various plans to divert part or all of the flood waters of the Sacramento River into the San Joaquin Valley; the proposal to excavate a deep and capacious waterway through the Montezuma Ridge in Solano County that would convey the flood waters of the Yolo Basin into Suisun Bay; and massive levees around some municipalities.

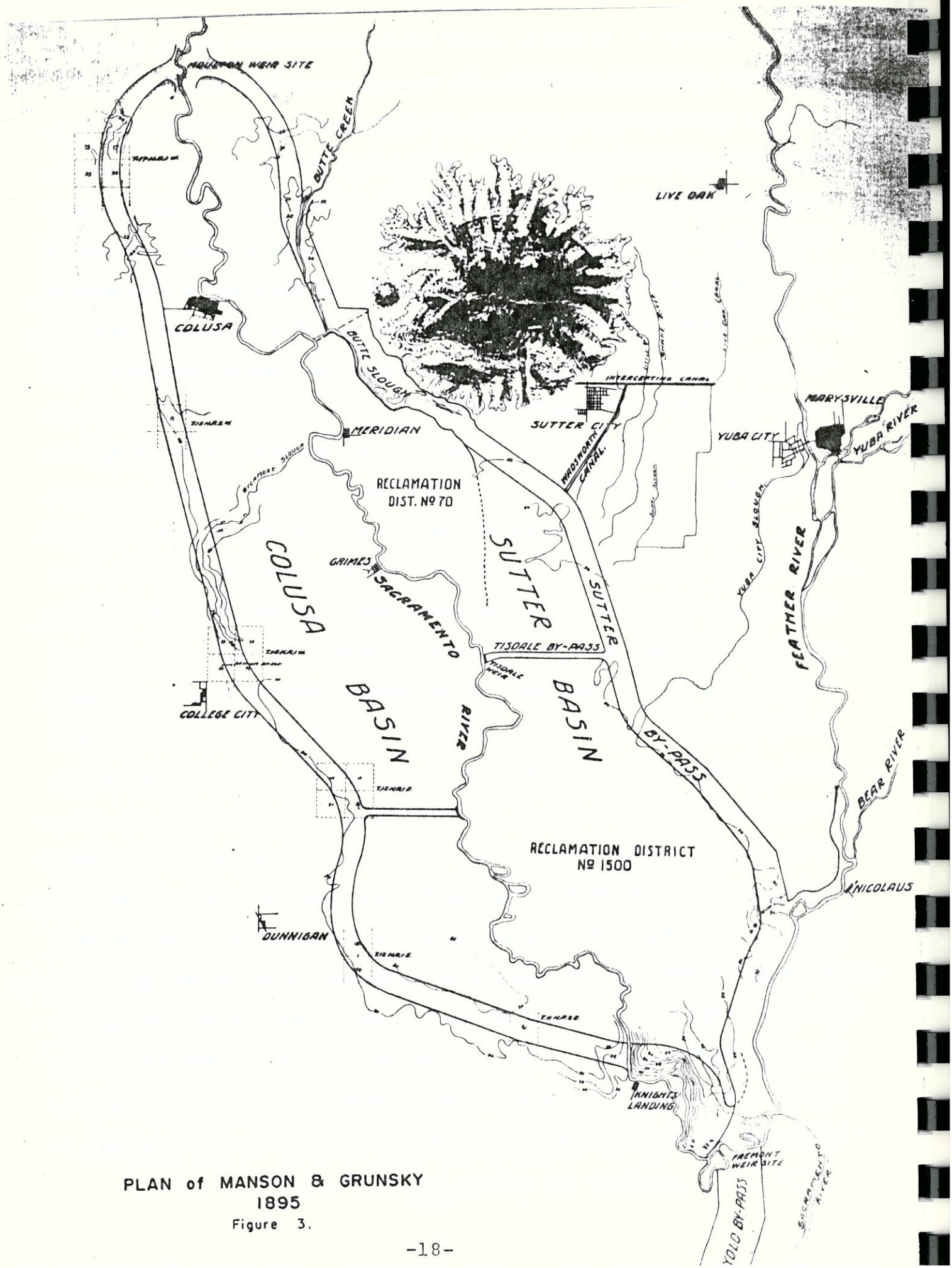
Gradually, projects for fully controlling the Sacramento River floods and making it possible to reclaim the bulk of the swamp and overflowed lands in the valley were developed. These followed two general theories - the "main channel plan" and the "bypass plan". Two plans following the main channel plan and two following the by-pass plan were developed and reported in considerable detail. These are summarized in the following paragraphs.

William Ham Hall Plan. A general plan of reclamation was devised in 1880 by Mr. William Ham Hall, then State Engineer, and a board of consulting engineers consisting of General S. Alexander and

Colonel George H. Mandell, Corps of Engineers and Mr. J. B. Eads. This plan proposed confining the river's flood flow between high levees, cutting off many bends to increase velocity and scour, enlarging some delta channels, with the intention that the river should eventually carry all of the flood flow in its own channel. Side relief channels were to accomodate the excess not carried by the river itself, but these relief channels were to be ultimately abandoned when the river had developed its ability under this treatment to carry all floods. This plan was never accepted or acted on by the State Legislature.

Manson and Grunsky Plan. The by-pass system was advocated by Messrs. Marsden Manson and C. E. Grunsky, who, as consulting engineers to the State's Commissioner of Public Works, submitted in 1894 a report on the flood control of the Sacramento River. The project involved (1) the enlargement and utilization of the stream channels to their maximum capacity as drainways, i.e. channel rectification; (2) the overflow of surplus waters from the stream channels at selected points; and (3) the control of the surplus waters between embankments forming by-pass channels and rapid delivery of these waters into Suisun Bay.

Channel rectification was to consist of increasing the river's capacity below the mouth of Cache Slough near Rio Vista by dredging and inducing scour, enlarging Steamboat Slough to make it the main drainage channel in the delta, and systematically improving the river's alignment above the mouth of the Feather River. By-pass channels were to be provided through Yolo Basin, Sutter Basin, Butte Basin and Colusa Basin. The by-pass through the Colusa Basin was to extend from a weir located about four miles below



PLAN of MANSON & GRUNSKY
1895
Figure 3.

Jacinto through the Colusa Basin and the Knights Landing Ridge and connect with the Yolo by-pass. It was intended to act principally as a drainage canal for the Colusa Basin and its drainage area. (See Figure No. 3) Some five other weirs were proposed and all to be located and designed so as to pass flood waters into the by-passes only at very high stages of the river.

Dabney Commission Plan. In 1904, a Commission of engineers was appointed to investigate the flood problems of the Sacramento and San Joaquin rivers and their tributaries and recommend a plan for correction of the faulty conditions. This Commission, commonly known as the Dabney Commission, consisted of Major T. G. Dabney, Chief Engineer of the Yazoo Mississippi Delta Levee District; Major Henry B. Richardson, member of the United States Mississippi River Commission; Major H. M. Chittenden, U.S.A., in charge of Yellowstone Park and the Missouri River; and Mr. M. A. Nurse, Chief Engineer to the Commissioner of Public Works for California.

The formation of this commission was brought about by the disastrous flood in the spring of 1904 and the desire to prevent similar damage in the future. A State River convention was called in San Francisco on May 28, 1904, with delegates attending from representative and public bodies interested in the improvement of the rivers and the reclamation of the valleys. The River Improvement and Drainage Association of California was formed and a resolution unanimously passed to appoint the Commission.

The Commission organized August 9, 1904 and proceeded to assemble and analyze all available data on floods and flood control plans then available. It received substantial assistance from earlier investigators and others concerned with the problem. A number of field trips were made to observe conditions on the ground.

channel and the remainder into a river by-pass system. This system would return the flood waters back into the Sacramento River through Cache Slough, just north of Rio Vista in Solano County. The proposed by-pass system was to traverse the entire length of the Yolo Basin (Yolo By-Pass), cross the Sacramento River near the mouth of the Feather River, then proceed through the Sutter Basin (Sutter By-Pass) and into the Butte Basin to Moulton Weir. (See Figure No. 3)

The California Debris Commission Plan was approved by the California Legislature in 1911 and, in addition, the Legislature created the State Reclamation Board to administer the approved project. In 1913, the Sacramento and San Joaquin Drainage District was formed to acquire lands and assess benefits for the project. The State Reclamation Board also acts on behalf of the District.

The approved plan later called the Sacramento River Flood Control Project, was authorized as the Federal Flood Control Project in 1917. The project, now essentially completed, consists of a system of levees, overflow weirs and flood by-pass channels. It was not until 1958 that the levee system in the Colusa Basin was completed as part of the project. This recent work consisted of improving the levee to project standards from just below the City of Colusa south to Knights Landing along the east side of the Colusa Basin Drain Channel.

G. COLUSA BASIN DRAIN AS AN IRRIGATION SUPPLY FACILITY

The Colusa Basin Drain also serves as a water supply facility for lands adjoining the drain. To be effective as a source of supply, the water surface must be maintained at a level adequate

for pump submergence to allow for pumped diversions. In the upper basin check structures maintain the water level. Some of these structures are maintained and operated by irrigation districts. There are also a number of small structures which have been installed by individual farmers in order to make pumped diversions from the drain.

The details of the actual use of the Colusa Basin Drain and the Knights Landing Ridge Cut as an irrigation facility are not part of this report.

H. HISTORY OF DISTRICTS IN AND ADJACENT TO THE COLUSA BASIN DRAIN

Note: Many of the districts have long and sometime stormy histories. The material included herein pertains only to those historical activities related to development of the Colusa Basin Drain.

H.-1 HISTORY - Reclamation District 2047

Reclamation District 2047 was formed on December 16, 1919 for the purpose of developing adequate drainage facilities to alleviate flooding due to overflow of irrigation waters in the Upper Colusa Basin. Reclamation District 2047 is situated in Colusa and Glenn Counties and includes practically all of the

Upper Colusa Basin from near the town of Artois on the north to just south of Williams.

The District is approximately 30 miles in length, with an average width of 11-1/2 miles, and covers an area of 220,000 acres. In 1920, 200,000 acres were under irrigation, and approximately 100,000 acres of this area were planted in rice.

As of 1905, no well-defined channel existed in the Colusa Basin. The District's plan, as designed by District Engineer Mr. Chas. de St. Maurice, was to construct a channel of varying width along existing natural drains or newly constructed channels from the northern limit of the District to a point at the northern end of Reclamation District No. 108's back levee borrow pit, north of College City. The borrow pit was then to serve as the main drain, taking water south approximately twenty miles to the pit's southern end. The drain would then utilize Reclamation District No. 787's borrow pit for a distance of five miles, terminating at the Sacramento River near the town of Knights Landing. A drainage easement was acquired along the north borrow pit of the Reclamation District No. 787 levee to conduct drainage water to a proposed pumping plant at El Dorado Bend. Various laterals were also constructed to drain lands along the main channel unable to drain directly into it. However, as conceived, the District was not allowed to pass water down the Knights Landing Ridge Cut since no drainage flow rights were acquired.

The purpose of the above-described drainage system was to provide a gravity drainage system, the outlet of which was into the Sacramento River near Knights Landing. During periods when gravity flow into the river was not possible due to high water levels, the gravity system was to be supplemented by pumping water

from the El Dorado Bend and Rough and Ready Bend pumping plants.

Right-of-way for the construction of the main channel and laterals in the District was obtained from the various landowners by purchase. The right-of-way agreements between the District and the landowners contained no reference to water use or responsibility for flood damage from waters associated with the District. Some of the agreements contained requirements that the District construct wooden bridges across the channel for the farmer's access to his property. Many of these structures have since been removed.

Even though no specific mention of water use was included in the right-of-way agreements, the consensus within the District was that landowners had the right to use any water crossing to their property but that no obstruction could be allowed in the channel

AGREEMENTS:

In order to accomplish the drainage plan previously described, it was necessary that the District obtain the rights to use certain improvements and works of various Districts located at the southern end of Reclamation District No. 2047, to wit:

Reclamation District No. 108

That Reclamation District No. 2047 use the west borrow pit of Reclamation District No. 108 for its entire length as a drainage canal.

That Reclamation District No. 2047 occupy and use a portion of Lower Sycamore Slough and the Main Canal of Reclamation District No. 108 to transfer water to the Reclamation District No. 108 pumping plant at Rough and Ready Bend.

That Reclamation District No. 2047 construct a sluice gate in the back levee of Reclamation District No. 108 to admit water to the canal leading to the pumping plant at El Dorado Bend.

That Reclamation District No. 2047 construct a weir across Lower Sycamore Slough to control the flow of drainage waters to the Rough and Ready Bend pumping plant.

That Reclamation District No. 108 would be allowed to use the El Dorado Bend Pumping Plant during the winter months to pump surface and flood waters in exchange for allowing Reclamation District No. 2047 to use a portion of Reclamation District No. 108's pumping plant at Rough and Ready Bend to pump irrigation drainage waters.

Reclamation District No. 787

That Reclamation District No. 2047 occupy, reconstruct and use the borrow pit along the western levee of Reclamation District No. 787 for its entire length as a drainage canal.

That Reclamation District No. 2047 occupy, enlarge and use the southern borrow pit of Reclamation District No. 787 for its entire length to the Knights Landing Outfall Gates.

Knights Landing Ridge Drainage District

That Reclamation District No. 2047 occupy and use such channels owned or controlled by the Knights Landing Ridge Drainage District, and the Outfall Gates situated in said borrow pit, near Knights Landing, except for the Knights Landing Ridge Cut to the south.

That Reclamation District No. 2047 construct a weir structure across the upper end of the Knights Landing Ridge Cut to control the flow of Reclamation District No. 2047 drainage waters.

Sacramento River West Side Levee District

That Reclamation District No. 2047 occupy a certain portion of the Sacramento River West Side Levee District right-of-way and levee at El Dorado Bend for the purpose of construction, operation and maintenance of a pumping plant.

The above agreements were made with the understanding that no cost would be incurred by Reclamation District 2047 for using the facilities, other than power and maintenance costs, after construction. It was provided, however, that Reclamation District 2047 control its drainage waters in such manner as not to damage the properties of the other districts.

