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North-of-the-Delta Offstream Storage Investigation

Progress Report

February 2000

Gray Davis
Governor
State of California

Mary D. Nichols
Secretary for Resources
The Resources Agency

Thomas M. Hannigan
Director
Department of Water Resources

Integrated
Storage
Investigations

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Chapter 1. Introduction

The California Department of Water Resources, in cooperation with CALFED, is studying the feasibility of four offstream storage sites north of the Delta: (1) the Sites Project, (2) the Colusa Project, (3) the Thomes-Newville Project, and (4) the Red Bank Project. Offstream storage involves diverting water out of a river and transporting it through canals to a storage site that may be miles away from the primary water source. Offstream storage reservoirs are typically constructed on small streams that do not significantly contribute to the water supply of the reservoir.

This progress report summarizes the work conducted under the North-of-the-Delta Offstream Storage Investigation during the last two years. While the investigation is not complete, this status report has been prepared to document findings to date. This document provides information to CALFED agencies and the public about the projects under evaluation. Comments received from the agencies and other stakeholders on the direction of the work in progress and future program activities will help formulate a sound and balanced program.

The North-of-the-Delta Offstream Storage Investigation consists of three phases. Phase I includes extensive field surveys of environmental resources; geological, seismic and foundation evaluations; potential environmental impact evaluations; engineering analyses; and studies of the costs and accomplishments of these four alternative sites. Phase I has provided basic information on the costs, benefits, and potential impacts of North-of-the-Delta offstream storage for consideration in CALFED's programmatic Environmental Impact Report/Environmental Impact Statement. Phase II will include preparation of a feasibility report, environmental documentation, and the permits necessary to construct the project. Phase II will start mid-2000 after CALFED completes its programmatic EIS/EIR and a Record of Decision is filed if a finding is made that north-of-the-Delta offstream storage is consistent with CALFED's programmatic preferred alternative. Phase III will consist of final design and construction, and will proceed contingent on findings during the Phase II investigation.

CALFED Programs and Section 404 Screening Process

In 1995, the CALFED Bay-Delta Program was established to formulate a long-term program to address and resolve the environmental and water management problems associated with the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Since then, CALFED agencies and stakeholders have been working to develop a balanced plan to restore ecosystem health, improve levee stability in the Delta, and improve water quality and water supply reliability. After initial evaluations and extensive stakeholder input, the study to address supply reliability evolved into an all-inclusive analysis of water management tools: water use efficiency (conservation and recycling), water transfers, operational strategies (such as real-time diversion management), conveyance, and storage.

Early in the process, CALFED compiled a list of 52 potential surface storage projects in the Central Valley and began an initial screening to reduce the number of sites to a more manageable number for more detailed evaluation. CALFED was specifically looking for potential sites that could provide broad benefits for water supply, flood control, water quality, and the ecosystem. This initial screening of potential surface storage projects is intended to be consistent with the federal Clean Water Act Section 404 alternative analysis requirements.

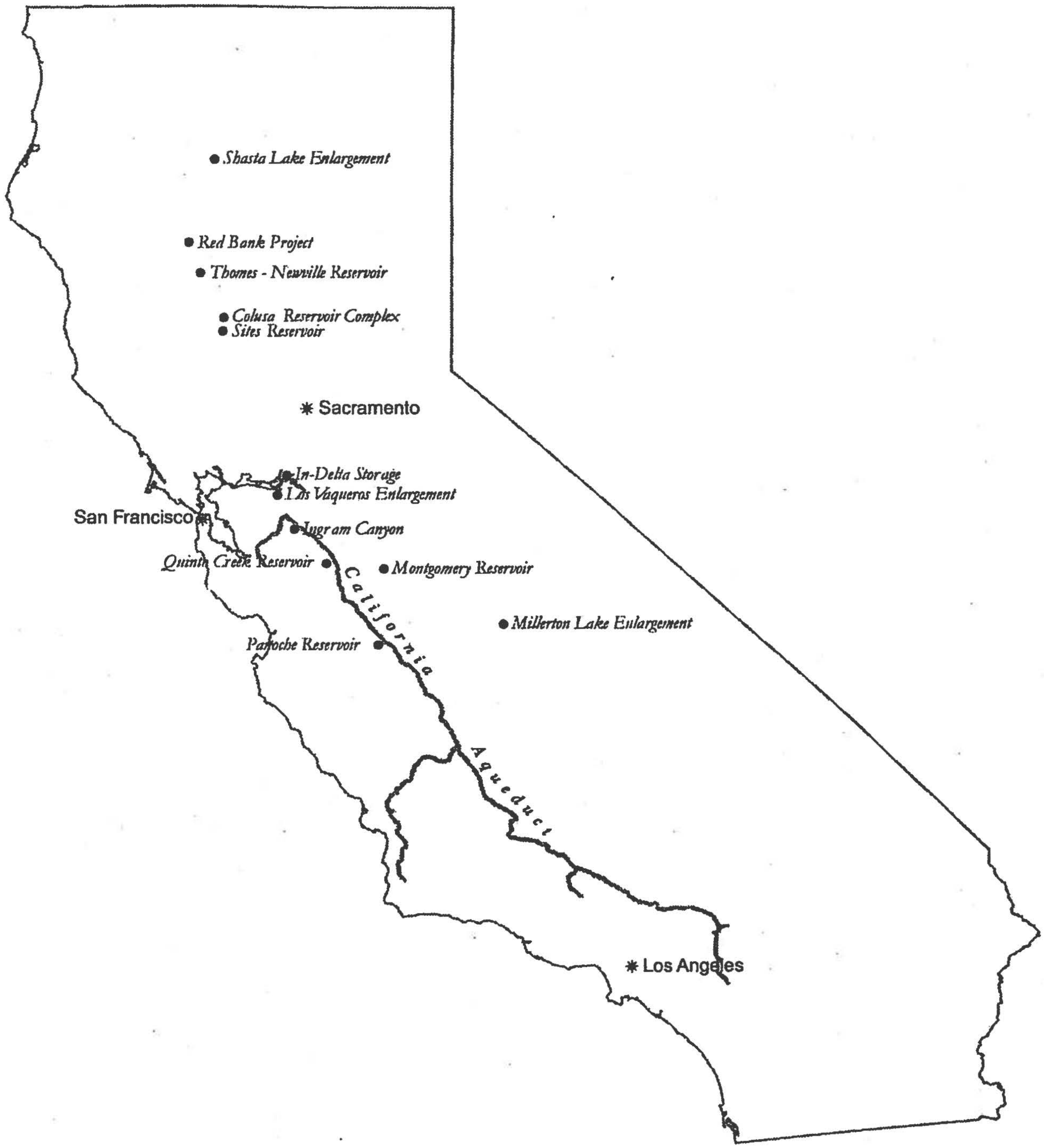
The CALFED reservoir screening process consists of two stages, an initial screening and a second stage screening. The initial screening identified and eliminated those reservoir sites that were clearly impracticable. The initial screening was based on minimum storage capacity (200 taf), potential conflict with CALFED's restoration programs, and CALFED's solution principles and policies. An interagency team of CALFED agencies cooperated in the initial screening, which was based on available information. Forty surface storage sites were removed from the initial list. The remaining 12 storage sites are:

- Four north-of-the-Delta offstream storage alternatives, including the Red Bank Project, Thomes-Newville Project, Colusa Reservoir, and Sites Reservoir.
- In-Delta storage and enlargement of Los Vaqueros Reservoir.
- Four south-of-the-Delta storage alternatives, including Ingram Canyon Reservoir, Quinto Creek Reservoir, Panoche Reservoir, and Montgomery Reservoir.
- Enlargement of Shasta Lake and Millerton Lake.

