Twitchell Reservoir
Sediment Management Plan

Prepared for:
Santa Maria Valley Water Conservation District

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EXECUTIVE SUMMARY

Twitchell Dam and Reservoir were constructed in the late 1950's with the dual purpose of flood control and water conservation. Since its construction, sediment inflow has been estimated at 1,200 acre-feet per year, more than twice the predicted inflow. To date, a calculated 44,000 acre-feet of sediment has accumulated in the reservoir and threatens the operation of the outlet works and decreases the conservation pool capacity. Concerns over this issue led the Santa Maria Valley Water Conservation District and the Santa Barbara County Water Agency to establish a Sediment Management Working Group, whose purpose is to develop a sediment management plan that identifies feasible alternatives for protecting the outlet works and maintaining storage capacity.

Initially, the working group identified alternatives that would remove sediment from the reservoir, transport sediment through or from the reservoir, prevent sediment from entering the reservoir, and structural alterations which would mitigate the accumulation of the sediment. Once the alternatives were described, cost estimates were generated along with general technical and permitting and environmental constraints. Using this information, the group ranked the alternatives numerically and identified the alternatives that will be pursued into the permitting phase. The goal of the sediment management plan is to select viable alternatives based upon preliminary cost estimates, technical and permitting feasibility, and environmental considerations. The alternatives selected included sluicing sediment downstream of the reservoir, and dredging sediment to the outlet works, immediately downstream of the reservoir, or to Fugler point. The selected alternatives will be pursued into the permitting phase, which will examine each selected alternative in greater detail. Those not selected will be remain possible alternatives, but not now actively pursued.

The following report presents the findings of the Sediment Management Working Group.

SECTION 1: INTRODUCTION

Background

Twitchell Dam and Reservoir were constructed by the United States for two principle purposes: conservation of water for groundwater recharge and flood control. Since the completion of its construction in 1958, the reservoir has accumulated sediment at an average annual rate of 1,200 acre-feet per year, more than twice the rate expected. Sedimentation threatens the operation of the outlet works that control releases from the reservoir. If the outlet works become inoperable, the unregulated overflow spillway would be the only conduit for flood waters. Due to the size of the watersheds that contribute to the inflow to Twitchell Reservoir and the peak inflow of the design flood, operations of the outlet works are imperative to maintain the flood control ability of the reservoir. Sedimentation also threatens water conservation, because the conservation pool of the reservoir has lost approximately 25 percent of its original capacity.

Drainage

The Santa Maria River watershed is a diverse drainage system with extensive valuable natural resources and important human development. The Santa Maria Basin itself is a broad alluvial plain across which the Santa Maria River flowed freely until the construction of the levee system to control the river flow. The Cities of Santa Maria and Guadalupe share the basin with successful agribusiness development.

The Santa Maria River has two tributaries, the Sisquoc River and the Cuyama River. In the late 1950s, the Twitchell Dam and Reservoir were constructed on the Cuyama River to conserve water and provide flood control. The Sisquoc remains unregulated.

Drainage to Twitchell Reservoir includes three watersheds: the Alamo, the Huasna, and the Cuyama. The Alamo Creek watershed is located in San Luis Obispo County, north of the reservoir, and has a drainage area of approximately 86 square miles. The Huasna River watershed is located immediately west of Alamo Creek. The Huasna River originates in the Garcia Mountain Range and has a watershed drainage area of approximately 103 square miles. The Cuyama River watershed drains portions of Santa Barbara, San Luis Obispo, Kern, and Ventura counties between the Sierra Madre Mountains to the south and the Caliente Mountain Range to the north. The headwaters of the Cuyama River are on the north side of Pine Mountain and west side of Mount Pinos; the river flows northwesterly for approximately 70 miles through the Cuyama Valley to the reservoir. The drainage area from the Cuyama River tributary to Twitchell Reservoir is approximately 885 square miles.

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Origins of Plan

Local concern over the sedimentation of Twitchell Reservoir led the Santa Maria Valley Water Conservation District (SMVWCD) Board of Directors to vote for the establishment of a Sediment Management Working Group in 1997. The group was to be open to all interested persons and invitations to participate were extended to San Luis Obispo County, Santa Barbara County, the United States Bureau of Reclamation (USBR), the United States Army Corps of Engineers (USACE), the City of Santa Maria the Newhall Land Company and local landowners.

USBR has delegated responsibility to local interests for operations and maintenance of the dam and reservoir; specifically, SMVWCD, under contract with SBCWA, provides for operations and maintenance of the dam and reservoir. Therefore, it is the mutual interest of SMVWCD and SBCWA to define the sedimentation problem and develop a plan for its management.

Many local landowners and private citizens have also participated in the Working Group meetings. In addition several other agencies have participated as well, including the Cachuma Resource Conservation District (CRCD), the City of Santa Maria, USACE and the USBR.

Purpose of the Sediment Management Plan

The working group developed the following goals and objectives for the sediment management plan. The goal of this plan is to manage the sediment in Twitchell Reservoir through removal of sediment deposited in the reservoir, routing of sediment through the reservoir, and upstream erosion control and sediment trapping.

The following objectives are the basis for the sediment management plan:

- Ensure public health and safety by maintaining the normal operational capacity of the reservoir and its facilities.
- Directly increase the quantity of recharge and thus improve the quality of the water in the Santa Maria Basin.
- Minimize upstream creek bank erosion, restore the riparian corridor through the Cuyama Valley and trap sediments upstream of the reservoir.
- Minimize adverse impacts to the environment
- Ensure viability of the outlet works

SECTION 2: PROJECT SETTING

Existing Facilities and Appurtenances

Twitchell Reservoir is located in northern Santa Barbara County along the San Luis Obispo County border, east of the City of Santa Maria. Twitchell Dam was constructed in the 1950s and is owned by the USBR but operated by the SMVWCD. The principle structures of Twitchell Dam consist of the earth embankment, the outlet works, and the spillway. The dam is a zoned earth-fill embankment with a crest length of 1,804 feet and a crest width of 30 feet. The top of the dam is at elevation 692 feet MSL. The outlet works consist of an approach channel, inlet tower with trash racks, a series of conduits and tunnels including a gate chamber. The gate chamber houses four 7-foot by 12-foot high outlet gates, with two gates in each of two gate passages. The upper gate in each passage functions as an emergency gate; the lower gate functions as the service gate for regulating outflows. The spillway, commonly known as a "glory hole," is an inclined, concrete-lined shaft bored through the mountainside and is located in the western abutment of the Twitchell Dam. Releases through the spillway are uncontrolled.

The Twitchell Reservoir and Santa Maria River Levee system rely on each other for effective flood control. The levee system begins at Fugler Point (the confluence between the Sisquoc and Cuyama Rivers) and extends approximately 20 miles west to a point downstream of the City of Guadalupe. The levee system protects the surrounding areas, including the Cities of Guadalupe and Santa Maria, from flood damage.

Current Reservoir Operations

Water conservation operations consist of storing runoff in the water conservation pool for subsequent release to recharge the Santa Maria Valley groundwater basin. Water can be stored to the top of the water conservation pool, which is at elevation 623 feet. At this elevation, the net capacity of the water conservation pool is 109,000 acre-feet (the original net capacity was 150,000 acre feet). The magnitude and timing of the recharge (water conservation) releases depends on the amount of unregulated flow in the Santa Maria River originating in the Cuyama River watershed downstream from Twitchell Dam and in the Sisquoc River watershed. Releases are made such that the total flow in the Santa Maria River is percolated before reaching the Bonita School Road crossing, approximately 23 river miles downstream from Twitchell Dam. The crossing is located near an interface of highly permeable soils and soils that contain confining layers that impede effective recharge of the deep groundwater aquifer.

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Flood control operations, prescribed by USACE, call for release of water from the flood control pool (which is between elevations 623 and 651.5 feet) to be made according to the schedule shown in Table 1.

TABLE 1: RESERVOIR RELEASE REGULATIONS

Step Number	Reservoir water surface (feet above mean sea level)	Gate setting for gates (feet of opening)	Discharge (cubic feet per second)
1	504.0 - 623.0	0.0	0
2	623.0 - 623.2	0.5	500 - 510
3	623.2 - 623.4	1.5	1,500 - 1,510
4	623.4 - 623.6	3.0	3,000 - 3,010
5	623.6 - 623.8	5.0	5,000 - 5,010
6	623.8 - 624.0	8.0	7,800 - 7,820
7	624.0 - 651.5	12.0	11,630 - 12,700

Above elevation 651.5 feet, which is the spillway crest elevation, the gates remain fully open in order to maximize the project's emergency release capability. This procedure is necessary due to the spillway's limited capacity.

However, to protect the levees, USACE normally limits releases to 5,000 c.f.s. through emergency deviations from its Flood Control Plan.

Reservoir Sediment Accumulation History

It is estimated that approximately 44,000 acre-feet of sediment has been deposited in the reservoir. Almost 91 percent, 40,000 acre-feet, of this accumulated sediment is located in the water conservation pool (below 623 feet MSL). As expected the distribution of the sediment is based upon particle grain size. The coarser material such as gravel, cobbles and sands are deposited further upstream at the confluence of the three watersheds. The finer clays have settled out closer to the dam and outlet works. It is assumed that 21,119 acre-feet of sediment has accumulated in the reservoir below elevation 560 feet (URSGWC, 1999). The average sediment inflow below elevation 560 feet has been about 603 acre-feet per year with the balance of the 1,200 acre-feet being deposited above the 560-foot elevation.

Sediment removal will be focused on the area around the dam and outlet works to reduce the risk of obstruction of the outlet works.

Need for Sediment Management

Proper function of reservoir outlet works is critical for both conservation and flood control operations. Normal function of the outlet works will become increasingly threatened if sediment accumulation near the dam is not managed. If the

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operations of the outlet works are inhibited by sediment, water can only exit the reservoir by means of the uncontrolled spillway. This scenario would eliminate conservation releases and reduce control of storm runoff. The flood control operations are based upon the combined capacities of the outlet works and spillway. Not having the ability to evacuate the lower portion of the reservoir to control releases of flood flows would undoubtedly threaten downstream agricultural lands and pose imminent danger to the Cities of Santa Maria and Guadalupe.

In addition, upstream landowners in the Cuyama watershed continue to lose significant areas of productive farmland to erosion by the Cuyama River. The sediment management plan reviews and summarizes erosion control and sediment trapping methods that may be implemented upstream of the reservoir to preserve agricultural land while at the same time reduce the amount of sediment flowing into the reservoir. As part of a larger study of non-point pollution sources, CRCD is currently investigating best management practices for upstream erosion control. Upon completion of this study, the recommendations of this study could be incorporated into the sediment management plan or may be implemented independently.

Effect of No Sediment Management

If sediment continues to enter the reservoir at the current average annual rate, the conservation pool will continue to lose capacity at a rate over twice the original estimated rate. At the current rate of sedimentation, the conservation pool will be filled in approximately 70 years; this assumes that the outlet works will no longer function long before the conservation pool fills. One of the original objectives of the Twitchell Project was water conservation for the purpose of groundwater recharge via the Santa Maria River. Losing capacity in the reservoir directly conflicts with the purpose of the Project. Furthermore, decreased recharge to the Santa Maria Groundwater Basin reduces transport of accumulated salts from the system and may result in a decline in water quality. In addition, recharge to the groundwater basin will be reduced by approximately 22,000 acre-feet per year (SBCWA), causing long term overdraft despite ongoing importation of costly water from the State Water Project and successful conservation efforts by the agriculture industry and local communities.

Concurrent Studies and Efforts

Currently there are several studies that are directly related to sediment management at Twitchell Reservoir underway by several agencies. Establishing new operational criteria at the reservoir, upstream erosion control and downstream estuary management are the studies that are currently underway in the vicinity.

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SMVWCD and SBCWA are beginning an investigation into new operational criteria which may result in the equitable redistribution of the conservation and flood control pools at the reservoir. Federal documentation states that under certain criteria, *"the operating plan described herein with respect to storage allocations shall be reviewed with the view of re-establishing an equitable distribution between the primary reservoir uses"*.(Reference 16) The criteria that initiates the review has been exceeded as of 1998. An increase in the conservation pool capacity would directly increase the amount of water available for groundwater recharge as well as for sediment removal alternatives that consume water(such as sluicing).

CRCD has begun a non-point source pollution study for the Cuyama Watershed. This study will analyze potential erosion control methods for the watershed as well as investigate and provide preliminary cost analysis for sediment basins. This study is expected to be complete in the next year and the information provided could then be incorporated into the Sediment Management Plan.

The California State Coastal Conservancy is beginning a study to develop an Estuary Management Plan for the mouth of the Santa Maria River. Because the sediment in Twitchell Reservoir is directly related to the condition of the estuary, the two management plans are closely related. The Estuary Management Plan study will include a sediment transport model from Twitchell Dam to the mouth of the Santa Maria River. The Sediment Management Plan will also require a model to be developed for the same river reaches and therefore the agencies involved should attempt to work jointly. Efforts can be reduced if the involved agencies coordinate and ensure that a single model is developed that meets the needs of both plans. This study is expected to be completed in the next 24 months.

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SECTION 3: SEDIMENT CHARACTERISTICS

The information in the following section is a brief summary of the report "Twitchell Reservoir Sedimentation Study" prepared for the Santa Barbara County Water Agency by Fugro West, Inc. in December of 1995. Sediment core samples were obtained from seven locations between the upstream face of the dam and the Huasna River. Sampling emphasis was placed on the area within 1,500 feet of the dam. The information is important for environmental and permitting considerations.

Sediment Type and Distribution

Within the general vicinity of the dam, high plasticity clays are present from the mudline down to the maximum depths (8 to 12.5 feet)(NOTE: This interval is now well below the current "mudline") penetrated by the vibrocores. Further upstream from the dam, high plasticity clays were present from the mudline to a depth of 6.5 feet. Below that depth, sand with silt and silty sand were present in the bottom 1.0 feet of the retrieved core. Adjacent to the Huasna River outlet, silty sand to sandy silt were found within the 6.0-foot depth explored.

The high plasticity clays encountered may be divided into two distinct layers based on sediment consistency: recently deposited, unconsolidated, very soft clays (upper clay layer); slightly older, soft to firm clays (lower clay layer). Near the dam, the upper clay layer is typically 3 to 4 feet deep. Seismic reflection records indicate that the upper clay layer gradually becomes thinner upstream from the dam. It is estimated that the upper clay layer becomes nonexistent about 5,000 to 7,000 feet upstream from the dam.

Grain Size and Plasticity

The fine-grained sediments (including both the upper and lower clay layers) consist of high plasticity clay (CH). The clays contain less than 2 percent sand-sized particles and about 35 to 50 percent clay-sized particles (less than 0.002 millimeters), with a mean grain size of about 0.002 to 0.005 millimeters. The plasticity indices of the clay range from 30 to 47 percent.

The coarse-grained sediments are classified as fine sand with silt (SP-SM) and silty fine sand (SM), however, sandy silt (ML) was also encountered. The sands typically contain 10 to 50 percent fines and have a mean grain size of about 0.07 to 0.15 millimeters.

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Water and Organic Carbon Content

In the clay layers, distinctly different water contents were measured for the upper and lower clay layers. The upper layer has water contents ranging from about 85 to 120 percent (of the dry weight), with the higher values correlating to the mudline. The lower layer has water contents typically ranging from about 45 to 58 percent, suggesting that this layer has been desiccated. Water contents for the coarse-grained sediments range from 21 to 35 percent.

For the clay deposits, the Total Organic Content (TOC) content typically ranged from about 4.7 to 7.0 percent. There were only two values measured on the coarse-grained sediments, which were 1.8 and 2.1 percent. While this data is too sparse to establish a definite trend, the results suggest that there is a general trend for the TOC content to decrease with increasing grain size of the sediment.

Toxic or Hazardous Materials

Sediment samples were analyzed for heavy metals regulated under Title 22 using Inductively Coupled Plasma (ICP) Spectroscopy. As shown in Table 2, very low levels of metals were detected. Other compounds were also measured including TRPH, volatile organics, semi-volatile organics and pesticides.

Regulatory Standards

There are several regulatory standards that apply to heavy metals in soils, sludges, and sediments. Those regulatory standards include the following:

- Total threshold limit concentration (TTLC);
- Soluble threshold limit concentration (STLC);
- Toxic characteristic leaching potential (TCLP) regulatory level (RL);

In addition to having regulatory standards for heavy metals in soil, sludges, sediment, and drinking water, some of the heavy metals are also listed as chemicals known by the State of California to cause cancer or reproductive harm (Proposition 65 list of carcinogens and reproductive hazards).

The TTLC is applied to media where the total metal concentrations are determined in the sample matrix. The analytical program for the Fugro West study determined total metal concentrations in the sediments of Twitchell Reservoir and, therefore, the analytical results of the samples are directly comparable to TTLC's. Concentrations in sediments that exceed the TTLC's are considered "hazardous waste." Hazardous waste is regulated under Title 22 of the California Code of Regulations (CCR). These regulations apply to the generation, transportation, storage, treatment, and disposal of hazardous wastes. None of the samples taken from Twitchell Reservoir had concentrations of metals that would qualify the sediment as a hazardous waste.

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TABLE 2: METAL CONCENTRATIONS AND STANDARDS

Analyte (Number of Detected Samples)	Measured Concentrations		Regulatory Standards					
	Average (mg/kg)	Highest (mg/kg)	Cal TTLC (mg/kg)	Cal. STLC (mg/l)	TCLP RL (mg/l)	Cal MCL (mg/l)	Cal. AL (mg/l)	EPA MCL (mg/l)
INORGANIC ANALYTES								
Antimony	ND	ND	500	15	--	--	--	0.006
Arsenic*	8	9.7	500	5	5	0.05	0.05	0.05
Barium	120	140	10,000	100	100	1	1	2
Beryllium*	ND	ND	75	0.75	--	--	--	0.004
Cadmium* (2)	1.15	1.3	100	1	1	0.01	0.01	0.005
Chromium, Tot*	16	21	2,500	5	5	0.05	0.05	0.1
Chromium, Hex*	--	--	500	5	--	--	--	--
Cobalt	8.8	11	8,000	80	--	--	--	--
Copper	20.6	25	2,500	25	--	--	--	1
Lead*	8.8	11	1,000	5	5	0.05	0.05	0.015
Mercury	ND	ND	20	0.2	0.2	0.002	0.002	0.002
Molybdenum	1.8	2.6	3,500	350	--	--	--	--
Nickel*	17	20	2,000	20	--	--	--	0.1
Selenium (4)	1.1	1.2	100	1	1	0.01	0.01	0.05
Silver	ND	ND	500	5	5	0.05	0.05	0.1
Thallium	9.4	12	700	7	--	--	--	0.002
Vanadium	35	42	2,400	24	--	--	--	--
Zinc	65	82	5,000	250	--	--	--	5
TRPH	ND	ND	--	--	--	--	--	--
VOLATILE ORGANICS								
Acetone (4)	0.012	0.013	--	--	--	--	--	--
Methylene Chloride (1)	0.002	0.002	--	--			0.04	0.005
SEMI-VOLATILE ORGANICS								
None Detected	--	--	--	--	--	--	--	--
PESTICIDES								
2-delta-BHC (Lindane) (1)**	0.087	0.087	4	0.4	--	--	--	--

* Listed as a carcinogen or reproductive hazard per Proposition 65.
All concentrations and standards are expressed on wet weight basis.
Measured concentrations are for 5 reservoir sediment samples.
Where the constituent was not detected in all specimens, the number of detected specimen is shown (x).
Average concentrations are averages of the measured concentrations at locations where the constituent was detected.