The agreements between Reclamation District No. 2047 with the various districts have been breached. Structures that were built including the back leveee sluice gate and lower Sycamore Slough weir, were abandoned and have deteriorated to the point where they are unusable. The weir structure across the upper end of the Knights Landing Ridge Cut was never constructed. The El Dorado Bend pumping plant has been rebuilt and the pumps used for irrigation as per the agreement with Reclamation District No. 787. The easements in the borrow pits obtained for the flow of summer drainage water still hold.

HYDRAULIC CAPACITIES:

As mentioned previously, the Colusa Basin Drain was designed to relieve flooding due to excessive irrigation drainage waters. On the assumption that 100,000 acres of rice land would be the maximum amount within the district, the channel was designed for a maximum flow of 1,450 c.f.s. The water surface at this flow was taken as being one foot below adjacent lands to give some margin of safety during peak runoffs and also to preclude complaints from landowners not able to drain their lands. It was also assumed that one-half of the seasonal runoff from this rice acreage would occur within a period of 30 days beginning around September 15th and terminating on October 15th. In regard to pumping requirements, as required by high river stages, June 1st was felt to be the earliest date that pumping

would be required. Occasional pumping during the fall months of September and October was also expected.

The Colusa Basin Drain was sized in proportion to the amount of land it drained in various locations. In the Jacinto area, at the upper end of the system, the Drain was sized to handle 60 c.f.s., while the lower reaches were designed for 1,450 c.f.s. The channel as it exists today at the Highway 20 Bridge has a capacity of approximately 2,100 c.f.s. In comparison to this, the maximum measured winter flood flow at this location is 24,000 c.f.s.

In order to have the capacity to pump 1,450 c.f.s., the plant at El Dorado Bend was designed for a capacity of 800 c.f.s. at 10 feet of head, augmented by a pumping capacity of 650 c.f.s. at a 10 foot pumping head at the existing Rough and Ready plant.

HISTORICAL FLOODING PROBLEMS:

Even as early as June, 1922, after the upper drain had been constructed, complaints of flooding due to spring irrigation water runoff were received by Reclamation District No. 2047 from D. N. Hershey, whose land was located below the Knights Landing Ridge Cut. In addition, some flooding above the Knights Landing Ridge Cut was caused by the control barrier at the outlet being too high; the barrier has since been lowered. However, spring flooding problems have continued to this day, hampering spring planting and agricultural operations in general from College City to the Yolo Bypass.

Many changes have occurred in the operation of the drainage system since the early years of its existence. Today, when river stages are too high for gravity flow through the Knights Landing Outfall Gates, due to controlled releases at Shasta Dam, the Knights Landing Ridge Cut conveys drainage water into the Yolo Bypass.

The El Dorado Bend pumping plant is no longer maintained for pumping drainage water into the river, and the cross tie channel from the Colusa Basin Drain is now used primarily as an irrigation canal by the adjacent districts.

H.-2 HISTORY - Knights Landing Ridge Drainage District

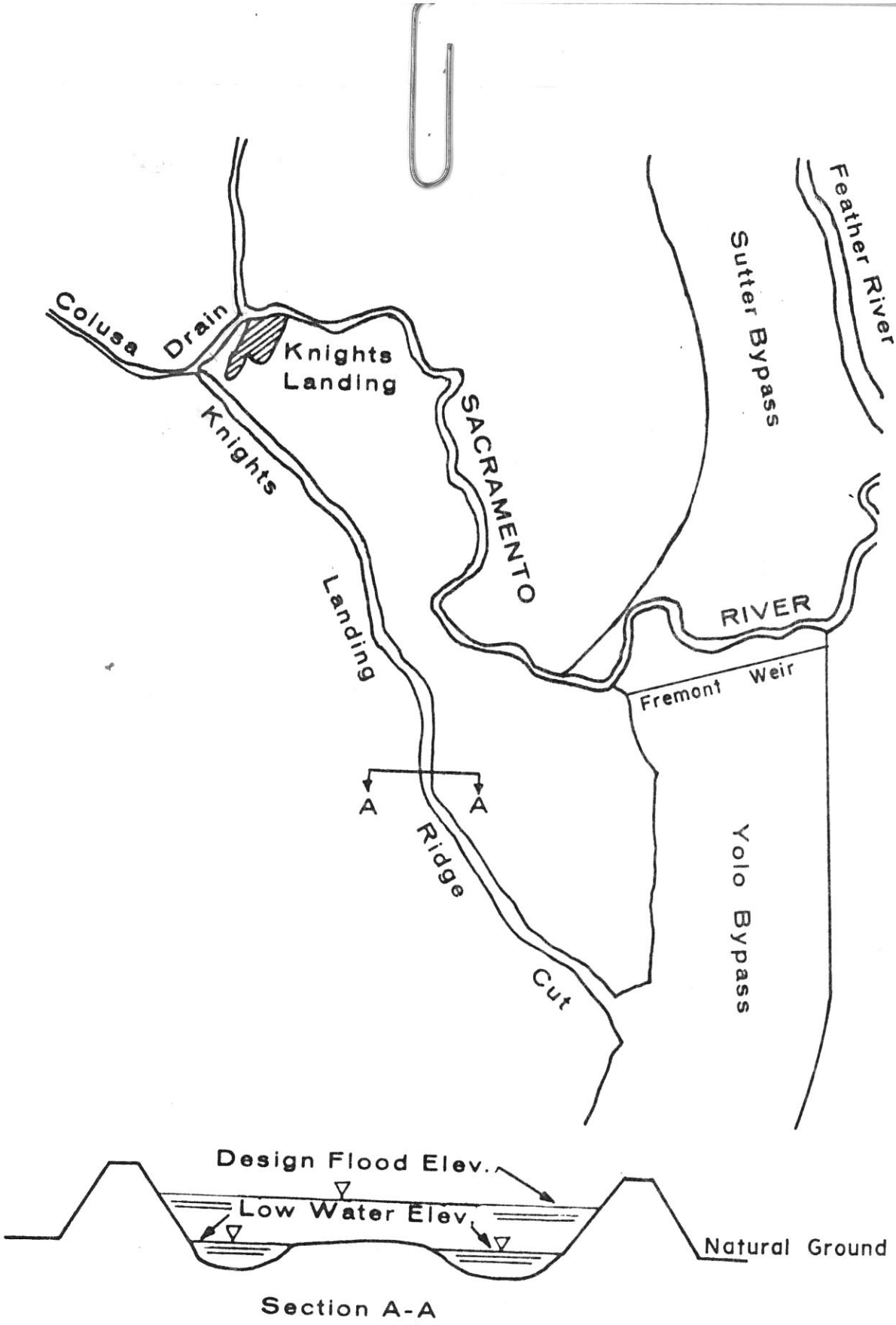
The Knights Landing Ridge Drainage District was formed on April 30, 1913, under a special act of the Legislature.

The District is located in Yolo and Colusa Counties, California, in T11, 12, 13 and 14 N., R1W, 2 and 3 E, M.D.B.&M. The District boundaries include Reclamation Districts 108, 730, 787 and 819, as well as the town of Knights Landing, a portion of the Sacramento River West Side Levee District, and Yolo County Service Area No. 6.

The District was formed to develop a plan to provide an outlet for water ponded between the back levee of Reclamation Districts 108, 479 and 787 and high ground on the west and south. This ponded water is prevented from flowing through the Knights Landing Outfall Gates by high stages in the Sacramento River. The District proposed a cut through the high ground on the south to provide an outlet for the ponded water. The report on the proposed cut is reviewed later in this text.

The Knights Landing Ridge is a broad elevated strip of land, built up by the overflow from Cache Creek, which separates Colusa Basin from the Yolo Basin. The Knights Landing Ridge Cut was dredged through the Knights Landing Ridge for a distance of about seven miles. This cut terminates in low lying land in the Yolo Basin at the western edge of the Yolo Bypass. The cut is about 400 feet wide at the bottom and has a maximum flow depth of nearly 20 feet. It has a discharge capacity of about 20,000 c.f.s. when the water surfaces elevations (USED Datum) are 39 feet at Knights Landing and 34.5 feet at the Yolo Bypass. The Ridge Cut was completed and in operation during the flood of September, 1915.

The Knights Landing Ridge Cut provides a gravity outlet for



KNIGHTS LANDING RIDGE CUT

(No Scale)

Figure 4.

floods occurring in the Colusa Basin. The outlet does not prevent the flooding of extensive areas along the Colusa Basin Drainage Canal during flood periods, but it greatly reduces the length of inundation.

When the Knights Landing Ridge Cut was dredged through the Knights Landing Ridge, the dredged material was placed along each bank to form levees. These levees constitute the only District works. The levees are 6.43 miles in length along the right bank and 6.14 miles in length along the left bank. These levees are maintained by the Knights Landing Ridge Drainage District which is responsible only for maintenance and operation of these levees.

The Knights Landing Outfall Gates, located adjacent to the Sacramento River just upstream of Knights Landing, consist of eight 66-inch and two 42-inch diameter outlets through the concrete structure. Each of the 66-inch outlets is equipped with a slide gate on the upstream end. The Knights Landing outfall structure, the gates and the floodway channel of the Knights Landing Ridge Cut are all maintained by the State Department of Water Resources under authority of Section 8361(g) of the California Water Code.

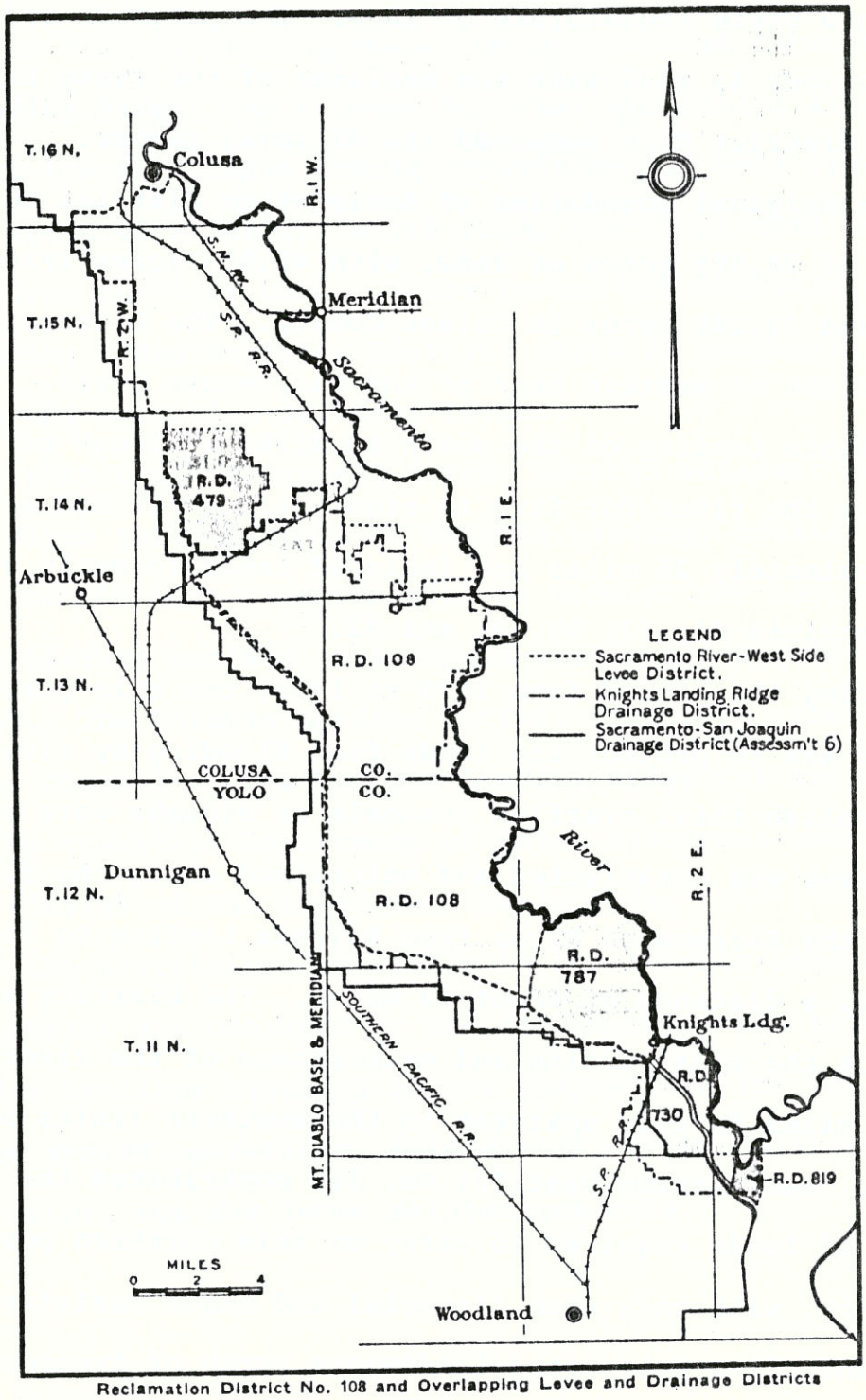
All of the irrigation facilities in the Knights Landing Ridge Drainage District are operated by the landowners. The Knights Landing Ridge Drainage District is not responsible for the irrigation and drainage system operations, maintenance or the delivery of irrigation water, but for levee maintenance only.

H.-3 HISTORY - Reclamation District No. 108

Reclamation District No. 108 was created September 28, 1870 by an order of the Board of Supervisors of Yolo County, acting under the provisions of the Swamp and Overflowed Land Act of the California State Legislature of 1868. The petition and order was filed October 4, 1870 with the Register of the State Land Office and the District then received its official number.

The original boundaries of Reclamation District No. 108 embraced a total of 74,085 acres of land, with 40,805 acres lying in Yolo County and 32,280 acres in Colusa County. The District was located on the right or western bank of the Sacramento River. It extended from Knights Landing on the south to Wilkins Slough on the north and west from the river for five to eight miles. It had a river frontage of approximately 25 miles and included lands formerly within Swamp Land Districts 64, 67, 90, 91 and 92.

During the period from 1870 to 1902, the sole purpose of the District was to protect its lands from flooding by river water. To accomplish this, overflow channels or sloughs were blocked off and a levee was constructed and maintained along the right or west bank of the Sacramento River from Knights Landing to the town of Sycamore, a distance of about 39 miles. The District also actively undertook the construction and maintenance of the river levee for some 40 miles further upstream to the southern limits of the town of Jacinto. Reclamation District No. 108 contributed the greatest portion of funds required to carry on this northern portion of levee work, with only such financial and other assistance as could be obtained from interested landowners north of Sycamore.



