State of California
The Resources Agency
Department of Water Resources

SP-G2: EFFECTS OF PROJECT OPERATIONS ON GEOMORPHIC PROCESSES DOWNSTREAM OF OROVILLE DAM

TASK 3 – CHANNEL CROSS-SECTIONS AND PHOTOGRAPHY AND TASK 4 – MONITORING

Oroville Facilities Relicensing FERC Project No. 2100

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REPORT SUMMARY

The construction of Oroville Dam has altered the hydraulic, geomorphic, and sediment transport regimes of the Feather River. This study is designed to identify and evaluate ongoing effects of altered downstream hydrology and sediment retention in Lake Oroville on channel morphology and sediment transport in the Lower Feather River, Oroville. Specifically, this task of the study will address the following components:

1. Identify and acquire historic cross section data.
2. Establish locations of historic cross sections.
3. Reoccupy and survey or calculate existing conditions at historic cross sections.
4. Perform comparative analysis of channel cross section changes through time.
5. Perform comparative analysis of channel thalweg changes through time..
6. Monitor to the extent practicable flow and sediment movement during flow events.

Results from these tasks will be used to identify ongoing channel changes and develop a comprehensive sediment management plan for the purposes of protection, mitigation and enhancement measures to improve form and function in the Feather River. The study results will also be used by other studies to help assess the project's ongoing effects on downstream water quality, aquatic and riparian resources, and protection of private lands and public trust resources.

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1.0 INTRODUCTION

Study Plan G2 was designed to evaluate Feather River geomorphic changes resulting from the construction of Oroville Dam. The study reach begins at the Fish Barrier Dam near Oroville and extends to the mouth of the Feather River at Verona, a river distance of about 70 miles. The study reports identify the hydraulic, geomorphic, and sediment transport changes that have occurred. The effect of these changes on salmonid spawning riffles, flooding, riparian vegetation, riparian habitat, and river habitat was also considered.

Changes in sediment transport were evaluated by use of a sediment transport model. This model will also be used to predict changes in sediment transport and channel meandering resulting from various proposed flow regimes. Based on the results of the study, we will identify needs for protection, mitigation or enhancement activities. The study results can also be used by other studies to help assess and predict the Oroville Facilities ongoing effects over the next 25 and 50 years on downstream water quality, aquatic and riparian resources, and protection of private lands and public trust resources.

This report, *Task 3- Channel Cross Sections and Task 4 – Monitoring* is one of seven reports that fulfill the scope of Study Plan G2.

1.1 BACKGROUND INFORMATION

The Feather River is an important resource for salmonid spawning habitat in California, second only to the Sacramento River. The completion of Oroville Dam in 1967 reduced this habitat by blocking access to upstream reaches. This includes 25 miles to Miocene Dam on the West Branch, 21 miles to Poe Powerhouse on the North Fork, 19 miles to Curtain Falls on the Middle Fork, and 8 miles to Ponderosa Dam on the South Fork. This loss of spawning habitat was mitigated by the Feather River Fish Hatchery. The Hatchery provides an artificial spawning and rearing facility for Chinook salmon and steelhead.

Oroville Dam also affects hydrology and sediment transport characteristics, altering the movement of water, sediment, and woody debris in the river. The primary function of the dam is to store winter and spring runoff for release into the river as necessary for project purposes. This results in an altered hydrologic regime that includes changes to the yearly, monthly, and daily stream flow distributions; bankfull discharge, flow exceedance, peak flow, and other hydraulic characteristics.

The reservoir, along with other hydroelectric projects on the Feather River, also captures almost all of the sediment eroded from the upper Feather River watershed.

This changes patterns of sediment transport and deposition, scour, mobilization of sediment, and levels of turbidity. These changes can result in the coarsening of spawning gravel on riffles, which in turn may adversely affect salmon and steelhead.

These changes to the river hydrology and sedimentation patterns will in turn alter the channel morphology. These can include changes to the channel shape, meandering, and capacity.

These potential impacts may extend downriver from Oroville Dam to the junction with the Sacramento River or beyond. These are further complicated by a long history of a variety of land uses along the Feather River including hydraulic mining, gravel mining, gold dredging, timber harvesting, water diversions, and urbanization.

1.1.1 Study Area

The Lower Feather River flows about 72 miles from Oroville Dam to the Sacramento River at Verona. The river flows past distinctive geographic and geomorphic features. These are shown in Table 1.

Table 1.1-1. River Miles, Valley Miles and Related Geographic Features of the Feather River

RIVER MILE (1997 USACE)	RIVER MILE (USGS)	VALLEY MILE	GEOGRAPHIC FEATURE
71.5			Oroville Dam
67.2	67.8		Thermalito Diversion Dam
66.5	67.2		Fish Barrier Dam
66.3	67.0		Table Mountain Bridge
65.0	65.6		Highway 70 Bridge
58.7	59.0		Confluence with Thermalito Afterbay Outflow
50.6	50.8		Gridley Bridge
44.3	44.0		Confluence with Honcut Creek
42.5	42.3		Live Oak
27.9	28.5	24.9	Yuba City and Marysville
27.1	27.5	24.4	Confluence with Yuba River
N/A	25.4	22.6	Upstream End of State Cutoff (1909)
N/A	22.5	20	Downstream End of State Cutoff (1909)
N/A	19.5	17.4	Abbot Lake
N/A	18.8	16.7	Star Bend

RIVER MILE (1997 USACE)	RIVER MILE (USGS)	VALLEY MILE	GEOGRAPHIC FEATURE
N/A	17.0	15.7	O'Conner Lakes
N/A	13.0	12.3	Lake of the Woods
N/A	12.5	11.6	Confluence with Bear River
N/A	9.6	9.1	Town of Nicolaus
N/A	9.3	8.9	99 Bridge (Garden Highway)
N/A	8.2	8	Upstream End of State Cutoff (post-1911)
N/A	7.5	7.3	Upstream End Sutter Bypass; Downstream End State Cutoff (post-1911)
0.0	0.0	0	Verona, Confluence with Sacramento River

More effort was spent on the 39-mile reach from the Fish Barrier Dam to Yuba City (Figure 1.1-1). Below Yuba City, the Yuba and Bear Rivers join the Feather, and the overall effect of Oroville Dam is greatly reduced. The study boundary extends laterally to the edge of the 100-year floodplain as defined by the USACE (2002).

The study reach is further divided into four subreaches based on differences in the hydrologic flow regime. The first (the Low Flow Reach) is the 8-mile stretch between the Fish Barrier Dam and the Thermalito Afterbay outflow. The second is the 39-mile reach between the Afterbay outflow and the Yuba River. The third, is 15 miles from the confluence of the Yuba River to the confluence of the Bear. The fourth, about 12 miles long, begins at the confluence with the Bear and ends at the confluence of the Feather and the Sacramento River at Verona.

Most of the SP-G2 study effort was on the salmon spawning reach between the Fish Barrier Dam and Honcut Creek. The activities included in this reach are: FLUVIAL-12 model, sediment sampling, permeability, dissolved oxygen, and temperature measurements. Below Honcut Creek, geomorphic and mesohabitat typing was done, including bank erosion, bank composition, habitat, geology, soils and woody debris.

1.1.2 Description

The Feather River watershed is mainly in the northern Sierra Nevada geomorphic province. The river drains the western slope of the Sierra Nevada and is tributary to the Sacramento River. Some of the headwaters also lie within the Basin and Range geomorphic province, containing both steep forested mountains and large intermountain valleys. The climate is Mediterranean, with mostly dry summers and wet winters. Annual precipitation ranges from 75 inches in the upper watershed to 30 inches in the lower watershed near Oroville Dam.

The Feather River is underlain by resistant metamorphic, volcanic, and plutonic rocks in the 4-mile reach downriver of Oroville Dam to the Fish Diversion Dam. It is incised into these rocks, forming steep canyon walls.

Below the town of Oroville, the Feather River emerges from the Sierra Nevada into the foothills of the Sacramento Valley. At about three quarters of a mile below the Diversion Dam, at the first major spawning riffle, bedrock is still exposed in the channel. Below Bedrock Park, the river begins to flow in an alluvial channel incised into dissected older alluvial uplands.

The Oroville Wildlife Area, consisting of dredger tailings and borrow pits, occurs from a few miles below Oroville to a few miles above Gridley. Below the dredger tailings, the river meanders through hydraulic mining debris, floodplain deposits, and older terrace deposits.

1.1.3 River Access

The river is accessible by vehicle through the Oroville Wildlife Area and public parks. Numerous public boat ramps are also available. Jet boats can often be used in the High Flow Reach and sometimes in the Low Flow Reach dependent on flow. Seasonal variations in flow can make some riffles difficult or impossible to navigate and submerged snags can be an additional hazard.