Figure 1.1 shows the location of the 12 remaining reservoir sites. For more detailed information about the initial screening, please refer to the *Draft Initial Surface Water Storage Screening*, CALFED Bay-Delta Program, December 22, 1999. (This report will be finalized in the near future.)

The second stage screening will be performed at a more detailed level and will be based on more specific project purposes. The second stage will evaluate the remaining reservoir sites based on detailed project purpose and environmental, engineering, and economic analyses. An extensive environmental inventory, detailed engineering analyses, and geological exploration are currently under way for the North-of-the-Delta Offstream Storage Investigation. Information gathered will be used for the second stage screening as well as for environmental documentation, permits, and project feasibility evaluations. The second stage screening will lead to selection of a preferred alternative for the North-of-the-Delta Offstream Storage Investigation.

Figure 1.1. Integrated Storage Investigations Potential Surface Water Storage Alternatives



Program Development and Funding

In 1996, voters approved Proposition 204 -- the Safe, Clean, Reliable Water Supply Act -- which provided $10 million for feasibility and environmental investigations of regional water recycling, water transfer facilities, desalination, and offstream storage projects upstream of the Delta. In 1997, DWR began a two-year reconnaissance-level study of North-of-the-Delta Offstream Storage Investigation under Proposition 204. In fiscal year 1997-98, DWR expended $3 million of Prop 204 funds to start this investigation. The Budget Act of 1998 authorized DWR to spend up to $10 million of its General Fund appropriation in FY 1998-99 for feasibility and environmental studies pertaining to the Sites Reservoir site and alternatives. As a result, DWR expanded the 1997 reconnaissance study to a broader investigation which could eventually lead to feasibility reports, environmental documentation, and project permits. DWR expended $8.4 million on these studies during FY 1998-99.

In early 1999, CALFED consolidated all storage investigations under a comprehensive program called the Integrated Storage Investigations. The North-of-the-Delta Offstream Storage Investigation was incorporated into one of seven original ISI program elements. In FY 1999-2000, $10 million of State general funds has been allocated to ISI, of which up to $4.2 million is available for the North-of-the-Delta Offstream Storage Investigation.

Offstream Storage, Alternative Reservoir Sites, Water Supply Sources, and Conveyance Facilities

Traditionally, reservoirs have been created by constructing dams on major rivers to form artificial lakes. These reservoirs are considered onstream storage. In contrast, an offstream storage reservoir is typically constructed on a small and generally seasonal stream that does not significantly contribute to the water supply of the reservoir. Offstream storage involves diverting water out of a river and transporting the water through canals or pipelines to a reservoir that may be miles away from the river. Therefore, offstream storage investigations include extensive evaluation of conveyance facilities to carry the water to the reservoirs.

Storing water in offstream reservoirs can provide opportunities to increase dry year water supply availability and improve the timing of its availability for multiple uses in an environmentally sensitive manner. Storing water during times of high flow, when environmental impacts tend to be fewer, would help provide flood control benefits and increase water supplies for environmental, urban, and agricultural water uses, and improve water quality during dry periods when conflicts over available water supplies are most pronounced. Additional supplies from offstream storage would also provide cooler water for Sacramento River salmon.

Offstream storage north of the Delta would allow water to be diverted and stored during winter and early spring, when the Sacramento River and local streamflows are highest, which could reduce flood damage downstream. Then, from May through

October, water from the reservoir could be released for irrigation and wetlands in the Colusa Basin in exchange for diversions that would have occurred from the Sacramento River. Such an exchange program will reduce diversions from the Sacramento River during the irrigation season, therefore reducing Sacramento fishery impacts.

Water that would otherwise have been diverted from the Sacramento River for local irrigation in late spring and summer could be kept in Shasta Lake and could later become available for other downstream uses. The water exchange program described here will result in increased storage and cooler water in Shasta Lake during the spring and early summers. In addition, cooler water available in Shasta Lake could be used to benefit winter-run salmon habitat in the Sacramento River. Additional water supply in dry periods could enhance the flexibility of the project's operations. This could result in ecosystem benefits by reducing diversions from the streams during the times when fish and ecosystem are in their critical stage and diversions may have the greatest impacts on fish.

The four offstream storage sites investigated include the following:

- Sites Reservoir is located about 10 miles west of Maxwell (Figure 1.1). Sites Reservoir is formed by constructing dams on Stone Corral Creek and Funks Creek. Two alternate Sites Reservoir sizes are being evaluated, 1.2 million acre-feet and 1.8 maf. A larger 1.8 maf Sites Reservoir would require construction of nine additional saddle dams along the southern edge of the Logan Creek watershed.

- Colusa Reservoir is a 3.0 maf proposal that would include the area inundated by the 1.8 maf Sites Reservoir, plus the adjacent watersheds to the north: Logan and Hunter Creeks. Most of the land in the Sites and Colusa Project areas are now used for grazing or dry-farming grain because little water is available for summer irrigation.

  Floodflows from the Colusa Basin Drain, the Sacramento River, and local tributaries are potential sources of water supply for the Sites and Colusa Projects. Using the Colusa Basin Drain floodflows would reduce local flooding in the Colusa Basin.

For Sites and Colusa Reservoirs, 14 alternative conveyance facilities are being evaluated to convey Sacramento River and Colusa Basin Drain floodflows to the reservoirs. These conveyance facilities include the existing Tehama-Colusa Canal and Glenn-Colusa Canal. Enlargement of these two canals is also being considered. Two gravity flow conveyance alternatives are also being studied for diverting floodflows from Stony Creek at Stony Gorge and East Park Reservoirs to Sites and Colusa Reservoirs.

- The Thomes-Newville Project, upstream of Black Butte Reservoir, is located about 15 miles west of Orland. Newville Reservoir would be formed by constructing a dam on Stony Creek and a small saddle dam at Burrows Gap.

Two alternative reservoir sizes are being evaluated, 1.9 and 3.0 maf. The Newville Reservoir would be supplied by Stony Creek, Thomes Creek, other local tributaries, and the Sacramento River.

Thomes Creek is the primary water supply source of the Newville Reservoir. However, conveyance alternatives to carry floodflows of Stony Creek (from Black Butte) and the Sacramento River are also being considered. Prior Thomes-Newville Project studies included a diversion dam on Thomes Creek. Current planning challenges include investigating a diversion facility that would allow anadromous fish migration in Thomes Creek while allowing the creek's floodflows to be diverted to Newville Reservoir. Thomes-Newville conveyance facilities planning is not yet complete.

- The Red Bank Project is located about 18 miles west of Red Bluff. This project consists of constructing two major dams to create 350,000 acre-feet of storage in Dippingvat Reservoir on South Fork Cottonwood Creek and Schoenfield Reservoir on Red Bank Creek. Most of the water supply for this project would come from South Fork Cottonwood Creek because the Red Bank Creek flows upstream of Schoenfield are inadequate for this project. Floodflows would be diverted for short-term storage in Dippingvat, and then diverted to Schoenfield, the main storage reservoir. However, because of the importance of South Fork Cottonwood Creek to Sacramento River health and fisher production, CALFED has removed Dippingvat Reservoir from its list of surface storage options under consideration. This alternative would consist of a diversion dam on South Fork Cottonwood Creek, and a canal and pumping plant to convey water to Schoenfield Reservoir.