Reclamation District No. 108 and Overlapping Levee and Drainage Districts

Figure 5.

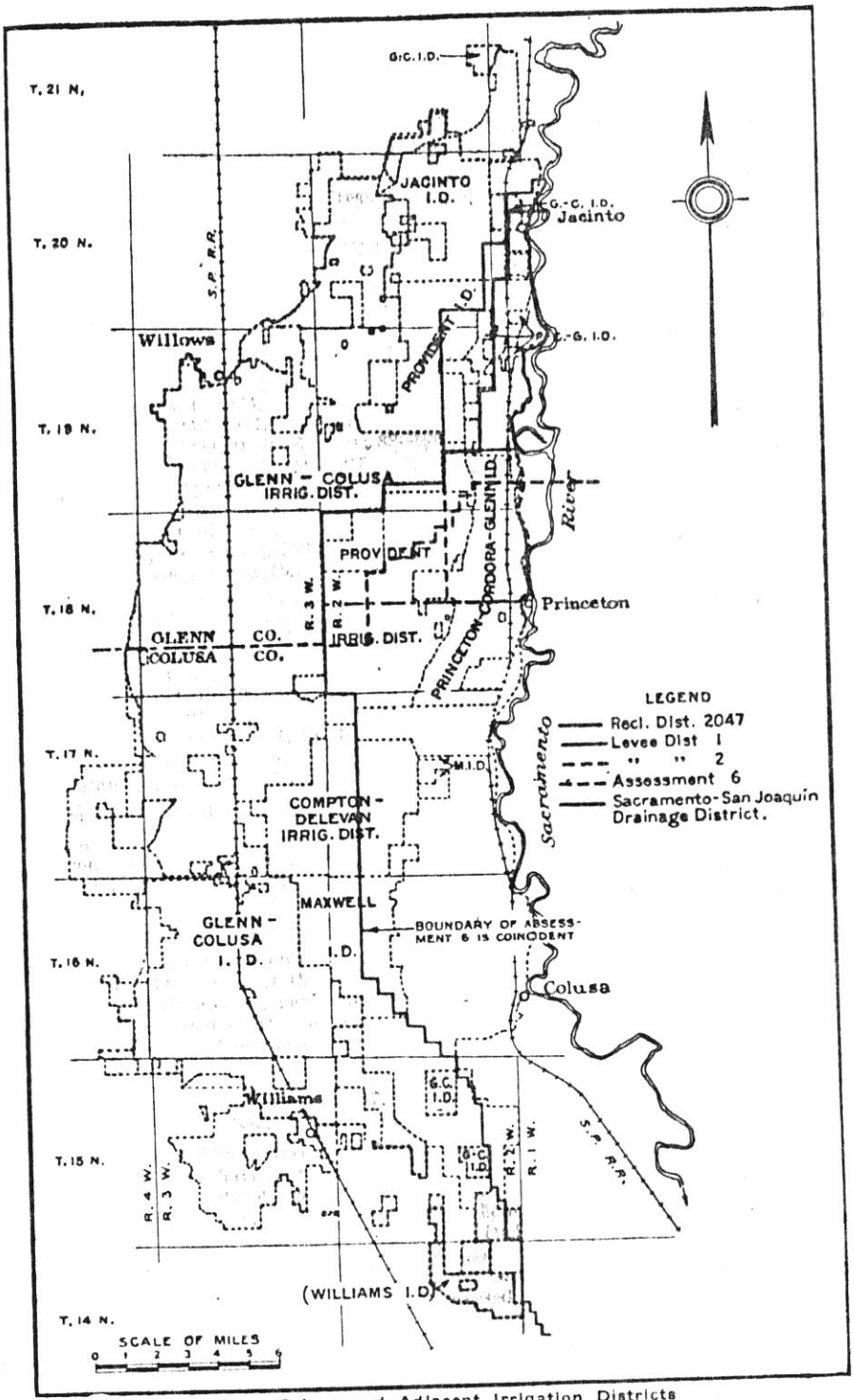
1930

After the District was reorganized in 1902, the new plan for reclamation included works to protect District lands from flood waters originating in the Coast Range foothills to the west and from breaks in the river levee upstream from Sycamore. To do this, the District acquired the then-existing levees between the northwest corner of Reclamation District No. 108 (at the junction of its boundary with that of Reclamation District No. 479 in Mormon Basin) and Howell Point, a distance of approximately ten miles. The levee was strengthened, raised and extended to high ground along the Sacramento River near Boyers Bend.

During major flood periods, such as in 1907 and 1911, water ponded west of the back levee was 15 feet or more in depth and some five miles in width. The strong southerly winds usually accompanying the winter storms resulted in waves of such size that during severe storms the levee was subject to severe wave wash and was breached several times.

Again in 1911, after another reorganization, the District's reclamation plan was modified to extend the back levee from the northwest corner of Reclamation District No. 108 to Jacob's Point, connecting with the back levee of Reclamation District No. 787. The borrow pits created during the construction of these back levees now form the lower portion of the 2047 Drain.

The Sacramento River West Side Levee District was formed in 1915 for the purpose of protecting its lands from overflow from the Sacramento River. As formed and now existing, the District embraces close to 100,000 acres of land. The Levee District extends from Knights Landing to Colusa along the west bank of the Sacramento River and includes all of the land in Reclamation Districts 108, 479 and 787, as well as a large area in no organized district that lays north



Glenn-Colusa and Adjacent Irrigation Districts
and Overlapping Reclamation, Drainage and Levee Districts

Figure 6

1930

of Districts 108 and 479 and south of Colusa. The Levee District raised, strengthened and maintains the 50 miles of river levee under its jurisdiction.

Through consolidation of Reclamation Districts 92, 94, 467 and 729 with 108 and the exclusion of other land from overlapping districts, the present boundary of Reclamation District No. 108 was redefined July 22, 1919, the effective date of reformation of the present district, and now contains 57,994 acres gross.

Reclamation District No. 108 is now protected from overflow by levees along the right bank of the Sacramento River and along the left bank of the Colusa Basin Drainage Canal. These levees are part of the authorized Sacramento River Flood Control Project. Internal drainage is provided by a well-conceived system of canals and laterals terminating at a drainage pumping plant at Rough and Ready Bend on the Sacramento River. The levees within Reclamation District No. 108 have been improved and strengthened progressively to conform fully with requirements of the Sacramento River Flood Control Project.

The levee along the left bank of the Colusa Basin Drainage Canal, (commonly called the back levee), the middle portion of which Reclamation District No. 108 maintains, extends from Knights Landing to high ground near Colusa protects land to the east from flood runoff of the western foothills. The portion of the back levee from north of Reclamation District No. 108 to Colusa is maintained by the State of California, Department of Water Resources and the southern portion from Jacobs Point to the Knights Landing Outfall Gates, by Reclamation District No. 787. As previously mentioned, in flood periods an extensive lake would form west of the back levee, then wind-caused waves would wash away the levee sections. In the early years, breaks

were frequent. In some years ponding became so extensive that flood waters would overtop the levee to flood the reclaimed area and overtop the Knights Landing Ridge to flood lands in the Yolo Basin.

In 1913, after the formation of the Knights Landing Ridge Drainage District but before the completion of the Knights Landing Cut, as the result of a decision of the Superior Court of Yolo County, the District was required to provide a space 1,200 feet in length in the back levee to a height not greater than elevation 37.3 U.S.E.D. (the elevation of the Knights Landing Ridge) until such time as the cutting of the Knights Landing Ridge could be effected. The weir was constructed and maintained until the opening of the cut. After completion of the Knights Landing Ridge Cut, this structure was completely buried and the back levee was brought up to grade. Not until 1958 was the levee brought to full standards of the Sacramento River Flood Control Project for its entire length.

H.-4 HISTORY - Reclamation District No. 479

Reclamation District No. 479 was formed on July 29, 1885, under the act of March 12, 1872, as amended, at which time the petition and order was filed and numbered.

The District is located in Colusa County, laying approximately midway between Arbuckle and Grimes, and comprises about the southern two-thirds of the Mormon Basin. The Mormon Basin is a part of the much larger Colusa Basin. The gross acreage of the District is 6,505 acres.

The primary purpose of the District is the protection of its lands from flood waters. Prior to 1909, the individual landowners performed such work as each thought proper for the protection of his land. Following the serious floods of 1907 and 1909 levees were constructed along Sycamore Slough and Dry Slough to provide flood protection for all lands in the District.

The western levee along Sycamore Slough ridge was relocated further west, adjacent to the Colusa Basin Drain, and was brought to full standards of the Sacramento River Flood Control Project by the Corps of Engineers in 1958. The levee is maintained by the State of California, Department of Water Resources.

H.-5 HISTORY - Reclamation District No. 730

Reclamation District No. 730 was formed on December 16, 1902. The certified copy of the petition and order of the Yolo County Board of Supervisors, as required by Political Code Section 3450, was filed in the office of the Register of the State Land Office on December 16, 1902. The District, as formed, was legalized and validated by a special act of the State Legislature on March 6, 1909 (Stats. 1909:145). The District boundaries were established and defined by a special act on the same date (Stats. 1909:146).

The District is located in Yolo County adjoining the town of Knights Landing and contains 4,498 acres of the upper Yolo Basin.

The District was protected from overflow by a levee along the right bank of the Sacramento River and by smaller levees on its southern and western boundaries as protection from Cache Creek overflows.

Prior to construction of the Knights Landing Ridge Cut, this district was flooded when the Knights Landing Ridge was overtopped by flood waters from the Colusa Basin.

The District was divided into two portions by the Knights Landing Ridge drainage cut. Adequate levee and drainage facilities have been constructed and irrigation water is pumped from the Sacramento River and Knights Landing Ridge Cut by the landowners. The levees are part of the authorized Sacramento River Flood Control Project.

H.-6 HISTORY - Reclamation District No. 787

Reclamation District No. 787 was formed under the general reclamation district laws, and the petition and order was filed and numbered on August 20, 1908. The District is protected from overflow by levees constructed along the Sacramento River and Colusa Basin Drain.

In 1917 the Knights Landing Ridge Cut Extension was planned to provide a still more direct outlet for hill drainage collected outside of the back levees. This new project, which was completed in 1919, involved the relocation of about 3-1/2 miles of the back levee of District 787 between the Knights Landing Ridge and the lower corner of District 108 at Jacob's Point. These levees are now part of the Sacramento River Flood Control Project. Prior to this work, this section of back levee projected much further west

to the rim land than the back levee of District 108. This projection obstructed the free passage of flood water toward the Ridge Cut. The result of this extension was reduced flood heights in the lower basin, and shorter durations of flood exposure. Those lands now outside (or west) of the back levee have since been leveed by the landowners. The levees are low and are overtopped at high flood stages, but do have some effect on low flood flows. At one time flowage rights existed over the land, but no records could be located.

I. REPORTS AND INVESTIGATIONS

PERTAINING TO

COLUSA BASIN DRAIN

(PRIOR TO 1940)

Report on Canal

Hughes and Butler - May 17, 1892

Summary:

This report was prepared for landowners situated in the lower Colusa Basin in the late 1800's. Several of the items in the report pertained to the protection of lands against flooding by waters from the north and the west.

The general topography of the Sacramento Valley, including the west side basins, is described in detail. The lower Colusa Basin is described as the area below the trough strait, a location near College City where the Basin becomes very narrow, terminating near Grafton (now Knights Landing) because of the ridge built by Cache Creek overflow (Knights Landing Ridge). The lower Colusa Basin covers an area of nearly 100 square miles in Yolo and Colusa Counties.

The lower Basin was frequently flooded by water coming from the upper Colusa Basin, which collects the drainage of 700 square miles of hills and 650 square miles of plains, and from the local or southern streams draining 160 square miles of hills and 140 square miles of plains to the west. It is against these flood waters that the area needs protection. The river levees in the lower Basin were to some degree already in existence from construction by the landowners and districts.

Several alternatives were proposed. One was the construction of an earth embankment or levee along the eastern edge of the trough to protect the lands between the embankment and Sacramento River. The second alternative was to construct another embankment parallel with the one proposed to the east, forming a channel with a capacity of 8,000 cubic feet per second of water. The cross section of the most economical channel was 585 feet wide and 6.25 feet

in depth with a slope of 1 foot in 15,000 feet. The channel was to terminate at Grafton and discharge 7,000 cubic feet per second to the Sacramento River at river flood stage. It was estimated that at high river stage this discharge would raise the water about 2 feet, which would endanger the existing Sacramento River levees.

To remedy the rise in the river at flood stage caused by the increased flow from the basin, river cut-offs below Portuguese Bend to the mouth of the Feather River were recommended as one solution.

It was also recognized that detritus (gravel and sand) and sediment would enter the channel from the western streams, so areas to hold this material (settling basins) were to be constructed, along with pipes and automatic valves through the embankments at various locations.

The cost of this proposed project, including rights-of-way (2,250 acres), earth work (1,978,250 yds) control structures and bridges, and construction overhead, was estimated at $330,337.90, excluding any legal expenses.

Comments:

This report, although based on data that may not have been complete or factual, did present valid concepts for overcoming many of the flood problems that existed at the time. Many of the items mentioned, some of which had been mentioned in previous reports, were accomplished in later years. A River and Harbor Commissioner's Report at some earlier date had recommended the Sacramento River cut-offs.

American Society of Civil Engineers

Transactions, Vol. LXI, December 1908:

The Flood of March, 1907, in the Sacramento and San Joaquin River Basins, California; W. B. Clapp, E. C. Murphy, and W. F. Martin.

Summary:

In March 1907, the Sacramento and San Joaquin Valleys had one of the most destructive floods that ever occurred in California, with the resulting financial loss being unquestionably greater than that from any other flood on record up to 1907.

The flood was remarkable in many respects. In the first place, it was preceded by a period of heavy precipitation, followed by flood stages of all streams, a condition which had prevailed intermittently for several preceding weeks. As a result, the earth was thouroughly saturated and all the surface basins which impound and store flood waters were temporarily full. In particular this was true of the large flood basins on each side of the Sacramento River.