ND	=Not Detected
TTLC	=Total Threshold Limit Concentration
STLC	=Soluble Threshold Limit Concentration
TCLP-RL	=Toxic Characteristic Leaching Potential, Regulatory Level
Cal-MCL	=California's drinking water Maximum Contaminant Level
Cal-AL	=California's drinking water Action Level
EPA-MCL	=Federal drinking water Maximum Contaminant Level
--	=No regulatory standard
TRPH	=Total recoverable petroleum hydrocarbons
**	=TTLC and STLC are for all BHC isomers; the following regulatory standards are applicable for the closely related gamma-BHC isomer: TCLP-RL: 0.4µg/l; Cal-MCL: 4µg/l; EPA-MCL: 0.2µg/l.

The STLC, like the TTLC, is a regulatory standard that determines whether a soil, sludge, or sediment is a hazardous waste. The standard is applied to a laboratory procedure called the Waste Extraction Test (WET). The WET is a procedure where leaching from soil, sludge, or sediment is simulated in a laboratory procedure using aqueous citric acid as an extraction solvent. Concentrations of soluble, leachable heavy metals in sediments that exceed the STLC are considered hazardous waste and are subject to Title 22 regulations. The laboratory procedure is designed to determine the leaching potential of the heavy metal contaminants in the sediments.

The TCLP-RL is a federal standard that, like the STLC is used to determine the leaching potential of contaminants from soils, sludges, and sediments. Concentrations of heavy metals in sediments that exceed the TCLP-RL are defined as "hazardous waste" and are subject to regulations promulgated from the Resource Conservation and Recovery Act (RCRA). The provisions in RCRA are similar to the Title 22 regulations described above. The extraction procedure used in the analyses of samples is less rigorous than WET used in California. Hence, soils, sludges, and sediments that do not exceed the STLC generally will not exceed the TCLP-RL.

The Cal-MCL, Cal-AL, and MCL are standards that apply to drinking water. The concentrations of heavy metals in water are representative of contaminates that have already leached into ground water or impacted surface water. Concentrations of heavy metal contaminates in surface and ground water in California that exceed these drinking water standards are required to be remediated or at least the Cal-MCL's, if not the natural background concentrations.

No TTLC or STLC have been established for lithium. Similarly, Cal-MCL, Cal-Al, and MCL standards have not been established for lithium.

Environmental Significance of Measured Concentrations

The highest and average concentrations of the individual heavy metals in the five analyzed specimen collected from sediments of Twitchell Reservoir are significantly less than the TTLC's. Therefore, the sediments are not considered hazardous waste if discharged as a waste material. In addition, the concentrations of the heavy metal detected in the five specimens of the Twitchell Reservoir sediment do not exceed other regulatory standards for hazardous waste classification.

Additionally, the highest and average concentration of the individual heavy metals concentrations in the sediment samples do not exceed 10 times (10x) the STLC value for any metal in the sediment samples analyzed. The 10x factor is applied to the STLC because of the dilution performed during sample preparation and analysis when using WET protocols. The STLC is a standard designed to evaluate the potential for contaminates leaching through soil and sediments to ground water and impacting surface water at hazardous (i.e., toxic) concentrations. Therefore, if the STLC is not exceeded, the contaminant should not dissolve in ground water or surface water at concentrations exceeding the MCL's for drinking water. Thus, the data also suggest that the concentrations of metal are not leachable enough to impact water in the reservoir above MCL's.

The concentrations of the heavy metal detected in the sediments of Twitchell Reservoir probably represent natural background concentrations and are of no environmental significance.

Total Recoverable Petroleum Hydrocarbons

TRPH were not detected, using U.S. EPA method 418.1 analysis procedure, in the five specimens of the sediment samples collected for this study. As shown on the laboratory analytical report, presented in Table 2, the detection level for the TRPH analyses was 2 mg/kg.

Volatile and Semivolatile Organic Compunds

VOC's were measured using U.S. EPA method 8240 and SVOC's were determined using U.S. EPA method 8270.

Presence and Concentrations of Volatile Organic Compounds

Only two of the 41 analytes included in the U.S. EPA method 8240 were detected in the sediment specimen submitted for chemical analyses. The two VOC's detected in the sampling program were acetone and methylene chloride.

Acetone was detected at concentrations between 11 and 13 micrograms per kilogram (µg/kg) in four of the five specimen. Those four specimen correspond to the four specimen that were composted from the vibrocore samples. In contrast, acetone was not detected in the one discrete specimen that was directly removed from the vibrocore sample. Because acetone is a component of the latex sampling gloves used during the composting process, the presence of very low levels of that analyte in the four composite specimens, together with its absence from the discrete-depth sample specimen, strongly suggest the low concentrations of acetone are due to the sample handling process during composting. It was noted that acetone also is used in the laboratory to clean glassware and in extraction.

Methylene chloride was detected in specimen 3 at the very low concentration of 2µg/kg. Because this solvent is used to clean glassware and as a solvent in some laboratory extraction procedure, its presence at a very low concentration in one sediment specimen suggests the compound may have been introduced in the sampling and analytical processes.

None of the other 39 VOC analytes included in U.S. EPA method 8240 were detected in the five sediment specimen. Minimum detection limits for those 39 analytes varied from less than 0.1 to 4 μg/kg, as listed on the analytical chemistry lab report included in Appendix D.

Presence and Concentration of Semivolatile Organic Compounds

None of the other 85 SVOC analytes included in U.S. EPA method 8270 analysis were detected in the five sediment specimen. As shown on the analytical chemistry laboratory report included Appendix D of the Fugro West report, the minimum detection limit of about 85 percent of the analytes is 50 μg/kg. Minimum detection limits for the other 15 percent of the analytes range from 60 to 680μg/kg.

Regulatory Standards

There are no regulatory standards for acetone in soils, sludges, sediments, or drinking water. Neither are there regulatory standards for methylene chloride in soil, sludges, or sediments. However, methylene chloride has a drinking water standard, a Cal-Al, and a federal MCL. Acetone and methylene chloride are not known to the state of California to cause cancer or reproductive harm.

Environmental Significance

There is no environmental significance to the detection of the two VOC's in some of the sediment samples at low concentrations. As discussed, the contaminants are at low enough concentrations and their presence is consistent with incidental contamination during sampling and analytical procedures.

Organochlorine Pesticides and Polychlorinated Biphenyls

Presence and Concentrations of Organochlorine Pesticides and Polychlorinated Biphenyls

Only one of the 19 organochlorine pesticides included in U.S. EPA method 8080 was detected in one sediment specimen. The organochlorine pesticide delta-benzene hexachloride (delta-BHC) was detected in specimen 1 at a concentration of 87 μg/kg. This analyte is one of several isomers of the BHC series of compounds, which is also known as Lindane.

The detection of delta-BHC at low concentrations is not surprising given the agricultural operations upstream of the Twitchell Reservoir. The Cuyama River passes by the Cuyama and New Cuyama area where agricultural operations include alfalfa and vegetable farming and cattle ranching. The detection of a low level of that organochlorine pesticide in one specimen suggests those compounds were used upstream of Twitchell Reservoir or were introduced in the immediate vicinity of the reservoir via agricultural operations.

None of the other 18 organochlorine pesticides were detected. Some of the nondetected organochlorine pesticides included in the analyses were DDT, DDE, DDD, toxaphene, chlordane, endosulfan, and several other BHC isomers. Minimum detection limits for those analytes were 2µg/kg.

None of the seven PCB arochlor series of compounds were detected in the five sediment specimen. The minimum detection limits for those analytes were 2 µg/kg.

Regulatory Standards

The TTLC for Lindane compounds, including delta-BHC, is 4,000 µg/kg and the STLC is 400 microgram per liter (µg/l). As noted in the Fugro West report, Delta-BHC does not have: a TCLP-RL, a Cal-AL, nor a EPA- or Cal-MCL. The closely related Lindane isomer gamma-BHC, however, does have: a TCLP, a Cal-MCL, and an EPA-MCL; those values are noted in Table 2. Delta-BHC are not known to the State of California to cause cancer or reproductive harm.

Environmental Significance

The 1988 Farm Chemical Handbook indicates that Lindane is no longer produced or sold for use in the United States. Organochlorine pesticides, including delta-BHC, are persistent compounds that do not degrade readily in the environment. The presence of the compound in the sediments attests to the compounds persistence. As with most other organochlorine pesticides such as DDT, toxaphene, and chlordane, delta-BHC is largely water insoluble with high soil adsorption tendencies. Therefore, the mobility of the compound is limited. The detected concentration of 87 µg/kg is well below the TTLC and 10x the STLC and suggests the sediments would not be a "hazardous waste" if discharged as a waste material. This low concentration of one Lindane isomer in one of five analyzed specimen is not considered to be of environmental significance.

Potential Spatial Variation

The chemical analysis results from the five analyzed specimen provide insight relative to the likelihood of the possible presence of problematic levels of the analytes in the sediments throughout the reservoir. Those results however are inadequate to fully characterize the sediments in the reservoir because of the limited spatial distribution and depths of the samples recovered for the investigation presented herein.

Resource Value

The clay sediments in the reservoir have a number of potential commercial uses. The material could be utilized to manufacture clay products such as roof and floor tiles. A manufacturing plant could be sited in the vicinity of the reservoir that could generate revenue to offset the costs of sediment removal efforts. Also, the plant may use methane gas generated at the City of Santa Maria landfill as energy for production.

The sediment from Twitchell Reservoir has been tested for use as a ceramic glaze and possesses a number of valued characteristics. Laguna Clay Manufacturing, located in the City of Industry, has expressed interest in acquiring 100 tons of the sediment to research its commercial value. In addition to this option, it may be feasible to establish a clay manufacturing facility that would store, process and sell the removed sediment.

Finally, the clay material may be used daily or final cap material for landfills in the area. Transportation costs may make this concept prohibitive.

SECTION 4: SEDIMENT MANAGEMENT METHODS

Sediment Removal

Based upon information provided by SBCWA URS Greiner Woodward Clyde, a consultant hired to analyze sediment removal alternatives, estimated 1,200 acre-feet of sediment would have to be removed from the reservoir each year to maintain current available water capacity (URSGWC, 1999). The initial analyses for the various alternatives including their costs, were calculated using 1,200 acre-feet. This estimation was used as an upper bound for the volume of sediment removal in the evaluation efforts for this report. After reviewing the initial results, the Working group determined that alternatives that remove less than 1,200 acre-feet also need evaluation. These scaled alternatives are presented here as well. Three removal rates were further analyzed, 400, 900 and 2,000 acre-feet per year. The goal of the evaluation of alternatives which remove less than 1,200 acre-feet is to minimize costs, permitting and environmental impacts while providing protection of the outlet works and extending the life of the reservoir.

Dredging

A dredge is a generic term for equipment used to remove sediment from below the water surface. All dredges are designed to mount on a floating barge that can be anchored near the area to be excavated. The barge may be self-propelled or towed into new positions. Examples of dredges include hydraulic, siphon and mechanical. The advantages and disadvantages are discussed below.

One of the general disadvantages of using any dredge at Twitchell Reservoir is that the reservoir does not hold water throughout the year. The unique operations at Twitchell would limit the amount of time that a dredge can operate in the reservoir.

An estimated 4,800 acre-feet of water would be required to dredge 1,200 acre-feet of sediments and transport them via a slurry pipeline to a disposal site (URSGWC, 1999). Due to the fine nature of the sediment, it would be difficult to recover the water used during the dredging operation (URSGWC, 1999). To alleviate this loss of water, operational changes may be implemented making use of water stored in the flood control pool to remove sediment. Assuming the dredge would operate four months per year, to achieve the goal of 1,200 acre-feet of sediment removal per year, the dredge would need to be sized to operate at a minimum capacity of 300 acre-feet per month, or approximately 1,000 tons per hour (URSGWC, 1999) on a 24 hour per day basis.

Hydraulic Dredges

Hydraulic dredges have the ability to excavate material up to 150 feet below the water surface. The hydraulic dredge consists of a cutter head that digs and loosens material to be suctioned up the inlet pipe known as a ladder. At the top of the ladder is a suction pump that directs the slurry through a pipeline to a disposal site.

Hydraulic dredges come in various sizes that range in capacity from about 50 cubic yards per hour to 10,000 cubic yards per hour. The smaller sized dredges can be hauled by trailer while the larger sized dredges weigh many tons and are shipped in pieces and assembled on-site.

Siphon Dredges

Siphon dredges are different from hydraulic dredges due to the absence of pumps and the use of a continuously submerged discharge line. The sediment slurry is forced through the pipeline by the differential head between the water surface of the reservoir and the discharge point. This type of dredge may work well for the Twitchell Reservoir because of the elevation difference between the dam discharge and the water surface elevations. An inherent problem with siphon dredging is that the water surface elevation is critical to the amount of flow that can be achieved in the slurry pipeline. Because in general, Twitchell Reservoir operations release holdings annually, the lowering of the water surface elevation during releases will lower the available head for the siphon flow.

Mechanical Dredges

Mechanical dredges are barge-mounted equipment that use a bucket system to remove sediment from below the water surface. The sediment is then placed in a scow alongside the dredge and periodically towed to the shore for mechanical unloading and transport to a disposal site. Different mechanical dredges are available including; clamshell bucket, bucket ladder, and dipper dredges. The clamshell bucket is attached to a boom like a crane's pulley system and consists of a bucket with halves that are forced together by the pulling action in the center of the bucket. This type of bucket is capable of excavating at great depths but lacks the digging action of other equipment. The bucket ladder consists of a continuous chain of open buckets that scoop into the sediment and continuously scoop and dump as the chain is operated. The bucket ladder is more suitable for gravel and larger material. The dipper dredge is most like a backhoe. It has an arm with a bucket that has the ability to dig into the sediment and deposit it into the scow alongside the barge.

Sluicing

Sluicing is the removal of sediments through the outlet works at the bottom of the reservoir using the existing reservoir head, or assisted by discharge from a submerged slurry pipeline. On a limited scale, and within the operating criteria for the reservoir, sluicing occurs at Twitchell Reservoir under normal operations.

Agitation of the sediments may accompany the sluicing to increase the sediment load in the flush flow and/or to target specific areas for sediment removal. Agitation would need to occur within a specified distance from the dam at various times to ensure that sluicing would sufficiently suspend the sediments for transport through flushing. However, the efficiency of sluicing would decrease with distance from the outlet works because much of the agitated material would settle over the long distance to the outlet works.

To examine the efficiency of sluicing, with agitation, from the outlet works, a hydraulic simulation model was developed for Twitchell Reservoir (URSGWC, 1999). This model is discussed in Appendix C.

Additionally, sluicing combined with a slurry pipeline that discharges at the outlet works would be a viable option for further study. Agitation of the sediments adjacent to the outlet works results in almost 100% efficiency in sediment removal. To capitalize on this condition, a dredge could operate throughout the lower reservoir with a submerged slurry pipeline discharging in front of the outlet works. The hydraulic model discussed in Appendix C was used to simulate sediment discharges to the outlet works using the historic releases from the conservation during the last five years when release records are available (1993-94 through 1997-98). The amount of sediment that would be flushed from the reservoir to the downstream river channel during each year is summarized below in Table 3 (URSGWC, 1999).

TABLE 3: ESTIMATED SEDIMENT RELEASES

Water Year	Annual Releases from the Reservoir (Flood Control and Water Conservation Releases Combined)(acre-feet)	Predicted Annual Sediment Discharge to the Cuyama River below the Dam in Cubic Yards (acre-feet)
1993-94	53,866	1,849,369 (1,146)
1994-95	68,240	1,654,729 (1,026)
1995-96	92,414	3,563,139 (2,208)
1996-97	77,149	2,925,511 (1,813)
1997-98	141,151	2,925,511 (1,813)

The sediment discharge rate from a slurry pipeline in front of the outlet works will vary with the release rate from the outlet works. The efficiency of sediment discharge increases up to about 500 cfs, then levels off quickly. Low flows that are associated with the water conservation releases are suitable for sluicing sediments through the outlet works under this option. These results indicate that a prolonged low flow release (i.e., less than 200 or 300 cfs) would be the most efficient way to remove sediments by sluicing.

The results of the modeling indicate that sluicing using a dredge with a slurry pipeline to the outlet works would meet the project objectives and should be considered a viable option for sediment removal.

Earth-moving equipment

Earth-moving equipment may be used to remove sediments from the reservoir mechanically. Earth-movers can excavate sediments, scrape and collect the sediments and load the material into trucks for transportation to a disposal site. Earth-moving equipment includes bulldozers, scrapers, front-end loaders, draglines and excavators.

In order to achieve the sediment removal rates, mechanical excavation would need to involve large-capacity heavy equipment. Heavy earth-moving equipment would be used to move the sediment to the reservoir banks where it would be loaded into trucks for transport to a disposal site. The work could be accomplished under dry conditions with a front-end loader or scraper, or under wet conditions with a dragline or clamshell.

The use of mechanical equipment for sediment removal would be problematic. The most efficient method of removing sediments with heavy equipment to meet the desired annual amount would be to excavate the material using wheeled vehicles rather than using a dragline or clamshell. However, work in the reservoir, under this scenario, can only occur after water in the conservation pool has been fully released. This usually occurs in the fall, leaving only a few months to perform the excavation prior to the winter inflow. However, the exposed sediments may not be able to support the weight of the equipment during the limited work period due to the high moisture content. It may require two or more years of drying before fine-grained hydraulic fills, such as the Twitchell Reservoir sediments, would develop significant bearing capacity. Additionally, after the surface bearing capacity had been reached, further difficulties could be encountered when the excavators break through the upper crust and begin cutting into deeper soft sediments.