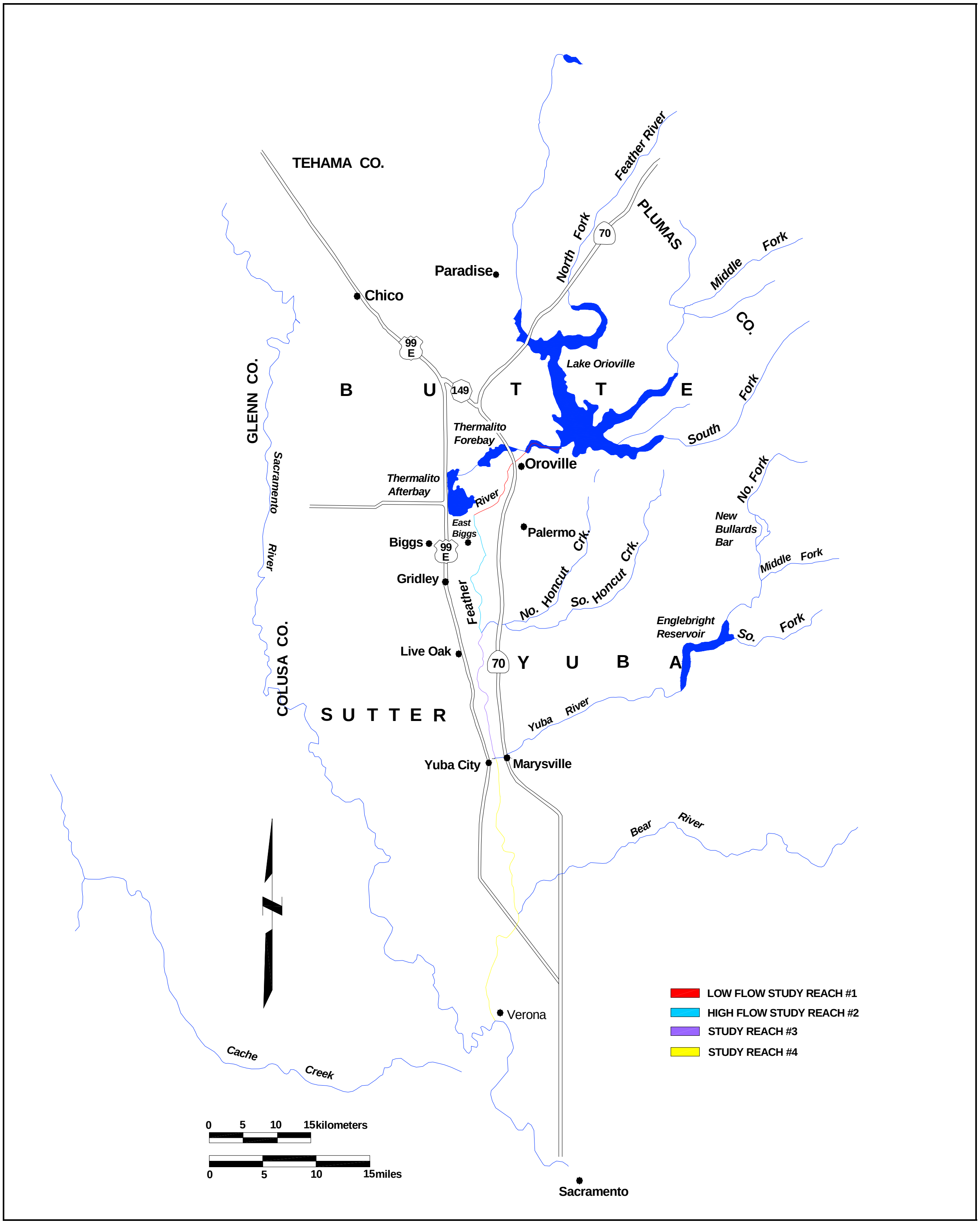


Figure 1.1-1. SP-G2 Geomorphic Study Area and Subreaches, Lake Oroville to Yuba City

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. Figure 1.2-1 shows an overview of these facilities and the FERC Project boundary. Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

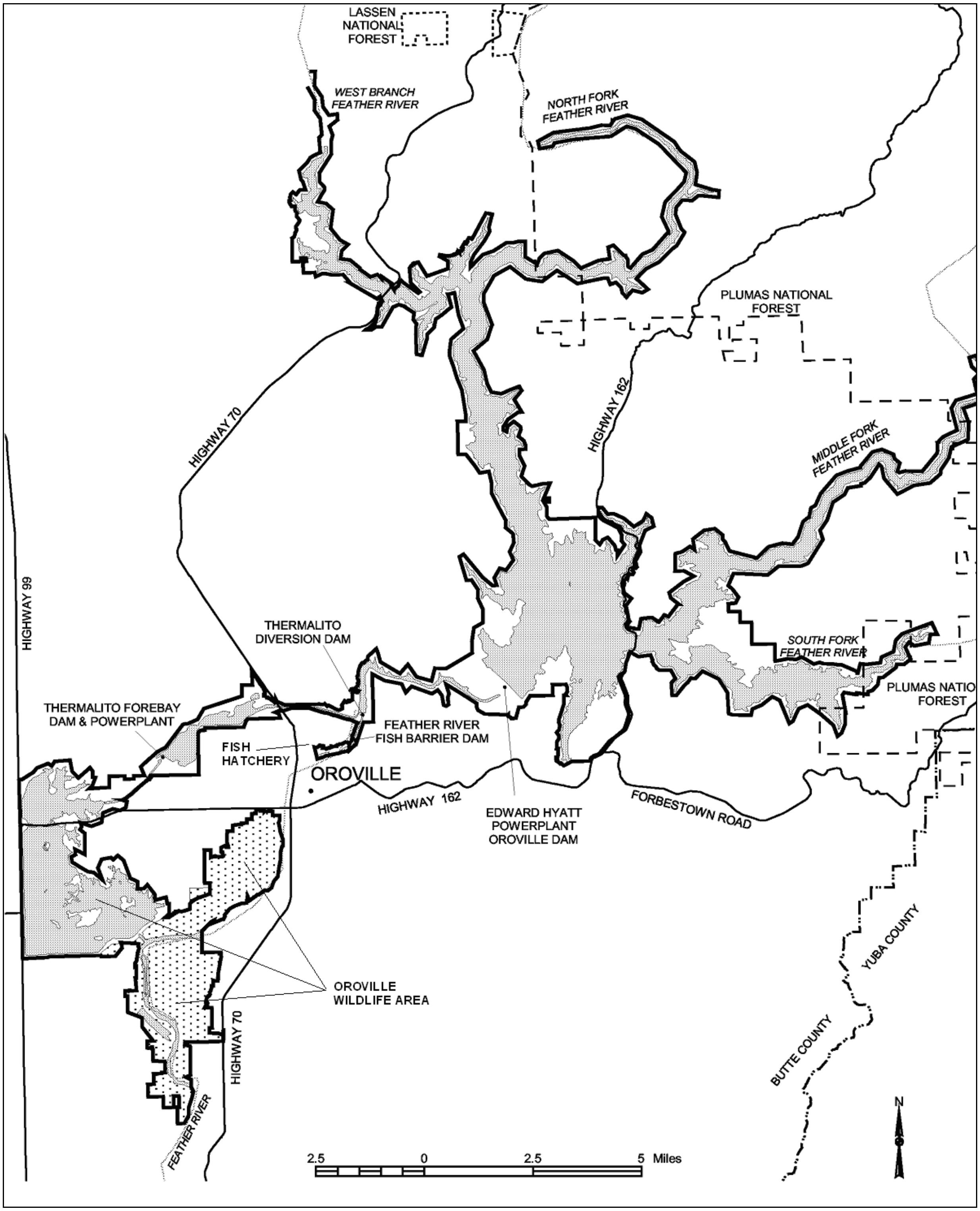


Figure 1.2-1. Overview of FERC Project No. 2100 Facilities

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning are conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrologic conditions are drier than expected or water requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, “Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife,” sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake

Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

2.1 PURPOSE AND SCOPE

A naturally functioning channel in dynamic equilibrium is capable of transporting the water and sediment delivered to it without significantly changing its geometry, streambed composition, or gradient through time. The flow conditions that promote this stability can be described as geomorphically significant flows (bankfull). These flows do the majority of the sediment transport and are considered most responsible for channel form. A natural flow regime typically includes flow ranges responsible for in-channel clearing and overbank flows to support riparian vegetation, along with channel-forming flows.