With all the basins full and the soil saturated, there occurred a general precipitation of extraordinary intensity throughout the entire drainage basin, coupled with comparatively high temperatures at upper altitudes. For the 4-day period of March 18th to 21st, the mean rate of run-off from the mountains and foot-hills of the Sacramento Basin was more than 22 cubic feet per second per square mile.

Comments:

This transaction report on the 1907 flood, along with the published reviews and discussions by noted engineers of that period, offers an excellent history of the great flood, including rainfall data, stream flow data, and background information.

It was noted that the basins acted as flood reservoirs and offered some downstream protection by their existence. The Colusa basin had a storage capacity of 880,000 acre feet and a surface area of 93,000 acres.

The flood stages and runoff volumes from the 1907 flood were the basis of design for many of the future proposed flood control projects of the Sacramento Valley.

House of Representatives, Document No. 81
62D Congress, 1st Session, 1911

Flood Control - Sacramento and San Joaquin River System, California; Report of the California Debris Commission, created by Crongress March 1, 1893.

Summary:

This report presents a project for control of floods and improved navigation of the Sacramento River. The proposed plan became known as the "by-pass system" because auxiliary channels through lowlands at some distance from the main river channel were proposed to provide passage of flood waters.

As an alternative to a smaller capacity Sutter-Butte By-Pass and shorter Fremont Weir, the Colusa Basin was evaluated as a potential part of the by-pass system. The main advantage was that the by-pass water would not have had to cross the river in order to flow over Fremont Weir, but would have flowed directly into the Yolo Basin By-Pass. This would also have reduced the required capacity of the Fremont Weir by about one half. The major disadvantage of this alternative was that it required an excavation through the Knights Landing Ridge. The channel was to be 4,900 feet wide and 1-1/2 miles long and the excavation would consist of approximately 6,000,000 cubic yards, cost of which would be twice the cost of the proposed Fremont Weir. The value of land, levees and road structures in the proposed Colusa Basin By-Pass were also evaluated. In a final comparison of economics and effectiveness, the larger Sutter-Butte By-Pass and enlarged Fremont Weir were selected for that segment of the "By-Pass System".

Comments:

The selection of the Sutter By-Pass eliminated the need for any by-pass in the Colusa Basin for the river flood control project.

(although adopted by the State of California in 1911), was not authorized as a federal flood control project until 1917. The project, now substantially completed, consists of a system of levees, overflow weirs, and flood bypass channels.

The levee system of the Knights Landing Ridge Cut, and the east levee of the Colusa Basin (back levee of R.D. 787, 108, and L.M.D. No. 12) are parts of the Sacramento River Flood Control Project.

Report on Knights Landing Cut Project,
Haviland & Tibbetts,Consulting Engineers,
San Francisco, November 12, 1912

Summary:

This report was prepared for the Knights Landing Ridge Committee. The Committee was appointed by the land owners in the vicinity of the Knights Landing Ridge to arrive at a plan for disposing of the flood waters coming into the Colusa Basin by cutting through the Knights Landing Ridge and constructing a canal below the ridge to carry off the water coming through the proposed cut.

The background and history contained in this report are very comprehensive and some of the history and area descriptions are contained elsewhere in this text. Although much of the information concerns historical reclamation development along the Sacramento River, most of these developments were attempts to solve flood problems of the Colusa Basin once there was some success in river levee protection efforts.

Most, if not all, earlier proposed plans for the control of Colusa Basin flood waters were based upon broad assumptions of watershed areas and runoff. Most were proven inadequate by later flood flow estimates and river measurements of the 1907 and 1909 floods. It was not until the storm of March 1911 that actual gaging of the flood flows was made. Measurements were begun on March 7, 1911 and were continued up to March 30th of the same year. With rainfall records of the Basin area dating back to 1878, detailed watershed areas, and runoff measurements, the storm of 1911 was analyzed in great detail. Runoffs from all tributary watershed subareas were computed. The storage capacity and water stage elevations were also determined. Flow rates at various locations and out-flow over the Knights Landing Ridge were determined from water

surface stages and observations. (See plate No. 9, watershed map)

From the above data, the capacity of the Knights Landing Ridge Cut was calculated. Because of the Basin storage capacity, and since only the back levees of the river reclamation districts were constructed, the maximum outflow was found to be 17,300 cubic feet per second. On the assumption that further reclamation be performed west of the existing back levees from the narrows south, forming a westerly levee and channel 1200 feet in width, a miximum outflow of 26,000 cubic feet per second was computed. The outflow was higher primarily because of the decreased flood storage capacity of the Basin.

In its conclusion the report states: "On the basis of these findings, it will be proposed to construct the Knights Landing Cut with a present capacity of 20,000 cubic feet per second with the water elevation 39 at Knights Landing. The rights of way and levees will be located so as to readily permit the ultimate enlargement to carry 30,000 cubic feet per second with the water at elevation 44 feet at Knights Landing." (U.S.E.D.)

The design capacity of the cut depended upon the water level at the Ridge Cut outlet into the Yolo Basin. The maximum elevation which water would reach in the Yolo Basin was to be 34.5 feet (USED Datum) when the "By-Pass Project" of the California Debris Commission was completed.

It was suggested, because of the small elevation differential between lands in the Yolo Basin and land above the Cut, that gates at the lower end might prove useful in preventing backwater from the Yolo Basin from flooding the low lands of the Colusa Basin. It was stated that in most cases, when the Yolo Basin (Yolo By-Pass) water

was flowing, there would also be flow from the Colusa Basin.

The channel cross section adopted for the required flow of 20,000 cfs was 6,250 square feet, with a slope of 0.59 feet per mile and friction coefficient of N=0.03 for use in Kutter's formula. This resulted in a mean velocity of 3.26 feet per second. For all portions except the extreme upper end of the channel (the Ridge), the bulk of the channel's carrying capacity is above the natural ground surface.

It was assumed that all excavation would be made by clam-shell dredges. Since the largest dredges required 7-8 feet of water to work in and construction without water damage to the crops of the adjacent lands was desired, provisions were made for construction of dredgers to work with the water surface at least 2 feet below the natural ground in most cases. As mentioned above, except for the upper end, the major portion of the channel is above natural ground, so the bulk of the dredging work was to obtain material for levee construction.

Comments:

This was the first engineering report on the Colusa Basin that was based on actual engineering surveys and rainfall runoff measurements. In many of the early-day engineering studies every aspect of the problem was examined in great detail, and this report was no exception.

The Knights Landing Ridge Cut was constructed for the passage of natural flood waters, runoff from rainfall on the Basin and tributary watersheds.

The stimuli for the construction of the Knights Landing Ridge Cut and the formation of the Knights Landing Ridge Cut Drainage District were several. The most pressing reason was encroachment

by the levees of the river reclamation districts into the water storage areas of the lower Colusa Basin and subsequent threats of legal action. Another was the flooding of the land below the Ridge when it was overtopped due to excessive rainfall. One of the design goals for the channel sizing was to maintain the water surface of the stored flood water equal to or lower than natural conditions. A secondary benefit to the low areas of the Basin was that with the cut constructed, the period of flooding was reduced from that before the cut construction.

The costs of construction and operation of the improvements were to be paid by taxes on lands within the reclamation districts that were responsible for the levee encroachments, lands below the Ridge protected from overflow by the waters of the Colusa Basin, and lands in the low Colusa Basin area that benefited from shorter periods of flooding.

Memorandum On Reclamation and Flood Control in Colusa Basin;
June 1, 1921, Fred H. Tibbetts, Consulting Engineer
San Francisco, California

Summary:

Portions of this memorandum have been used to develop the history section of this report.

One item not mentioned was the following: In 1863, former reclamation acts were amended by reducing the salaries of the Swamp Land Commissioners from $1,200 to $900 per year. These Commissioners reported in 1865 that fifty-four districts had been formed, the largest being District No. 16, covering the entire Yolo Basin, and reported the construction of the "Tule Canal".

The following was also in the Memorandum in reference to a Colusa Basin By-Pass Canal: as early as 1874 a plan was formulated for the construction of a large canal extending from Hamilton Bend on the Sacramento River above Colusa southerly to Knights Landing, along what now constitute the western lines of Reclamation Districts 479, 108 and 787, to intercept the hill drainage water and carry it into the Sacramento River.

Comments:

This is the only document that mentions the date of construction for the Tule Canal. The Yolo County Map of 1871 shows the Tule Canal starting near Big Lake at the head of Duck Slough, southwest of Clarksburg, and extending northward to Fifteen Mile Lake, which was located at the sink of Cache Creek near the mouth of the Knights Landing Ridge Cut. The canal was constructed to provide a central drain for the Yolo Basin and to allow access to floating dredges for reclamation construction.

The 1874 plan appears to have been developed into the Manson and Grunsky Plan of 1894 and the California Debris Commissioners Plan of 1911, both of which mentioned elsewhere in this report.

J. REPORTS AND INVESTIGATIONS

PERTAINING TO

COLUSA BASIN DRAIN

(1940 - 1980)

Note: Over the past 40 years, numerous engineering reports have investigated and described the water needs of the Sacramento Valley. These reports contain the results of studies by various individuals, local organizations, State and Federal agencies. Recent reports and investigations (1948 - 1980) by the various agencies as they apply to the Colusa Basin Drain are summarized. The reports are listed by date of publication, not by importance. Some of the information was extracted directly from the reports and other information summarized with comments.

Alternative Plans for Control of Floods in Upper Sacramento Valley. State Water Resources Board, State of California, 1948.

The major portion of this report is concerned with the Iron Canyon Project on the Upper Sacramento River and development of the Butte Basin for flood control purposes. The introduction, historical background of Northern California flood control development, and the projects proposed that would have included portions of the Colusa Basin Area are very interesting. A portion of the data has been used as material in this report.

Seepage Conditions In Sacramento Valley. Water Project Authority, State of California, 1955.

This study concentrates on Sacramento River and Feather River seepage problems associated with high river stages. Good background information and a listing of prior investigations and reports are also included.

The field investigation indicated that most seepage occurs south of Ord Ferry along the Sacramento River. Any seepage waters developing along or near the west levee of the Sacramento River eventually find their way into a local drainage system. Most of the local drainage systems discharge into the Colusa Basin Drain. Therefore during very wet years seepage affects a large portion of the land between the Sacramento River and the Colusa Drain, and these waters add to the flooding problems of the Colusa Basin.

Effect of the Sacramento Deep Water Ship Channel Project on Lands in the Lower Yolo By-Pass. Gerald H. Jones, Sacramento California, 1956.

This report analyzed the flood flows of the Yolo By-Pass and the effect of the flows on the flood plain elevations. The Yolo By-Pass project design as modified by the Ship Channel Project was analyzed in three sections: 1) design flood flows, 2) reduced flows 20,000 to 135,000 cubic feet per second, 3) hydraulic analysis of

the low flow water channels. It is area three which is of interest.

Actual stream flow measurements were made to determine the capacity of the existing borrow pit from the Yolo Causeway to the lower end of the Yolo By-Pass near Little Holland Tract. The upper end near the Yolo Causeway was not changed by the proposed construction of a toe drain. The maximum measured channel flow was 2,000 cubic feet per second.

The proposed toe drain was designed by the Corps of Engineers to convey 3,000 cubic feet per second. A hydraulic analysis done by Jones confirmed that with slight modifications because of tidal action, the toe drain would convey the design flow.

Since the construction of the toe drain, no known channel maintenance has been done except for minor work to the west low levee and road to allow for the passage of agricultural equipment. Visual observations indicate that bank erosion and sedimentation over the last two decades have probably decreased the original capacity 20 to 30 percent. The channel from the upper end of the toe drain to the Yolo Causeway has not changed much since the flow measurements for the above report were made.

The California Water Plan - Bulletin No. 3. Department of Water Resources, State of California, 1957.

As the title indicates, most of this report is concerned with the California Water Plan. However, there are certain sections that relate to the Colusa Basin. In order to have drainage of agricultural areas and maintain an acceptable salt balance, proper disposal of saline drain water is an important factor, especially in the maintenance of ground water quality. A drain for this purpose is shown on the development maps as approximately following the Colusa Drain down to the Sacramento River Deep Water Channel.

In another section of the report the Westside stream group of the Sacramento Valley is discussed with respect to foothill reservoirs, and the following information was presented. The run-off from some of the minor foothill streams between the drainage divides of Stony and Cache Creek could be partially conserved for recreation by constructing small reservoirs at Clark Valley on the South Fork of Willow Creek, at Squaw Flat on Logan Creek, at High Peak on Hunters Creek, and at Golden Gate on Funks and Stone Corral Creeks. These small reservoirs could be used for flood control and for terminal storage of pumped diversions from the Tehama-Colusa Canal. The impact of watershed management is discussed in detail, and many of the items, such as erosion, sediment control, water conservation, and water quality improvement, could all be related to any future management plan designed for the Westside of the Sacramento Valley and the Colusa Basin Drain.

Proposed Plan for Westside Drainage. Kenneth C. Laugenour, Consulting Engineer, Woodland, California, 1958.

This plan was investigated and reported to the landowners of the lower Colusa Basin and Knights Landing Ridge Cut area. The study was endorsed by the landowners and was one of the factors leading to the authorization of the Bulletin No. 109 investigation by the Department of Water Resources.

The basic plan was to increase the flow in the Knights Landing Ridge Cut by removing the high area at the head of the Cut and building a water control structure there. Other portions of the plan included constructing a channel across the Yolo Bypass and enlarging the Tule Canal to the Deep Water Channel toe drain. The toe drain had recently been completed and had a capacity of 2,400 cubic feet per second at its north end and 3,000 cubic feet per

second near Liberty Cut on the south end. Refer to map plat No. 38 for locations.

Yolo-Zamora Unit, Sacramento River Division, Central Valley Project, California. U.S. Bureau of Reclamation Region 2, Sacramento, California, 1957 and 1960.

This report on the feasibility of a water supply development for the Yolo-Zamora Water District was based upon a direct diversion from the Sacramento River upstream from Knights Landing. The water supply aspect has been subsequently changed, but the section on agricultural drainage problems due to the project is applicable regardless of the supply source.