Bulldozers

A bulldozer is a tractor with wheels or tracks that is equipped with a front-mounted earth-moving blade. A bulldozer can excavate sediment by lowering the blade and cutting into the sediment until the blade is full and can move the sediment to a pile for further handling. Bulldozers can move approximately 200 to 3,000 cubic yards of material per hour depending on the operating conditions, distances involved, type of machine used and the sediment conditions encountered. Bulldozers are usually used to move and prepare sediments to be handled by other earth-moving equipment such as scrapers or front-end loaders.

There are several disadvantages of using bulldozers. First, they have a limited push distance of approximately 400-600 feet. High equipment maintenance limits their availability to about 70 percent. Depending upon the operator the actual operating time is about 45 minutes an hour.

Scrapers

A scraper is a rubber tired vehicle that can excavate, haul and dump sediment over medium to long haul distances. The scraper can excavate sediment by lowering the front edge of its bowl (mounted in the middle of the vehicle) that is equipped with cutting blades that cut into the sediment and move it into the bowl. The scraper can then haul the sediment to a disposal site where it opens the bowl and dumps the sediment. Scrapers are particularly effective at excavating loose, dry material or material previously loosened by bulldozing. The capacities of scrapers vary between 14 to 44 cubic yards.

Scrapers do not operate well in muddy conditions and are not suitable for excavating very coarse material. The efficient haul distance is approximately one mile and the scrapers have an availability of about 75 percent and operate for about 45 minutes per hour.

Front-End Loaders

A front-end loader is a tractor equipped with a front-end bucket that may be equipped with rubber tires or tracks. Loaders are extremely versatile and can be used to excavate, transport and load other vehicles with sediment. Their capacities are generally in the 5 to 15 cubic yard range.

As with scrapers, rubber tired loaders do not operate well in muddy conditions. The maintenance requirements are high for loaders and their effective operating hour is approximately 45 minutes.

Draglines

Draglines have the ability to excavate in both wet and dry conditions. The bucket may be cast from shore or from a barge and dragged to a stockpile location. For the type of sediment excavation anticipated, bucket units in the 5 to 15 cubic yard capacity range would be utilized. Draglines can excavate loose, unconsolidated material but have difficulty with bulky material.

Due to the nature of the dragline process, double handling of the excavated sediment is necessary to get it into a transport vehicle.

Excavators

Excavators operate by using a crane arm that has a dipper bucket attached at the end. The digging action occurs when the dipper is pulled back towards the machine and excavates sediment. An excavator has the ability to work below grade and therefore can be positioned on dry land and excavate under water. Excavator buckets come in various sizes, but for sediment removal, probably a 3 to 5 cubic yard bucket would be appropriate.

Excavators are not particularly stable equipment and therefore need to be stabilized before operation, decreasing their overall efficiency. Compared to a front-end loader, the excavator has a lower production rate but can operate under conditions that the loader cannot (i.e. below grade).

Sediment Transport

Methods of transporting the sediment from the reservoir to various disposal sites downstream are discussed in this section.

Slurry Pipeline

Pipelines are used in conjunction with dredges to transport the sediment slurry to a designated site. The pipeline system consists of two components, the pump(s) and the pipeline. Depending upon the distance and terrain that the pipeline will travel, additional booster pumps may be necessary to keep the slurry flowing. The most common types of pumps used for slurry pipelines are horizontal centrifugal pumps.

The pipeline may be made out of steel or high-density polyethylene pipe, but both need flotation devices to support them. Abrasion in the pipeline is greatest when transporting coarse sands and gravel and minimal when moving clays and fines.

The pipeline may be directed to the outlet works of the dam or to some designated point downstream of the reservoir. One option is to discharge the pipeline directly into the outlet works. In doing this, the sediment would be removed from the reservoir via sluicing as water is released from the reservoir. The use of a slurry pipeline to discharge sediments to the outlet works is discussed above; this option is considered a variation of the sluicing alternative.

Another alternative would be to run the pipeline through the spillway or over the dam, to a designated point downstream. Points of potential discharge of slurry flow include Fugler Point, Bonita School Road, gravel mining pits, and the ocean. However, a slurry pipeline will require significant engineering effort, substantial land or right-of-way acquisitions and their associated costs, complex permitting, and a system of pumps that will require maintenance. Also, if the pipeline were to have an alignment through the spillway, capacity of the flood flows could be threatened.

The water used in the slurry would be taken from the conservation pool that would normally be used to replenish the Santa Maria Groundwater Basin. One disposal option is to pump the slurry 20 miles to the Bonita School Road crossing for discharge to the Santa Maria River and to allow winter flows to resuspend the sediment for ultimate disposal in the ocean. Under this scenario, there would be an average annual loss of 4,800 acre-feet of water that would not be replenishing the aquifer. This loss may be reduced if the dredge can operate efficiently with a higher concentration of solids (URSGWC 1999).

In order to mitigate the water loss, it would be appropriate to consider modifying the existing operational criteria to allow seasonal encroachment into the flood control pool, providing more water for dredging the sediment out of the reservoir. Between May 1991 and June 1998, the total number of days that the reservoir surface was above elevation 623 feet was 209, or approximately 20 percent of the total days available for dredge operation (URSGWC 1999).

Other disposal options that would allow the slurry water to be retained in the Santa Maria Groundwater Basin is to discharge the slurry to temporary sediment basins for dewatering then hauling, or to gravel mines along the Santa Maria River. A slurry pipeline between Twitchell Reservoir and the various downstream disposal sites would likely be constructed along the edge of the floodplains of the Cuyama, Santa Maria, and/or Sisquoc rivers. If the pipe were buried inside of the existing levee, or in a portion of the floodplain without levee protection, the depth of burial would be a function of the anticipated scour of the riverbed during extreme storm events. A pipeline installed outside the levee would be buried at a shallower depth. One viable location for a dewatering basin would be directly downstream of the dam on USBR property. This option would reduce the pipeline length saving capital and operations and maintenance costs.

<u>Flushing</u>

Flushing refers to the confined or unconfined riverbed transport of sediment using the natural processes of the river. At Twitchell Reservoir the sediment can pass through the outlet works through controlled reservoir releases. It is anticipated that the sediment saturated flows will deposit material in the lower Cuyama and the Santa Maria River. Winter flows in the Sisquoc and Santa Maria Rivers will resuspend the sediment and flush it to the ocean. On a limited scale, this process happens under normal operations at Twitchell.

The flushing process can be enhanced after further analysis is performed to determine optimal release rates to suspend material in the reservoir and keep the material in suspension as long as possible. The modeling for this analysis will be necessary for the environmental review process to determine the impacts to the downstream environment.

Laundering

Laundering is the transport process that utilizes an open trench, flume or pipe to convey sediment slurry under the influence of gravity alone. Sufficient grade is the most critical component of laundering. Adequate slope is necessary to maintain velocities that will keep the sediment in suspension without overflowing or clogging the conveyance system. With consideration to the fine sediments, laundering is an appropriate technique. However, the coarser material that has been deposited upstream will not be suitable for laundering because the available slope gradient is insufficient to move the larger deposits.

Open channel flow appears to be a viable means of transporting the sediments from the dredge discharge pipe to potential downstream disposal sites, including the ocean, because the hydraulic gradient is suitable (URSGWC 1999). However, upon closer examination this method of transport has many disadvantages. It involves an open channel that would require property acquisition or right-of-way. The channel must be fenced for public safety and would require continuous inspections and maintenance. Similar to the slurry pipeline, the water used for open channel transport would also be lost for water conservation purposes if discharged downstream of Bonita School Road. This method does not have any significant advantage over a slurry pipeline, and is more expensive.

On-highway Trucks

On-highway trucks have capacities of 30 tons consisting of a 20-ton main load and a 10-ton trailer. On-highway trucks can be used on existing roads, are easily loaded and are readily available. These trucks are versatile, they can haul different types of materials ranging from fines to cobbles and boulders, plus they can be directed to a variety of different disposal sites.

Based on the use of 30-ton capacity trucks (19-cubic yard capacity), the transport of 1,200 acre-feet of sediment each year would require about 100,000 truck trips (round trips) per year. Assuming 250 workdays per year, there would be about 400 truck trips (round trips), or 800 one-way trips, per workday each year (URSGWC, 1999). The magnitude of this type of material transport operation is high, equivalent to gravel mines that produce over 2 million tons of product per year.

Transporting sediment in this manner is very expensive. It requires well-developed roadways, involves public safety and noise issues along the access road, generates significant air pollution, and wears on public roadways. Caltrans would probably need to expand the capacity on Highway 166. However, it is a very flexible mode of transport that disposes sediments at various locations, including delivery to a commercial operation (e.g., ceramic factory, commercial fill site, landfill cover, or soil building operation). However, given the magnitude of the truck trips required, this method of transport is not considered a long-term viable option for the entire sediment management program involving 2 million cubic yards per year. Instead, it should only be considered viable for short hauls of smaller amounts. For example, a small portion of the sediments could be collected and dewatered, then hauled for commercial uses in the local area while the bulk of the sediments are flushed to the ocean or disposed at nearby gravel mine pits.

Off-highway trucks

Off-highway trucks are used in heavy construction and in the mining industry. They range in capacities from 35 to 200 tons. Off-highway trucks are easily loaded by various earth-moving equipment and are capable of handling materials ranging from fine sediments to large boulders. They also operate well in muddy conditions.

At Twitchell Reservoir, specially designed 50 to 100-foot wide roads would need to be constructed to operate off-highway trucks. The economic hauling distance limit for off-highway trucks is about 3 to 4 miles and the specialized trucks require maintenance facilities close to the site. Environmental impacts due to the use of these trucks include noise, dust and exhaust fumes.

Conveyor Belt

Conveyor belts are usually used to transport dry material over long distances. The mining industry uses overland belts having widths of up to 84 inches and capacities of up to 10,000 tons per hour. A conventional conveyor belt system is comprised of a series of belts that are supported on truss assemblies. The trusses are generally mounted on concrete footings about fifty feet apart for common soil conditions.

Conveyor belt systems have the ability to negotiate vertical curves but can only have horizontal curves under two conditions. First, if the curve is of very large radii and second, if a number of sections are used each with a transfer chute and drive belt. To use a conveyor system, a downstream sediment basin would need to be constructed to dewater the materials. Sediments from the basin could then be transported to a downstream permanent disposal site by conveyor belt. However, the possible downstream locations are too far away (i.e., gravel mines are about 10 miles away and the Bonita School Road crossing is about 20 miles away) to feasibly use a conveyor system.

Aerial Tramway

An aerial tramway consists of a continuous cable that is looped throughout the entire system similar to a ski lift. The "endless" cable is strung between towers and has hoppers attached that carry the sediment. The tramway has an advantage of being able to transport material over very steep or rough terrain. Transported material may act as the weight necessary to drive the tramway because of the gradient between the dam and eventual disposal area.

Historically, operating costs are high and the aerial tramways are not readily available. The capital costs are considerably high and the carrying capacity is limited to a few thousand tons per day.

Downstream Management of Sediment

This section discusses various disposal sites for the sediment that is removed from the reservoir.

Santa Maria River

One disposal option is to convey sediments in a slurry pipeline, open channel flume, or via the riverbed to the Santa Maria River at Fugler Point. Sediments would be discharged with the objective of the river flows to resuspend the material and deliver it to the ocean. Any sediment deposition in the Santa Maria River from the discharges could reduce the floodplain capacity and riverbed percolation, as well as impose additional loads on bridge piers and abutment structures (URSGWC 1999). As previously stated, further studies are necessary to determine the necessary flows to resuspend the material from the riverbed and what environmental impact this process may have. The studies will determine if suitable flows occur in the Santa Maria River to convey the discharged sediments all the way to the ocean, and if such discharges can occur without any adverse hydraulic effects.

Another option is to discharge the sediments to the riverbed at Bonita School Road crossing. This location is about seven miles from the ocean. This discharge point may be more suitable than upstream at Fugler Point because: (1) the flows in the river would be higher at this location and therefore more likely to carry the sediments to the ocean; (2) this location is substantially closer to the ocean; and there are fewer flood control improvement and crossings below this point.

Discharge of sediments at Bonita School Road crossing during the summer and fall would result in the deposition of sediments in the riverbed downstream of the discharge point because the flows from Twitchell Reservoir would not be sufficient to reach the ocean. This alternative may be infeasible if it causes adverse changes in the hydraulics and channel invert elevation along the lower river (URSGWC, 1999).

Fill Canyons

USGS 1:24,000 scale topographic maps for the Twitchell Reservoir watershed and downstream areas were examined to identify canyons that could be used for disposal of the sediments removed from the reservoir. The criteria used to identify potentially suitable canyons included:

- The absence of a mapped stream within the canyon
- The canyon was within five miles of an apparently existing road or trail
- There was less than a 10 percent gradient from existing road or trail to the top of potential fill canyon
- There was a maximum 25 percent gradient (4H:1V) within the canyon

The examination indicated seven relatively isolated canyons in the reservoir watershed that could potentially serve as permanent disposal sites for the excavated sediments. Each site is in an undeveloped area adjacent to, or within, the Los Padres National Forest. The potential capacity of the different sites ranged from 3 to about 14 million cubic yards.

While 14 million cubic yards appears to provide significant disposal capacity, the volume available for disposal of sediments would be reduced by the construction of an engineered embankment in the canyon for purposes of retaining the disposed sediments. In addition, considerations regarding the potential for erosion or mass wasting of the disposed sediments would likely result in grading schemes for the deposits that would further reduce the available capacity. Finally, there is some risk that erosion or mass wasting of the disposed sediments could contribute to the existing watershed sediment load (URSGWC 1999). For these reasons, disposal of sediments in fill canyons located within the watershed is not considered to be a feasible alternative.

One potential fill canyon, with a capacity of over 20 million cubic yards, was identified downstream from the reservoir above the left abutment of the dam. However, a conceptual layout of the site development indicated that approximately 2/3 of the available capacity would be required for the construction of an engineered retaining embankment. Due to access issues associated with both the construction of an engineered embankment as well as the deposition of sediments, development of the identified downstream canyon for sediment disposal is not considered a feasible alternative.

Downstream Sediment Basin

Under this option, sediments would be conveyed to temporary storage ponds or basins downstream of the dam. Earthen impoundments would need to be constructed for wet sediments to be dewatered by gravity. Once the sediments had been dewatered, they would be hauled to a permanent disposal site or sites by truck.

In order to collect the average annual slurry amount of 1,200 acre-feet and 4,800 acre-feet of water, a basin or series of basins must have a minimum capacity of 6,000 acre-feet. If the pond has a 20-foot high earthen berm, it would require 400 acres. The size of the basin would be reduced if higher berms were constructed. The most appropriate location for a basin would be downstream of the dam in order to avoid pumping up-gradient, and to remove the sediments from the reservoir watershed.

There are two major options for downstream impoundments. One option is to locate several ponds in the valley along the Cuyama River between the dam and Fugler Point. This would require acquisition and removal of most of the vineyards in the valley floor. The other option is to acquire agricultural lands in the Santa Maria Valley near the confluence of the Cuyama and Santa Maria rivers.

Another consideration is whether there would be sufficient time for settling and removal of sediments within the sediment basin, particularly since dredging operations are estimated to occur for only four months of each year. It may be necessary to partition the sediment basin into sub-basins to facilitate relatively rapid settling and removals; however, in this case, the overall dimensions of the sediment basin would need to be increased to make up the capacity lost to the sub-basin embankments. It is further noted that the sediment basin embankment would fall within the jurisdiction of the California State Division of Safety of Dams if constructed and owned by a non-federal agency. This option is considered viable, although it would require substantial land, engineering, and earthwork to construct a basin, and there would be ongoing dewatering and truck hauling operations all year.

Finally, an option that involves a smaller scale of sediment removal would store the material in basins constructed on USBR property immediately downstream of the dam, including portions of the stilling basin and borrow pits. A rough estimate of the area is 180 acres. This area has been considered because of its proximity to the reservoir; however, due to its limited size more study must be undertaken to determine whether there is sufficient area to adequately dispose of the sediment. This must be done taking into consideration the loss of area due to berm construction and disposal and or removal operations. This site has been considered a permanent site for disposal and trucking material from this site would be an option.

Nearby Gravel Pit Mines

There are two existing sand and gravel mines located along the Sisquoc/Santa Maria River, downstream of Twitchell Reservoir – the Coast Rock and SP Milling mines. New mining and reclamation permits were recently issued to both mines by Santa Barbara and San Luis Obispo counties. Coast Rock Mining consists of numerous parcels in the river and in adjacent agricultural lands along a 17-mile long reach of the Sisquoc/Santa Maria rivers. The mining area encompasses about 3,970 acres, portions of which occur in Santa Barbara County, San Luis Obispo County, and the City of Santa Maria. The SP Milling Mine encompasses 404 acres all within Santa Barbara County.

The Coast Rock mining plan includes both in-channel and off-channel excavations. The former involves excavations of the Santa Maria River channel, lowering the channel over the entire width of the river in the project area. Reclamation of the channel would occur primarily through natural sediment replenishment by river flows. The off-channel mining would occur in 14 pits ranging in size from 40 to 200 acres. These pits are located in agricultural fields. After mining, the pits are to be returned to agricultural production by placement of subsoils and topsoils, although the grade of the reclaimed land would be lower than prior to mining. The total acreage of agricultural lands to be mined and reclaimed over the 80-year permit period is about 1,464 acres.

Based on a discussion with a representative of Coast Rock Mine, there is a potential to place sediments as subsoils in farmlands that have been excavated and are about to be reclaimed as agricultural land. Under the current reclamation plan, these lands would be lower in elevation than before mining, but would still be viable croplands. Use of sediments from the reservoir would allow Coast Rock to raise the farmlands back to their original elevation. The amount of capacity available for receiving sediments is unknown at this time. The use of sediments for reclamation purposes would vary greatly from year to year, and as such, would not be a reliable long-term disposal option. The total capacity for sediments in these mined agricultural lands is expected to be less than 10,000 acre-feet over the 80-year life of the permit. Hence, the use of Coast Rock Mine for sediment disposal would need to be combined with other options.

The SP Milling mine is located in the Santa Maria River near Sisquoc where large pits are excavated then either replenished by natural sand deposition, or converted to wildlife habitat with open water and wetlands. There is a potential for several thousand acre-feet of capacity in these pits in the next 10 years for sediment disposal. However, use of the pits would require a change in the approved reclamation plans of SP Milling.

Use of the Coast Rock and SP Milling mines for disposal of sediments is considered viable; however, only a small amount of the sediment removed from Twitchell Reservoir could be stored at the gravel pits.