The altered sediment routing and hydrology caused by the Oroville Facilities have affected river morphology. There is a need to understand these relationships and identify potential protection, mitigation and enhancement measures.

The geomorphic investigation compares historic and current conditions to help identify ongoing project effects to the downstream reach defined in this study. This information is used to identify continuing project effects to downstream geomorphic processes. It will also be used by other studies to help assess the project's effects on plant, fish, animal, and riparian resources caused by hydrologic, channel, and sediment routing changes. These data, together with other study results, will provide boundary conditions for assessing potential management actions.

Project -related structures and operations also alter flow regimes, which can impact the occurrence of geomorphically significant flows. Potential adverse effects include loss of undercut banks, increased instream fine sediment, braiding, loss of channel capacity, reduced sediment transport capability, gravel displacement, unnatural channel scour, armoring, and impairment of the ability of the stream to maintain functional riparian and instream habitat. Project-related structures and operations can also impair the stream's ability to transport the sediment delivered to it from source areas.

3.0 STUDY OBJECTIVE(S)

3.1 APPLICATION OF STUDY INFORMATION

The objective is to determine the ongoing effects of altered downstream hydrology and sediment retention in Lake Oroville on channel morphology and sediment transport below Lake Oroville. Study results could be used to identify limiting factors (impacts associated with biological effects) and develop a comprehensive sediment management plan for the purposes of protection, mitigation and enhancement measures to improve form and function in the Feather River. The study results could also be used by other studies to help assess the Oroville Facilities ongoing effects on downstream water quality, aquatic and riparian resources, and protection of private lands and public trust resources.

This study will determine the ongoing effect of flows on the morphology of project affected streams and project impoundments downstream of Oroville Dam. Specifically, the study will address the following components:

1. Determine sediment conditions and sediment transport requirements.
2. Evaluate sediment sources (including tributaries) and conditions.
3. Map major sediment deposits.
4. Evaluate stream channel stability.
5. Evaluate project-affected sediment regimes.
6. Evaluate timing, magnitude, and duration of project-affected flows in relation to geomorphic effects.
7. Determine the effect of the project on fluvial geomorphologic features.
8. Evaluate erosional effects on farmland public trust resources.

3.1.2 Other Studies

Studies related to channel morphology began well before construction of Oroville Dam. In response to the tremendous influx of hydraulic mining debris, detailed flood plain topography and channel investigations were performed in 1909/1910 and were presented as part of the Debris Commission Report 1911. We have scanned and rectified the maps prepared for the Debris Commission for inclusion in the GIS system. DWR (1965) studied pre-dam channel characteristics, and then DWR (1969) and the USGS (Blodgett, 1972) conducted studies to document channel changes. In 1977 DF&G studied the interim impacts of the dam on salmonid escapement. In 1978 the USGS did another study to evaluate sediment transport and discharge. Because of the findings of several of the previous investigations, DWR (1982) prepared the Feather River Spawning Gravel Baseline Study to determine the condition of spawning gravel in the upper Feather River.

4.0 STUDY ORGANIZATION

4.1 STUDY DESIGN

The original seven individual tasks and sub-tasks specified in the study plan have been re-organized into the following:

- Task 1.1 - obtain, review, and summarize existing resource data and references;
- Task 1.2 – prepare a general description of the lower Feather River and watershed;
- Task 2 - map and characterize spawning riffles;
- Task 3, 4 - evaluate changes to the channel morphology by re-establishing historic cross-section surveys and photo points; perform limited monitoring during flow events if any occur
- Tasks 6 - assess current channel characteristics and monitor selected cross-sections for significant changes to those characteristics; establish bank erosion monitoring sites
- Task 5 - determine project effects on river hydraulic and geomorphic parameters;
- Task 7 - model sediment transport and channel hydraulics; make predictions

Each of these bulleted items will be output as a separate report. This specific report is organized by and fulfills the requirements for "Task 3 – Channel Cross Sections and Task 4 – Monitoring".

4.2 HOW AND WHERE THE STUDIES WERE CONDUCTED

The SP–G2 activities were performed during 2002 to mid 2004. Office work focused on researching and collecting references and data sets, performing sieve analyses of sediment samples, documenting field surveys, and preparation of maps, charts, and figures. Field work concentrated on finding and re-surveying historic cross-sections, collecting bulk and sediment samples, and river habitat classification. Most of the work has been done in the Low and High Flow Reaches between Oroville Dam and the mouth of Honcut Creek.

5.0 LOCATE AND RESURVEY HISTORIC CROSS-SECTIONS

5.1 METHODOLOGY AND RESULTS

Cross-sections have been surveyed in the low flow reach in the past. Many of these were re-established, and additional cross-sections were processed from existing topographic data to provide sufficient spacing for the study needs. Cross-sections were established below the Thermalito outfall, for some distance downstream and with spacing dependent on need. The end-points were permanently marked using steel pipe set in concrete monuments and surveyed using GPS. Each cross-section location has a photo point, and additional photo points were established in critical areas.

Field characteristics of sediment, floodplain, and riparian condition provide the basis for transect selection for detailed study. The study sites include sensitive sites with potential project-related impacts, representative sites for the range of identified stream types, stream gage locations, and reference reaches.

The topographic surveys for 1997-98 were taken from data derived for the Sacramento-San Joaquin Comprehensive Study (USACE 2002). These surveys were used in the form of both digital terrain models (DTM) and 2-foot contour maps. The data was provided by Ayres Associates and surveyed in 1997-98. For comparison purposes this survey data is referred to as 1997 surveys in this report. Hydrographic surveys were done for the entire Feather River. Additional surveys were done by LIDAR or photogrammetry. All data is referenced horizontally in the State Plane Coordinate System 1983, Zone 3. The reference datum is the North American Datum of 1983 (NAD83). Elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Cross sections for the Feather River used in this study were cut from the 2-foot contours developed by Ayres (2001) and imported into AUTOCAD.

Mapping was performed by the Army Corps of Engineers in 1909 for the California Debris Commission (1911). For the mapping performed in 1909, elevations are expressed in feet and tenths and are referred to U.S.E.D. datum plane which is 3.6 feet below mean sea level, the datum plane of the U.S. Geological Survey, and are based on a bench mark of that survey at Oroville. Soundings are expressed in feet and tenths and are referred to the water surface of the river, the elevation of which is marked at each section where soundings were taken.

For the 1972 USGS Blodgett cross sections, the geometry of the stream channel was determined by transit-stadia survey. Vertical control was established at several locations throughout the study reach from U.S. Coast and Geodetic Survey bench marks. All elevations were referenced to mean sea-level datum (1929 datum, 1946-47, 1957 adjustments).

Channel cross sections and intermediate points to aid in the analysis were surveyed at selected intervals throughout the study reach and related to the longitudinal water surface profiles. Sites were selected and horizontal control established using 7.5 minute topographic maps and aerial photos. In places, cross sections were extended across wide flood plains using data from the topographic maps.

Thirty-five cross sections were surveyed by DWR in early 1991 as part of the Feather River Instream Flow Incremental Methodology (IFIM) Study (DWR, 1994). The Feather River IFIM Study report does not describe the methodology used in surveying the cross sections; consultation with DWR staff who participated in the survey indicated that the surveys were performed using conventional total station surveying equipment. Assumed datum elevations were used at the time of the surveys and were converted to actual elevations by a level survey performed by DWR Land and Right-of-Way in June 1996.

Cross section surveys performed as part of this report were surveyed using real-time kinematic (RTK) Global Positioning System (GPS) equipment or a combination of RTK and conventional total station surveying equipment. The GPS equipment consisted of a Trimble 4000SSI dual frequency receiver base station near the Oroville Airport (upstream sections) or Honcut Creek (downstream sections) and a Trimble backpack 4700 receiver. Coordinates (i.e., northings and eastings) for each surveyed point were recorded in State Plane datum (i.e., NAD83 CCS, Zone 2). Elevations were recorded in NGVD29 datum. Existing monument locations were measured twice with GPS equipment with different satellite configurations to ensure location accuracy to within 0.1 feet. Conventional total station surveying equipment was used at some locations where overhead vegetation rendered the GPS equipment inoperable.

By surveying the cross-section control points with GPS equipment, the exact geographical location of the control point can be relocated for future sedimentation studies even if the control point monuments disappear in the future.

5.1.1 Locate Existing Cross-Sections

Activities performed for this task included establishing baselines, locating benchmarks and existing cross-section locations, and setting monuments. Monuments were surveyed using GPS.