The central and lower portion of this project, consisting of approximately 6,500 acres, would require surface and subsurface drainage. A total of 24 miles of district surface drains including 3 miles of main drain to the Colusa Basin Drain are mentioned. Some would be as deep as 8 feet in order to accomodate tile drainage if required at some future time. The estimated cost for the drainage network excluding farm improvements, was 10% of the total project cost.

West Sacramento Canal Unit, Central Valley Project, California. U. S. Bureau of Reclamation Region 2, Sacramento, California, 1964.

The West Sacramento Canal Unit plan involves enlargement and realignment of the Tehama-Colusa Canal from Funks Creek in northern Colusa County to Bird Creek in Yolo County. This enlargement provides additional capacity to allow for the extension of the canal into service areas of Yolo and Solano Counties. The enlarged and extended portion of the canal was designated the West Sacramento Valley Canal. Enroute reservoirs and a major off-channel pumped storage reservoir would be integral parts of the plan.

The major reservoir mentioned would be created by the Golden Gate Dam located on Funks Creek northwest of Maxwell and by Sites Dam located on Stone Corral Creek. The body of water created would be the Sites Reservoir. The reservoir would be used for offstream storage of surplus Sacramento River floodflows. The Golden Gate Dam would contain a penstock for a pumping-generating plant. This impoundment would have an active conservation storage capacity of 1,080,700 acre feet and a total capacity of 1,215,700 acre feet. Other dams of smaller capacity and purposes are listed as Funks Dam and Reservoir, 17,300 acre feet, Swifts Corral Dam on Stone Corral Creek, 3,720 acre feet, and Oat Dam and Reservoir, 14,500 acre feet. Design features for the dams and the two pump-generating facilities are shown on plate No. 1 of the appendix.

The report states that the Yolo-Zamora service area would have 16 miles of surface drains, 7 miles of interceptor drains, and 2 miles of terminal drain leading to the Colusa Basin Drain. The lower Cache Creek service area would have 320 miles of surface drains. Natural channels would be used for interceptor drains, and would drain into the Yolo Bypass using Willow Slough.

Colusa Basin Investigation - Bulletin No. 109. Department of Water Resources, State of California, Sacramento, 1964.

In 1959, the State Legislature passed Senate Concurrent Resolution No. 79 requesting the Department of Water Resources to conduct an investigation of the problems of flooding and drainage in the Colusa Basin. A copy of the resolution is included in the appendix, plate No. 2.

The result of the investigation was the Colusa Basin Investigation, Bulletin No. 109. This report has been widely circulated within the area of interest and is the most complete and factual re-

port yet produced that deals only with Colusa Basin. The background data and overall reconnaissance of the Basin is more than adequate to give an understanding of the flooding and drainage problems.

The investigation relates to winter and spring flooding and to crop-growing season drainage problems. Drain flows, channel profiles and other pertinent data are included, along with area economic data. Profiles and other data from this report are included in the appendix.

In summary, four possible solutions to the flood problems of the Basin were considered: (1) a system of levees along the Colusa Basin Drainage Canal. Various magnitudes of protection were considered but plan benefit-cost ratios were all less than 1.0. (2) flood control reservoirs in the western foothills. The capital cost for this possible solution was higher than the system of levees. Benefits from water conservation, recreation and wildlife enhancement were not considered. A summary of the foothill reservoir data and cost is included in the appendix, plate No. 3. (3) watershed management. The report states that runoff from the foothill drainage area makes the major contribution to flood flows occurring in the Colusa Basin. Watershed management is an effective flood control measure. However, the effectiveness of watershed management for the purpose of flood control would be lessened during extended periods of rainfall or in repeated storms. Further, because of time limitations and funds, field studies of watershed management practices were not made a part of the Bulletin No. 109 investigation. In its conclusion the report states that much time and experimental work would be required before conclusive results could be evaluated. These results might well indicate a relatively inexpensive method of reducing flood discharge. (4) improved drainage facilities from

the Knights Landing Ridge Cut through the Yolo Bypass. The construction of improved drainage facilities in the northern portion of the Yolo Bypass proved to be an economically justified solution to limited flood problems that occur in the spring and in late summer, which is the time when the possibility of crop damage is present. This possible solution was called the Yolo Bypass Project and was thoroughly investigated and reported upon. The benefit-cost ratio of the project was shown to be greater than 1.0.

Efforts have been made recently to encourage the Department of Water Resources to update the economic evaluation, but so far these efforts have been unsuccessful. The Corps of Engineers in December 1970 and again in May of 1980 have stated that their studies of the flood problems in the Colusa Basin, no solution recommended in Bulletin No. 109 for providing major flood control economically feasible.

As suggested earlier, the data and the conclusion of this report are in good detail and complete. Any further investigation, if ever needed, of solutions 1 and 4 should only require an update of this existing information. The watershed management and foothill reservoir solutions should be explored in more detail to determine what other benefits might be gained than just flood control.

Sacramento Valley Seepage Investigation - Bulletin No. 125. Department of Water Resources, State of California, Sacramento, 1967.

Most of the information of this investigation, like the 1955 study, concentrates mainly in the Sacramento and Feather River seepage problems associated with high river stages. The same conclusions are drawn; that is, any seepage water developing along or near the west or right bank of the Sacramento River eventually finds its way

into the local drainage systems. Many of these systems discharge their drainage into the Colusa Basin Drain. In addition, the report states that the Sacramento River can convey approximately 9,000 cubic feet per second of water for considerable periods of time without causing seepage between the Colusa Weir just above Colusa and Fremont Weir, which is just upstream from the mouth of the Feather River.

In the report is discussion on imported flows and it was stated that the magnitude of such flows could not be determined, but the report also states that seepage directly attributable to imported water could occur in the summer and fall if the imports and storage releases reach a significant level. The study relates to three flow conditions on the Sacramento River when studying the effects of imported water. The flows and river stages are included in the appendix, plate No. 4. Regardless of the seepage problems that might develop, it is interesting to note that the river stage at 10,000 cubic feet per second is 18.8 U.S.G.S. or, adding 3.0 feet, 21.8 U.S.E.D. at Knights Landing. This flow and stage would restrict the operation of the Knights Landing Outfall Gates when full flow is required during late spring and the rice drainage period. In addition, if the Feather River had increased flow as indicated in plate No. 4 there could be backwater conditions that would aggravate the problem. Even now (1981), with regulated flow in the Sacramento River, the period of time that the Knights Landing Outfall Gates can pass the full flow has been reduced.

It would seem appropriate, considering potential water imports, upstream storage releases into the Sacramento River, and the present conditions, the Department of Water Resources and the U.S. Water and

Power Resources Service would be more concerned with problems that now exist or will intensify sometime in the future.

Sacramento River Flows and Potential Seepage in Yolo County. Kaiser Engineers, Oakland, California, 1972.

The object of this report was to present findings, conclusions, and recommendations with regard to the relationship between historical and future flows of the Sacramento River and to past and potential future seepage into adjacent agricultural lands in Yolo County. The study included a review of Department Water Resources Bulletin No. 125 and an up-date to that document with supplemental information collected between 1965 and 1970.

The information on seepage parallels that of Bulletin No. 125. However, the projected flows and river stages, because of water imports and releases of upstream water, are somewhat higher. At this time it must be noted that many of the proposed projects of 1970 have been scrapped or delayed. Therefore, these flows would occur at some future time beyond the dates used in the report. However, the flow-stage relationships would still be applicable. At Knights Landing the maximum river stage project was 27.0 U.S.E.D. for a summer flow, a level at which the Outfall Gates would be completely inoperable. See plate No. 5 of the Appendix.

Proposal for A Wastewater Reclamation and Reuse Pilot Demonstration Program for the Suisun Marsh in Solano County, California. U.S. Bureau of Reclamation, Sacramento, California, 1972.

This is only one proposal of many that has been made in conjunction with the Department of Water Resources, Department of Fish and Game, Bureau of Reclamation and Bureau of Sport Fisheries and Wildlife study titled "Suisun Marsh Water Supply and Management Study". While this proposal deals mainly with creating a water supply by waste water reclamation, it does make the following statement: ". . . . . with the wastewater from Fairfield, Suisun, Travis and

Cordelia area and agricultural return flow from the Colusa Basin Drain could well supply all the water needs for a Suisun Marsh Management program". If this proposal was to be carried out, some type of conveyance channel would have to be constructed from the Colusa Basin Drain down through the Yolo Bypass. This channel could also be used to convey spring and fall drainage waters from the Basin.

Preliminary Investigation of Land Subsidence In The Sacramento Valley, California. United States Department of The Interior, Geological Survey, 1973.

The information available to define and isolate areas of land subsidence in the Sacramento Valley is somewhat inadequate. Available data in the Sacramento Valley suggests subsidence probably has occureed in areas of heavy ground-water pumping. Evidence shows that as much as 2 feet of suspected subsidence has occurred in the areas east of Zamora and west of Arbuckle.

Maps, limited surface profiles and elevation differences between various time periods are included in the report. Profiles that relate to the Colusa Basin area are included in the appendix as plates 6, 7, and 8.

The report further recommends that if subsidence is of concern, existing vertical control should be improved and compaction recorders installed. This would provide needed information for estimating past and future subsidence.

Colusa Basin Study - Water Quality Work Team Report. U.S. Bureau of Reclamation, September 1973.

Colusa Drain Unit - Water Supply and Water Rights, Work Team Report. U.S. Bureau of Reclamation, December 1973.

Colusa Basin Study - Environmental Appraisal, Work Team Report. U.S. Bureau of Reclamation, June 1974.

Colusa Basin Study - Flood Prevention and Drainage, Work Team Report. U.S. Bureau of Reclamation, October 1974.

The Bureau of Reclamation initiated an appraisal level study of the Colusa Basin and, in particular, the Colusa Drain. The purpose of the study was to examine the problems in the Colusa Basin and define present and future needs. Public involvement was solicited along with input from other public agencies, and work teams were formed in their areas of interest. The reports listed are team efforts with considerable input from the public members.

Although all the reports relate to various problems and future activities along the Colusa Basin Drain, only the Flood Prevention and Drainage Work Team Report will be summarized. The other three reports will become useful if a management plan of any magnitude is developed. The environmental inventory and other basic data that have been developed or collected in the reports will be especially useful.

Only some of the teams actually made any field trips to view the area under study. Most of the data in the studies was from other sources or verbal input from individuals at the team meetings and may not be factual.

The Flood Prevention and Drainage Work Team Report includes a section on the effect of Tehama-Colusa Canal water imports on the Colusa Drain outflows. This data is reviewed and analyzed in another part of this present report. Several pages of outflow data are included in the appendix on plates No. 10 and 11. Most of the flooding and drainage data is a repeat of Bulletin No. 109, except for a summary of alternatives and comments suggested by the report team. This data is included in the appendix as plates 12, 13 and 14, and does not appear to be totally factual or complete from an engineering standpoint. Flows within the drain are shown on Plates 15 through 18.

The discussion on existing drainage facilities relates to the fact that much of the Tehama-Colusa service area will require drainage facilities for tail water and shallow ground water control near and adjacent to the eastern portion of the area.

Return Flow Water Quality Appraisal, Glenn-Colusa Irrigation District Calendar Year 1973. Water Science and Engineering Paper 4007, Walton H. Low et al, University of California, Davis, 1974.

This study deals primarily with the Glenn-Colusa Irrigation District's water balance, salinity and suspended matter within its irrigation system. Limited flow information on drain laterals tributary to the Colusa Basin Drain are reported for the 1973 irrigation season. District outflow data is presented in tabular form along with water quality data.

Sacramento River Drainage and Seepage Utilization, Working Document. U.S. Bureau of Reclamation, Sacramento, 1977.

The purpose of this study was to seek alternative solutions to seepage problems along the Sacramento River, drainage problems associated with new irrigated lands in the Tehama-Colusa Canal service area, and flooding problems within the Colusa Basin, in a comprehensive manner which considers the utilization of any recaptured water. This was an appraisal study with the objective of determining if further feasibility-level studies are justified. Consequently, only data from existing reports and other readily available data was utilized. No field investigations were initiated to obtain new data.

This study relied on other reports summarized in this section, mainly the Department of Water Resources Bulletins Nos. 109 and 125 and the U.S. Bureau of Reclamation work team studies of the Colusa Basin area in 1973. These work team studies were primarily based on still other area studies, reports, and team member informa-

tion. The summary of drainage alternatives is included in the appendix, plates No. 12, 13 and 14.

Irrigation Tail Water Management. Water Science and Engineering Papers 4011 and 4014, K.K. Tanji et al, University of California, Davis, 1976 and 1977.

These two publications report on studies conducted in the Sacramento and San Joaquin Valleys. The studies were undertaken to analyze and conduct an assessment of return irrigation flows and overall tail water management. The area investigated in the Sacramento Valley was the Glenn-Colusa Irrigation District. In addition to basic background data, irrigation flows and return flows to the area investigated and to the Colusa Basin Drain are included for the years of 1975 and 1976.

Sediment Production (1978) and Nonpoint Sediment Production and and Transport in the Colusa Basin Drain (1979). Water Science and Engineering papers 4016 and 4018, K.K. Tanji et al. University of California, Davis, 1978 and 1980.

These reports on the Colusa Basin Drain are studies of sediment production and the ability of the drain to transport these sediments under various flow conditions. In addition to in-depth studies on the production of sediment, flows within the Colusa Basin Drain are tabulated on a weekly basis during the irrigation season. It is from these tabulations that plates No. 19 and 20 of the appendix are partially derived.

B.L.M. California 208 Draft Report. Bureau of Land Management, U.S. Department of the Interior, Sacramento, California, 1979.

This draft report relates to the "208 Water Quality Program - Best Management Practices" as administered by the State of California in compliance with the Federal Water Pollution Control Act of 1972 and amendments. Present B.L.M. management activities are discussed, problem assessments are made and best management practices were developed. Potential impacts of these proposed management activities

on water resources are reviewed. The report includes the Redding District and Ukiah District, which encompass all of the B.L.M. lands tributary to the Colusa Basin Drain. Each hydrologic area is described, and the problems, beneficial uses and information on water resource needs are discussed.