Establish A Clay Tile Factory Close To Santa Maria

The clays deposited in the lower portion of Twitchell Reservoir are considered to be excellent material for manufacturing clay products, especially roof and floor tiles. This concept is discussed previously under the Resource Value section on page 21 of this report.

Use The Material For Landfill Cover

Sediment from the lower portion of Twitchell Reservoir has characteristics of material that can be used for cover at a landfill. Intermediate or daily covers are placed on the surface of a landfill to eliminate the harboring of disease vectors, reduce or eliminate the amount of water infiltration and enhance the aesthetics of the landfill. The clay material available at Twitchell is impermeable enough to provide for the needs of daily and final cover. Final cover is used when a landfill or phase of a landfill is closing. Final cover meets the same needs as daily cover and also limits the uncontrolled releases of landfill gases. Further laboratory analysis of the sediment will be necessary to determine whether it is suitable to meet the requirements of final cover. These requirements include the ability to withstand extreme temperature changes, resist water and wind erosion, stability against slumping, cracking and slope failure, resistance to disruptions due to earthquakes, plants, animals etc. and withstand loads from vehicles. The material from Twitchell may not meet all of these needs but may be blended with other materials to complete the requirements necessary, further analysis is necessary. The City of Santa Maria operates a landfill approximately 5 or 6 miles downstream of Twitchell Dam that may utilize material from the reservoir. Volumes and tonnage of material that could be utilized for this process are unknown at this time and need to be investigated further.

Downstream Disposal Into The Riverine - Downstream Usage By Landowners

Disposal of sediments below the dam is the most economical disposal alternative. A detailed sediment transport model should be developed to determine the efficiency of this disposal method. It is important to ensure that the sediment deposited in the downstream riverbed can be resuspended by winter flows and transported ultimately to the ocean as this is the natural system. If the sediment is not able to be resuspended, the riverbed will aggrade and potentially have adverse impacts.

One option of this disposal method is the use of the material by downstream landowners. The material may be excavated from the downstream channel and used to terrace adjacent agricultural properties. Further research and analysis is necessary to determine the amount of sediment that can be effectively utilized in this process.

Alternatives to Sediment Removal and Disposal

In general, the following alternatives, when implemented exclusively, do not reclaim capacity in the conservation pool lost to sedimentation. The capital costs for these alternatives would need to be analyzed to determine an annualized cost over the life of the project life extension provided by the particular alternative.

Raising the Outlet Tower

Raising the outlet structure will ensure normal operations of Twitchell Reservoir by allowing the water to flow out of the reservoir at higher elevations. If this alternative is pursued exclusively, the sediment will continue to rise in the reservoir. The lower outlet works may become threatened to the point that they are inoperable, not allowing the sluicing operations to continue. The conservation pool's capacity will continue to diminish but the ability to continue operations will extend the life of the reservoir before operations have to be ceased.

Raising the Dam

Raising the dam at Twitchell Reservoir will provide for more capacity in the reservoir. Renegotiations with the Army USACE to adjust the flood control pool elevation would be necessary to increase the allowed capacity in the conservation pool.

Upstream Erosion Control and Sediment Trapping

The amount of sediment entering Twitchell Reservoir can be reduced through the implementation of erosion control and sediment trapping methods in the tributary watersheds, primarily the Cuyama watershed. Currently the Cachuma Resource Conservation District is conducting a study on non-point source pollution in the Cuyama Watershed, sediment is included as a pollutant. Pending the results of their study and further cost analyses, erosion control methods will be evaluated, selected and implemented.

Erosion control is a long-term commitment between all agencies involved and the numerous landowners that own property in the watersheds. Erosion control produces long-term rather than short-term results. Sediment removal methods in the reservoir, in addition to erosion control will be necessary to maintain operations, but effective erosion control will extend the life of the reservoir and reduce the amount of necessary sediment removal.

This section is intended to outline alternatives for erosion control and sediment trapping upstream of the reservoir to minimize the continuous sediment loading. Typical erosion control and sediment trapping methods have been adopted from various sources including the working group, local and federal agencies, and text references.

There are a few basic principles for erosion control; maximize vegetative cover, maximize infiltration, manage slopes to prevent flow concentration, trap sediment before it leaves a site, and protect and preserve vegetation in natural riparian zones (Morris, 1998). These principles can be broken down into various methods that are described in this report. These methods are; implementation of protective vegetation, protection of graded slopes from runoff, flexible channel protection, rigid linings, grade control, channel realignment, sediment detention basins and erosion control in farming practices. These are the predominant methods that are utilized in most erosion control practices.

<u>Protective Vegetation</u>

Vegetation can be utilized to protect banks, slopes, hillsides and terraces. The root systems of the vegetation will actually hold soils intact under the erosive effects of wind, streamflow and precipitation. Vegetative cover enhances infiltration and gives the best economically efficient, longest lasting control of erosion.

Several factors are used to determine the types of plants that are suitable for protective vegetation. The plants must be self-sustaining, require little or no maintenance and not increase the fire-hazard. Various types of vegetation have characteristics that are suitable for site specific applications. Additional information obtained from on-site studies of the three major watersheds contributing to Twitchell Reservoir will help determine the specific species for vegetation.

Bank stabilization with vegetation has been used in many creeks and rivers throughout Santa Barbara County to protect banks from erosion. To increase the effectiveness of the seeding seeds can be raked into the soil, drilled, or hydroseeded. Drilling utilizes a mechanical planting process by which seed and fertilizer are placed at proper depth and at approximately 4-inch intervals. Hydroseeding is the process by which a mixture of seed, mulch, and fertilizer is sprayed on to the soil by use of jet of water applied under pressure. Hand-planting of willow bundles along an appropriately graded bank has been shown successful for protecting banks.

Vegetative lining consists of grass or woody plants that line the waterway banks. Vegetative lining reduces the erosion along the channels and provides for the filtration of sediment. Also, vegetative lining gives an aesthetically pleasing appearance, and improves wildlife habitat. There are limited opportunities for bank stabilization through vegetation only, costly structural devices would be required as well.

Grass is an option for vegetative lining but due to the relatively shallow root systems, the design velocity of the channel should not exceed four feet per second. Cuyama River flows often exceed four feet per second, but the grass may be useful in certain tributaries.

Initially, it appears that much of the erosion is geologic and a large portion originates on public land. It is not feasible to remedy most of the erosion problems on public lands, either environmentally or economically.

<u>Protection Of Graded Slopes From Runoff</u>

Channel erosion due to rilling and deep incisions occurs when concentrated flows of runoff are sustained on sloping soils.

There are various methods available to control the flow and protect slopes and graded areas from eroding. Some of these methods are use of a diversion dike, downdrains, diversions and terraces.

A diversion dike is a berm of non-erodible material constructed at the top of a slope used to divert overland flow from running down and eroding a slope. These have primarily been used at the edge of roadways to prevent drainage from flowing over road fill. The dikes can direct the drainage to a drain outlet that is engineered to convey the water with minimal erosion to stable points of discharge below without eroding the sloped or graded banks.

The down drains may be of various types; flexible down drain, pipe drop or chute (flume). A flexible down drain is a flexible conduit of heavy-duty fabric or other material that is used as a temporary slope drain. Pipe drops are pipes placed on slopes as outlets for diversion dikes. A chute or flume is a high-velocity, open channel for conveying water to a lower level without erosion. Various inlet and outlet designs are available for these various down drains.

A diversion is a structure consisting of a channel or ditch and a ridge constructed across a sloping land surface on the contour or with predetermined grades to intercept and divert surface runoff before it gains sufficient volume and velocity to create erosion. The water is collected and conveyed laterally along the diversion at slow velocity and discharged into a protected area or outlet channel.

Terracing is a method which runoff is interrupted from flowing downslope. Cuts are made into a slope and the cut material is used to fill below the cut providing level land surfaces that cause runoff to lose velocity. Terraces are usually designed to collect water and drain laterally towards a downdrain system as described above.

In the Cuyama watershed, most of the badly eroded areas are too steep to employ diversions and terraces. These methods may be utilized in other areas though.

Flexible Channel Protection

Flexible channel protection is formed of individual pieces of materials such as rock, gabions and old tires. These flexible linings have the advantage of adjusting to differential settlement along the lined channel while still providing protection against erosion along the channels.

Gabions are rock filled, galvanized or stainless steel wire cages, which when wired together form large, flexible, permeable protective blocks. Relatively small rock fragments or gravel 4 to 8 inches in diameter can be used to form a coherent structure capable of streambank protection. Flexibility of gabions permits them to withstand differential settlement without fracture. Permeability of gabions prevents hydrostatic heads from developing behind the structure that may lead to damage.

Old tires, joined together by steel cables or bands, can form an effective protective lining against erosion of a streambank. Not only do the tires provide streambank protection, but also after they collect silt and become permanently imbedded, the tires protect the roots of vegetative cover. The advantages of old tires as protective lining are low cost of installation and maintaining the aesthetic view of vegetative cover along streambanks. The use of old tires would be advantageous along the Cuyama River where siltation and revegetation are likely to occur.

Rigid Linings

Rigid linings are non-flexible material which are used to line the channels. Rigid linings provide the maximum flow capacity due to a low roughness coefficient. Asphalt, concrete, grouted rock, sacked concrete and soil cement are the various forms of rigid linings.

Due to the length of the Cuyama River, rigid linings would have a very high cost and significant environmental impacts such as reducing groundwater recharge.

Grade Control

Grade control measures are structures that reduce channel energy and maintain channel gradients. By reducing the channel gradients, the flow velocities decrease, thus preventing erosion at the higher flow rates. Grade control structures include check dams and drop structures. These structures are also vital for enhancing streambank stabilization.

Check dams are structures used to stabilize the grade and control headcutting in natural channels. Headcutting is the erosion process where the streambed undermines the bank causing continued erosion in the upstream direction.

Drop structures are weir structures in which water flow passes through a weir opening and drops to a stilling basin, before passing into the downstream channel. Drop structures are also used to control streambed gradients in channels.

Channel Realignment

Channel realignment is a structural measure that changes the existing course of a waterway. Channel realignment is instituted when the stability of the natural channel is not suitable under existing runoff. Many considerations should be addressed if channel realignment is to be utilized. The upstream channel should be analyzed for at least one-half mile to determine the type of channel material and its susceptibility to erosion. The design of the structure should attempt to duplicate the hydraulic properties of the natural stream in the new section. Also, every attempt should be made to approximate the streambed slope of the natural channel in the new relocated channel.

Due to the size of the system, channel realignment may not be a feasible option.

Sediment Detention Basins

A sediment detention basin is a reservoir sufficiently sized to cause deposition of transported sediment. Sediment basins may either be temporary or permanent structures that prevent transportation of sediment in the channel. The design of the sediment detention basins is governed by the desired particle size to be removed from the flow. Gravity causes larger sized particles to settle out more rapidly than smaller particles. The smaller the particle size to be removed, the larger the basin must be. There are enhancement techniques that will help create a longer detention time, therefore increasing the deposition of material in a sediment basin. One of these techniques is the addition of baffles in the basin. The baffles will minimize the amount of hydraulic short-circuiting.

There are three sites that have been identified for potential sediment detention basin placement. The first site is Santa Barbara Canyon on the upper Cuyama. In 1977, SBCWA hired Bookman-Edmonston Engineering, Inc. to conduct a reconnaissance level report engineering study of potential dam projects. The report estimates that a Santa Barbara Canyon Reservoir would provide an additional 1,000-2,000 acre-feet per year increase in the amount of water retained in the Cuyama Valley. This additional water storage capacity could be used as in conjuncture with Twitchell Reservoir to provide additional flood control and water storage for the Santa Maria Valley. Unfortunately, this report does not include an estimate of sediment inflow to the proposed Santa Barbara Canyon

Reservoir. An estimate of sediment inflow to the proposed reservoir would have to be completed if other constraints do not preclude the construction of a dam on Santa Barbara Canyon.

A second site was identified in the 1951 Bureau of Reclamation report entitled "Santa Maria Project, Southern Pacific Basin, California." This report identified a site 22 miles upstream from Twitchell Reservoir. This site would serve a drainage area of 823 square miles that would include all of the Cuyama Badlands. The maximum height of this reservoir would be 225 feet above streambed, and the dam would retain 250,000 acre-feet of sediment, which would amount to several hundred years of sediment load. The sediment concentration was estimated to be four percent of the average annual flow of 11,000 acre-feet.

Erosion Control In Farming Practices

There are various measures that can be implemented on farms to decrease the amount of soil erosion that occurs. Many of these methods may already be in practice to some degree on many of the farms in the tributary watersheds. Contouring, strip cropping, grass filter strips, conservation tillage, grassed waterways, terracing as described above, and contour-grassed hedges are various basic erosion control strategies that farmers use to control erosion. The erosion from Cuyama Valley farms is hardly measurable due to the low rainfall and existing farming practices. Further studies are necessary to determine if farming practices can be enhanced to reduce the amount of erosion that does exist. Some of the controls which could be evaluated are discussed below.

Contouring is the practice of orienting field operations along the contours of the land. This reduces the surface runoff by holding the water in small depressions instead of allowing rill erosion to occur.

Strip cropping is the practice of growing alternate strips of different crops. The crops should follow or be rotated in a sequence so that the entire field is never bare.

A grass filter strip is a vegetated area fit to the contour that filters sheet flow from cropped areas. These filter strips can trap sediment, increase infiltration, retard concentrated flows and trap associated pollutants including agricultural chemicals. A drawback to filter strips is that they require a significant amount of space that may reduce the amount of productive lands.

Conservation tillage encompasses the processes by which tillage is significantly reduced or eliminated. The basic concept is that crop stubble is left and the remains are spread out evenly across the field as mulch instead of being plowed under. Conservation tillage can reduce soil erosion by as much as 90 percent, increase infiltration, increase soil organic matter, reduce peak discharges and downstream flood damages.

Grassed waterways are drainages in which vegetation protects the channel beds from being eroded. With the vegetation, the permissible velocities in the channel may be higher without erosion occurring.

Contour-grassed hedges can create natural terraces. The narrow strips of grass initially will pond water behind them allowing for deposition to occur. The terrace is formed behind the hedges and will follow the contour becoming more evenly dispersed and less erosive with time.

Initial Conclusions of Upstrwam Measures

The sediment that is collecting near the dam and threatening the outlet works is primarily clay. Clay is a fine material that is suspended in water flow at very minimal flow velocities. To achieve effective erosion control in the Cuyama watershed, the clay material would have to be preserved in the watershed or trapped within the waterways before collecting in Twitchell Reservoir. The clay material will not settle out of suspension unless there is virtually no flow. This requires enormous reservoirs along the Cuyama River to handle the peak flows. Therefore, the most practical method of preventing the clay material from entering into Twitchell Reservoir would by preventing the clay particles from becoming mobilized in the first place. Other material like sand and gravel could be trapped in relatively small sediment detention basins.

A field study and interviews with landowners and managers are necessary to determine if significant erosion is occurring within the watershed and if erosion can be controlled through implementation of upstream control measures. Until these fundamental questions are answered, costs associated with upstream sediment management cannot be evaluated, therefore they are not discussed further in sections 5 and 6.

SECTION 5: PLANNING COST ESTIMATES

Order-of-magnitude planning cost estimates (capital, operations, and maintenance) were developed for five sediment removal alternatives that included one or more viable sediment removal, transport, and disposal options identified in Section 4 as alternatives for future consideration (URSGWC, August 1999). These estimates are based on initial descriptions of the actions and preliminary engineering analysis performed by URS Greiner Woodward Clyde and SBCWA staff. These alternatives include the following combinations:

- Sluice sediments through outlet works using agitation and submerged slurry pipeline, and discharge to river below the dam (feasibility of downstream conveyance by river flows below the dam is unknown at this time)
- Dredge sediments and convey by slurry pipeline to Bonita School Road crossing for discharge to Santa Maria River
- Dredge sediments and convey by slurry pipeline to ocean
- Dredge sediments and convey by slurry pipeline to stilling basin, gravel pits, or for discharge to Santa Maria River near Fulger Point (feasibility of conveyance by Santa Maria River flows to below Bonita School Road crossing is unknown)
- Dredge sediments and convey by slurry pipeline to downstream sediment basin, then haul to gravel mine pits or nearby commercial use by trucks

The estimated costs are based on unit prices presented in the 1997 Mean's Guide for Heavy Construction Cost Data and the 1998 Mean's Guide for Building Construction Cost Data. The estimates include direct and indirect costs, such as labor, materials, and contractor's insurance, bond, taxes, overhead, and profit, but do not include the land or right-of-ways, engineering design, environmental studies, permitting, environmental mitigation, construction management/administration costs, and the cost of water.

Table 4 summarizes the estimated capital and operations and maintenance costs for viable alternatives.

Dredging

The estimated costs for dredging were based on the use of a hydraulic cutterhead pipeline dredge with a 1,000-ton per hour capacity. It is assumed that a government agency would purchase a dredge rather than contract the dredging operations each year because the cost of purchasing a dredge would be less than annual contracting costs. The cost of a dredge would be about $6 million, which could be paid over a 10-year period at $1 million per year. It was also assumed that

TABLE 4: ESTIMATED COSTS FOR VIABLE ALTERNATIVES

Alternative	Capital Cost (millions, 1998)					Operations Costs (millions, 1998)			Total Cost (millions, 1998)
	Dredge and pumps	Pipeline	Downstream Pumps	Upgraded Roads	Sediment Basin and Pumps	Dredge and Pumps*	Dewatering, Loading Sediments	Trucking	
Active Flushing with Dredge	6	0	0	0	0	7.5	0	0	13.5
Dredge and Slurry to Bonita School Road	6	9.3	0.4	0	0	7.5	0	0	23.2
Dredge, slurry to Ocean	6	13.5	1.2	0	0	8	0	0	28.7
Dredge, slurry to Fugler Point, river discharge or Gravel pits	6	5.6	0.4	0	0	7.4	0	0	19.4
Dredge, slurry to basin, haul to gravel pits/commercial use	6	1	0.4	1.9	12.2	7.4	19.7	3.5	52.1

* Dredging may range up to $13 million, depending on site factors.

use of the dredge includes pumping the sediment slurry from the dredge to the top of the dam, the spillway, or the intake structure for the outlet works for downstream

disposal. Removing 300 acre-feet of material per month and transmitting it to the top of the dam, the spillway, or the intake structure would require one pump station with two 400-hp pumps in series and a 30-inch diameter pipeline. It was assumed that the slurry pipeline would be constructed of welded steel pipe.