In our examination of the literature of the Feather River we found 22 reports that contained river cross section or profile data. These reports are shown on Table 5.1-1. The reports providing the most useful data included the 1909 War Department maps of the Feather River (USACE 1909) used by the Debris Commission, the 1972 US Geological Survey report (Blodgett, 1972), the DWR 1982 Spawning Gravel report (DWR 1982), and the USACE Comprehensive Study (USACE, 2002), that included 2-

foot contours for the Feather River from RM 7-66 for 1997. These data sets were supplemented with the other reports as necessary. The available data allowed the assessment of conditions pre- and post dam. The locations of the cross sections are shown in the Task 3 Atlas (sample provided on Figure 5.1-1a and b) and are included in the GIS system.

Table 5.1-1. Historical Cross-sections along the Lower Feather River, Lake Oroville to Verona

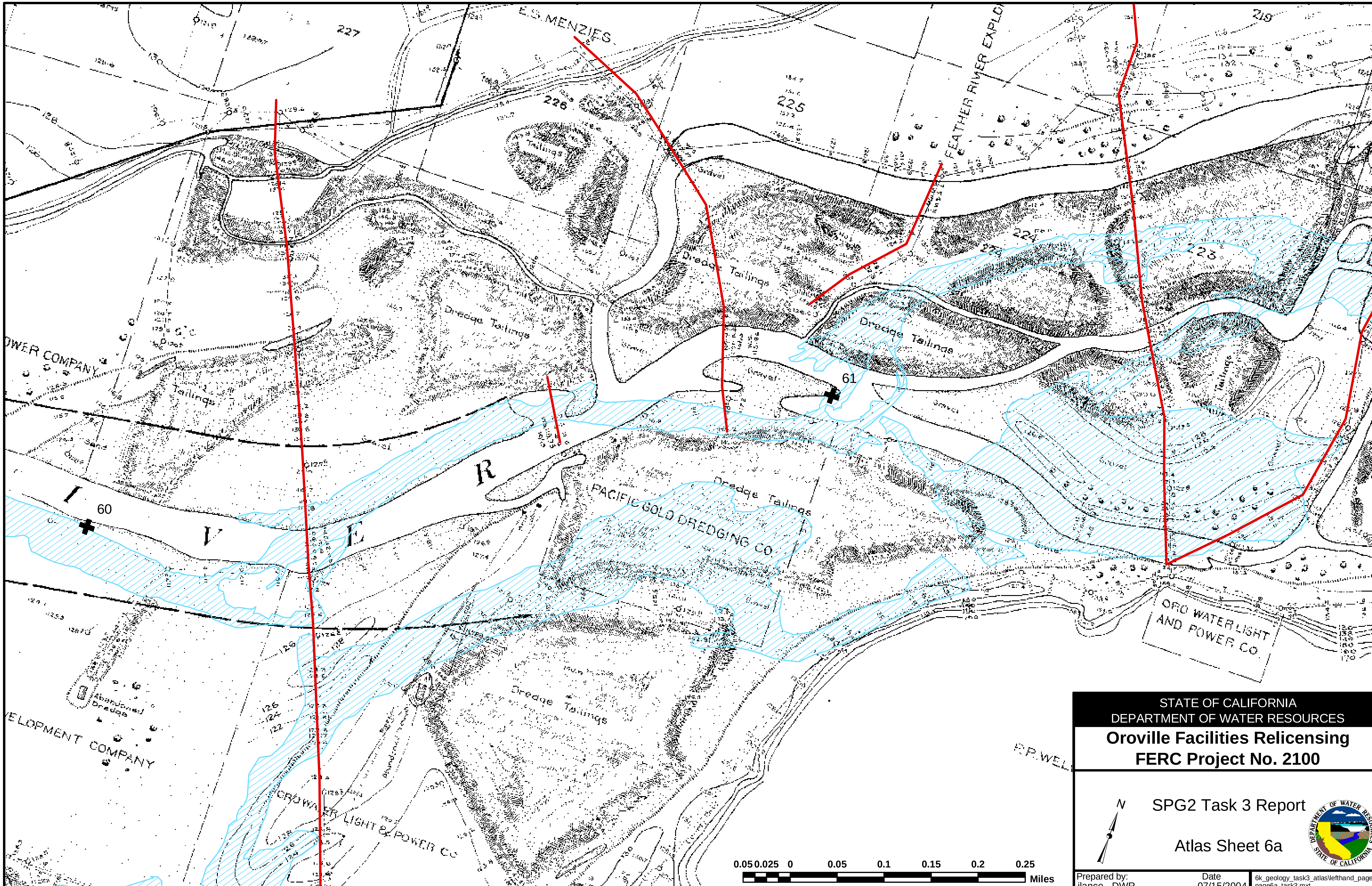
	DATE	AGENCY	TITLE	USACE River mile (start)	USACE River mile (end)	# of cross-sections
pre-Oroville Dam	1909	United States. War Dept and United States. Army. Corps of Engineers	Feather River, California	0.0	67.0	331
	1924	United States. Army. Corps of Engineers		6.9	24.5	13
	1925	United States. Army. Corps of Engineers	Sacramento River, California, revision of flood control project : showing profiles			
	1939	United States. Army. Corps of Engineers	Preliminary Examination			
	1965	California. Dept. of Water Resources	Determination of the Channel Capacity of the Feather River,	16.0	50.5	37
post-Oroville Dam	1968	United States. Army. Corps of Engineers. Sacramento District and California. State Reclamation Board	Flood plain information, Feather and Yuba Rivers, Marysville-Yuba City, California : prepared for the California State Reclamation Board ... et al.			
	1968	United States. Army. Corps of Engineers and California. Reclamation Board	Flooded areas, Nicolaus, California			
	1968	United States. Army. Corps of Engineers and California. Reclamation Board	Floods, Maryville-Yuba City, California			
	1968	California. Dept. of Water Resources - Central District	Progress Report of Documentation of the Feather River Floodplain Conditions	11.5	53.2	10
	1972	California. Dept. of Water Resources - Central District	Feather River : Safety			
	1972	United States Geological Survey	Determination of Channel Changes in the Feather River	44.7	67.2	71
	1978	United States Geological Survey	Sediment Transport in the Feather River			
	1981	California. Dept. of Water Resources - Northern District	Spawning Gravel Study	49.6	66.8	158
	1983	California. Dept. of Water Resources - Northern District	Spawning Gravel Study (Moe's Ditch)	66.5	66.8	42
	1986	United States. Army. Corps of Engineers	Feather River : Oroville Dam to Sacramento River			
	1990	United States. Army. Corps of Engineers. Sacramento District	Yuba River Investigation	5.0	29.3	37

	DATE	AGENCY	TITLE	USACE River mile (start)	USACE River mile (end)	# of cross-sections
	1991	California. Dept. of Water Resources - Northern District	IFIM Study (unpublished data)	45.5	66.6	34
	1992	United States. Army. Corps of Engineers. Sacramento District		6.9	27.3	15
	1994	California. Dept. of Water Resources - Central District	IFIM Study (unpublished data)	0.5	44.0	6
	1998	United States. Army. Corps of Engineers. Sacramento District and California. Reclamation Board	Yuba River Basin investigation, California : final feasibility report and appendixes			
	1999	United States. Army. Corps of Engineers. Sacramento District and California. Reclamation Board	Sacramento River Comprehensive Study - UNET Data			
	2002	California. Dept. of Water Resources - Northern District	Re-surveys of IFIM cross-sections (unpublished data)	44.7	67.2	12 of 34

Figure

Placeholder

Figure 5.1-1a. Aerial Photo Atlas of Cross-section Locations (example)((Two pages)