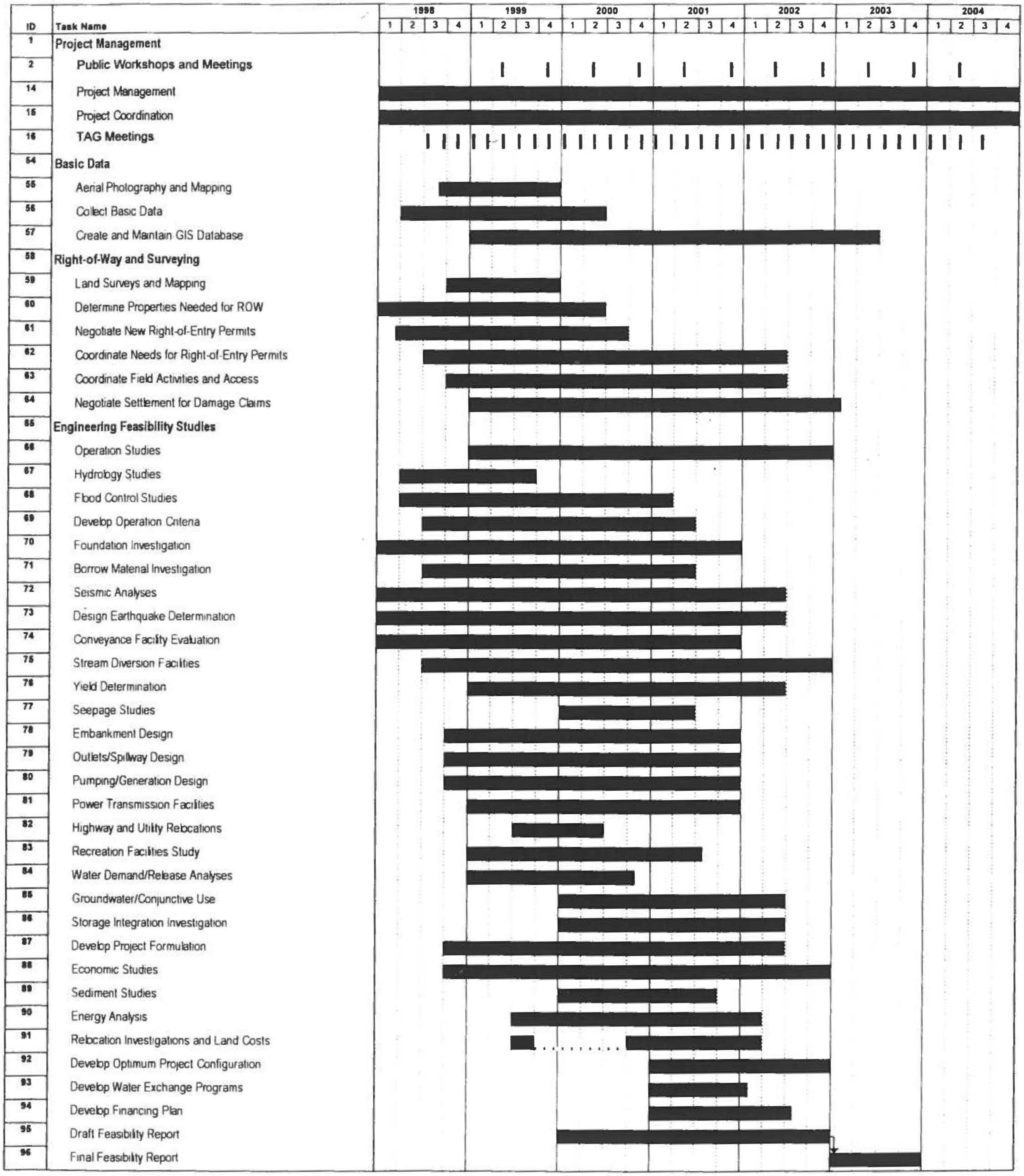
Project Schedule

Figure 1.2 shows the schedule for the Phase I and Phase II of the North of Delta Offstream Storage Program. Phase II consists of an environmental documentation and permit process which will start in mid-2000 after the Record of Decision for CALFED's Programmatic EIR/EIS is filed and if additional north-of-the-Delta offstream storage is consistent with CALFED's preferred program alternative. The schedule is subject to several important constraints. The CALFED Program has linked the implementation of surface storage projects with achieving specific objectives in other areas such as the water use efficiency program. Therefore, acquiring regulatory permits and beginning construction of new surface storage projects can only take place after specific actions on water use efficiency are implemented and threshold levels for water use efficiency are satisfied. Water use efficiency is one of eight early implementation actions in Stage 1 of CALFED's Programmatic EIR/EIS. While Stage 1 actions are undertaken, the North of Delta Offstream Storage Program will begin environmental documentation and feasibility evaluation for potential project alternatives and will move forward if the CALFED linkages and conditions are satisfied.

The Offstream Storage Program schedule is also subject to requirements imposed by the National Environmental Policy Act, California Environmental Quality Act, the Clean Water Act, and other laws and regulations that pertain to surface storage projects. CEQA requires public agencies to prepare an EIR that addresses environmental impacts, mitigation measures, alternatives, and public comments and responses. Project-specific CEQA/NEPA processes for surface storage projects can be initiated after the Record of Decision for the CALFED Programmatic EIS/EIR is issued.

Section 404 of the Clean Water Act has significant implications for proposed surface water storage projects, particularly the scope of alternative evaluations. Section 404 has been interpreted broadly and requires a reservoir project proponent to undertake an extensive evaluation of alternatives and to select the "least environmentally damaging practicable alternative". In addition to the nonstructural alternatives considerations (such as water use efficiency), different storage site alternatives should be evaluated to determine which alternative has the least environmental impacts. This evaluation includes detailed field surveys that follow multi-year protocols to identify the existence of threatened or endangered species or other species of concern in the project area. For example, botanical surveys require at least two consecutive years of detailed surveys within a given location. Fishery surveys must be conducted over the entire life cycle of the species of concern; for salmonids this requires a multi-year survey. The biological resources for each alternative reservoir site, conveyance facility, potential road relocation, and recreation facility must be surveyed in detail to provide a fair basis for comparison in selecting the least environmentally damaging alternative.

Figure 1.2
Offstream Storage Investigation -- Draft Workplan



Notes: 1998 = Fiscal Year 1997-98, etc.
1997-98 work was conducted under proposition 204 authorization.

* Includes both threaten, endangered, and general species.