Annual operations and maintenance costs are estimated at about $7.5 million, which would represent a unit cost of about $3.50 per cubic yard for the 2 million cubic yards (1,200 acre-feet) of sediments to be removed each year. However, it should be noted that operation and maintenance costs for similar dredging projects have ranged up to $6 per cubic yard depending upon site specific conditions (resulting in up to $13 million annual operational cost). The working group has considered scaled dredging operations that will reduce both capital and operations and maintenance costs. The amount of sediment that could be removed under a scaled system ranges from 380 to 2,000 acre-feet per year.

Slurry Pipeline

Capital costs were estimated for a slurry pipeline from the dam to Fugler Point. This pipeline could be used to discharge sediment to the Santa Maria River, or to the gravel mine pits. The distance from the top of the dam would be about 10.8 miles and require one pump station with two 400-hp pumps installed in series. If the pumps were located near the base of the dam, this would allow easy access by the dam tender to check on the operating status of the pumps. To extend the slurry pipeline to Bonita School Road would require a pipeline length of about 20.5 miles, with one pump station with two 400-hp pumps installed in series. To extend the slurry pipeline from the dam to three miles into the ocean would require a pipeline over 32 miles long with two pump stations each with two 400-hp pumps in series to get the slurry to ocean level; additional pumps to overcome the ocean pressure head at the end of the pipe may also be needed. If the elevation at the end of the pipe is about 400 feet below sea level, up to six additional 400-hp pumps in series could be required.

Sediment Basin

The estimated costs for construction of a 6,000-acre-feet capacity sediment settling basin downstream from Twitchell Dam were based on an assumed 40-foot high, 5,000-foot long embankment with 2H:1V side slopes, and an 8-foot wide crest. It was assumed that the foundation excavation was 10 feet deep beneath the footprint of the embankment. It was also assumed that additional material for construction of the embankment could be obtained from the Santa Maria and Sisquoc river channels. The construction of the diversion structure at the existing outlet works, the decant release structure, sub-basin embankments and weirs, and access facilities for earth-moving equipment were assumed to be 30 percent of the earthworks cost.

Again, scaled dredging operations would reduce the size necessary for the downstream sediment basins. In turn, the costs would be reduced as well. Additional studies are necessary to determine the actual costs associated with the scaled down systems.

Trucking to Gravel Mines

The equipment requirements for truck transport of the sediments removed from Twitchell Reservoir amount to about 400 trucks per working day, with loaders at the sediment basin or shore-side stockpile. It was assumed that the trucks would dispose of the sediments at the various Coast Rock and SP Milling mines, about 10.3 miles (on average) from the dam and sediment basin. Additional haul costs to more distant disposal sites or commercial uses would be approximately $1.00 per cubic yard per mile.

SECTION 6: EVALUATION OF SEDIMENT MANAGEMENT ALTERNATIVES

This section serves as a template to determine the preferred set of sediment management alternatives. Proposed is a numerical ranking scheme that results in the identification of the alternative that minimizes costs, environmental impacts, and technical/permitting issues.

Evaluation Procedure

Section four contains detailed descriptions of the materials and methods for each alternative and the reader is instructed to refer to this section for more information. Based on this information, URS Greiner Woodward Clyde identified preferred alternatives. These alternatives are listed below.

1. Dredging (at reservoir)
   - Slurry pipeline to Bonita School Road Crossing
   - Slurry pipeline to Ocean
   - Slurry pipeline to gravel pits (or other nearby commercial use)
   - Slurry to sediment basin, then hauled to gravel pits
   - Flushing to sediment basin, then hauled to gravel pits
   - Dredge and flush downstream
   - Dredge to Stilling Basin
2. Flushing (at reservoir)
3. Mechanical Removal (at sediment basin)

The ranking procedure consists of two phases. First a "fatal flaw" analysis is applied to each alternative. Second, each alternative that survived the fatal flaw analysis, is given a numerical score based upon cost estimates, environmental impacts, and technical/permitting issues. The alternatives were then ranked based upon their total numerical score. The lowest overall score represents the preferred alternative. The ranking process is described below in detail.

Phase 1: Fatal Flaw

The fatal flaw analysis serves to remove an infeasible alternative from future consideration. A fatal flaw is considered as any factor that would prevent the implementation of an alternative. There are four main criteria for the fatal flaw analysis.

1. Does the alternative conflict with the federal or California endangered species act and have unmitigiable adverse impacts?
2. Does the alternative conflict with the Clean Water Act and have unmitigiable adverse impacts?
3. Does the alternative meet the purpose and need of the project?
4. Is the alternative economically and technically feasible?

Because of the strict compliance necessary with both the Endangered Species Act and the Clean Water Act, any alternative that violates either of these acts is removed if it has unmitigable adverse impacts. To meet the purpose and need of the project an alternative must be able to effectively remove sediment to ensure the viability of the outlet works. A project is determined to be infeasible if it contains any prohibitive cost or engineering constraint that would prevent its implementation.

TABLE 5: FATAL FLAW ANALYSIS

Alternative		Conflict with State and Federal Endangered Species Act	Conflict with Clean Water Act	Meets Purpose and Need of Project	Economic & Technical Feasibility
Dredging-Hydraulic 1,200 AF/Yr					
	Slurry Pipeline to Bonita School	No	No	Yes	Yes
	Slurry Pipeline to Ocean	No	No	Yes	Yes
	Slurry Pipeline to Gravel Pits	No	No	Yes	Yes
	Slurry to Sediment Basin then Hauled to Gravel Pits	No	No	Yes	Yes
	Dredge and Flush Downstream	EIR/EIS	EIR/EIS	Yes	Yes
	Dredge to Stilling Basin	No	No	Yes	Further Study
Sluicing					
	Detention Basin then Trucked to Disposal	No	No	Yes	Yes
	to Ocean	EIR/EIS	EIR/EIS	Partially	Yes
Earth Moving Equipment					
	Scrapers	No	No	Yes	No
	Front-End Loaders	No	No	Yes	No
	Draglines	No	No	Yes	No
	Clamshell	No	No	Yes	No
Scaled-Dredging					
	Small 400 AF/Yr	No	No	Partially	Yes
	Medium 900 AF/Yr	No	No	Partially	Yes
	Large 2000 AF/Yr	No	No	Yes	Yes

Phase 2: Application of Criteria

Each of the ranking criteria contains a set of points. Points will be specific to each criteria, and fewer points will correlate with decreased cost, less environmental impact, or greater ease with either technical or permitting issues.

Economic Factors

Economic factors are evaluated based upon order of magnitude costs presented in Table 4: "Summary of Estimated Costs for Viable Alternatives," found in Section 5. Capital scores are based upon a straight conversion of $1,000,000 equals one point (rounded to the nearest point). For example, the capital cost of $15.7 million dollars for dredging with a slurry pipeline to Bonita School Road crossing would be given a score of 16.

For this evaluation, we assumed that the sediment would be removed below elevation 560 feet and between the dam and the confluence of Huasna Creek and the Cuyama River. By removing 1,200 acre-feet of sediment each year, there would be a net removal of sediment from the reservoir below elevation 560 feet because the average annual sediment input below elevation 560 is 603 acre-feet per year. Based on these numbers, it would take approximately 25 years to remove the sediment below 560 feet.

To represent the Operations and Maintenance (O&M) cost over the life of the project (25 years), annual O&M cost will be multiplied by 25. For example, the O&M cost for dredging with a slurry pipeline to Bonita School Road is estimated to be 7.5 million dollars annually. Multiplied by 25, gives an annual cost score of 187.5. The capital and O&M scores are then added to obtain the total score. The total score is normalized to a 200-point scale.

TABLE 6: ECONOMIC EVALUATION

Alternative	Capital Costs (Millions of Dollars)	Annual O & M Costs (Millions of Dollars)	Capital Score	Annual O & M Score	Total Score	Normalized Score
Dredging-Hydraulic						
Slurry Pipeline to Bonita School 1,200 AF/Yr	15.7	7.5	16.0	187.5	203.5	40
Small 400AF/Yr	3.4	3.1	3.0	77.5	80.5	16
Medium 900 AF/Yr	13.1	5.8	13.0	145.0	158.0	31
Large 2,000 AF/Yr	18.3	16.8	18.0	420.0	438.0	85
Slurry Pipeline to Ocean	20.7	8.0	21.0	200.0	221.0	43
Small 400AF/Yr	4.5	3.3	4.0	82.2	86.2	17
Medium 900 AF/Yr	17.3	6.2	17.0	155.0	172.0	34
Large 2,000 AF/Yr	24.2	17.8	24.0	445.2	469.2	92
Slurry Pipeline to Gravel Pits	12.0	7.4	12.0	185.0	197.0	38
Small 400AF/Yr	2.6	3.1	3.0	76.4	79.4	15
Medium 900 AF/Yr	10.0	5.7	10.0	142.5	152.5	30
Large 2,000 AF/Yr	14.0	16.6	14.0	414.1	428.1	84
Slurry to Sediment Basin, then Hauled to Gravel Pits	21.5	30.7	22.0	767.5	789.5	154
Small 400AF/Yr	4.7	26.3	5.0	657.5	662.5	129
Medium 900 AF/Yr	17.9	29.0	18.0	725.0	743.0	145
Large 2,000 AF/Yr	25.1	40.0	25.0	1000.0	1025.0	200
Dredge and Flush Downstream	6.0	7.5	6.0	187.5	193.5	38
Small 400AF/Yr	1.3	3.1	1.0	77.5	78.5	15
Medium 900 AF/Yr	5.0	5.8	5.0	187.5	192.5	38
Large 2,000 AF/Yr	7.0	16.8	7.0	420.0	427.0	83
Sluicing						
Detention Basin then Trucked to Disposal	15.5	23.2	0.0	580.0	580.0	147
to Ocean	0.0	0.0	0.0	0.0	0.0	0

Environmental Factors

The environmental factors are based on the following areas of potential impact:

- Topography and Land Use
- Biology
- Air Quality
- Traffic
- Geology
- Hydrology
- Noise
- Cultural resources/Archeology

- Human Environmental Resources
- Water Quality

Lower range point scores (0-3) represents little or no significant impact. Middle range point scores represent an impact which could be mitigated (4-6), and a high range point scores (7-10) represents an impact which cannot be mitigated. The total environmental score will be the sum of each criterion. Total maximum score for the environmental factor is 90 points, and the scores are normalized to that value. For information regarding the environmental baseline of the area the reader is instructed to refer to Appendix A. Appendix B contains the specific environmental considerations for each viable alternative.

TABLE 7: ENVIRONMENTAL SCORE

Alternative		Topography and Land Use	Geology	Biology	Hydrology	Air Quality	Noise	Traffic	Cultural Resources/ Archeology	Human Environmental Resources	Total Score	Normalized Score
Dredging-Hydraulic												
	Slurry Pipeline to Bonita School	6	4	3	6	6	4	0	2	0	31	66
	Slurry Pipeline to Ocean	6	4	4	6	6	4	0	2	0	32	68
	Slurry Pipeline to Gravel Pits	6	4	2	4	6	4	0	2	0	28	60
	Slurry to Sediment Basin then Hauled to Gravel Pits	6	4	4	4	8	6	6	4	0	42	90
	Dredge and Flush Downstream	0	0	4	2	6	4	0	2	0	18	39
	Dredge to Stilling Basin	6	4	3	4	6	4	0	2	0	29	62
Sluicing												
	Detention Basin then Trucked to Disposal	8	0	4	4	4	6	6	4	0	36	77
	to Ocean	0	0	4	4	0	0	0	0	0	8	17

Technical/Permitting Factor

The implementation factor is broken up into 2 main sub-factors, technical feasibility and permitting issues.

Technical Feasibility: This factor is based upon hydrologic and hydraulic constraints. A consideration with regard to technical feasibility is whether an alternative has been done elsewhere with success.

Permitting Issues: This factor is based upon permit constraints and estimated timing.

A summary of the technical and permitting factors specific to each viable alternative is presented in Appendix B. Each criteria is assigned a maximum of 15 points, for a total of 60 for the implementation factor. Scores are normalized to this value. Higher points will signify an increased difficulty.

Applying the permitting issues factor to alternatives is illustrated in the following example. In order to construct a pipeline, right-of-way must be acquired through an easement or fee title purchase. The acquisition of a right-of-way for the longer pipeline routes (e.g., the 32-mile long route to the ocean) would involve substantial time, effort, and cost.

The pipeline would traverse one or more natural watercourses (e.g., Cuyama or Santa Maria rivers, tributaries to the river, etc.) along its route. Construction of a pipeline crossing would require the following permits and approvals:

- Section 404 permit from the USACE would be required for the installation of a pipeline across intermittent streams, Cuyama River, Sisquoc and Santa Maria River. This permit requires involves a public noticing and review period, as well as consultation with other federal and state agencies, including the US Fish and Wildlife Service (USFWS), National Marine Fisheries Service, California Department of Fish and Game (CDFG), and Regional Water Quality Control Board (RWQCB).

- A 401 water quality certification or waiver is required from the RWQCB for all Sections 10 and 404 permits issued by the USACE.

- A Streambed Alteration Agreement from the CDFG pursuant to Section 1601-1603 of the Fish and Game Code.

The design and construction of a slurry pipeline to any disposal site by a local special district, the County of Santa Barbara, or a federal agency would require the preparation of an environmental document. It is likely that an Environmental Impact Report (EIR) would be required for a locally sponsored project, while an Environmental Assessment (EA) or possibly an Environmental Impact Statement (EIS) would be prepared by a federal sponsoring agency. Both documents involve multi-disciplinary studies and a public review period. Thus, the permitting and timing score for dredging with a slurry pipeline is relatively high, with an increasing score correlating with an increased pipeline distance.

TABLE 8: TECHNICAL/PERMITTING SCORE

Alternative		Hydrologic Constraints	Hydraulic Constraints	Permit Constraints	Timing	Total Technical Score	Normalized Score
Dredging-Hydraulic							
	Slurry Pipeline to Bonita School	7	9	10	9	35	47
	Slurry Pipeline to Ocean	7	12	14	12	45	60
	Slurry Pipeline to Gravel Pits	4	6	8	6	24	32
	Slurry to Sediment Basin then Hauled to Gravel Pits	4	6	8	10	28	37
	Dredge and Flush Downstream	5	3	6	3	17	23
	Dredge to Stilling Basin	4	6	7	5	22	29
Sluicing							
	Detention Basin then Trucked to Disposal	6	0	9	6	21	28
	to Ocean	5	0	0	3	8	11

SECTION 7: RECOMMENDED SEDIMENT MANAGEMENT ALTERNATIVES

This section will serve to identify the alternatives that ranked the highest for sediment removal based upon the process presented in Section 6. The top alternatives will be carried into the permitting and environmental review phase for further evaluation. Alternatives that are not evaluated further will remain viable alternatives, but will not be actively pursued.

Discussion of Ranking Results

The use of earth moving equipment for sediment removal was deemed infeasible and removed from further consideration by the fatal flaw analysis. Because of the extensive amount of trips needed to sufficiently remove sediment (about 100,000 round trips per year) the group determined that mechanical removal would be infeasible. This takes into consideration the limited time that is available for the equipment to operate and the concentration of truck trips in this time period.

An investigation was conducted to determine the costs of scaled down dredging operations (i.e. under 1,200 acre-feet/year). The costs associated with this are presented in the economics table, see Table 6, along with the amount of sediment that would be able to be removed under each schedule. It remains to be determined if the removal rates are adequate to warrant further investigation. Similarly, the amount of sediment that can be removed via passive sluicing needs to be determined. If the sediment removal goals are changed by the working group, scaled down dredging, or passive sluicing, may be viable alternatives.

Currently, a CRCD study is investigating upstream erosion control methods, however adequate information to rank these alternatives at this time is lacking. The group believes that regardless of which alternative is implemented, upstream erosion control will enhance any selected alternative, and will be integrated into the sediment management plan.

Finally, the area immediately downstream of the dam needs to be investigated for siting a stilling basin. The study is necessary in order to determine the area available, and the feasibility of locating a basin in this area to dispose of dredged sediment.

The final scores are summarized in Table 9 on the following page.

TABLE 9: TOTAL SCORE

Alternative		Economic Score	Environmental Score	Tech/Permitting Score	Total Score
Dredging-Hydraulic					
	Slurry Pipeline to Bonita School*	40	66	47	153
	Small	16	66	47	129
	Medium	31	66	47	144
	Large	85	66	47	198
	Slurry Pipeline to Ocean*	43	68	60	171
	Small	17	68	60	145
	Medium	34	68	60	162
	Large	92	68	60	220
	Slurry Pipeline to Gravel Pits*	38	60	32	130
	Small	15	60	32	107
	Medium	30	60	32	122
	Large	84	60	32	176
	Slurry to Sediment Basin, then Hauled to Gravel Pits*	154	90	37	281
	Small	129	90	37	256
	Medium	145	90	37	272
	Large	200	90	37	327
	Dredge and Flush Downstream*	38	39	23	100
	Small	15	39	23	77
	Medium	38	39	23	100
	Large	83	39	23	145
Sluicing					
	Detention Basin then Trucked to Disposal*	147	77	28	252
	to Ocean*	0	17	11	28

*1200 Acre-feet per year

Table 9 shows that sluicing and flushing to the ocean is the alternative with the lowest score and therefore the highest ranking. However, more analysis is necessary with regard to this alternative before it can be selected. It has not been determined whether this alternative complies with the Endangered Species Act, the Clean Water Act, and whether it meets the purpose and need of the plan.
As previously stated, a detailed downstream sediment routing analysis is needed to determine the effects of sluicing and flushing.

Following sluicing in the rankings are alternatives that involve dredging with transport via the riverbed or slurry pipeline to designated areas, which may or may not need improvement. Again, sediment routing needs to be analyzed, and further studies are needed to determine the storage capacities of these sites. In addition the costs of using a slurry pipeline at these distances is very high.

Upon consideration of ranking procedure and the studies that need to be completed, the sediment management working group has chosen the following alternatives to pursue into the permitting phase.

- Passive Sluicing and flushing
- Dredge and flush

- Dredge with a slurry pipeline to stilling basin
- Dredge with a slurry pipeline to the Fugler point/Sisquoc River

Summary of Environmental Impacts

Sluicing

The primary environmental issues that may be associated with the discharge of sediment-laden water below the dam or at Fugler Point or Bonita School Road crossing are as follows:

- Disturbance to aquatic species and fish due to high dissolved and suspended solids, particularly the endangered steelhead trout which may occasionally occur in the Santa Maria River and the red-legged frog
- Possible contamination of river water due to residual pesticides and herbicides in the sediments
- Change in the riverbed invert, causing adverse hydraulic effects or higher water surface elevations
- Reduction in recharge capacity due to deposition of fines in the riverbed upstream of Bonita School Road crossing

Discharging the sediment slurry in the winter when river flows are high and turbid may reduce the biological effects, and would also facilitate the transport of sediment to the ocean.