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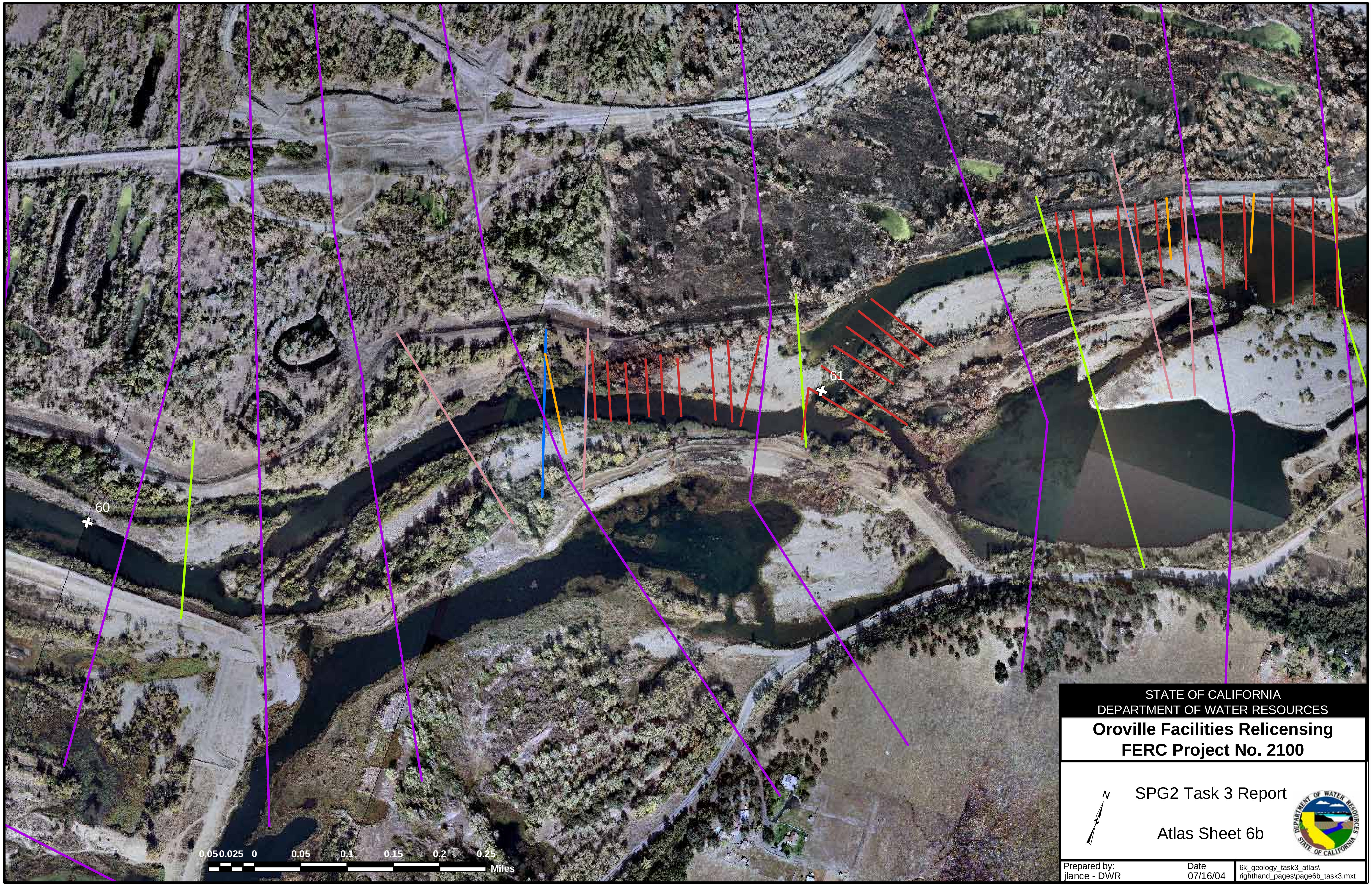
SPG2 Task 3 Report

Atlas Sheet 6a

Prepared by: jlance - DWR | Date 07/15/2004 | 6k_geology_task3_atlas\lefthand_pages\page6a_task3.mxt

Figure 5.1-1b. Aerial Photo Atlas of Cross-section Locations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61
0.05 0.025 0 0.05 0.1 0.15 0.2 0.25
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STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
SPG2 Task 3 Report
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Prepared by:
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5.1.2 Resurvey Cross-Sections

Because of the availability of the 1997 2-foot contours for the Feather River from Oroville Dam to the confluence with the Bear River (USACE 2002), it was possible to reproduce any of the historic cross sections for comparison to recent conditions. This was done for 46 of the 331 cross sections between Oroville and Yuba City originally surveyed in 1909. These cross sections are shown in Appendix A and include the 1909 survey data, a 1952 section using the 5-foot contours from the USGS Quadrangle maps that does not include bathymetry, and a section with the 1997 2-foot contours with the channel bathymetry. These sections show the changes in the river cross section between 1909 and 1997 that can be documented with the available data and are arranged by River Mile (RM) designation.

The same type of comparison was made by using the cross sections published in 1972 by the USGS (Blodgett 1972), measured in 1970, and the 1997 2-ft contours. The comparison of those two sets of cross sections provides information the post dam changes to the channel. Unfortunately, the 1909 and 1972 cross sections are not co-located so the pre dam changes can only be assessed by inference in comparing the 1909 to 1997 and 1972 to 1997 cross sections. Cross sections done by Blodgett (Blodgett 1972) were located in some instances by inspection of 7.5' quadrangle maps. Because of relative imprecision of these locations some of these sections were adjusted in order to more closely align with permanent topographic features. Information for these cross sections is provided in Appendix B.

In order to look at selected areas in more detail, though over a shorter time period, the cross sections prepared by DWR in the early 1990's were resurveyed. However, of the 34 cross sections only 17 of the end point monuments or other features enabling an accurate re-occupation of the cross section were found. Evidently the 1997 flood event altered the banks and destroyed the markers that were close to the waters edge. These cross sections are listed in Table 5.1-2 and are shown in Appendix C

Table 5.1-2. 1992 IFIM Cross-sections and 2002 Re-surveys

River Mile	Riffle/Feature	Cross-section	Length of Cross-section	DWR Geology Right Bank Point	DWR Geology Left Bank Point
	AR-LB-CP-3	monument found and GPS surveyed in 2002			
	Transect 1	entire transect GPS surveyed in 2002			
	Table Mountain Bridge				
	Hatchery Riffle	Transect 1	563.0	I - 1	I - 2
66.4	Auditorium Riffle	Transect 3	492.9	I - 3	I - 4
	Auditorium Riffle	Transect 2	504.2	I - 5	I - 6
	Auditorium Riffle	Transect 1	541.6	I - 7	I - 8