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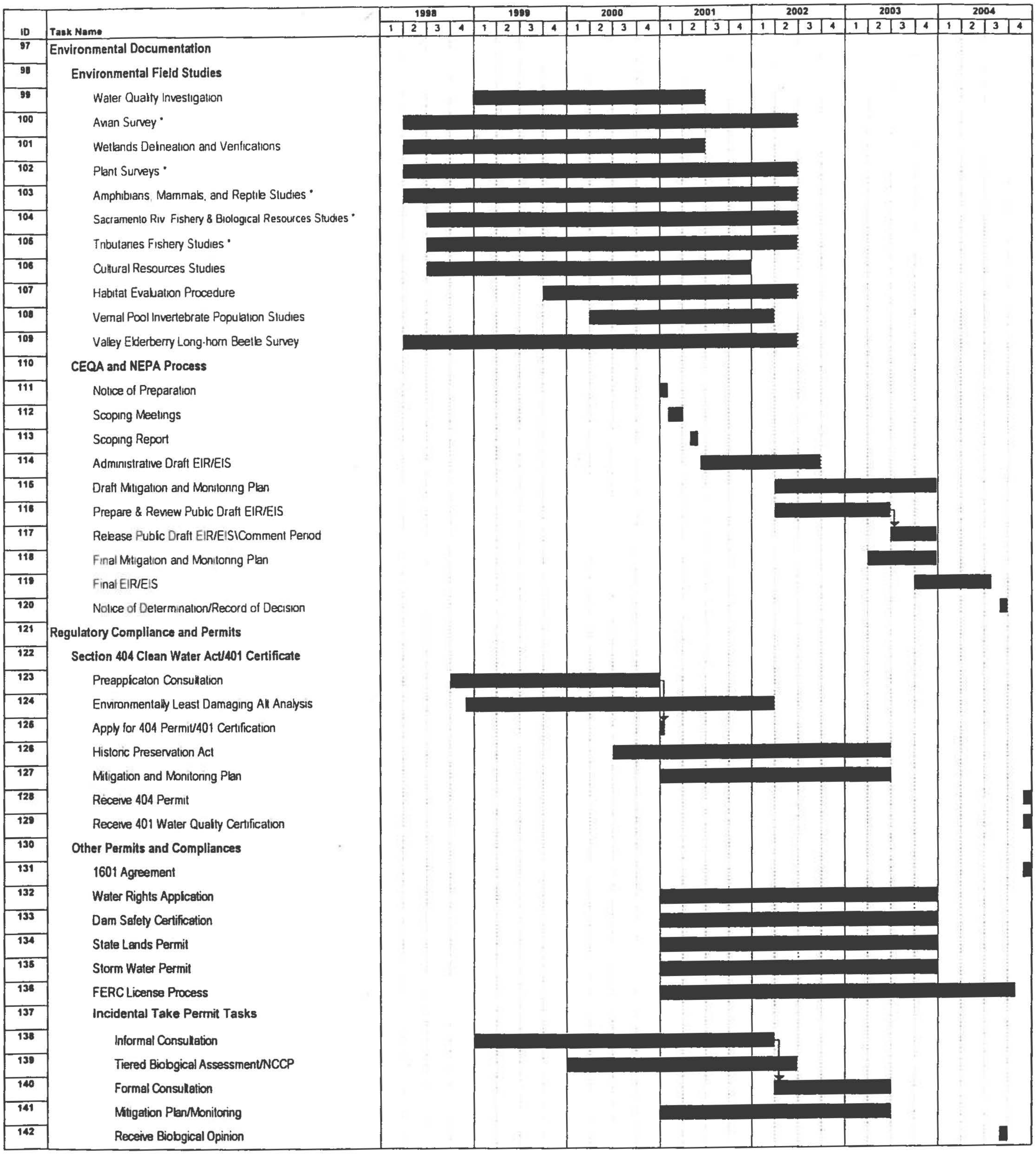
Offstream Storage Investigation -- Draft Workplan



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* Includes both threaten, endangered, and general species.

Past Studies

This section gives a brief description of the studies that have been conducted at the four alternative projects prior to the current investigation.

Sites and Colusa Projects

The topographically-attractive dam sites on Stone Corral and Funks Creeks appear suitable for dam. Both are deep narrow gorges with steep rock walls. The rock at Sites Dam site on Stone Corral Creek is hard enough to be used for masonry purposes and large quantities were transported by railroad to San Francisco to help rebuild after the 1906 earthquake.

The earliest published reference to a Sites Project is found in DWR Bulletin 3, *The California Water Plan 1957,* which mentions a 48,000-af offstream storage reservoir on Stone Corral and Funks Creeks supplied by the Tehama-Colusa Canal.

DWR's Bulletin 109, *Colusa Basin Investigation 1964*, evaluated potential flood control projects and considered two separate reservoirs of 5,800 and 7,600 af on Stone Corral and Funks Creeks, respectively. An update of this report in 1990 found these reservoirs economically unjustified for flood control alone. A July 1995 draft report by the Colusa Basin Drainage District on its proposed "Water Management Program" recommends a 62-foot-high dam on Funks Creek that would impound 9,500 af in "Golden Gate Reservoir." Project benefits are listed as flood control and modest springtime irrigation yield.

Consideration of larger projects at the Sites location was first documented in December 1964 in the U.S. Bureau of Reclamation's *West Sacramento Canal Unit Report,* which studied the feasibility of extending the TCC (via a new West Sacramento Valley Canal) into Solano County near Fairfield. To develop additional water supply to support this canal extension plan, a 1.2 maf Sites Reservoir was proposed. This study did not evaluate the potential of Sites as a stand-alone project, but only as part of the extended canal system. USBR unsuccessfully attempted to obtain funds for a full feasibility study of Sites in 1977 and documented its finding in a report published in 1981.

Throughout the 1960s and 1970s, DWR performed unpublished analyses of the larger Colusa Project's water supply potential in connection with regional investigations. Two unpublished office reports in 1967 and 1968 on potential Klamath-Trinity development projects include conveyance systems that would terminate at Colusa Reservoir. DWR's progress report titled *Major Surface Water Development Opportunities in the Sacramento Valley 1975* presented details of a Colusa Reservoir Offstream Storage Project. A slightly modified version of the Colusa Reservoir plan is shown in the DWR's Bulletin 76-81: *State Water Project - Status of Water Conservation and Water Supply Augmentation Plans November 1981.* This report states that studies of Colusa Reservoir to date indicated that the incremental cost of storage would be excessive in comparison to storage costs of Sites Reservoir.

In March 1990, the engineering consulting firm CH2M-Hill, Inc. prepared a long-range plan for Glenn-Colusa Irrigation District that included an 870,000 af Sites Reservoir with normal water surface elevation of 460 feet. This project was based on USBR's 1964 report, but was judged non-implementable by GCID because of the financing needed to cover the capital cost of $152 million. In 1993, CH2M-Hill published a report on *Meeting California's Water Needs in the 21st Century,* which presented a conceptual Westside Storage and Conveyance System. The report mentioned a Sites/Colusa Reservoir with a feeder pipeline from Lake Oroville.

In late 1995, DWR received numerous requests from water interests for information, including the Northern California Water Association, regarding the potential of an offstream storage reservoir at the Sites/Colusa site near Maxwell. In response to this renewed interest, DWR reviewed historic documents on a Sites/Colusa Project to assess its potential to augment local and statewide water supplies during drought periods. DWR conducted a brief investigation of current environmental literature, studies, project area aerial photos, and conducted limited field work in the project area. DWR published its findings in a July 1996 report entitled *Reconnaissance Survey – Sites Offstream Storage Project.*

This report briefly summarized the Sites/Colusa Project's planning information and updated earlier cost estimates to 1995 cost levels. No insurmountable problems were identified that would prevent further evaluation of this project. Rather, DWR found that the project had several unique characteristics that make it an attractive candidate for further feasibility level investigations. It has a significantly lower cost per unit of storage than most sites and the area is sparsely populated. The geography of the site permits a range of storage options to be considered, from a minimum of approximately 1.2 maf to a maximum of 3.0 maf when it is combined with Colusa Cell and forms the Colusa Project.

Thomes-Newville Project

Newville Dam site was first examined by the U.S. Geological Survey sometime between 1901 and 1903. USGS noted that the natural runoff was quite limited and briefly considered the possibility of diverting Thomes Creek water to Newville Reservoir; the current Thomes-Newville Plan is a direct descendant of this early USGS idea.

Newville Reservoir was again examined during the California Water Plan studies in 1947-57. The resulting framework plan, presented in DWR's Bulletin 3, suggested a 950,000 af. Newville Reservoir that would be supported by gravity diversion of surplus flows from a Paskenta Reservoir on Thomes Creek and a 38-mile gravity diversion canal from upper Stony and Grindstone Creeks. This proposal is the closest ancestor of the current Thomes-Newville Plan, since it would divert floodflows of the same sources.

The first intensive investigations of Newville Reservoir were conducted by DWR in the 1958-63 period as a part of the North Coastal Area Investigation. These studies indicated the dam site was suitable for the reservoir elevation of about 1,000 feet that was then being considered, but noted that more study of Rocky Ridge should be performed if the reservoir were to be higher than elevation 950 feet. Based on these studies, DWR's Bulletin 136 presented a plan for early construction of a Newville Reservoir at elevation *845* feet with a diversion from a Paskenta Reservoir on Thomes Creek. The bulletin envisioned later integration of the Paskenta-Newville facilities into a full-fledged Glenn Reservoir development for reregulation of water imported from the north coastal area.