Water Quality Management for National Forest Systems Land in California. Forest Service Pacific Southwest Region, U.S. Department of Agriculture, 1979.

This is a tabulation and review of the recommended "best management practices" (BMP's) as proposed by Forest Service. The BMP's are in accordance with the "208 Water Quality Program", and are intended to be in compliance with the Federal Water Pollution Control Act of 1972 as amended. Management practices as they relate to vegetative manipulation, watershed management, timber production, and other activities are discussed and analyzed. Individual assessments were prepared for each of the National Forests in California. The information in this study will be very useful in the development of any watershed management plan implemented for the Colusa Basin.

Erosion and Sediment Control Handbook. Perry Y. Amimoto, Division of Mines and Geology, Department of Conservation, State of California, 1978.

This handbook primarily deals with erosion problems related to road construction, nonurban development, and other practices that may disturb the soil. The information is basic and very useful, especially the data that relates to stream channel modifications, road crossings and sediment detention basins.

Buckeye and Dunnigan Creeks Pilot Study Area - Mini-Reports. Soil Conservation Service, U.S. Department of Agriculture, Davis, California, 1978 and 1979.

1) Resources Capabilities Affecting Sedimentation
2) Sources of Sediment
3) Alternative Management Practices
4) Comparison of Alternate Management Practices

This series of mini-reports is the result of an investigation on a watershed area of 41,650 acres which are all tributary to the Colusa Basin Drain. The study area data on climate, soil erodability, stream characteristics, and descriptions of the agricultural community are very complete. These reports in conjunction with other recent studies on sediment control should be part of any overall management plan developed for the Colusa Basin.

Recommended Plan of Best Management Practices for the Reduction of Agricultural Sediment, Central Valley Region. Soil Conservation Service, U.S. Department of Agriculture, Davis, California, 1979.

The objectives of this study were to identify erosion and sedimentation problems from agricultural and other lands in the Central Valley Region. Eight pilot study areas were established, one of which was the Buckeye and Dunnigan Creeks Pilot Study located in Yolo County. Land use, soils, hydrology, and topography were evaluated. Erosion rates from various land surfaces, stream banks, transportation facilities (roads), and gullies were separately assessed. Erosion yields have been determined and are related to various agricultural and watershed management practices. Assessments of existing practices and of recommended practices for sediment production control are made. Several assessment samples of irrigation practices are included as plates No. 21, 22, 23 and 24 in the appendix.

Colusa Basin Drainage Problem Colusa and Yolo Counties, California. U.S. Army Corps of Engineers, Sacramento, 1970. (1980)

This reconnaissance study investigated many of the same problems and details as Bulletin No. 109, including the lower Colusa Basin and Yolo Bypass. The findings were that a major drainage project for the southern Colusa Basin and the Yolo Bypass was not economically feasible. The public notice of the project, results and termination of the project, and the findings of an update study in

1979 and 1980 are part of the appendix as plates No.'s 25 through 29. The 1980 study was a review of data from the 1970 report. No new information was included that pertained to the lower Colusa Basin Drain.

A History of Irrigation in Butte, Sutter, Glenn and Colusa Counties. Joseph F. McGie, Joint Water District Board, Gridley, California, 1980.

This publication is an assemblage of information on the history of irrigation in the Sacramento Valley. It includes bits of water right data and disputes of the past and brief history sketches of six irrigation districts in the Colusa Basin. Most of the publication is devoted to the Sutter-Butte area and the development of the irrigation systems there.

3) CHANNEL AND FLOODWAY ENCROACHMENTS

On April 23, 1971, the State of California Reclamation Board adopted a designated floodway for the Colusa Basin between Knights Landing and Willows. The adopted floodway follows the Colusa Drain northerly to its confluence with Willow Creek and follows Willow Creek to a point near Willows and varies in width from 1100 feet at Knights Landing to 500 feet near Willows at the Glenn Colusa Canal crossing. All encroachments within the floodway limits are required to meet certain physical requirements, and the owners must have a permit issued by the Reclamation Board for continued use. Encroachments must not impair flood flows in the drain or cause any damage or impairment to adjacent lands. Levees and bridges must be maintained and kept free of conditions which would cause any adverse channel conditions.

A review of available data from the Reclamation Board's inventory of existing encroachments disclosed several areas that needed further investigation. A field review of the drain was made at various times of the year in an attempt to visually see what effect varying water levels and irrigation practices had on outflow restrictions. The drain floodway review was broken down into two study areas: (1) the lower Colusa Basin Drain from Knights Landing to Tule Road, and (2) the Upper Colusa Basin Drain and Willow Creek from Tule Road to the Glenn Colusa Canal near Willows. An analysis of the review from north to south is as follows:

A. UPPER COLUSA BASIN DRAIN

The first mile of the Willow Creek Drain below the Glenn Colusa Canal Crossing has extensive vegetation along the banks and within the floodway which restrict localized flow. Removal of downed trees

and control of vegetation would reduce the amount of drift and trash that can clog channels and hang up on structures downstream.

There are many physical encroachments within the floodway; most do not impede the outflow but several should be discussed.

Just upstream from Glenn County Road "P", a concrete check and timber flashboard diversion structure slightly impairs outflow when the flashboards are in place and spring flooding occurs. These boards and the structure are monitored daily by the Glenn Colusa Irrigation District. Debris, catching in the structure reduces the waterway opening and can impair the overall capacity of the structure. Winter outflow appears to be substantially impaired by the structure, but not normal irrigation flows.

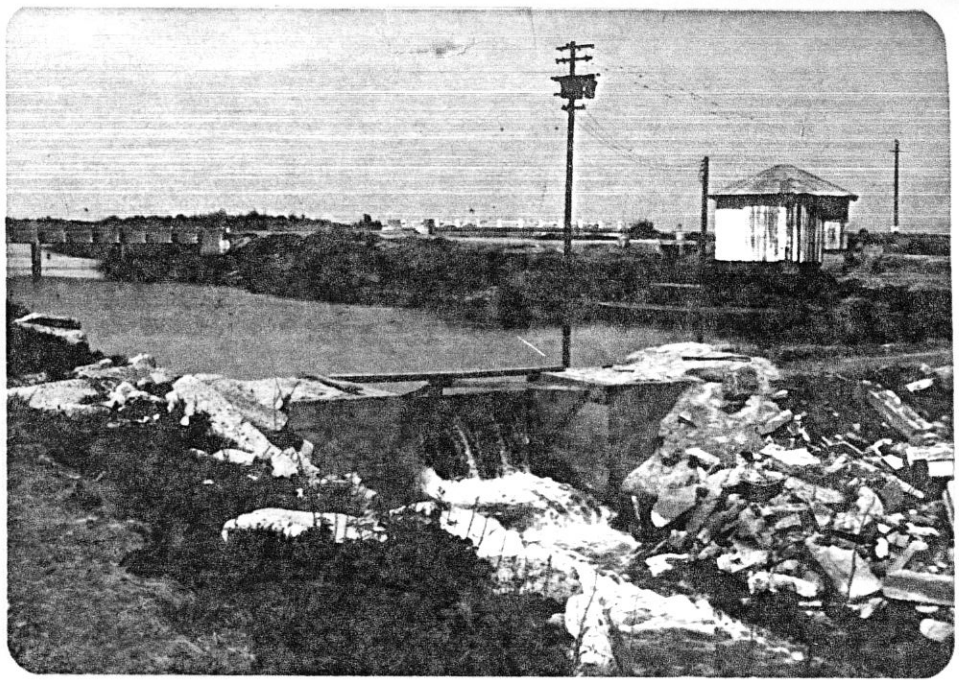
A concrete bridge located 0.6 miles below County Road "P" and a twenty foot wide concrete diversion structure 1.5 miles below County Road "P" each create substantial blockages in winter.

The next impediment to outflow on the drain is located some 200 feet south of County Road 61. A low concrete and timber flashboard diversion structure restricts local outflow due to backwater, which extends about 1 mile upstream during spring runoff when the boards are in place. Winter flood flows also appear to be impaired by the structure.

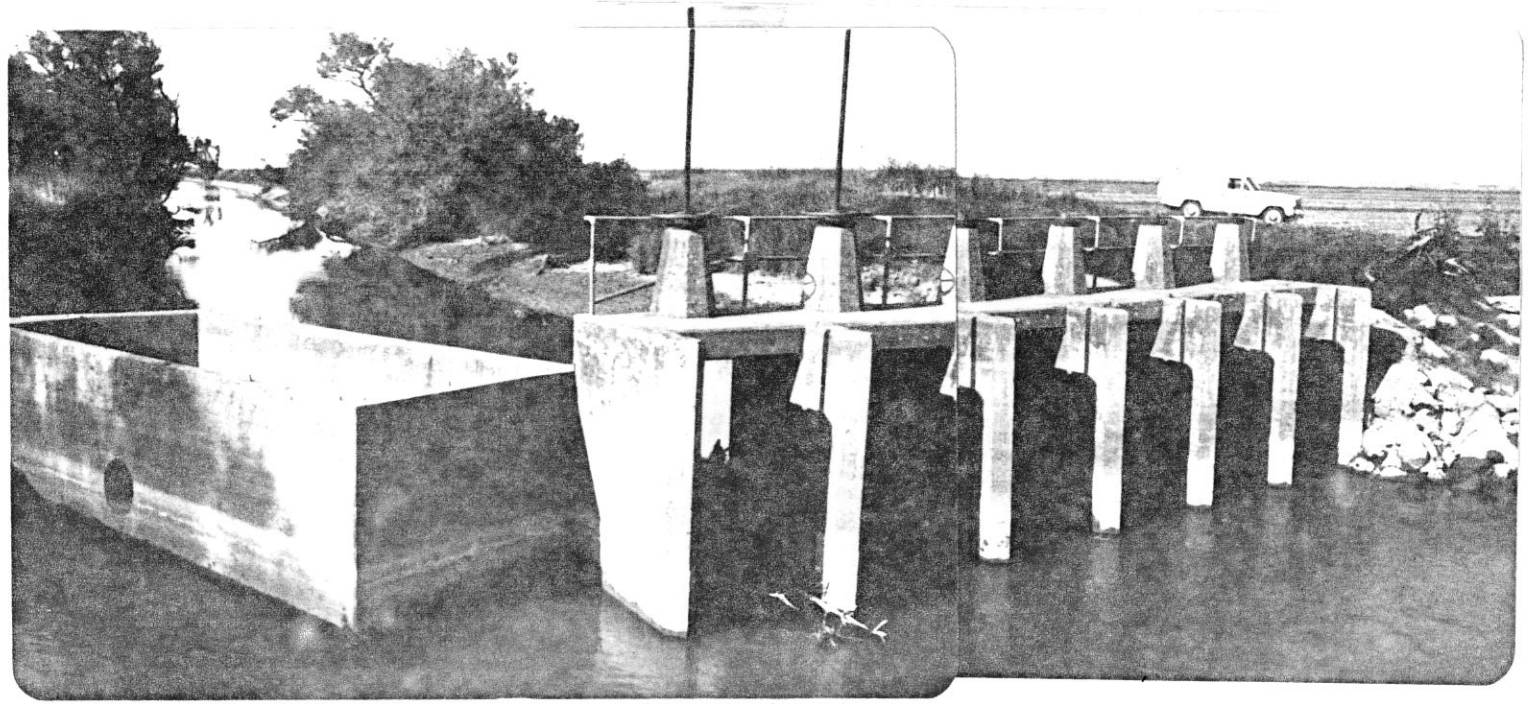
A wooden bridge on steel piles and concrete bents across the drain about 1.75 miles south of County Road 61 shows little sign of flow restriction, except when trash hangs up on it. Proper trash removal by the owners is essential.

A small concrete and timber flashboard check and diversion structure south of Norman Road does not cause any apparent outflow restriction except at low flow with the boards in place. The storage area upstream from the structure, however, may fill with sediment and cause temporary restrictions.