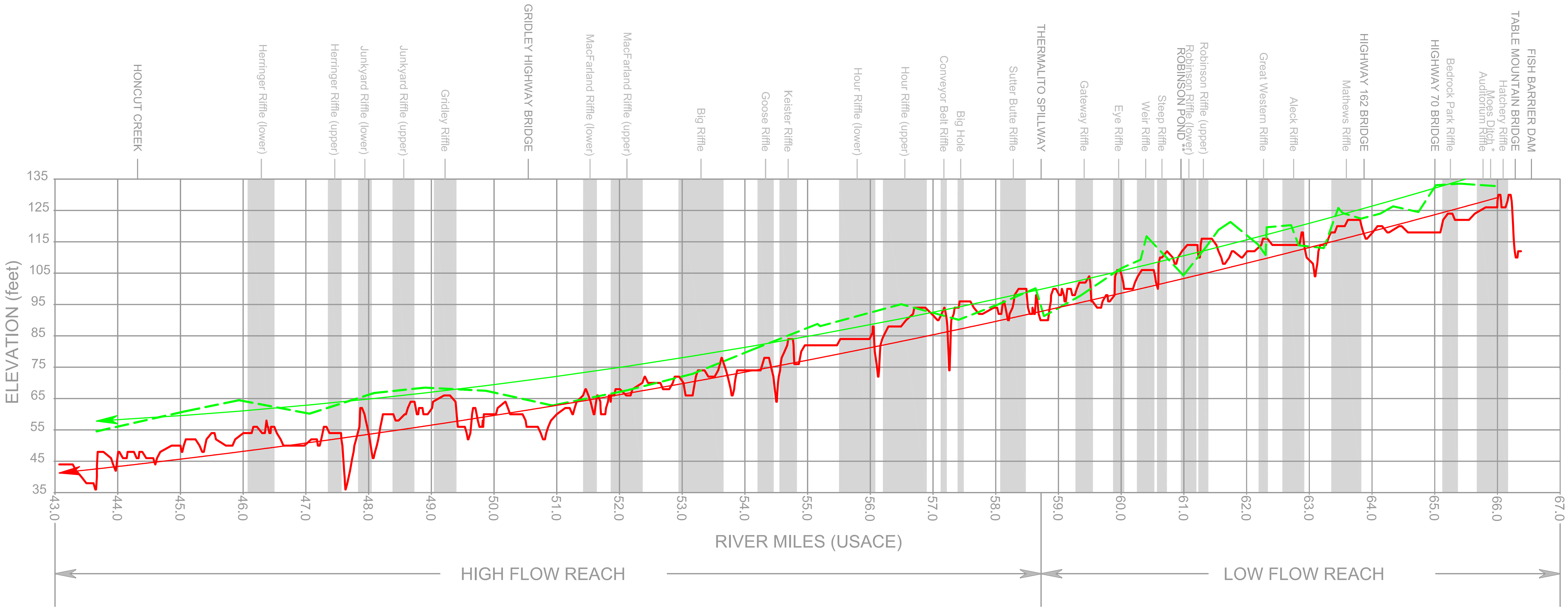
River Mile	Riffle/Feature	Cross-section	Length of Cross-section	DWR Geology Right Bank Point	DWR Geology Left Bank Point
65.8	Bedrock Park Riffle				
	Bedrock Park Riffle				
	Highway 70 Bridge				
	Highway 70 Bridge				
	River Bend Park				
	River Bend Park				
64.5	Highway 162 Bridge	Transect 1		I - 9	I - 10
63.8	Mathews Riffle	Transect 3		I - 11	I - 12
	Mathews Riffle	Transect 2		I - 13	I - 14
	Mathews Riffle	Transect 1		I - 15	I - 16
63.4	Aleck Riffle	Transect 3	191.4	I - 17	I - 18
	Aleck Riffle	Transect 2	198.9	I - 19	I - 20
	Aleck Riffle	Transect 1	393.6	I - 21	I - 22
62.7	Great Western Riffle	Transect 1	280.6	I - 23	I - 24
61.1	Robinson Riffle	Transect 3	393.0	I - 25	I - 26
	Robinson Riffle	Transect 2	419.1	I - 27	I - 28
	Robinson Riffle	Transect 1	417.9	I - 29	I - 30
60.8	Steep Riffle				
	Steep Riffle				
60.6	Weir Riffle	Transect 2	324.2	I - 31	I - 32
	Weir Riffle	Transect 1	299.5	I - 33	I - 34
60.4	Gateway Riffle				
	Gateway Riffle				
58.7	Sutter Butte Riffle			I - 35	I - 36
	Sutter Butte Riffle				
57.5	Conveyor Belt Riffle	Transect 2LC	162.6	I - 37A	I - 37B
	Conveyor Belt Riffle	Transect 2RC	196.2	I - 38A	I - 38B
	Conveyor Belt Riffle	Transect 1	467.8	I - 39	I - 40
56.7	Hour Riffle	Transect 3	342.1	I - 41	I - 42
	Hour Riffle	Transect 2	362.0	I - 43	I - 44
	Hour Riffle	Transect 1	346.2	I - 45	I - 46
55.2	Keister Riffle				
	Keister Riffle				
54.8	Goose Riffle	Transect 3	186.9	I - 47	I - 48
	Goose Riffle	Transect 2	284.7	I - 49	I - 50
	Goose Riffle	Transect 1	265.5	I - 51	I - 52
	Goose Backwater	Transect 1	492.4	I - 53	I - 53.5
	Goose Backwater	Transect 1		I - 53.5	I - 54
53.7	Big Riffle	Transect 2	298.1	I - 55	I - 56
	Big Riffle	Transect 1	257.7	I - 57	I - 58
	Macfarland Riffle				

River Mile	Riffle/Feature	Cross-section	Length of Cross-section	DWR Geology Right Bank Point	DWR Geology Left Bank Point
	Macfarland Riffle				
	Gridley Bridge				
	Gridley Bridge				
50.3	Gridley Riffle				
	Gridley Riffle				
	Shallow Riffle	Transect 3		I - 59	I - 60
	Shallow Riffle	Transect 2A		I - 61	I - 62
	Shallow Riffle	Transect 2B		I - 62	I - 63
	Shallow Riffle	Transect 1		I - 64	I - 65
46.7	Herringer Riffle	Transect 3		I - 66	I - 67
	Herringer Riffle	Transect 2		I - 68	I - 69
	Herringer Riffle	Transect 1		I - 70	I - 71
	Honcut Creek				

5.1.3 Thalweg Profiles

Thalweg profiles were prepared from data available for 1909, 1924, 1964, and 1997. The thalweg profiles are shown on Figure 5.1-2, Oroville to Honcut Creek, and Figure 5.1-3, Oroville to Verona.

Figure 5.1-2, Thalweg Profiles Oroville to Honcut Creek



LEGEND

1997 Thalweg

1909 Thalweg

1997 Thalweg - Polynominal Best Fit

1909 Thalweg - Polynominal Best Fit

NOTES

1) River miles based on USACE 1997 river center line. 0.0 = Feather River intersection with Sacramento River.
2) 1997 Best Fit line generated from data extending from RM 40.1 to RM 66.0.
3) 1909 Best Fit line generated from data extending from RM 39.6 to RM 65.9.
4) * Spawning gravel injection at Moe's Ditch from 1971 to 1982
5) ** Robinson Pond - apparent gravel trap

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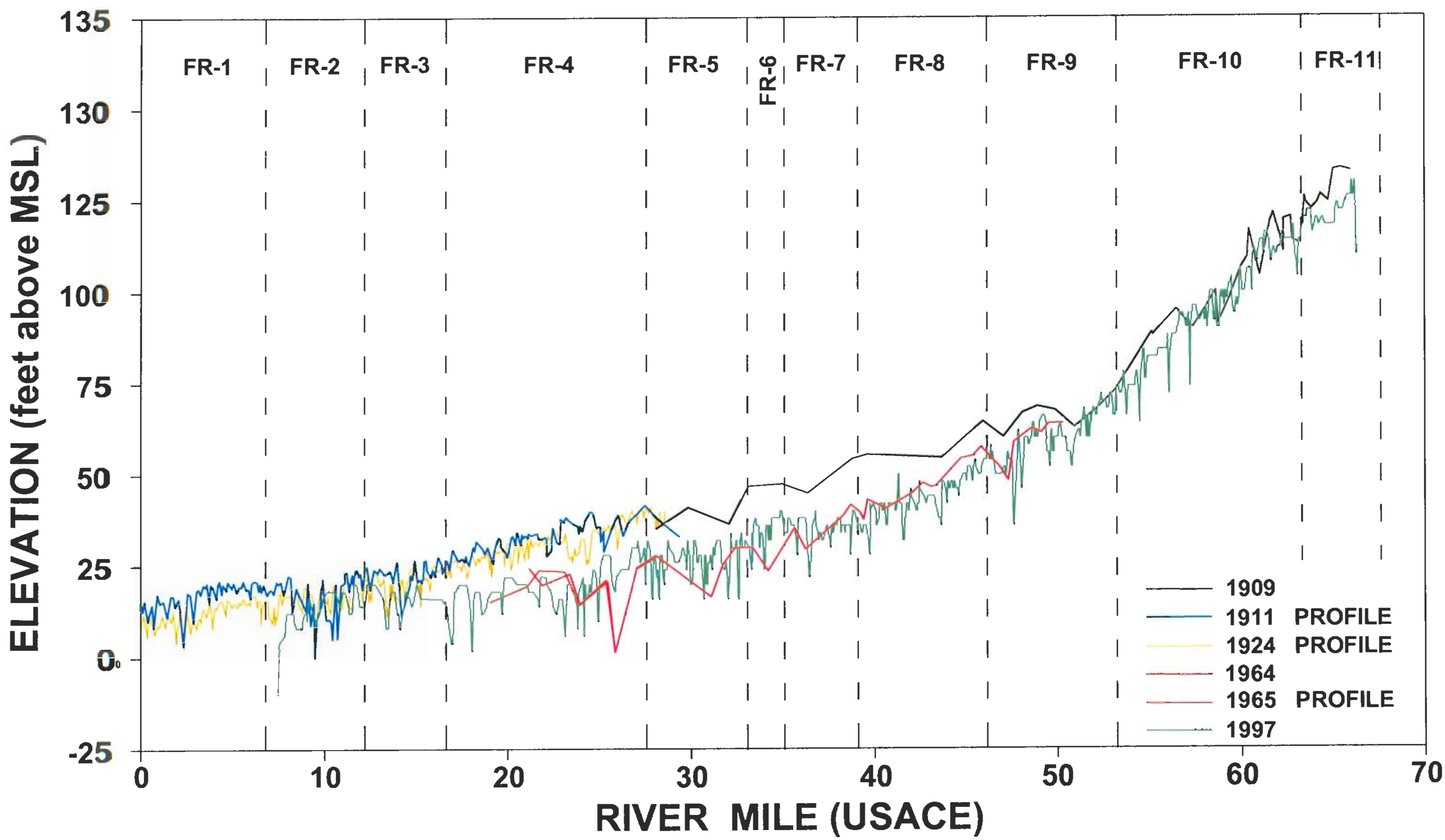
FIGURE 5.1-2
SP-G2 TASK 3
FEATHER RIVER
THALWEG PROFILES 1909 - 1997
OROVILLE TO HONCUT CREEK

Prepared by: GMG -- DWR	Date 8/19/ 04	Filename Feather River Thalweg.dwg

Filename:H:\6-graphs\Completed Graphs\Completed Figures\FTP\Feather River Thalweg.dwg
Layout Name:Thalweg Plot Time: Aug 19, 2004 - 11:10am

Figure 5.1-3, Thalweg Profiles Oroville to Verona

Figure 5.1-3 FEATHER RIVER THALWEG PROFILES (1909 - 1997)



5.1.4 Channel Planform

The cross sections information presented in Appendix A includes maps/aerial photos for the data dates of 1909, 1952, and 2001. This information allows for a comparison of land use changes along the river during this time span. Analysis of channel migration, erosion and meander is presented in the SP-G2 Task 6 report.