USBR conducted much more detailed studies of the Paskenta-Newville Plan in 1965-71. USBR also concluded that conditions were suitable for construction of a large Newville Reservoir. USBR's 1971 status report outlined a plan including a Newville Reservoir at elevation 975 feet, forming a 2,986,000 af reservoir. (The reservoir size was limited by hydrologic considerations, not geologic.) The feasibility design drawings presented in USBR's report showed both Newville Dam and Chrome Dike as rolled earth-fill structures.

While USBR's studies were in progress, DWR was conducting its own studies of the possible integration of a Newville Reservoir with an upper Eel River development. DWR's design criteria led to a Newville Dam design that incorporated substantial zones of quarried rock upstream of the central rolled earth core. Preliminary designs and cost estimates for reservoir elevations up to 1,000 feet were prepared, but Newville Reservoir was eventually dropped from the Eel River plans in favor of the more favorably located Rancheria Reservoir.

In the early 1970s, DWR made additional planning studies of Newville Reservoir as a component of a Glenn Reservoir that would be used for storage of surplus water pumped from the Sacramento River. The 1975 report on these studies presented a 987 foot Newville Reservoir elevation as "near the maximum size feasible due to topographic and geologic limitations" of Rocky Ridge. No new geologic studies were conducted during this planning phase.

Additional field investigations of Rocky Ridge were undertaken in 1979 as a part of the next round of planning effort. These additional geologic studies addressed lingering concerns about the structural integrity and leakage potential of Rocky Ridge; the studies concluded that the suitability of the ridge for a reservoir elevation of up to at least 1,000 feet has been adequately established.

In November 1980, DWR published the *Thomes-Newville and Glenn Reservoir Plans – Engineering Feasibility,* which discussed the physical and operational feasibility of two potential plans for developing additional water supplies for the State Water Project. At that time, water supply and demand projections indicated that the smaller of these, the Thomes-Newville Plan to develop additional supplies from Stony and Thomes Creeks, could be needed in the mid-1990s. Subsequent studies concentrated on the

Thomes-Newville Plan as a viable development in its own right. Larger offstream storage developments of the scale of the Glenn Reservoir Plan would not be needed until after the turn of the century. Further study of Glenn Reservoir was deferred.

Continuing studies showed that the Thomes-Newville would fit well into a staged sequence. Accordingly, DWR elected to focus its planning efforts on the Thomes-Newville Plan to produce a plan formulation report and draft environmental impact report scheduled for release in June 1983.

The project was deferred in June 1982 when the voters of California defeated Proposition 9, which was a referendum on water projects. The Thomes-Newville was included among the projects mentioned by that legislation.

Red Bank Project

Initial water development planning studies in the Cottonwood Creek Basin were conducted by USBR in the mid-1940s. USBR's staff deferred further action on the projects due to the State of California's initiation of a comprehensive study to develop "The California Water Plan". After 10 years of intensive effort, that study culminated in a publication called Bulletin 3: *The California Water Plan*, May 1957. Bulletin 3 investigations of the Redding Stream Group and the Westside Stream Group concluded that the tributary reservoirs -- Hulen, Fiddlers, Rosewood, Dippingvat, and Schoenfield -- should be developed primarily for local water supply, recreation, flood control, and streamflow enhancement to improve the anadromous fishery.

After the publication of Bulletin 3, DWR initiated more detailed studies of the upper Sacramento River and its tributaries between Shasta Dam and Red Bluff. This study was focused on a large Iron Canyon Reservoir on the Sacramento River, but also investigated the tributary reservoirs as possible alternatives. Bulletin 150: *Upper Sacramento River Basin Investigation* (published in May 1965), concluded that the Iron Canyon Project was not economically justified, but that several of the tributary reservoirs, including Hulen and Dippingvat on Cottonwood Creek, were justified and should be considered for initial development of the Upper Sacramento River Basin.

The U.S. Army Corps of Engineers, under authority of the Flood Control Act of 1962, conducted a survey "for flood control and allied purposes" of the Sacramento River drainage, including the Cottonwood Creek Basin. The Corps' survey report in December 1970 proposed two large reservoirs, (Tehama and Dutch Gulch) to provide 100-year flood control on lower Cottonwood Creek, reduce flood damages downstream along the Sacramento River and in Butte Basin, and develop a water supply that would be contracted for by the State Water Project.

The Corps' two-reservoir project was authorized by Congress in the Flood Control Act of 1970, but funding for Advanced Engineering and Design Studies did not start until 1976. By the time the Corps' completed their Phase I plan formulation in 1981, the 1970 project cost of $170 million had increased to almost $700 million due to inflation and increasing interest rates. The Corps' General Design Memorandum, May 1983, showed a total project cost of $802 million, which pushed the cost of water to near $400 per af. The SWP contractors concluded that they could not afford the water supply at that price. Early in 1984, the Corps was asked to reanalyze the project, with the objective of reducing costs as much as possible. At the same time, DWR initiated a reanalysis of the upstream tributary reservoirs as possible alternative developments.

In May 1985, the Corps reanalysis estimated a total cost of $571 million for a reformulated Dutch Gulch -Tehama Project, with an allocated cost of water of about $216 per acre-foot. The DWR study, conducted concurrently with the Corps analysis and using the same design and economic criteria, showed that a combination of three tributary reservoirs -- Hulen, Fiddlers, and Dippingvat -- could be built for about $427 million. These three reservoirs would develop about two-thirds the water supply of the Corps project, at a combined cost of about $197 per acre-foot. Furthermore, the DWR study concluded that the cost of the tributary reservoirs might be reduced by:

1. Using the new roller-compacted concrete method of dam construction, which could provide a substantial saving over standard concrete or earthfill construction.

2. Using Schoenfield Reservoir on Red Bank Creek to provide offstream storage for South Fork Cottonwood Creek water, thus reducing the size of Dippingvat Reservoir, the least cost-effective of the three reservoirs studied.

In May 1985, DWR announced the withdrawal of State Water Project participation in the authorized Corps project and expressed the intent to continue evaluation of the tributary projects as possible features of the SWP. The Corps terminated their work on the project in October 1985. In July 1985, DWR started the first of a proposed series of studies to evaluate the engineering and economic feasibility of the tributary reservoirs.

In November 1987, DWR reported on a two-year pre-feasibility study of the Dippingvat-Schoenfield Project on South Fork Cottonwood Creek and Red Bank Creek in western Tehama County. The objective of that study was to develop information on the Dippingvat-Schoenfield Project (Red Bank Project) comparable to that available on the other Cottonwood Creek tributary projects – Hulen Reservoir on the North Fork, Fiddlers Reservoir on the Middle Fork, and Rosewood Reservoir on Dry Creek – as a basis for selecting one project for further study at the feasibility level. Efforts on this study were centered primarily on geologic investigation of the project dam sites and sources of construction materials and on engineering analysis of project operations and cost estimates.

The roller-compacted concrete dam construction alternative was recommended. These studies were completed in 1993 and were deferred until CALFED renewed interest in 1996.

Public Involvement

Extensive public involvement activities are planned for the North-of-the-Delta Offstream Storage Investigation. Program participants have briefed local entities frequently during the course of the investigation. DWR, in cooperation with CALFED, has held public workshops and meetings to provide information about the proposed reservoir alternatives and to answer questions about the investigation. Public workshops will continue periodically throughout the duration of the program.

In November 1999, a technical briefing and tour of the Sacramento River and Sites Reservoir was provided to Legislative and Governor's Office staff. During this tour, information was provided on the Sacramento River ecosystem restoration, geomorphology, conveyance alternatives, biological field surveys, and geologic and seismic findings at Sites Reservoir.

In April 1998, DWR established a technical advisory group to assist DWR staff in developing study plans. The Technical Advisory Group meetings are held bimonthly to review work in progress and comment on the content and adequacy of various elements of investigation. The TAG consists of interested parties from federal, State, and local agencies, as well as environmental groups, and property owners in the project area.