It does not appear that any permits would be required to flush sediments from the dam using the outlet works and releases from the reservoir, if the sluicing is incidental to normal operational releases.

Dredging

There are several environmental issues associated with the operation of a dredge, none of which are considered fatal flaws or severe impacts. A dredge will represent a continuous source of air pollutants, particularly nitrogen oxides and hydrocarbons (both precursors to ozone). Under federal and state standards, Santa Barbara County has been designated by EPA as a "serious" non-attainment area for ozone. Due to this designation by the EPA, the County amended its Clean Air Plan in December 1998 to show how it would achieve compliance with the federal and state ozone standard by November 1999. Santa Barbara County is also designated non-attainment for the state PM_{10} standard. Operation of a dredge may contribute to ozone and particulate pollution in the County, although the emissions would not be regulated by the APCD.

Operation of the dredge would cause localized water quality impacts in the reservoir due to agitation of sediments during operations and potential oil or fuel leaks from the dredge. In addition, agitation of sediments during dredging could release any herbicides or pesticides contained in the sediments from upstream agricultural operations. The nature and level of such contamination are unknown, initial results demonstrate that additional studies may be warranted. These impacts are not likely to be significant because the reservoir water is not used directly for Municipal and Industrial (M&I) uses, and because the reservoir is not managed for fisheries, other aquatic species, waterfowl, or wildlife.

The dredge will represent a new continuous noise source. However, there are no noise-sensitive land uses at the reservoir because it is not used for recreation, nor are there any nearby public trails.

The use of a dredge at the reservoir would not require any permits because the dredge would be a portable piece of equipment brought to the reservoir each year. It would operate on federal lands where the County or SMVCWD do not have any land use jurisdiction. The dredge would be powered by diesel engines and as such, would emit air pollutants. However, air permits for mobile or portable sources are normally not required by the Santa Barbara or San Luis Obispo Air Pollution Control Districts (APCDs). For example, the dredge at the Santa Barbara Harbor does not operate under an air permit.

SECTION 8: THE NEXT PHASES OF THE PLAN

The Sediment Management Plan will be presented to the SMVCD Board of Directors in January of 2000. With their support, the Working Group will begin the next phase of the Plan development, environmental review and permitting.

The environmental review will most likely consist of development of an Environmental Impact Report/Environmental Impact Statement (EIR/EIS). The EIR/EIS will include detailed analysis of the impacts to the environment for each alternative. Also included will be detailed engineering and cost analysis for the alternatives selected.

Intricate to the environmental review process will be a detailed sediment transport model to determine the effects of transporting sediment via the river system.

The permitting phase will include meeting with all of the regulatory agencies to brief them on the various alternatives that are being analyzed for implementation. The regulatory agencies will notify the Working Group which permits are necessary to implement the selected alternatives. The Working Group can then begin the lengthy application process for many of the alternatives that are applicable to all of the select alternatives.

It is anticipated that the environmental review and permitting phase will take up to 15 – 18 months to complete.

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16. Reservoir Regulation Manual for Flood Control Storage at Twitchell Dam and Reservoir, United States Army Corps of Engineers. August, 1960

Appendix A: ENVIRONMENTAL BASELINE

Geographical Regions of Interest
Twitchell Reservoir and the immediately surrounding area
Canyons surrounding Twitchell Reservoir
Cuyama River: Twitchell Reservoir Dam to Fugler Point
Santa Maria River: Fugler Point to Suey Creek
Santa Maria River: Suey Creek to Guadalupe Oil Fields
Santa Maria River: Guadalupe Oil Fields, River mouth, and coastal area

Twitchell Reservoir and the immediately surrounding area

Topography and Land Use

Topography

Twitchell Reservoir is situated at the confluence of the Huasna River, Alamo Creek, and the Cuyama River. The bottom of the reservoir is flat (due to terraces on the west side and accumulated sediments) and has an elevation of approximately 526-ft MSL. The reservoir spillway, at the south of the reservoir, has an elevation of 651.5-ft MSL.

Beyond the immediate reservoir the slopes increase dramatically:

- Huasna Peak is approximately 3.7 miles to the north-northwest of the spillway, 1.8 miles from the water, and has an elevation of 1810-ft MSL.
- 3.2 miles north of the spillway, 0.3 miles from the Huasna River and 0.7 miles from Alamo Creek, there is a peak with an elevation of 1424-ft MSL.
- 1.0 miles to the north of the spillway, 0.4 miles east of the water is a peak with 1775-ft MSL.
- 1.1 miles to the west of the spillway, 0.4 miles from the water is a peak with approximately a 1280-ft MSL elevation. This peak is along a ridge that runs northwest to southeast. Beyond this ridge to the southwest, the elevation decreases down to the Santa Maria Valley.

For more detail on the topography of this region, see USGS 7.5-minute series topographic quadrangles for Huasna Peak and Twitchell Dam.

Land Use

Surrounding land use is predominantly agricultural with the majority of land immediately adjacent to the reservoir used for livestock grazing.

Geology

Surface

Starting at the dam and going north up the east bank of the reservoir, the soils consist of clay loams and riverwash with small areas of loamy sand. Further inland on the SE side of the reservoir the soil consists almost exclusively of rocky loam.

Bedrock

Tertiary sedimentary rocks and structure. No known active faults in the area. No significant accumulation of alluvium, except sediments in the reservoir.

Biology

Vegetation

Several plant communities are found in the vicinity of Twitchell Reservoir. These may be broadly categorized as riparian, oak woodland, coastal sage scrub, and annual grassland.

Riparian woodland and riparian scrub occurs within the primary drainages that contribute to the reservoir. Emergent marsh is located only within shallow portions of the main reservoir. Three main types of upland habitat are found in proximity to the reservoir: annual grassland (pasture), coastal sage scrub, and oak woodland. As is typical of the region, these communities occur in a mosaic pattern that is dictated by factors such as proximity to water, soil type, topography, and exposure.

The Huasna River near the north end of the reservoir supports willows (*Salix* sp.), cottonwoods (*Populus* sp.), and sycamores (*Platanus racemosa*) along its banks. Large sycamores and cottonwoods also occur within the floodplain adjacent to the river channel. Alamo Creek is similar in vegetative character, although the drainage contains less woodland as it approaches the reservoir. The Cuyama supports alluvial scrub vegetation as it flows into the east end of the reservoir. The non-persistent character of this vegetation type is reflective of the dynamic nature of the river channel.

Live oaks (*Quercus agrifolia*) commonly occur along the upper banks of the creeks and rivers and are also found on the perimeter of the main body of the reservoir. Valley oaks (*Quercus lobata*) are more frequently seen on elevated terraces or hillsides flanking the drainages.

Fish and Wildlife

Wildlife values of the area are relatively high, due to its rural context and diversity of habitats. Common species of wildlife are expected to occur within the general area of Twitchell Reservoir. Species such as the opossum, raccoon, gopher snake, rattlesnake, coyote, skunk, Western fence lizard, Pacific tree frog, California quail, road runner, and other common song birds and raptors, etc. are likely to occur in the area.

Sensitive Species

There are no breeding records for the Southwestern willow flycatcher (*Empidonax traillii extimus*) or least Bell's vireo (*Vireo bellii pusillus*) for the vicinity of Twitchell Reservoir. Both of these species are listed as endangered by the state and federal wildlife authorities. There are at least two records for Bell's vireo at Twitchell Reservoir in 1993 (Lehman 1994), however, breeding has not been documented. There is suitable habitat for the federally listed California red-legged frog (*Rana aurora draytonii*) and southwestern pond turtle (*Clemmys marmorata pallida*) within the reservoir and its tributary drainages, however, neither of these species is known to occur within the area.

Hydrology

Groundwater

Groundwater resources in the immediate vicinity of the dam and reservoir are limited. Shallow groundwater is developed in the vicinity of the reservoir by the surrounding landowners for limited agricultural purposes.

Air Quality

The reservoir is located in the Santa Maria air basin. The basin is in nonattainment for the State of California standard for PM10. All of Santa Barbara County is in non attainment of both state and federal standards for O_3 (ozone), a regional pollutant. The area is in attainment for all other regulated pollutants according to the Santa Barbara County Air Pollution Control District (1996 Annual Report, SBCAPCD). Each region of interest is within the Santa Maria Air Basin and thus has the same environmental baseline.

Pollutant	Averaging Time	Federal Standard	California Standard
Ozone	1 hour	0.12 ppm	0.09 ppm
Carbon Monoxide	1 hour	35.0 ppm	20.0 ppm
	8 hour	9.0 ppm	9.0 ppm
Nitrogen Dioxide	1 hour	--	0.25 ppm
Sulfur Dioxide	24-hour	0.14 ppm	0.05 ppm
Particulate Matter	24 hour	150 $\mu g/m^3$	50 $\mu g/m^3$

Noise

Ambient noise levels in the vicinity of the reservoir are low. Only two noise sources occur in the vicinity; agricultural operations downstream of the reservoir and State Highway 166. Neither sources cause noise levels to approach Santa Barbara County thresholds of significance for noise.

Traffic

A 2 mile paved road from Highway 166 accesses the reservoir. Access to the project is restricted since the reservoir is surrounded by private property.

Cultural Resources/Archeology

No information is available at this time.

Human Environmental Resources

No information is available at this time.

Canyons Surrounding Twitchell Reservoir

Topography and Land Use

The topography is similar to Twitchell Twitchell Reservoir and the immediately surrounding area, see the above description.

Geology

Starting at the dam and going north up the east bank of the reservoir, the soils consist of clay loams and riverwash with small areas of loamy sand. Further inland on the southeast side of the reservoir the soil consists almost exclusively of rocky loam.

Biology

No information is available at this time.

Hydrology

No information available at this time.

Air Quality

This region is located in the Santa Maria Air basin, see above for discussion of environmental baseline.

Noise

No information available at this time.

Traffic

Along Highway 166 near Twitchell Reservoir Caltrans operates a traffic station which monitors traffic conditions at postmile 8.927. Average Annual Daily Trips number 974.

Cultural Resources/Archeology

No information is available at this time.

Human Environmental Resources

No information is available at this time.

Cuyama River: Twitchell Reservoir Dam to Fugler Point

Topography and Land Use

Below the dam, the Cuyama River meanders approximately five miles through vineyard farmland in a valley less than a mile wide surrounded on both sides by hills that rise quickly to elevations of 800 ft MSL. About a half mile before Fugler Point the river enters the Santa Maria valley where the terrain flattens out.

For more detail on the topography of this region, see USGS 7.5-minute series topographic quadrangle for Huasna Peak.

Geology

Starting just below the Twitchell reservoir dam the soil directly next to the Cuyama consists of riverwash. On the Santa Barbara (east) side of the river the soils consist of gravelly fine sand loam, silty clay loam, Elder loam, Sorrento loam, sedimentary rock, Metz loamy sand, Santa Lucia shaly clay loam, Mocho sandy loam, and sandy alluvial land.

According to the Dibblee Quadrangle, within this geographical area of interest, the Cuyama River flows over sand and silt gravel. It is bounded on the west by Obispo Formation with periodic occurrences of floodplain alluvium and landslide debris. On the east, the river is bounded by Monterey Shale with periodic occurrences of older alluvium, floodplain alluvium, Obispo Formation, and landslide debris. Fugler Point itself is composed of older alluvium and Careaga sand. The only fault in the area is the West Huasna-Foxen Canyon Fault which near Fugler Point runs in the river bed and bisects the confluence of the Cuyama and Sisquoc rivers.

Biology

No information is available at this time.

Hydrology

The river drains arid and semi arid watersheds in the California Coastal Ranges. It is characterized as "flashy" with relatively rapid response to rainfall and little or no flow in its reaches during the summer months. Due to the variation of flow in the river, no significant surface water diversions from the Cuyama occur. Water quality is variable, ranging from 800 to 1000 PPM TDS depending on which tributary is contributing the majority of flow to the river. In addition, significant volumes of silt are carried by the Cuyama River during high flow.

Air Quality

This region is located in the Santa Maria Air basin, see above for discussion of environmental baseline

Noise

No information is available at this time.

Traffic

Several private stream crossings occur below the reservoir. These crossings are dry weather designs that are washed out when winter flows exceed approximately 500 cfs. These provide crossing of the Cuyama River below the dam for agricultural operations.

Cultural Resources/Archeology

No information is available at this time.

Human Environmental Resources

No information is available at this time.

Santa Maria River: Fugler Point to Suey Creek

Topography and Land Use

Fugler Point, 5.5 miles south of the spillway, lies at the confluence of the Cuyama and Sisquoc rivers, where they become the Santa Maria River. The Santa Maria River flows westerly to the ocean. Highway 101 crosses the river about two miles downstream from Suey Crossing. From Highway 101 to the confluence of the Cuyama and Sisquoc rivers, there are high bluffs along the north side of the flood plain and flood control levees define a flood limit along the south side of the river. The upstream levee ties into Fugler Point, a promontory just opposite the confluence.

For more detail on the topography of this region, see USGS 7.5-minute series topographic quadrangles for Twitchell Dam and Santa Maria.

Geology

This area lies within the Santa Maria Groundwater Basin (SMGB). The SMGB is physically comprised of generally unconsolidated, water-bearing, marine and non-marine sediments of Pliocene to Recent age. These deposits are up to 2300 feet thick and overlie consolidated bedrock of Jurassic to Miocene age. The consolidated bedrock units are generally considered non-water bearing as low production rates and poor water quality characterize wells in these units. Water-bearing units in the SMGV include the Careaga Sand, Paso Robles Formation, Orcutt Formation, and Holocene alluvial deposits.

From Fugler Point to the northwest, again the river runs through riverwash soil, but bounding the river on the Santa Barbara County side are soils comprised mostly of Metz loamy sand, sandy alluvium, and Mocho sandy loam composed of sand and silt gravel. Orcutt Formation and older alluvium bound the riverbed on the northeast side. The riverbed is bounded on the southwest side by floodplain alluvium. The Santa Maria River Fault runs in the river bed, starting north of Grant Boundary and running southeast where is intersects the Huasna Fault just north of Fugler Point and becomes the West Huasna-Foxen Canyon Fault.

Biology

Vegetation

Examples of Central Coast Arroyo Willow Riparian Forest occur in this region. This area has been subjected to varying amounts of grazing. Dominant plant species vary within each grazed location, but usually include one or two of the following weedy invasive species: black mustard (*Brassica nigra*), ripgut brome (*Bromus diandrus*), and slender tobacco (*Nicotiana glauca*) in other areas; and occasional thickets of hoary cress (*Cardaria draba*) in association with castor bean (*Ricinus communis*) and purple star thistle (*Centaurea calcitrapa*). Mulefat Scrub dominates in areas that are still subject to periodic inundation, with mulefat as the dominant species. Further west, near the levee, sand bar willow (*Salix hindsiana*) becomes co-dominant with mulefat.

Hydrology

This area lies within the Santa Maria Groundwater Basin (SMGB). The SMGB is currently the primary source of water supply for the agricultural, municipal, and industrial land uses in the cities and counties within Santa Maria Valley. Seepage of river flows through the riverbed along the Santa Maria River and the lower reaches of the Cuyama and Sisquoc rivers is the primary source of recharge to the SMGB. These segments of the Santa Maria River system flow over unconsolidated, permeable alluvial deposits of the SMGB. Percolation of river flows through these deposits account for approximately 75-85% of the 83,000 AFY average annual recharge to the groundwater basin. The remaining recharge occurs through direct percolation of rainfall.

Historically, the stream meander has eroded the banks, stripped farmland of soil, and undercut portions of the flood control levees downstream from Fugler Point. The Santa Maria River is ephemeral, with no surface flow occurring about 83% of the time. Discharges that occur are highly variable. The sediment sizes making up the bed and parts of the banks of the river also have a large range of sizes. They range from fine sand having an equivalent diameter of less than 0.2 millimeters (0.01 inches) in the downstream reaches through boulders having an equivalent diameter of over 500 mm (20 inches) in the upstream reaches. The bed slope near Suey Crossing is about 15 feet per mile. Twitchell Dam has induced channel-bed degradation in the Santa Maria River downstream of Gary Bridge. The degradation in turn induces head cutting at the bridge crossing. Downstream of Fugler Point, the USACE levees experienced undermining, also due to the angle of impingement from relatively low flows. River channel mining will continue to be done in this area throughout the 64-year life of the Coast Rock project, gradually widening and deepening the floodway without creating a defined low flow or pilot channel. Mining depth for the Coast Rock project will average approximately five feet below the elevation of the existing river thalweg and mining width will be consistent with the location of the existing river bank, varying from 400 to 1200 feet at various locations along the river. The channel is designed to convey a 100-year flood event through the project area. The overall average gradient of the river channel is not proposed to change significantly throughout the project area as a result of mining operations. Channel side slopes will be left at a 3:1 gradient, and adjacent levee tops will be a minimum of 50 feet wide. The operation will not mine within flowing waters of the river channel.

Air Quality

This region is located in the Santa Maria Air basin, see above for discussion of environmental baseline

Noise

No information is available at this time.

Traffic

There is a public crossing of the Santa Maria River at Suey Road to provide dry weather access between Santa Barbara County and San Luis Obispo County.

Cultural Resources/Archeology

No information is available at this time.

Human Environmental Resources

No information is available at this time.

Santa Maria River: Suey Creek to Guadalupe Oil Fields

Topography and Land Use

Throughout this stretch, the Santa Maria River is bounded on the south by a levee up to the Highway 1 crossing, north of Guadalupe. It is also bounded on the north by a levee that starts at Nipomo Mesa and ends at the Santa Barbara-San Luis Obispo county line, west of the Bonita School crossing.

For more detail on the topography of this region, see USGS 7.5-minute series topographic quadrangles for Santa Maria and Guadeloupe.

Geology

The soils surrounding the river are comprised of river wash. Starting at Suey Creek and heading west, the soils immediately outside of the south levee are sandy alluvial soil up to Bonita School crossing then a combination of Mocho fine sandy loam and Metz loamy sand. North of the City of Guadalupe, there is again sandy alluvial soil, followed to the west by Mocho sandy loam up to the beginning of the Guadalupe Oil Fields. According to the Dibblee Quadrangle, the Santa Maria River flows on a bed of sand and silt gravel. The riverbed is bounded to the north and south by floodplain alluvium, with the exception of the north side of the riverbed running from Suey Crossing to Nipomo Mesa which is comprised of Orcutt Formation and older alluvium. There are no known faults in this area.