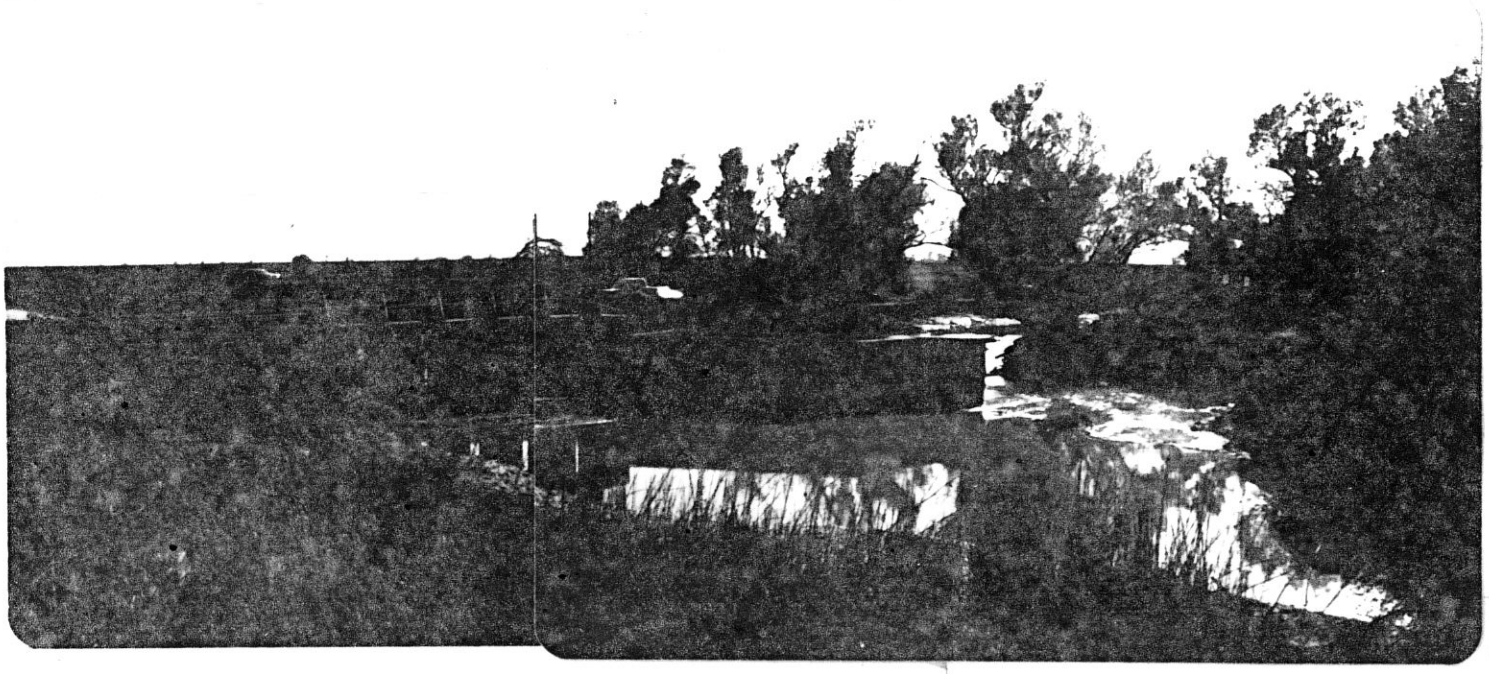
NORMAN ROAD DIVERSION DAM



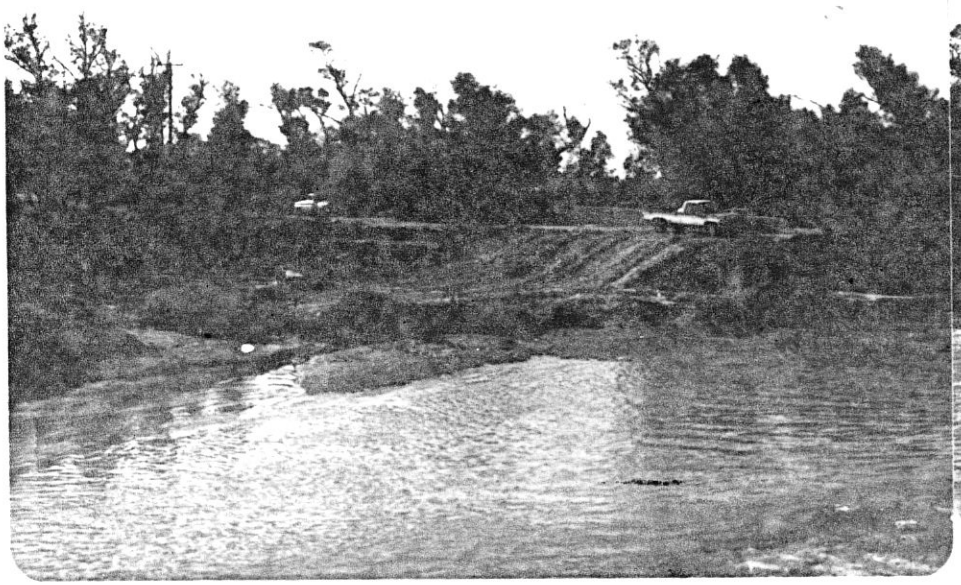
ROAD 61 DIVERSION DAM

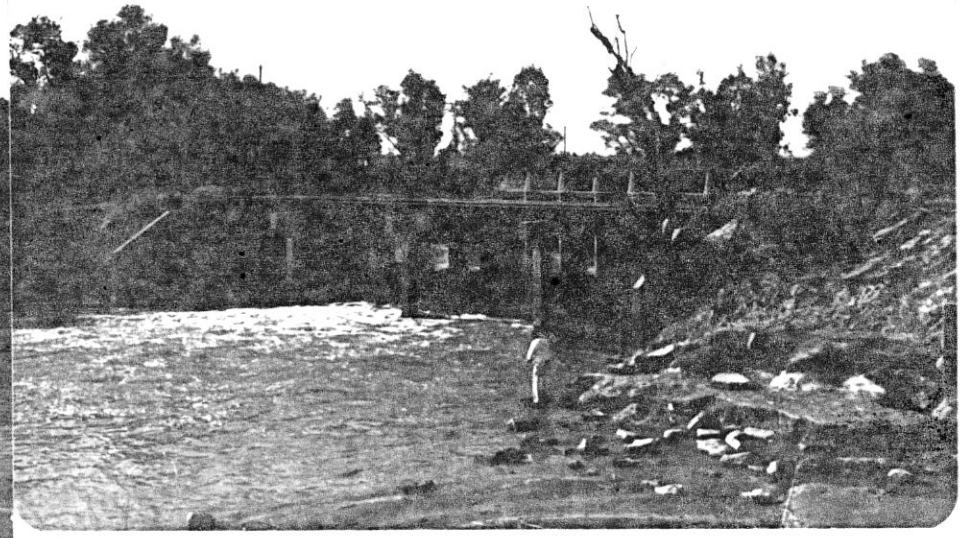


ABANDONED CONCRETE SIPHON STRUCTURE
5 MILES NORTH OF MAXWELL ROAD
Figure 7



LOOKING
DOWNSTREAM





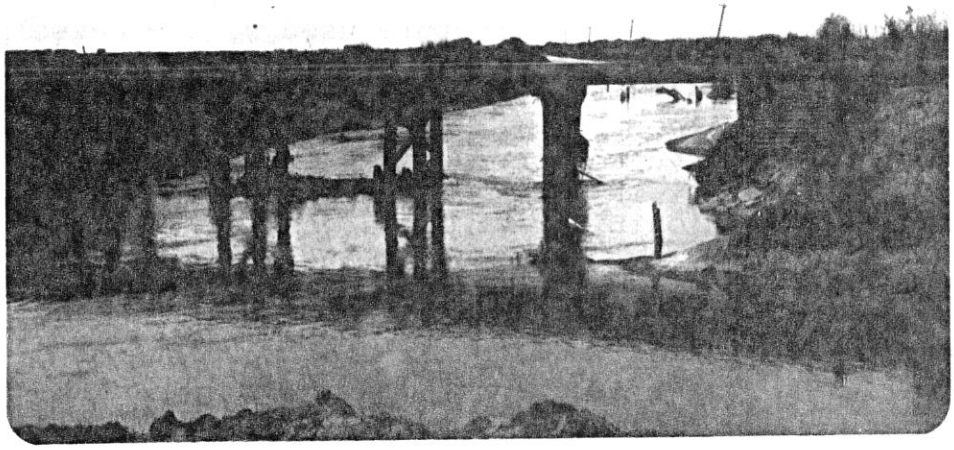
LOOKING UPSTREAM

ABANDONED SIPHON STRUCTURE – 5 Miles North of Maxwell Road

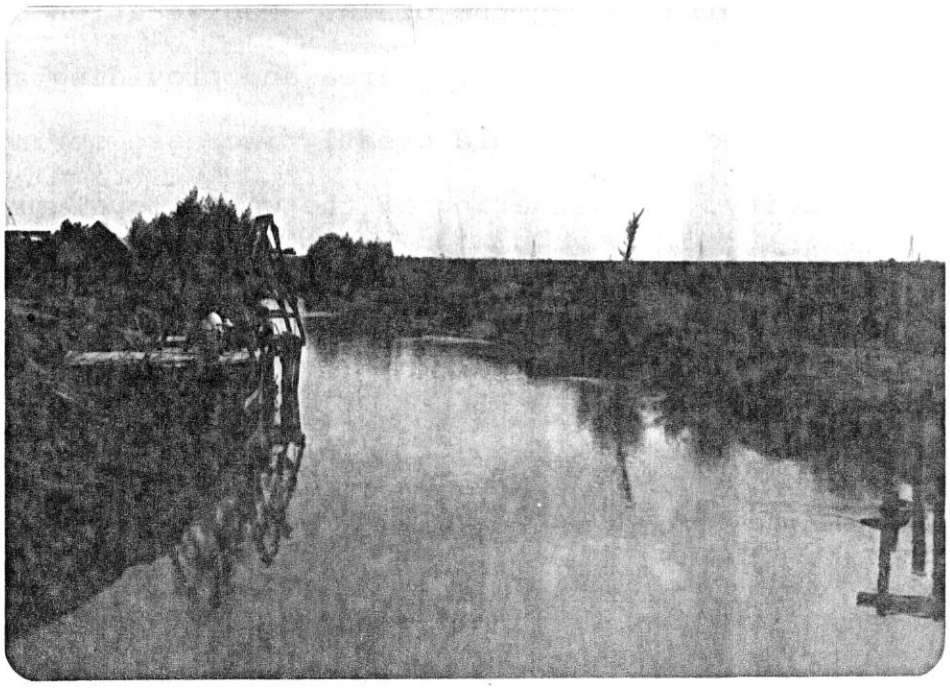
Figure 7A

The grade of the drain begins to flatten out just below this point and for some distance becomes wider and shallower, necessitating the construction of levees to contain outflow. The water level during periods of flooding and spring irrigation outflow closely parallels the ground elevation causing some difficulty in draining adjacent fields. Encroachments restricting low flows become more critical than winter flows as the backwater effects cover a much longer reach at the drain. An example of this situation occurs at a partially abandoned concrete siphon and diversion structure used by the Maxwell Irrigation District located about midway between Norman Road and Maxwell Road. The structure was used to convey water from the Sacramento River to the Maxwell Irrigation District lands west of the Colusa Drain, and the drain flow was conveyed under the structure by use of a siphon. The siphon is no longer used, but abandoned portions of it remain in the channel and impair outflow. A concrete check and diversion structure immediately downstream creates up to a 7 foot drop in the water level during periods of normal summer flow. The backwater effect reaches some 2.25 miles upstream, with the pond itself backing up some 2 miles along the drain. Modification of the drop structure by increasing the opening area and providing adjustable level regulation facilities would greatly increase spring and winter flood flow capacity. The lowering of the water level may necessitate the modification of adjacent water diversion facilities. Lift pumps located along this reach of the drain might have to be lowered, or, in some circumstances, installed where none exist at this time.

Numerous other minor encroachments which could restrict flows exist between the location just discussed and the State Highway 20 crossing. A bridge crossing the drain at Harbison Road collects



HARBISON ROAD BRIDGE DEBRIS



LURLINE ROAD PUMP STRUCTURES

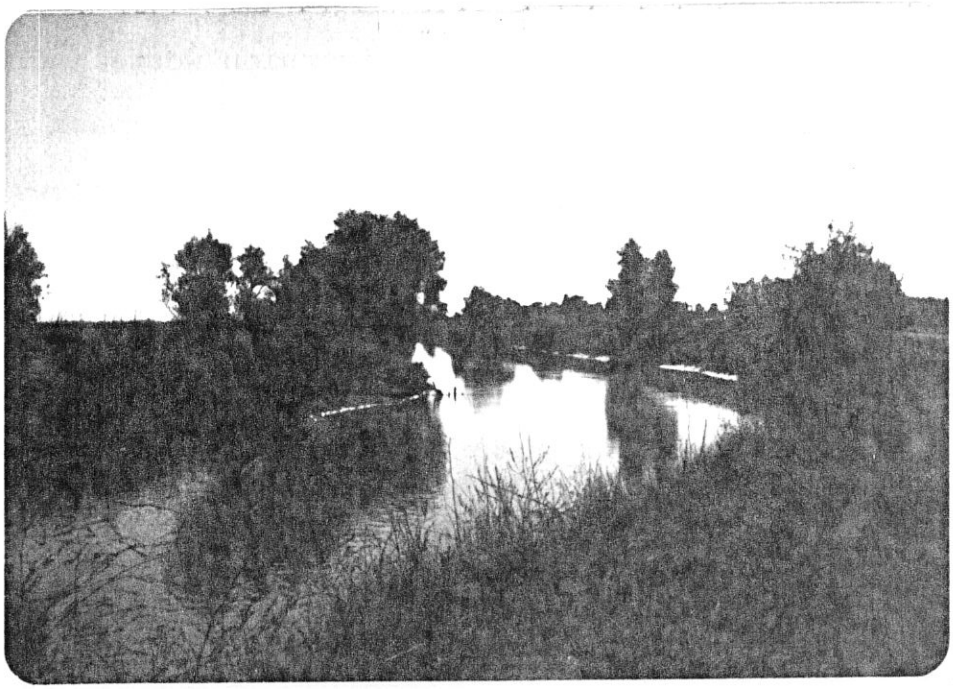
Figure 8

debris on several of the supports in the channel. The remains of an abandoned structure upstream could dislodge and drift into the bridge, seriously impeding winter flows. Diversion works including pumps and structures at the Lurline Road crossing encroach into the floodway but do not appear to seriously impede winter flows.

Numerous low and medium height levees have been constructed along east and west sides of the drain to contain spring and summer high flows. The high winter flows are not usually contained by these levees and flooding occurs on a regular basis. Construction, reconstruction and maintenance of levees all come under the Reclamation Board's jurisdiction when within the designated floodway limits.

At various locations along the drain, particularly within the Colusa Game Refuge, bank erosion and slip-outs were in evidence. The material displaced will in time travel downstream as sediment and cause restrictions in channel capacity. The banks along the drain where the erosion occurs will be subjected to additional stress during periods of high flow, and additional material will be displaced. If erosion is left unchecked, the structural integrity of the natural bank and levee systems will be in danger, with breaching as a result. Management of the channel section will be an important aspect of the overall maintenance and improvement of the drain system. Timely repairs to damaged areas will pay back much greater returns than any savings accrued by allowing the problems to continue unchecked.

Below the State Highway 20 crossing few encroachments appear to impede flow, other than trees and vegetation growing within the existing channel area. Since this area lies adjacent to the Colusa Game Refuge, any removal of natural habitat (i.e., trees and vegetation) would come under the close scrutiny of the U. S. Fish and



DENSE VEGETATION

COLUSA GAME REFUGE

COLUSA BASIN DRAIN

Figure 9.