Special thanks go to the advisory group members. DWR is indebted to the members for providing critical feedback on the content and direction of the investigation. The committee members' comments and support contribute greatly to the process and to developing a balanced approach for the North-of-the-Delta Offstream Storage Investigation. DWR gratefully acknowledges the input and advice from the members:

Members	Organization
O. L. Van Tenney	Glenn-Colusa Irrigation District
Art Bullock	Tehama Colusa Canal Authority
Mark Cowin	CALFED
Terry Erlewine	State Water Project Contractors
Steve Evans	Friends of the River
Jerry Hemsted	California Cattlemens Association
Dan Keppen	Northern California Water Association
Gaye Lopez	Colusa Basin Drainage District
Jerry Maltby	County of Colusa
Rick Massa	Orland Unit, Water Users Association
John Merz	Sacramento River Preservation Trust
Jim Smith	U.S. Fish and Wildlife Service
Mike Vereschagin	Farm Bureau
Larry Vinzant	U.S. Army Corps of Engineers
Frank Wernette	Department of Fish and Game
Dick Whitson	U.S. Bureau of Reclamation

Chapter 2. Environmental Setting

This chapter contains a general description of the environmental setting of the watersheds draining the Coast Range eastward toward the northern Sacramento Valley as well as a more detailed description of the environmental setting for the area of the four reservoir project alternatives. The sections of the chapter are: physical location, topography, climate and hydrology, geology and soils, land use, vegetation, fish and wildlife resources, cultural resources, transportation, air quality, and recreation.

Physical Location

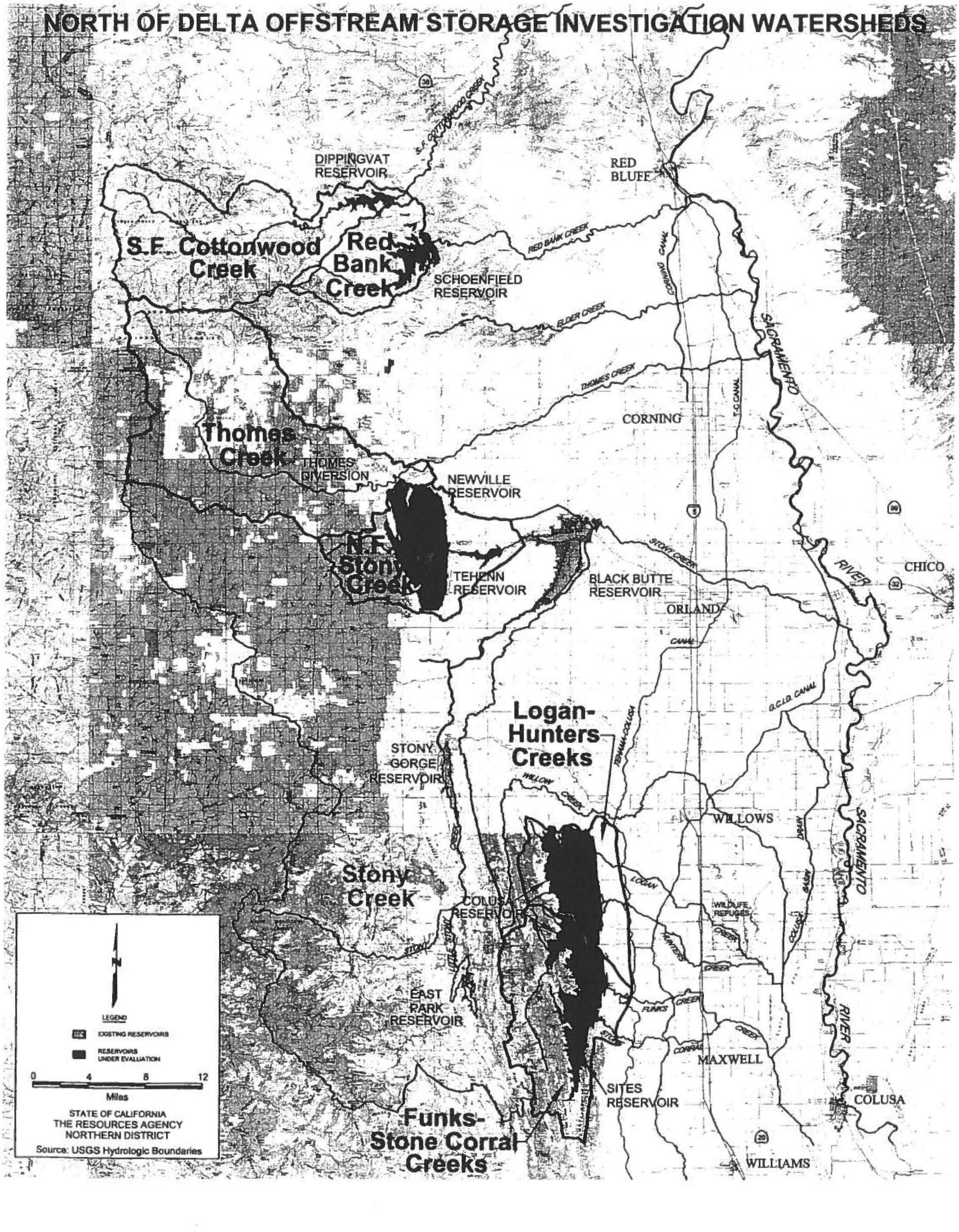
All four of the proposed reservoir projects are located within the Coast Range foothills along the western edge of the northern Sacramento Valley (Figure 2.1).

The proposed Sites Reservoir is in north-central Colusa County and south-central Glenn County, approximately 10 miles due west of the community of Maxwell. The proposed reservoir inundation area includes most of Antelope Valley and the small community of Sites. The project is in the Stone Corral Creek and Funks Creek watersheds (101,500 acres). A mean full pool elevation of 520 feet would result in inundation of 14,200 acres and maximum storage of 1.8 million acre-feet.