Biology

No information is available at this time.

Hydrology

Around the US-101 bridge, there has been significant erosion around the bridge piers and a general lowering of the river channel. This erosion appears to be related to mining activities by other (not Coast Rock or Kaiser) operators in close proximity both upstream and downstream of the bridge.

Air Quality

This region is located in the Santa Maria Air basin, see above for discussion of environmental baseline

Noise

No information is available at this time.

Traffic

There is a public crossing of the Santa Maria River at Bonita School Road to provide dry weather access between Santa Barbara County and San Luis Obispo County.

Cultural Resources/Archeology

No information is available at this time.

Human Environmental Resources

No information is available at this time.

Santa Maria River: Guadalupe Oil Fields, River Mouth, and Coastal Area

Topography and Land Use

The Guadalupe Oil Field site is located on the central coast of California approximately 15 miles south of San Luis Obispo. The topographic relief varies with the dunes and ranges from sea level to approximately 160 feet above mean sea level. It is part of the UNOCAL LeRoy Lease that covers approximately 3,000 acres within the Nipomo Dunes system. Most of the lease is within San Luis Obispo County, though a small portion extends into Santa Barbara County along the southern boundary. The City of Guadalupe is located approximately three miles east of the site; Nipomo is approximately five miles to the northeast; and Santa Maria is approximately ten miles to the east.

Surface waters bound the site on two sides, the Pacific Ocean on the western side and the Santa Maria River and estuary/lagoon system on the southern side. Agricultural land is located to the east; and the Guadalupe Nipomo Dunes Preserve (including Mobile Coastal Reserve, Oso Flaco, Dune Lakes, etc.) is located to the north. Freshwater ponds and marshes are also present at the site.

The Nipomo Dunes system is one of the largest dune systems along the California coast. The area has been designated as a National Natural Landmark by the US Secretary of the Interior because of the presence of extensive sand dunes, dune uplands, lakes, and wetlands. In addition to oil development activities, the coastal area is a popular recreation destination. There is public access at Oso Flaco Lake Natural Area two miles to the north, and at Rancho Guadalupe County Park just south of the Guadalupe Oil Field.

Another important riverine feature is the associated wetland communities located at the southwest corner of the area. It is a broad area (approximately 2,400 feet by 400 feet) of wetland vegetation and open water that most likely occupies a former channel position of the Santa Maria River. The area is very flat and gently grades into upland along its eastern boundary. Steeper grades exist along the western boundary of the wetland where over wash and dune migration processes have occurred. Arguably, all the dune and beach deposits seaward of this wetland area could be considered barrier beach environment.

For more detail on the topography of this region, see USGS 7.5-minute series topographic quadrangles for Guadalupe and Point Sal.

Geology

A wedge-shaped bowl-like structural basin containing Pliocene and younger formations to depths of 1,600 feet constitutes the groundwater basin of the region. This basin, the Santa Maria Valley, is bounded to the northeast by the Coast Ranges and to the south by the Casmalia-Solomon Hills. The basin is approximately fifty miles long and opens toward the west. The western portion of the Santa Maria Valley extends offshore for about 35 miles where it terminates at the Santa Lucia Bank. Between Point Sal and Point San Luis, five miles north and twenty miles south of the Santa Maria River, respectfully, the longshore movement of sediment is within a confined area known as the Pismo Littoral Cell. The most predominant onshore features within the valley are an extensive sand dune system and a broad river valley. Between Mussel Rock, just north of Point Sal, and Pismo Beach is the area collectively known as the Nipomo Dunes. However, this area is divided into several sub-units. The Mussel Rock unit is that portion of the Nipomo Dunes lying in Santa Barbara County between the Santa Maria River and Mussel Rock. It is the sheet of dunes lying partly on the Santa Maria River floodplain and partly on the Orcutt Mesa. The Guadalupe unit lies entirely on the alluvial plain of the Santa Maria River between the Santa Maria River mouth and Oso Flaco Lake. The Callender unit lies north of Oso Flaco

Lake and is the sheet of dune that rests on the Nipomo Mesa and partially on the alluvial strip between the mesa and ocean.

Surface soil types consist primarily of beach sands, aeolian dune sands, plus sands and silty sands from stream and alluvial deposition. The beach and dune sand deposits have occasional thin layers of silty sand or sandy silt. A clay layer (or aquitard) separates the unconfined aquifer from the upper zone of the regional aquifer. The exact upper and lower boundaries of this clay layer have not been determined across the entire site, but available data indicate a thickness ranging from 30 to 70 feet (Levine Fricke Recon, 1997). Some borings indicate that layers or lenses of sand and silt are prevalent through the clay layer. Although the available stratigraphy data does not allow a complete definition of this surface, it appears to slope downward from northeast to southwest across the site (Levine Fricke Recon, 1997).

The geologic terrain at the Guadalupe Oil Field consists of an extensive dune network including foredunes, backdunes, and the Santa Maria River estuary. The dunes are part of the Nipomo Dunes which include recent and Wisconsin-age (10,000 to 70,000 years old) systems.

The regional geologic units identified on the USGS area geology map (1989) are beach sand deposits, dune sand deposits, stream channel deposits of sand and silt, and valley and floodplain alluvium. The unconsolidated deposits average 230 feet thick in this area; and are part of the Arroyo Grande-Santa Maria Groundwater Basin (Chipping, 1987). The regional aquifer separates into two zones, upper and lower. The upper zone is generally silty sand with finer and coarser layers. The lower zone is primarily sand and gravel with silt and clay layers. Exact depths of the layers are unknown at the sit. Based on its thickness, it is likely that the upper zone, as referenced by Chipping, refers to the regional agricultural-use aquifer. The localized dune sand aquifer does not correspond directly to Chipping's upper zone, but overlays it.

The sands and silty sands that compose the beach area and the dunes appear to have similar engineering properties across the site, as one would expect from the natural sorting which occurs due to the river sediment transport process, transportation by and deposition out of the littoral current, and the eolian migration inland.

According to Soil Conservation Service (SCS) maps, the soil around the river is river wash. From east to west, the soils surrounding the river in this area are Mocho sandy loam, Camarillo sandy loam, marsh, sandy alluvial, and coastal beaches.

<u>Biology</u>

For a detailed description of vegetation and wildlife, the habitats in which they occur, and sensitive species known to occur within or near the Guadalupe Oil Field area, see Table 5.3.1 of the Guadalupe EIR.

Vegetation

Federal or state listed species in the area:

- La Graciosa thistle (*Cirsium loncholepis*) - Fed candidate, CA threatened
- Surf thistle (*Cirsium rhothophilum*) - Fed candidate, CA threatened
- Beach spectacle-pod (*Dithyrea maritima*) - CA threatened
- California Native Plant Society listed rare or endangered species in area:
- Dune larkspur (*Delphinium parryi* var. *blochmaniae*)
- Blochman's leafy daisy (*Erigeron blochmaniae*)
- Kellogg's horkelia (*Horkelia cuneata* ssp. *sericea*)
- Dune Mint (*Monardella crispa*)
- San Luis Obispo monardella (*Monardella frutescens*)

California species of special concern:

- Red sand-verbena (*Abronia maritima*)
- San Luis Obispo Wallflower (*Erysimum insulare* ssp. *suffrutescens*)
- Southwestern spiny rush (*Juncus acutus* ssp. *leopoldii*)
- Dunedelion (*Malacothrix incana*)
- California spineflower (*Mucronea californica*)
- Giant coreopsis (*Coreopsis gigantea*)
- Pholisma (*Pholisma arenarium*)
- Straggly gooseberry (*Ribes divaricatum* var. *pubiflorum*)

Wildlife

Federal or state listed species in the area:

- Steelhead trout (*Oncorhyncus mykiss*) - Fed proposed endangered
- Tidewater goby (*Eucyclogobius newberryi*) - Fed endangered, CA species of concern
- California red-legged frog (*Rana aurora draytonii*) - Fed threatened, CA species of concern
- American peregrine falcon (*Falco peregrinus anatum*) - Fed endangered, CA endangered
- California brown pelican (*Pelecanus occidentalis californicus*) - Fed endangered, CA endangered
- California least tern (*Sterna antillarum*) - Fed endangered, CA endangered
- Western snowy plover (*charadrius alexandrinus*) - Fed threatened, CA species of concern

California species of special concern:

California horned lizard (*Phrynosoma coronatum frontale*)
Silvery legless lizard (*Anniella pulchra pulchra*)
Two-striped garter snake (*Thamnophis hammondii*)
Osprey (*Pandion haliaetus*)
White-tailed kite (*Elanus leucurus*)
Northern harrier (*Circus cyaneus*)
Sharp-shinned hawk (*Accipiter striatus*)
Cooper's hawk (*Accipiter cooperii*)
Ferruginous hawk (*Buteo regalis*)
Golden eagle (*Aquila chrysaetos*)
Merlin (*Falco columbarius*)
California horned lark (*Eremophila alpestris*)
Loggerhead shrike (*Lanius ludovicianus*)
Yellow warbler (*Dendroica petechia*)

Hydrology

The Santa Maria River has played a major role in creating and maintaining the dunes by bringing sediment to the coast and depositing it on offshore sandbars during the winter season. The mouth of the river migrates north and south periodically. Although river/beach dynamics are more affected by the gross movement and transport of material, net longshore sediment transport (the difference between transport to the north and to the south) is estimated to be 64,000 cubic yards per year to the south based on the longshore component of wave energy (USACE, 1986). Others believe it is near zero in the Pismo Littoral Cell except following sediment discharges in the Santa Maria River. A sand contribution from the river creates a disequilibrium delta condition whereby an onshore sand transport from the delta followed by longshore transport to the north or south is the typical post-flood condition. Transport to the north is, over time, larger than transport to the south as evidenced by the greater volume of the dune fields north of the river (Everts, 1995).

The beach profile (cross section perpendicular to the shoreline) on this portion of the southern California coast changes seasonally. Beginning in the late fall (November to December), winter storms begin to attack the shoreline principally from the northwest. These winds create a storm surge that raises the water level and exposes higher portions of the beach not vulnerable to waves during the summer. The storm surge allows the waves to pass over the offshore bar without breaking. When the waves finally break, the energy is spent eroding the beach, berm, and sometimes the dunes. The eroded material is moved offshore, where it is deposited on an existing bar or forms a multiple bar system. The winter profile is generally flatter than the summer profile and the horizontal distance of the backshore (distance from berm crest to dune) is reduced. For open portions of the shoreline subject to direct storm wave attack, this distance can be 30 to 100 feet, depending on storm magnitude and frequency (personal communication William Reynolds, 1994).

Floods in the Santa Maria River initiate outlet migration, and subsequent river and marine phenomena compound it. Most of the northward migration probably occurs during the post-flood stage. While the outlet could shift position by closing at one location and opening at one further to the north or south, it appears that its shift in position usually occurs as the result of a progressive, but not steady, migration. A progressive northward movement of the outlet occurs when the barrier spit elongates on the south side of the outlet. This happens when alongshore sand transport is to the north. The rate of spit elongation is, to a large extent, a function of the rate of alongshore transport. The cross-sectional area of the outlet as it passes through the spit is controlled by the freshwater discharge in the river plus the tidal prism (ebb-tidal flow of saltwater from the lagoon), and the longshore sand transport rate. As the barrier spit elongates at the south side of the outlet, the spit on the north side is cut by the migrating channel. There must be some flow in the river for this to occur. High flows through the outlet reduce the migration rate. Low to moderate flows that occur when the alongshore transport rate is large favor migration. At very low flows, the outlet may close. This occurs when freshwater flow in the river is less than the combination of percolation through the barrier and evaporation from the lagoon. Closure occurs when incoming sand transported along the coast cannot all be removed by coastal processes and freshwater flow through the outlet. The river will break out when flows increase. Usually the breach will occur where the barrier is lowest and not necessarily where it was last open (Everts, 1994).

Air Quality

This region is located in the Santa Maria Air basin, see above for discussion of environmental baseline

Noise

No information available at this time.

Traffic

There is public access at Oso Flaco Lake Natural Area two miles to the north, and at Rancho Guadalupe County Park just south of the Guadalupe Oil Field.

Cultural Resources/Archeology

No information available at this time.

Human Environmental Resources

No information available at this time.

Appendix B: ENVIRONMENTAL AND PERMITTING ISSUES SPECIFIC TO EACH VIABLE ALTERNATIVE

The major environmental and permitting issues that would be associated with viable sediment removal, transport, and disposal options are summarized below.

Dredging

Environmental Issues

There are several environmental issues associated with the operation of a dredge, none of which are considered fatal flaws or severe impacts. A dredge will represent a continuous source of air pollutants, particularly nitrogen oxides and hydrocarbons (both precursors to ozone). Under federal and state standards, Santa Barbara County has been designated by EPA as a "serious" non-attainment area for ozone. Due to this designation by the EPA, the County amended its Clean Air Plan in December 1998 to show how it would achieve compliance with the federal and state ozone standard by November 1999. Santa Barbara County is also designated nonattainment for the state PM_{10} standard. Operation of a dredge would contribute to ozone and particulate pollution in the County, although the emissions would not be regulated by the APCD.

Operation of the dredge would cause localized water quality impacts in the reservoir due to agitation of sediments during operations and potential oil or fuel leaks from the dredge. In addition, agitation of sediments during dredging could release any herbicides or pesticides contained in the sediments from upstream agricultural operations. The nature and level of such contamination are unknown. These impacts are not likely to be significant because the reservoir water is not used directly for municipal and industrial (M&I) uses, and because the reservoir is not managed for fisheries, other aquatic species, waterfowl, or wildlife.

The dredge will represent a new continuous noise source. However, there are no noise-sensitive land uses at the reservoir because it is not used for recreation, nor are there any nearby public trails.

Permitting Requirements

The use of a dredge at the reservoir would not require any permits because the dredge would be a portable piece of equipment brought to the reservoir each year. It would operate on federal lands where the County or SMVCWD do not have any land use jurisdiction. The dredge would be powered by diesel engines and as such, would emit air pollutants. However, air permits for mobile or portable sources are normally not required by the Santa Barbara or San Luis Obispo Air Pollution Control Districts (APCDs). For example, the dredge at the Santa Barbara Harbor does not require an air permit.

Sluicing

The sluicing of sediments from the reservoir to a downstream sediment basin using the conservation or flood control pool may have environmental impacts or "fatal flaws." Active sluicing using a hydraulic dredge will discharge sediments to the Cuyama River downstream of the dam. The deposition of sediments in the river channel is unknown at this time. Sediments could be conveyed downstream to the Santa Maria River and/or accumulate in the channel below the dam. The amount and distance of sediment transport on the Cuyama River (and the Santa Maria River eventually) will depend upon the sediment transport characteristics of the rivers and the timing of the sluicing. An analysis of the river sediment transport is required to determine how far the sediments will be conveyed downstream, and if sediment will accumulate in the river channel and possibly cause adverse impacts to the floodplain (e.g., flooding, redirection the river flows, etc).

It is not anticipated that a lengthy permitting process will be required for the sluicing alternative.

Slurry Pipeline

Environmental Issues

A slurry pipeline would be used to convey sediments and water from a dredge to one of the following locations: downstream sediment basin, gravel mines near Sisquoc, the Santa Maria River at Fugler Point or below the Bonita School Road crossing, or the ocean. The pipeline would be steel and would be buried for most of its length. There would be one or more electrical pump stations along the pipeline, depending upon the pipeline length and head loss.

Environmental impacts associated with the construction of a pipeline generally involve temporary disturbance of the following resources:

- Native vegetation, including uplands and wetlands or riparian habitat
- Possible sensitive fish and wildlife species
- Agricultural lands
- Streets and roads (i.e. temporary road closures)
- Soils (i.e. temporary erosion impacts)
- Cultural resources (e.g., archeological sites)

Installation of a slurry pipeline to any of the above disposal sites would have environmental impacts along the route. However, significant environmental impacts may be avoided by selecting a preferred route for the pipeline. In addition, the physical impacts of the pipeline construction are generally very localized, usually restricted to a 50 to 75-foot wide construction corridor, and temporary in nature. Once operating, the pipeline would not have additional long term impacts.

Land and Permitting Requirements

In order to construct a pipeline, a right-of-way must be acquired through an easement or fee title purchase. The acquisition of a right-of-way for the longer pipeline routes (e.g., the 32-mile long route to the ocean) would involve substantial time, effort, and cost. It is noted that no right-of-way issues are anticipated for a pipeline leading to the immediate downstream of the dam.

The pipeline would likely traverse lands within both Santa Barbara and San Luis Obispo counties. However, a land use permit from Santa Barbara or San Luis Obispo counties is not expected to be required for a slurry pipeline and pump stations constructed by the federal government or a local special district (e.g., SMVCWD) because such facilities are normally exempt from local land use permitting requirements.

The pipeline would traverse one or more natural watercourses (e.g., Cuyama or Santa Maria rivers, tributaries to the river, etc.) along its route. Construction of a pipeline crossing will require the following permits and approvals:

- Section 404 permit from the USACE would be required for the installation of a pipeline across intermittent streams, Cuyama River, Sisquoc and Santa Maria River. This permit requires involves a public noticing and review period, as well as consultation with other federal and state agencies, including the US Fish and Wildlife Service (USFWS), National Marine Fisheries Service, California Department of Fish and Game (CDFG), and Regional Water Quality Control Board (RWQCB).

- A 401 water quality certification or waiver is required from the RWQCB for all Sections 10 and 404 permits issued by the USACE. The certification or waiver is issued after a review of the permit application to determine if the discharge associated with the pipeline crossings will meet all applicable state water quality standards, which are contained in the California Ocean Plan for nearshore waters, and in the Central Coast Basin Plan for inland waters.

- A Streambed Alteration Agreement from the California Department of Fish and Game (CDFG) pursuant to Section 1601-1603 of the Fish and Game Code would be required for the installation of a pipeline across intermittent streams, Cuyama River, Sisquoc and Santa Maria River.

The design and construction of a slurry pipeline to any disposal site by a local special district, the County of Santa Barbara, or a federal agency would require environmental review under both NEPA and CEQA. It is likely that an Environmental Impact Report (EIR) would be required for a locally sponsored project, while an Environmental Assessment (EA) and an Environmental Impact Statement (EIS) would be prepared by a federal sponsoring agency. Both documents involve multi-disciplinary studies and a public review period.