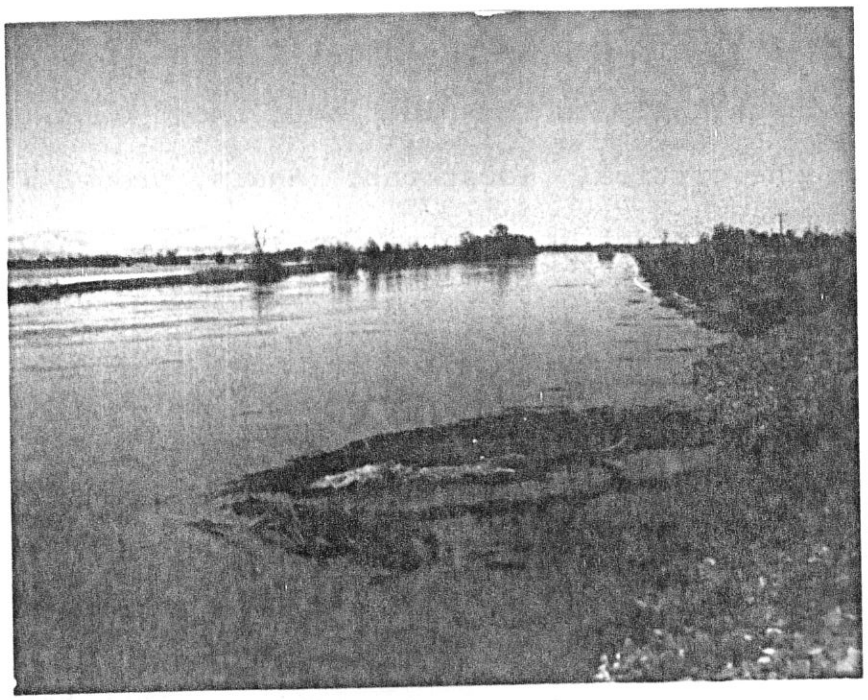
Wildlife Service. Discussions indicate a willingness on the part of Refuge managers to consider, as mitigation for removal of growth within the channel limits the planting of new young trees outside and adjacent to the critical locations. Again, proper management of vegetation is important in maintaining adequate drain capacity and debris control.

B. LOWER COLUSA BASIN DRAIN

The lower Colusa Basin Drain, from Knights Landing to Tule Road, is relatively free from major encroachments that retard flows under present conditions. It is important to stress the phrase "under present conditions". During winter and spring floods, the Basin is a large water storage and sometimes settling basin because of subsidence and the backwater situation caused by downstream channel and flow conditions in the Yolo Bypass. Most cross levees in the lower Basin are less than four feet in height. The only permanent major encroachment or flow blocking structure is the reconstructed County Line Road, west of the Drain. If downstream conditions were improved to eliminate the backwater conditions, this road would probably impair the winter Basin out-flow. However, "under present conditions" it has been determined by the State Reclamation Board's staff that the reconstructed road does not impair outflow.

Within the channel itself, structural encroachments that would be flow-restrictive are few in number when some maintenance or trash removal is provided by the owners. The structures themselves do not cause any apparent flow restriction.

In October 1980, when the water surface was lowered in the Drain, the exposed channel bank slopes were generally uniform and clean, that is, no vegetative growth appeared below the summer water level.



TRASH COLLECTION IN DRAIN
LOOKING NORTH FROM GRIMES-ARBUCKLE ROAD

VEGATATION OVERGROWTH IN DRAIN
LOOKING SOUTH FROM TULE ROAD BRIDGE

Figure 10.

At the existing bridges and at one abandoned bridge location, old wood piling projects above the water surface by a foot or two, and there is concrete rubble under two of the bridges. These channel impairments probably cause only localized channel problems in the condition observed. During flood periods the above mentioned channel encroachments offer excellent places for trash and trees to hang up on. The Counties should keep the bridges under close surveillance to implement trash removal.

At some locations along the west channel-bank tree growth is extensive. Most of the trees do not interfere with "in-channel" flow except between White Road and Tule Road. The overgrowth is such that trees have fallen in the channel or are projecting into it, and old snags and other trash are in the channel. When these conditions are present, some removal of the fallen trees and snags would be desirable and would improve summer localized flow.

Upstream from the entrance to the Knights Landing Ridge Cut the tree growth is not extensive, but it appears that beavers working the trees are causing considerable amounts of small trees and drift to accumulate in the area.

Sediments from west side streams accumulate at the mouths of the streams, forming deltas in the Drain and causing temporary restrictions. Sedimentation is discussed more thoroughly in another section.

Low to medium-height levees (4-6 feet) have been built on the west side of the Drain by some of the adjacent landowners. These levees give protection from spring and fall high flows. During winter flood flows portions of these levees are breached in many locations and are usually repaired early in the spring before the

planting of any crops. State Reclamation Board encroachment permits are required for levee construction within the floodway. It is suspected that portions of the levees are in violation of the Reclamation Board requirements, for instance, in not having encroachment permits for their construction or in exceeding the height standard that has been established.

C. KNIGHTS LANDING RIDGE CUT ENCROACHMENTS:

At first appearance, the Knights Landing Ridge Cut looks like a channel that has not had any maintenance for a long period of time. Before any judgement is made, however, the original purpose of the Ridge Cut must be recalled. The Knights Landing Ridge Cut was built to provide a gravity outlet for natural flooding that occurred in the Colusa Basin at the time of construction, 1915. The outlet does not prevent the flooding of the Colusa Basin, but it reduces the period of inundation. The changing physical conditions of the Cut and new demands such as irrigation and crop season drainage are now of immense local concern. As recently as 1977, the California Department of Water Resources, the maintaining agency for the channel, stated that the removal of cottonwood and willow growth in the center of the channel was all that was needed for the channel to adequately pass the design flood flow of 20,000 cubic feet per second. This clearing work was subsequently done by the Department. Reviewing the 1912 discharge curve for the proposed Ridge Cut reveals that because of tree growth, sedimentation, and perhaps other reasons, the lower end of the curve has shifted very little. The curve showed a flow of 1,200 c.f.s. at a water surface of 27.00 and 600 c.f.s. at elevation 26.00; zero or no flow below elevation 25.00 U.S.E.D. when there is no back water in the Yolo Bypass from the Sacramento River. As mentioned previously, except

for the extreme upper end of the channel (the actual Ridge), the bulk of the channel's maximum carrying cross-section is above natural ground surface. Therefore, except for the cut through the ridge, what appear to be clogged and unmaintained channels are actually borrow pits for the levees on each side. These borrow areas are being gradually filled in by sediment and are also accumulating snags. In the summer months, the tules and dense water hyacinth growth are also limiting the flow of the water for irrigation purposes. The only flow in the Knights Landing Ridge Cut in the summer is created by irrigation use, so there is no actual summer outflow to the Yolo Bypass except for controlled irrigation spills.

At the upper end of the Ridge Cut, where it intersects the Colusa Basin Drain, the full channel excavation was never done. Only the east channel was excavated but below the elevation required for winter flood flows, while the west side was not. The unexcavated material served as a barrier to prevent excessive summer flows from entereing the Ridge Cut and flooding crop land in the Yolo Bypass area. Because most summer flows are not natural waters, Reclamation District No. 2047 was required to construct a water control structure at this location by the local Districts as a condition for its use of the Colusa Basin Drain. No evidence of the structure being built has been found. In place of the structure an earth dam was constructed by the landowner at the mouth of the Ridge Cut to protect his crops from damage by upstream agricultural drainage waters.

Two small water control structures with limited outlet capacity for irrigation are located at the lower end of the Knights Landing Ridge Cut for the purpose of water level control and supply. Any excess summer flow returns to the Sacramento River through the Knights

Landing Outfall Gates. Once the boards are set on the two lower irrigation control structures the water surface is actually regulated or controlled by the outfall gate openings. The Outfall Gates are operated by the State Department of Water Resources.

The two irrigation structures at the outlet of the Ridge Cut are sufficiently low (Elev. 27.0 U.S.E.D.) that major floods, usually occurring during the winter flood season, can be discharged into the Yolo By-Pass. The two lower structures or headgates at the outlet of the Ridge Cut are connected by a roadway constructed to elevation 25.5 (U.S.E.D.) pursuant to an option and agreement dated July 17, 1937 between the land owners and the State Reclamation Board for the Sacramento and San Joaquin Drainage District. The documents were executed and recorded in 1943. The roadway between the structures also extends beyond the structure and ties into the levees of the Yolo By-Pass. The roadway serves as a barrier or low dam to prevent flooding of the By-Pass lands by summer drainage waters. As mentioned it was constructed to approximately elevation 25.5 (U.S.E.D.) compacted, and had a top width of 40 feet with cobble protection placed on the downstream slope. The roadway was constructed by the Corps of Engineers.

There are times during the late spring (May and June) when the water level in the Sacramento River is too high to permit gravity drainage. The spring runoff and or irrigation return flows cannot be adequately discharged. The water then backs up in the channel and the lower Colusa Basin until the elevation of the roadway is reached and it is overtopped; flooding of the Yolo By-Pass then occurs. Because of the limited hydraulic capacity of the irrigation control structures, flood relief is not obtained until the roadway washes out. There have been occasions when this barrier was reconstructed above

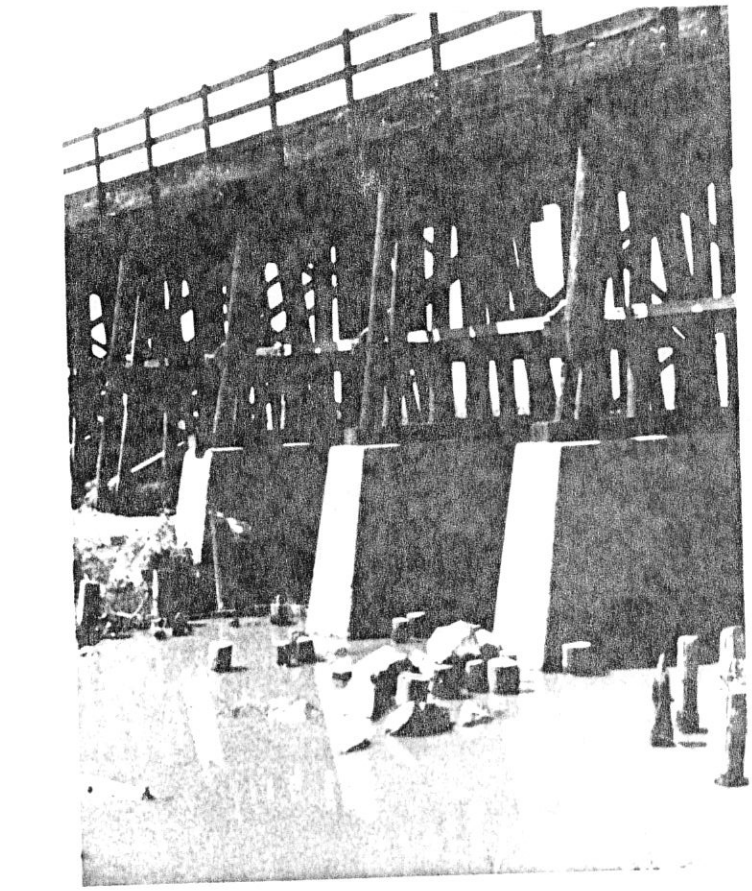
the prescribed elevation, but it has been lowered to design grade in recent years. Once the roadway - barrier is breached for any period of time it is ineffective as a flow restriction to winter floods.

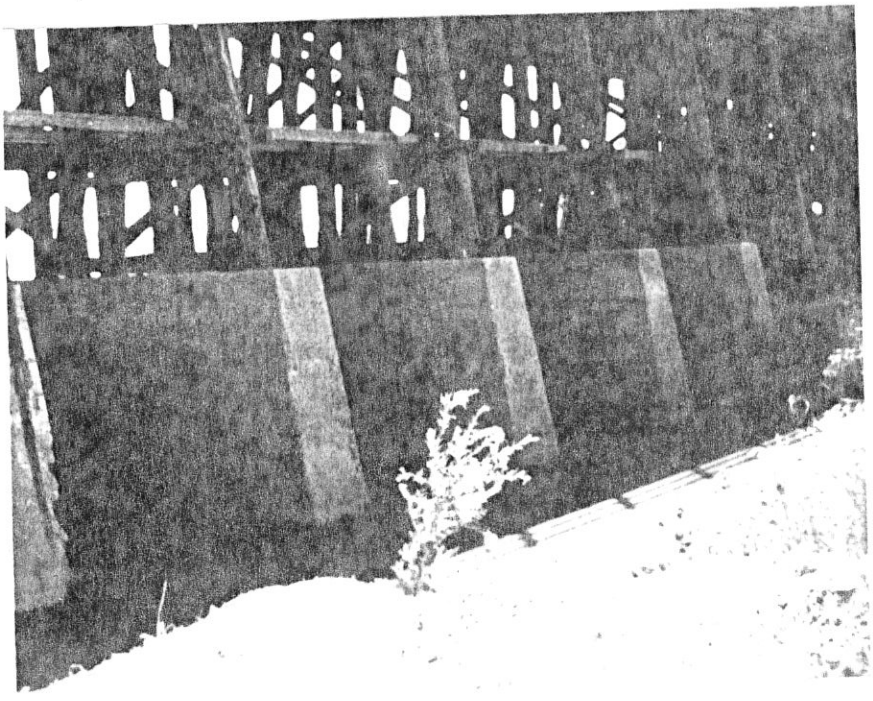
Recognition of the annual replacement of this barrier or low dam and an established top elevation are contained in an agreement between the landowner and the Sacramento and San Joaquin Drainage District.

Above the location just discussed, there are some encroachments that affect low flow conditions when the channel is used for irrigation conveyance. In addition to the sedimentation that has taken place over the years, several alterations to the channel have been made. The strip of land in the middle of the channel (figure 4) at one time was cut at intervals to allow cross-flow from one borrow channel to the other. To gain access to this land strip the Department of Water Resources, as part of its maintenance program, has filled in most of the cuts and, in addition, constructed a low water road or ramp to the land strip from the west levee. Even though there is now a pipe crossing under the access road, flow appears to be blocked off. This access road is also used to get cattle onto the land strip. The grazing or browsing more than likely is a benefit for vegetive control but, there are also gates and a corral with a loading ramp constructed on the center land strip. These items should be considered encroachments to flood flows. With the above mentioned center cuts filled in and the upper end of the west borrow area blocked off, there is no noticeable flow during the summer season. This makes an excellent environment for the growth of hyacinths and subsequent problems.

D. TULE CANAL ENCROACHMENTS:

As mentioned, there is no channel from the mouth of the Knights Landing Ridge Cut across the Yolo By-pass to convey water to the Tule





SOUTHERN PACIFIC RAILROAD ACROSS TULE CANAL

ABOVE I-80

Figure 11.