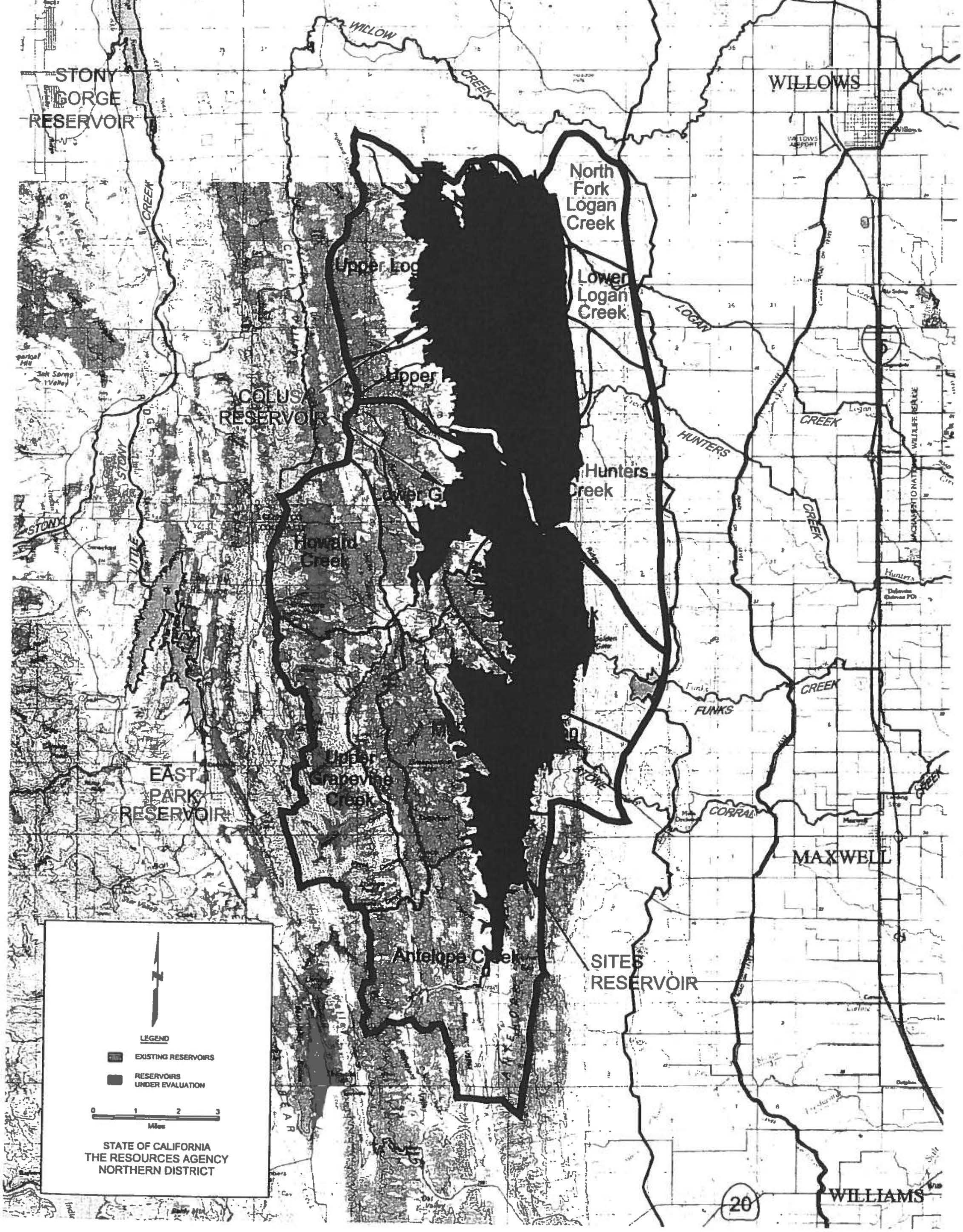
The proposed Colusa Project would also be located in south-central Glenn County and north-central Colusa County, approximately 12 miles southwest of the community of Willows and 7 miles west of Interstate 5. The Colusa Cell would be due north of the proposed Sites Reservoir and could be constructed with Sites Reservoir to form a single 27,800 acre reservoir (Colusa Reservoir). The proposed project area is within Hunter and Logan Creek watersheds (35,235 acres). A mean full pool elevation of 520 feet would result in inundation of about 13,700 acres within the Colusa Cell and maximum storage of 1.2 million acre-feet.

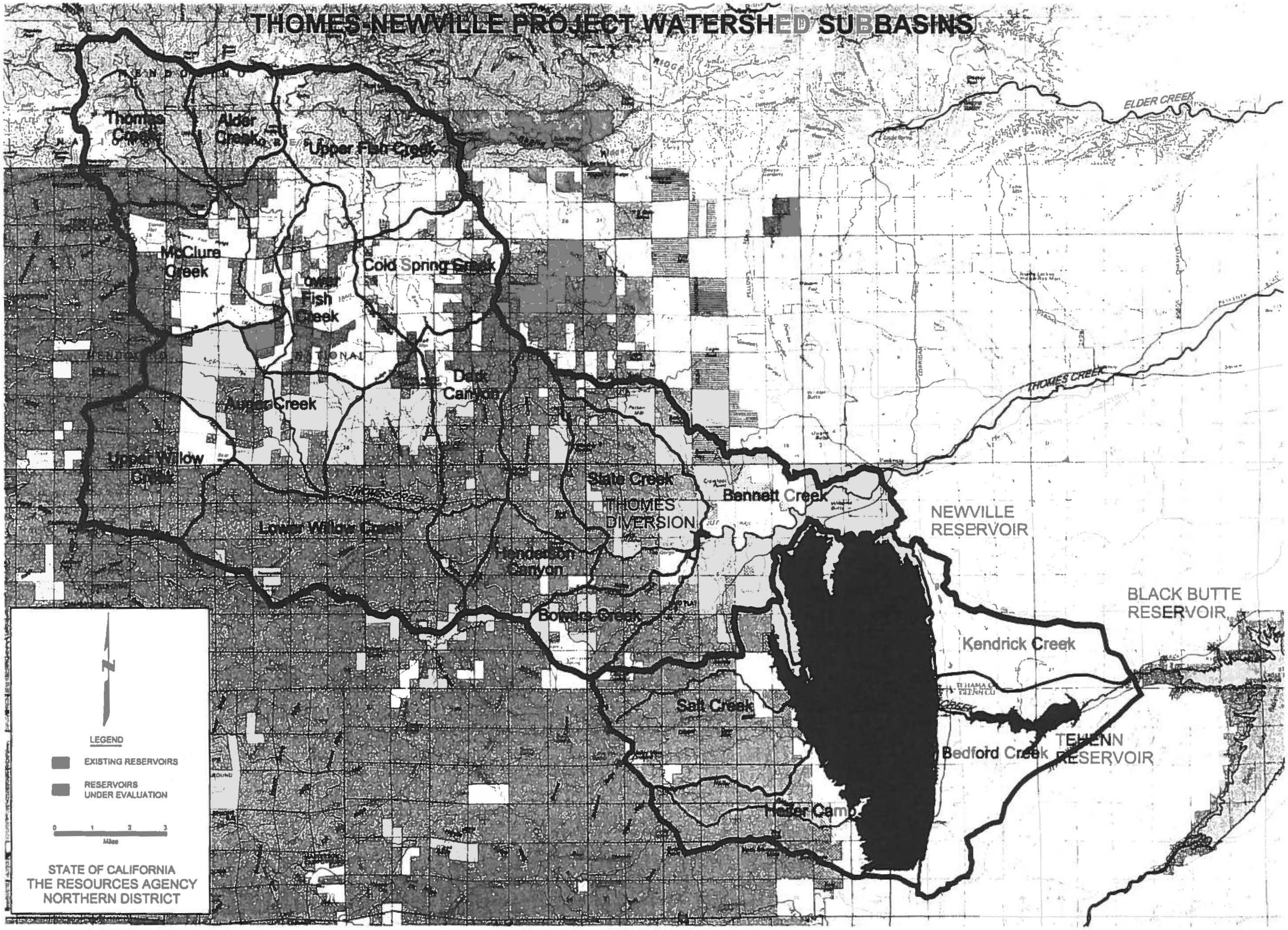
The Thomes-Newville Project would be situated within north-central Glenn County and south-central Tehama County. Newville Reservoir is approximately 18 miles west of the community of Orland and 23 miles west-southwest of the community of Corning. This proposed reservoir project would be within portions of the North Fork Stony Creek (66,212 acres) and Thomes Creek (130,510 acres) watersheds. A small diversion along Thomes Creek would transfer water to the 14,492 acre Newville Reservoir in the North Fork Stony Creek watershed. A mean full pool elevation of 975 feet is currently being used for planning purposes. The Thomes-Newville project would provide a maximum storage of 1.8 million acre-feet.