Sediment Basin Disposal and Hauling

Environmental Issues

The construction of a sediment basin downstream of the dam along the Cuyama River would require the following activities:

- Construction of earthen berms, 20 to 40 feet in height
- Excavation of an area for impoundment, 200 to 600 acres, depending upon the height of the berms, depth of excavation, and slope of the site
- Construction of access roads into and out of the basin
- Improvement of the private road that extends from the river to the dam
- Construction of civil works to direct flows into the basin, and to dewater the basin

Environmental impacts associated with the construction of a sediment basin include the following:

- Loss of native vegetation, including uplands and wetlands or riparian habitat
- Disturbance to sensitive wildlife species
- Loss of agricultural lands
- Erosion and sedimentation during construction
- Disturbance to cultural resources (e.g., archeological sites)

The establishment of a dewatering operation at the sediment basin could affect water quality along the Cuyama River due to increased total dissolved solids from decanted water, or due to uncontrolled spills from upset conditions at the basin.

The sediments would be dried, loaded onto trucks and hauled to the nearby gravel mines or other commercial sites (e.g., commercial fill sites, ceramic factory, soil building operation). Impacts of this type of operation could be significant and include:

- Air pollution emissions from loaders and trucks, including fugitive dust
- Interference with nearby agriculture due to fugitive dust
- Traffic impacts on private and public roads due to substantial increase in truck traffic

The environmental sensitivities of the land below the dam where a sediment basin could be constructed, and along the Cuyama River between the dam and the Santa Maria River are summarized in Section 5.1. The basin would primarily remove agricultural lands, but could also remove the extensive wetlands below the dam.

Land and Permitting Requirements

A substantial amount of private land would need to be purchased in order to construct a sediment basin downstream of the dam. The floodplain along the lower Cuyama River contains mature vineyards. Hence, the land values would be very high. The acquisition of property would involve substantial time, effort, and cost. Again, it should be noted that no land acquisition is necessary if the basin were sited on USBR property.

A land use permit from either or both Santa Barbara or San Luis Obispo counties would normally be required due to the size and nature of the basin. However, water resource projects constructed by the federal government or a local special district (e.g., SMVCWD) are usually exempt from local land permitting requirements.

The basin would likely be located in all or part of the large wetland located downstream of the dam in the river floodplain. Construction of the basin would require the following permits and approvals:

- Section 404 individual permit from the USACE would be required for filling of the wetlands for the basin. The permit application process and evaluation criteria are described above.

- A 401 water quality certification or waiver would be required from the RWQCB for the 404 permit. The permit application process and evaluation criteria are described above.

- A permit from the State Division of Safety of Dams (DSOD) would be required if height of the earthen dikes exceed 25 feet and/or the impounded area exceeds 50 acre-feet of water. It is likely that the impoundment will require approval by the DSOD. A permit would involve extensive engineering design review and approval.

The design and construction of a sediment basin by a local special district, the County of Santa Barbara, or a federal agency would require the preparation of an environmental document. It is likely that an Environmental Impact Report (EIR) would be required for a locally sponsored project, while an Environmental Assessment (EA) and an Environmental Impact Statement (EIS) would be prepared by a federal sponsoring agency. Both documents involve multi-disciplinary studies and a public review period.

Riverbed Discharge

Environmental Issues

The primary environmental issues associated with the discharge of sediment-laden water below the dam or at Fugler Point or Bonita School Road crossing are as follows:

- Disturbance to aquatic species and fish due to high dissolved and suspended solids, particularly the endangered steelhead trout which may occasionally occur in the Santa Maria River and the red-legged frog
- Possible contamination of river water due to residual pesticides and herbicides in the sediments
- Change in the riverbed invert, causing adverse hydraulic effects or higher water surface elevations
- Reduction in recharge capacity due to deposition of fines in the riverbed upstream of Bonita School Road crossing

Discharging the sediment slurry in the winter when river flows are high and turbid would reduce the biological effects, and would also facilitate the transport of sediment to the ocean.

Permit Requirements

Permit requirements for the construction of a slurry pipeline from Twitchell Dam to a location along or near the Santa Maria River for discharge to the Santa Maria are discussed in Section 5.2.3. The discharge of dredged material from the pipeline to the river will require the following permits:

- Section 404 permit from the USACE would be required for the discharge of dredged material to the Cuyama River and Santa Maria River. This permit requires involves a public noticing and review period, as well as consultation with other federal and state agencies, including the US Fish and Wildlife Service (USFWS), National Marine Fisheries Service, California Department of Fish and Game (CDFG), and Regional Water Quality Control Board (RWQCB). The primary issues to be addressed in the permit review will be affects to water quality, aquatic organisms, and steelhead trout.

- A 401 water quality certification or waiver is required from the RWQCB for all Sections 10 and 404 permits issued by the USACE. The certification or waiver is issued after a review of the permit application to determine if the discharge will meet all applicable state water quality standards in the Central Coast Basin Plan for inland waters.

- A National Pollution Discharge Elimination System (NPDES) permit from the RWQCB is required for discharges from a pipeline to the river. An NPDES will establish effluent limitations on the discharge to protect beneficial uses of the surface water and groundwater and to ensure consistency with the Basin Plan. The permit process includes a public review period and hearings before the RWQCB.

Ocean Disposal

Environmental Issues

The primary environmental issues associated with the discharge of sediment-laden water into the nearshore waters at Guadalupe Dunes are as follows:

- Disturbance to wetlands, dune habitats, and various sensitive coastal fish and wildlife species at the mouth of the river due to pipeline installation
- Possible contamination of ocean waters due to residual pesticides and herbicides in the sediments
- Adverse effects of sediment plume on benthic and water column marine invertebrates, plankton, and fish

Discharging the sediment slurry in the winter when wave action is high and natural sediments are being deposited in the ocean would reduce the biological effects.

Permit Requirements

The disposal of sediments to the ocean through discharges from a slurry pipeline in the nearshore waters will require the following permits:

- Section 10 Permit from the USACE is required for the installation of a pipeline in the nearshore waters (which represent "navigable waters") pursuant to Section 10 of the Rivers and Harbors Act. This permit requires a public noticing and review period, as well as consultation with other federal and state agencies, including the US Fish and Wildlife Service (USFWS), National Marine Fisheries Service, California Department of Fish and Game, and Regional Water Quality Control Board. The permit can be issued if the construction of the discharge is not contrary to the public interest, and if there are no less environmentally damaging practicable alternatives. In addition, a Section 404 permit is required for the discharge of dredged material into the ocean under Section 404 of the Clean Water Act. The 404 permit process and evaluation criteria are identical to those of the Section 10 permit.

- A 401 water quality certification or waiver is required from the RWQCB for all Sections 10 and 404 permits issued by the USACE. The certification or waiver is issued after a review of the permit application to determine if the discharge will meet all applicable state water quality standards, which are contained in the California Ocean Plan for nearshore waters, and in the Central Coast Basin Plan for inland waters.

- A Section 103 Permit is required from the USACE to dispose of dredged materials to the ocean pursuant to Section 103 of the Marine Protection, Research, and Sanctuaries Act. The USACE must evaluate the physical and biological impacts of the proposed dumping using criteria developed by the Environmental Protection Agency (EPA). To determine the suitability of the dredged material for dumping at an EPA designated site or at another site, the material must be tested in accordance with the EPA's Evaluation of Dredge Material Proposed for Ocean Disposal testing manual. The manual contains procedures to evaluate contaminant-related impacts of the ocean disposal. Materials to be disposed must not exceed the applicable marine water quality criteria established by the EPA based on the liquid phase concentration of a dredge material in the water column.

- A National Pollution Discharge Elimination System (NPDES) permit from the RWQCB is required for discharges from a pipeline to the ocean or other surface waters. An NPDES will establish effluent limitations on the discharge to protect beneficial uses of the marine waters and to ensure consistency with the California Ocean Plan and any applicable federal effluent limitations. The permit process includes a public review period and hearings before the RWQCB.

- A Coastal Development Permit will be required for the portion of the slurry pipeline within the Coastal Zone. The California Coastal Commission would evaluate and issue a permit for the portion of the pipeline in tidelands and nearshore waters, while Santa Barbara County would issue a permit for the pipeline in the Coastal Zone, landward of high tide. In order to issue a permit, the project must be consistent with the Coastal Act and Local Coastal Plan policies to protect coastal resources, public recreation, and public access, among other resources and public trust issues.

- A Land Use Lease Permit would be required from the State Lands Commission, which has jurisdiction over tidelands and nearshore waters within three miles of the shore. The lease would be necessary for a slurry pipeline for ocean disposal. The criteria for issuing a permit are primarily environmental.

Summary of potential permits:

USACE, Section 404 permit

1. Required for the installation of pipeline across intermittent streams, filling of wetlands for a basin, or discharge of dredged material into the ocean.
2. Involves public noticing and review period, as well as consultation with US Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), and Regional Water Quality Control Board (RWQCB).

USACE, section 10 permit (pursuant to Section 10 of Rivers and Harbors Act)

3. Required for installation of a pipeline in the nearshore waters.
4. Involves public noticing and review period, as well as consultation with US Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), and Regional Water Quality Control Board (RWQCB).

USACE, section 103 permit (pursuant to Section 103 of Marine Protection, Research and Sanctuaries Act)

5. Required to dispose of dredged materials to the ocean.

RWQCB, 401 water quality certification or waiver

6. Issued for all USACE 404 permits.
7. Determines if discharge will meet state water quality standards contained in the California Ocean Plan and Central Coast Basin Plan.

RWQCB, National Pollution Discharge Elimination System (NPDES) permit

8. Required for discharges from a pipeline to the river or ocean.
9. Establishes effluent limits.
10. Involves public review periods and hearings before the RWQCB.

CDFG, Streambed Alteration Agreement (pursuant to section 1601-1603 of code)

11. Required for installation of pipeline across intermittent streams.

State Division of Safety of Dams (DSOD) permit

12. Required if height of an earthen dike exceeds 25 feet and/or impoundment area exceeds 50 acre-feet of water.

California Coastal Commission, Coastal Development Permit

13. Required for slurry pipeline in tidelands and nearshore waters.
14. Santa Barbara County would issue permit for the pipeline in the Coastal Zone, landward of high tide.

California State Lands Commission, Land Use Lease Permit

15. Required for slurry pipeline disposal to ocean.

Simultaneous efforts – CRCD, State Coastal Conservancy

It is anticipated that no one alternative will meet all the goals of the management plan

Appendix C: DISCUSSION OF SLUICING MODEL

A quasi three-dimensional model of the lower three-quarters of a mile of Twitchell Reservoir was developed using EPA's Water Quality Analysis Simulation Program (WASP). The reservoir was represented by 136 three-dimensional units. The units varied in shape and size to conform to the reservoir bathymetry. The dredging was represented as a sediment load into a single unit. The model dispersed sediments throughout the reservoir based on user-specified flow rates and dispersion coefficients. A settling velocity was also specified (based on sediment data) which allows sediment to settle onto the reservoir bottom. Velocities in the reservoir were estimated using the following methodology:

1. Determine "equi-velocity" surfaces based on bathymetry of the reservoir near the intake structure.

2. Assemble model units based on assumed flow paths, existing channel near the intake, and locations of "equi-velocity" surfaces.

3. Calculate flows across each unit face according to percentage of facial area to the total flow area of each surface.

4. Estimate the amount of vertical flow between layers by comparing inflow from an outer surface with outflow to an inner surface for each layer.

5. Distribute the vertical flow among the units based on the relative magnitudes of the vertical velocity components and the bottom areas of the units at each layer.

6. Perform mass balance for each segment by inputting all known flows from previous steps

Two important parameters used in the model are the dispersion coefficient and the settling velocity. Dispersion results from horizontal and vertical velocity gradients in the reservoir, and is defined by a dispersion coefficient. The magnitude of the coefficient is dependent on the size and type of the waterbody and by meteorological conditions. It can vary by an order of magnitude at different times of the year. Estimates of the vertical dispersion coefficient in different waterbodies are reported by Thomann et. al. (1987). Based on aspect ratio and depth of Twitchell Reservoir, data in Thomann indicate a range from 0.05 to 2 cm^2/s would be appropriate. Therefore, a conservative value of 0.1 cm^2/s was selected for this study. Since longitudinal shear spreading is usually more efficient than vertical spreading, horizontal dispersion was given the value of 1 cm^2/s.

A particle will reach the intake structure if it is carried to the intake before it settles out by gravity. The settling velocity can be estimated using Stokes' Law and is a function of the particle size and the relative density between the particle and the carrier medium. Sieve analyses were performed in a previous sediment study by Fugro-West (1995). Samples collected in the vicinity of the intake structure were mostly silt or clay. The median particle size was about 0.0025 mm, which corresponds to a Stokes Law settling velocity of 5.6×10^{-6} m/s. The settling velocity selected for this study was 5.6×10^{-5} m/s. This corresponds to a particle size of 0.008 mm, and represents 20% of total solids, that is, 80% of the particles are expected to have a smaller settling velocity.

The simulation model included a 1,000-ton/hour dredge operating 24 hours per day with a cutter head that agitates sediments on the reservoir bottom. The model assumed a constant release from the outlet works of 250 cfs to simulate sluicing using a typical summer release. Simulations were conducted in which sediments were stirred up by the dredge near the reservoir bottom at different distances from the outlet. The modeling showed that the percent of dredged material removed from the reservoir by the low-level outlet decreased exponentially with distance from the outlet. At a distance of about 100 feet from the outlet, almost 80 percent of the sediment is removed by the low-level outlet. At 200 feet, the removal is reduced to about 60 percent, and at 400 feet the removal rate is less than 40 percent. By 900 feet, from the outlet the removal rate is less than 10 percent.

The predicted amount of sediment released through the outlet works was calculated for releases of 100, 250, and 500 cfs. These data show that up to 14,000 cubic yards (8.7 acre-feet) would be flushed from the reservoir when the dredge operates next to the outlet works. However, sediments are not conveyed to the outlet works beyond 1,000 feet from the reservoir. Hence, sluicing by agitation of the sediments on the bottom of the reservoir using a range of summer releases would affect only a small area in the reservoir, and would not provide an adequate rate of sediment removal to meet the annual sluicing objective of 1,200 acre-feet. Nevertheless, passive sluicing is considered a viable option for a smaller scale program, particularly one designed to prevent blockage of the intake structure to the outlet works through regular agitation and sluicing directly in front of the intake structure.

SANTA MARIA RIVER WATERSHED
NON-POINT SOURCE POLLUTION
MANAGEMENT PLAN

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Approved by the Board of Directors on ??????, 2000

AM 03415

EVALUATION OF TRANSFER OF TITLE

OF THE SANTA MARIA PROJECT -

TWITCHELL DAM AND RESERVOIR

No letter of Transmittal Necessary

Submitted to:

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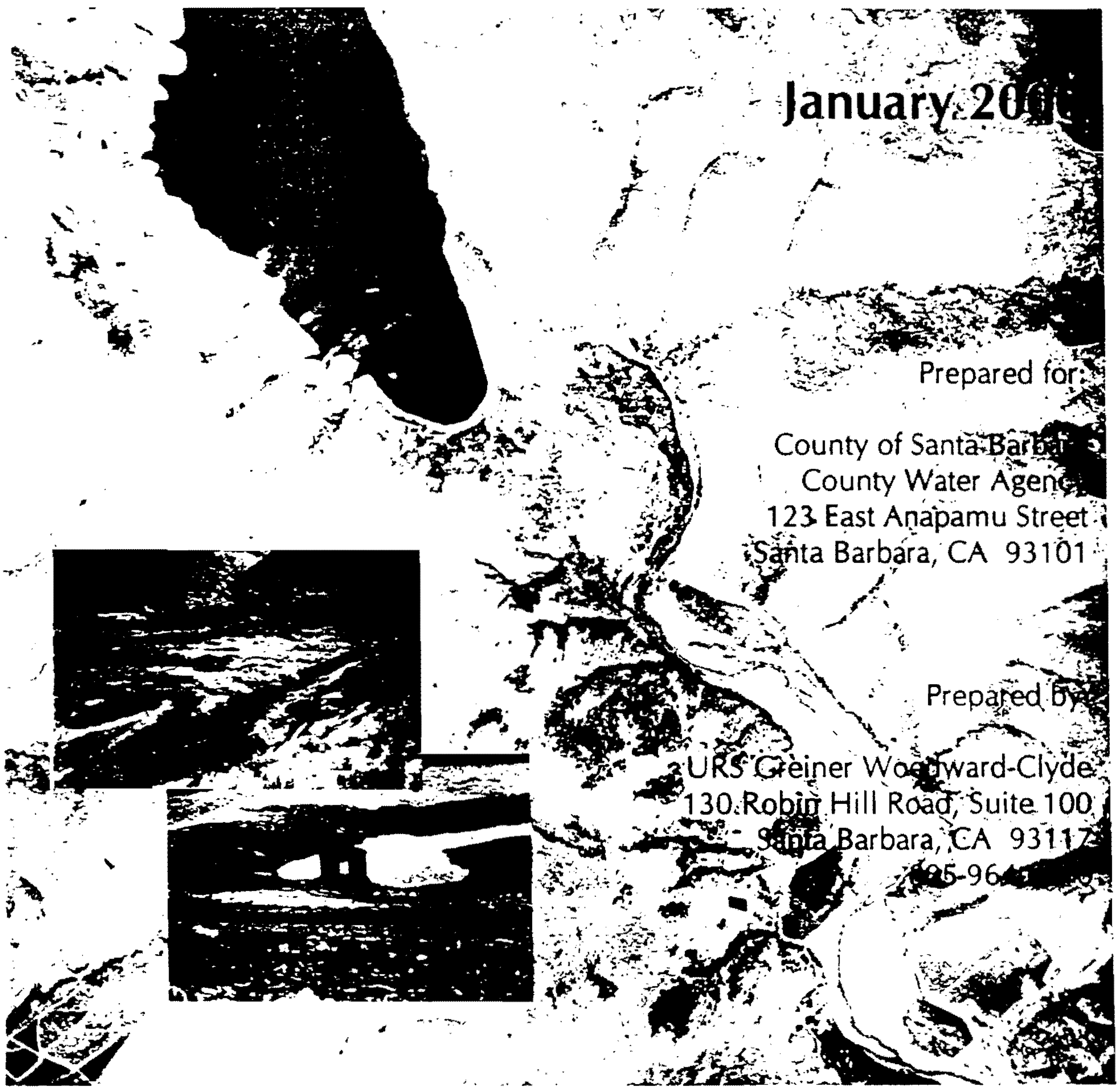
AM 03416

Preliminary Analysis of Engineering Alternatives, Environmental Issues, and Planning Level Costs

Twitchell Reservoir Sediment Management Program



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