5.2 ANALYSES

5.2.1 1909 to 1997 Cross Sections

Generally the cross sections show that between the Gridley Bridge and Yuba City the river channel has incised and widened between 1909 and 1997. Note that the water depths are not necessarily deeper, only that the channel has incised into the underlying deposits. For example at RM 32.65 the channel thalweg is 15 feet lower in elevation and the channel is about 100 feet wider in 1997. At RM 34.88 in an area of active channel migration the thalweg elevation is 12 feet lower and the channel width increased by over 200 feet. Above Honcut Creek, RM 45.77 and 46.77, the thalweg has lowered about 10 feet and the channel widened 300 to 400 feet.

Between the Gridley Bridge and the Thermalito Outfall the channel incision is much less. The bed materials are much coarser and the area has been disturbed by dredger mining between 1909 and 1965. At RM 51.11, just above the Gridley Bridge, the thalweg is only two feet lower and the channel is less than 200 feet wider. At RM 53.59 the thalweg is five feet lower but the channel is 400 feet wider. At RM 57.83 the thalweg elevation is the same and the channel width is highly disturbed by dredging and gravel removal operations.

In the Low Flow section, above RM-59, the cross sections show a general narrowing of the channel. This would be in response to the nearly constant 600 cfs flow allowing vegetation to encroach upon and stabilize the channel. At RM 62.35 the thalweg has lowered by about 7.5 feet and the channel narrowed from 750 to 450 feet. At RM 63.81 the thalweg is at the same elevation and the channel has narrowed from 750 to 500 feet. At RM 66.09 the thalweg has lowered by about 10 feet and the channel narrowed from 750 to 550 feet.

In order to provide a measurement of the average change in elevation of both the flood plain and the channel, the cross-sectional areas of the different segments were calculated, the average elevation computed, and the change between the two years determined. The data are summarized in Appendix A. Generally the average channel elevations decreased by about 10 feet downstream of the Gridley Bridge, five to 10 feet between the Gridley Bridge and Thermalito outfall, and five feet or less in the Low Flow

Reach. Flood plain elevations decreased by about three feet for the Feather River from Oroville to Yuba City.

Additional analysis of the cross section changes is provided in the SP-G2 Task 5 Report

5.2.2 1970 to 1997 Cross Sections

Comparisons of cross sections from 1970 to 1997 show the post dam changes in the river channel and flood plain from the Fish Barrier Dam to the mouth of Honcut Creek. Generally, the cross sections show channel migration at a few areas, widening of the channel, and some lowering of the thalweg. Between Honcut Creek and the Gridley Bridge, RM 44.32 to RM 50.55, there was channel movement at RM 44.32, 44.66, and RM 46.0. Channel widening is evident at the migration sites and at RM 47.48 and 48.8. The thalweg lowered by 4 ft or more at RM 44.32, 47.72, 48.07, and 49.92.

Between the Gridley Bridge and the Thermalito outfall, RM 50.63 to 58.48 there was channel movement and widening at RM 54.55, but otherwise there was remarkably little change in the channel planform. The thalweg lowered slightly at RM 51.26, 53.84 to 54.87, and lowered by over 10 feet at RM 57.26 but otherwise did not change much.

In the Low Flow reach above Thermalito Outfall there were substantial changes in the cross sections at RM 60.93, 61.58, 63.60, and 63.86. These changes are related to gravel extraction operations at these locations. This data set shows little change in the Low Flow Reach in either channel width or thalweg elevation.

In order to provide a measurement of the average change in elevation of both the flood plain and the channel, the cross-sectional areas of the different segments were calculated, the average elevation computed, and the change between the two years determined. The data are summarized in Appendix B. Generally the average channel elevations decreased by about two to five feet downstream of the Gridley Bridge to Honcut Creek, one to four feet between the Gridley Bridge and Thermalito outfall, and one to five feet in the Low Flow Reach. Gravel extraction operations appear to influence the channel elevations in the Low Flow Reach. Flood plain elevations generally increased by about one to two feet for the Feather River from Oroville to Honcut Creek for 1970 - 1997.

5.2.3 1992 to 2002 Cross Sections

Comparisons of cross sections between 1992 and 2002 show the effects of the 1997 flood event. The cross sections are shown in Appendix C. In the High Flow reach, at Goose Riffle, RM 54.27, the thalweg deepened by about a foot and the left bank shifted about 10 feet left. At Hour Riffle, RM 56.2-56.4, the thalweg deepened by over a foot in the downstream section with very little change upstream, and the right side of the channel filled slightly, one to three feet. The cross section at Conveyor Belt Riffle, RM 57.25 shows very little change.

In the Low Flow reach, at Weir Riffle, RM 60.2 to 60.35, the thalweg aggraded by one to 1.5 feet, widened slightly on the outside of the bend downstream, and filled a backwater. At Robinson Riffle, RM 61-61.3, in the downstream sections the main channel has filled by over four feet with the development of a secondary channel while upstream the channel deepened four feet. The entire area has been disturbed by gravel extraction activities. At Aleck Riffle, RM 62.62, the thalweg aggraded by over two feet and the channel widened on the right bank by 85 feet. At the lower end of Mathews Riffle, RM 63.19, the thalweg has deepened by about two feet and migrated from the left to the right bank and the channel has widened by 85 feet to the right. Above the Highway 162 Bridge, RM 64.3, there has been little change as expected because of the geologic control at this site. At Auditorium Riffle, RM 65.67-65.77, the upstream sections show areas of channel fill. These areas are directly downstream of the outlet of Moe’s Ditch and probably represent the re-deposited gravels eroded from the ditch. Hatchery Riffle, RM 65.87, shows a slight widening and deepening.

5.2.4 Thalweg Changes

From Oroville to Honcut Creek the Feather River thalweg profiles for 1909 and 1997 were analyzed by developing a best fit polynomial line. This shows an average of five feet of thalweg lowering from the fish barrier dam to just above the Gridley Bridge. Between the Gridley Bridge and Honcut Creek the average thalweg elevation lowering increases to about 12 feet.

Examination of the thalweg profiles for 1909, 1964, and 1997 for the length of the river, show that the Feather River below the Gridley Bridge, about RM 50, has been incising into the flood plain and has continued to incise since completion of Oroville Dam. The maximum lowering of the thalweg occurs from Yuba City downstream and approaches 25 feet through this reach. This would be expected because the condition in 1909 was a river channel choked with sediment from hydraulic mining. The rate of incision would be expected to be decreasing as the river removes more of the hydraulic mining debris from the channel.

5.2.5 Planform Changes

Inspection of the 1909 maps with the 2001 aerial photography reveals substantial land use changes within the zone of influence of the Feather River. During 1909 much of the land along the river is indicated to be in a natural state with descriptions such as jungle, willow brush, weeds, and agricultural uses include alfalfa and beans field. Much of this land is now in orchards. An example would be at RM 51.11 where a network of flood distributary channels has been leveled for orchards. Detailed analysis of channel migration and erosion is provided in the SP-G2 Task 6 Report.

6.0 LOCATE AND REPHOTOGRAPH PHOTOPOINTS; DOCUMENT CURRENT CHANNEL CONDITIONS

6.1 METHODOLOGY AND RESULTS

6.1.1 Locate Existing Photo-Points

The photos for the fourteen photo stations that were established by DWR in 1983 at Hatchery and Auditorium Riffles were never located and assumed either lost or destroyed.

6.1.2 Re-photograph Existing Photo-Points

Two sets of panoramas were made at prior photo locations at Hatchery Riffle. The other 12 photo points were not reestablished

6.1.3 Establish Additional Photopoints

From the summer of 2002 to until spring of 2004 photos were taken at all Bulk Sampling, Permeability Testing, and at most Wolman and Cross-section sites. Photos were taken at every major spawning riffle from Fish Barrier Dam to Herringer Riffle (excluding Gridley Riffle that was not sampled). In addition 12 sets panoramas were made at GPS locations along the Low Flow Reach of the Feather River with river flows at approximately 1,800 cfs. Two sets of panoramas were made at prior photo locations at Hatchery Riffle. Over 1200 photos were taken from 2002 to 2003. These photos were scanned then compiled into a searchable directory by date taken, location and by personnel in the photos.

Over two hundred photos taken from January 1981 to October 1983 of miscellaneous riffles and gravel restoration projects were found and scanned. An additional 217 photos taken from November of 1991 to June of 1992 for the IFIM studies were scanned and placed in their own directories.

6.2 ANALYSES

No analyses were made using photographs. The historic photographs were used in the field to help locate cross section end points and sample locations. Table 6.1-2 shows the number of photographs available at features/locations on the Feather River. Comparisons can be made by searching the database and comparing photos of different years from similar vantage points. Figure 6.2-1 and Figure 6.2-2 are examples from 1982 and 2002 at Auditorium Riffle.

Table 6.2-1 Number of photos taken at various features on the Feather River by years that exist in data base.

Location/Feature	'81-'83	'91-'93	02-'04
Oroville Dam	12	2	
Fish Barrier Dam			4
Fish Hatchery			3
Hatchery Riffle	7	9	75
Hatchery Riffle/Moe's Ditch	5		3
Moe's Ditch	124		46
Hatchery Riffle/Auditorium Riffle			10
Moe's Ditch/Auditorium Riffle	1		
Auditorium Riffle	5	12	96
Bedrock Park Riffle	14		33
River Run Park			4
Highway 162 Bridge		8	
Mathews Riffle		14	59
Mathews Riffle (tailings)			11
Aleck Riffle	2	13	39
Aleck Riffle (tailings)			20
Great Western Riffle		8	
Great Western Riffle/Robinson Riffle			28
Robinson Riffle	15	24	111
Robinson Riffle/Steep Riffle		1	
Robinson/Steep/Weir/Eye/Gateway		1	
Steep Riffle			89
Weir Riffle		14	38
Eye Riffle			82
Eye Riffle/Gateway Riffle		1	
Gateway Riffle			28
Thermalito Afterbay Outlet	12	1	25
Thermalito Afterbay Outlet (tailings)			23
Sutter Butte Riffle	9		34
Big Hole	1		
Conveyor Belt Riffle	3	15	15
Hour Riffle	6	27	27
Keister Riffle	2		31
Goose Riffle	1	21	14
Goose Backwater		2	
Goose Backwater (tailings)			30
Big Riffle	1	8	26
MacFarland Riffle	7		25
Gridley Launch			4
Gridley Riffle	10		
Junkyard Riffle			13

Location/Feature	'81-'83	'91-'93	02-'04
Herringer Riffle		16	71
Honcut Creek			21
Noname Riffle	1		
Shallow Riffle		20	
Total Number of Photos	238	217	1138

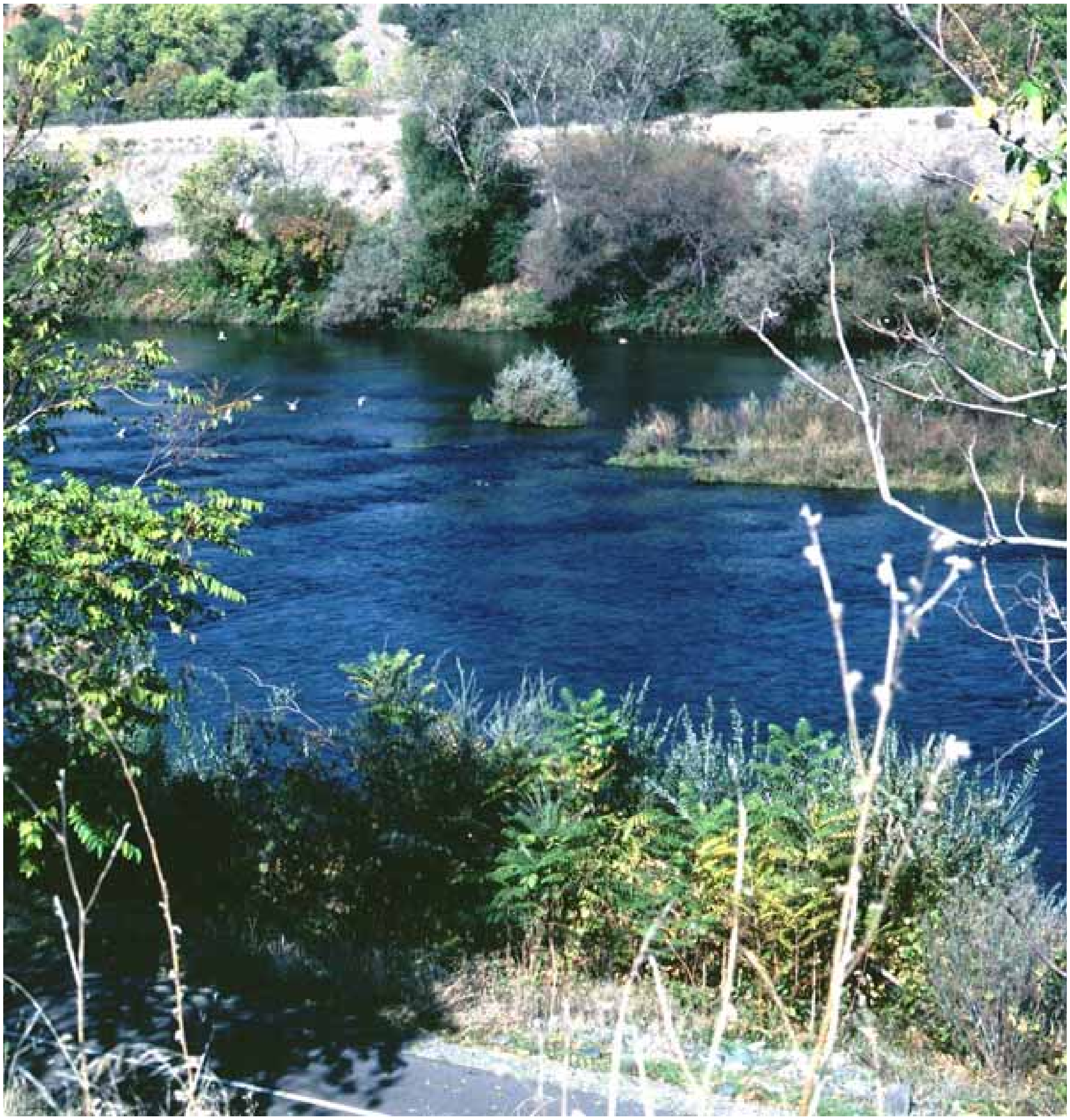


Figure 6.2-1 Auditorium Riffle showing the riffle in 1982

Figure 6.2-2 Auditorium Riffle showing the riffle in 2004 from similar vantage point.

7.0 MONITORING

Task 4 monitoring activities were to include the following items. Selected cross-section locations were to be monitored for changes periodically. A representative number were selected to measure hydraulic and sediment transport conditions at a variety of discharges. Monitoring activities were to be conducted at representative low, medium, and high flows to cover the full spectrum of streamflow and sediment transport, including the evaluation of flow velocities for the initiation of bedload movement. These measurements would have been used to calibrate the sediment transport and geomorphic models used in the Task 7 report. The monitoring was to consist of setting a tag line or traversing between the cross-section monuments; measuring the depth and stream velocity; measuring bedload transport using a Helley-Smith bedload sampler; monitoring bedload movement by using painted and radio tagged rocks, measuring temperature; measuring the hydraulic radius; and other stream parameters as necessary. Unfortunately during the course of the study no high flow events occurred. During a moderate flow event in March 2004, some velocity profiling and minor bedload and suspended sediment samples were collected. With only one event there was not enough data collected to perform any analysis. The data is on file at DWR Northern District.

Other monitoring activities were included in Task 6 and included the following items. In areas where bank erosion is occurring, monitoring sites have been established to determine erosion rates and the nature of the material eroded. The survey control points were marked using steel pipe set in concrete monuments. Bank lines were surveyed using GPS. The bank was re-surveyed once during the study to establish bank erosion rates. The results are included in the SP-G2 Task 6 Report.

8.0 REFERENCES

Blodgett, J.C. 1972. Determination of channel capacity of the Feather River between Oroville and Honcut Creek, Butte County, California. United States Department of the Interior. Geological Survey, Water Resources Division, Menlo Park, California and The Reclamation Board, State of California. 54pp.

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