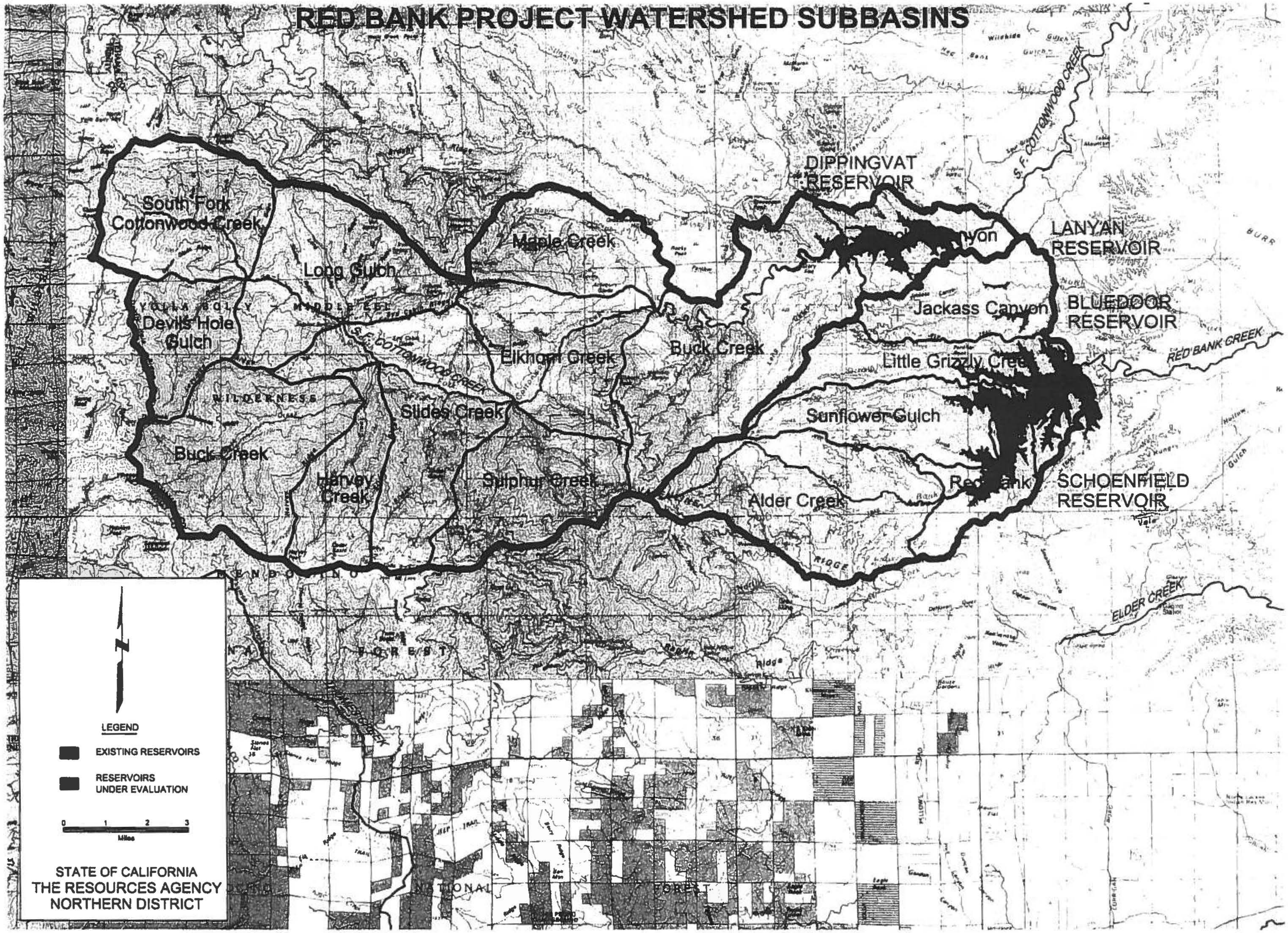
The proposed Red Bank Project is in north-west Tehama County approximately 17 miles west of the community of Red Bluff. This project would include a diversion on the South Fork Cottonwood Creek (Dippingvat Reservoir), two small reservoirs in the headwaters of the north fork of Red Bank Creek (Blue Door and Lanyan Reservoirs), and a larger storage reservoir on Red Bank Creek (Schoenfield Reservoir). The South Fork Cottonwood Creek watershed is 123,000 acres, while the Red Bank Creek


NORTH OF DELTA OFFSTREAM STORAGE INVESTIGATION WATERSHEDS
DIPPINGVAT RESERVOIR
RED BLUFF
S.F. COTTONWOOD CREEK
S.F. Cottonwood Creek
Red Bank Creek
RED BANK CREEK
SCHOENFIELD RESERVOIR
ELDER CREEK
CORNING CANAL
SACRAMENTO
THOMES CREEK
CORNING
T-C CANAL
Thomes Creek
THOMES DIVERSION
NEWVILLE RESERVOIR
N.F. Stony Creek
TEHENN RESERVOIR
BLACK BUTTE RESERVOIR
STONY CREEK
RIVER
CHICO
ORLAND
CANAL
G.C.I.D. CANAL
Logan-Hunters Creeks
TEHAMA-COLUSA
STONY GORGE RESERVOIR
WILLOW CREEK
WILLOWS
SACRAMENTO
Stony Creek
LOGAN
COLUSA RESERVOIR
WILDLIFE REFUGES
HUNTERS
EAST PARK RESERVOIR
FUNKS
CREEK
CORRAL
MAXWELL
RIVER
SITES RESERVOIR
COLUSA
Funks-Stone Corral Creeks
WILLIAMS
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
0 4 8 12
Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT
Source: USGS Hydrologic Boundaries

SITES AND COLUSA PROJECT WATERSHED SUBBASINS




THOMES-NEWVILLE PROJECT WATERSHED SUBBASINS
Thomas Creek
Alder Creek
Upper Fish Creek
ELDER CREEK
McClure Creek
Lower Fish Creek
Cold Spring Creek
Dark Canyon
Auger Creek
THOMES CREEK
Upper Willow Creek
State Creek
THOMES DIVERSION
Bennett Creek
NEWVILLE RESERVOIR
Lower Willow Creek
Henderson Canyon
Bowers Creek
BLACK BUTTE RESERVOIR
Kendrick Creek
Salt Creek
Bedford Creek
TEHENN RESERVOIR
Heifer Camp
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
0 1 2 3
Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT


RED BANK PROJECT WATERSHED SUBBASINS
South Fork Cottonwood Creek
Long Gulch
Maple Creek
Devils Hole Gulch
Elkhorn Creek
Buck Creek
Slides Creek
Harvey Creek
Sulphur Creek
Jackass Canyon
Little Grizzly Cree
Sunflower Gulch
Alder Creek
DIPPINGVAT RESERVOIR
LANYAN RESERVOIR
BLUEDOOR RESERVOIR
SCHOENFIELD RESERVOIR
S.F. COTTONWOOD CREEK
RED BANK CREEK
ELDER CREEK
WILDERNESS
FOREST
NATIONAL
RIDGE
LEGEND
EXISTING RESERVOIRS
RESERVOIRS UNDER EVALUATION
0 1 2 3
Miles
STATE OF CALIFORNIA
THE RESOURCES AGENCY
NORTHERN DISTRICT

watershed is 34,800 acres. Schoenfield Reservoir, with a normal pool elevation of 1,210 to 1,017 feet, would inundate 4,600 acres and have a maximum storage of 350,000 acre-feet.

Topography

The physical topography of the watersheds draining the east side of the Coast Range toward the Sacramento Valley is diverse. The topography ranges from steep rugged mountainous terrain within the upper watersheds to rolling foothills in the project area to relatively flat alluvial terrain as the watersheds enter the Sacramento Valley. Elevations range from less than 40 feet on the valley floor to over 8,092 feet along the Coast Range divide.

The Sites Project area is situated between the Sacramento Valley to the east and the mountainous portion of the Coast Range on the west. The Coast Range mountains are a series of rugged, north/south tending ridges dissected by narrow canyons containing steep gradient, and entrenched streams. A relatively narrow band of steep rolling foothills, approximately 2 to 3 miles wide, separates the proposed reservoir area from the Sacramento Valley. Antelope Valley, the primary inundation area of the proposed Sites Reservoir, lies between this narrow band of foothills and the more mountainous Coast Range. This relatively narrow north-south tending valley is approximately 13 miles long and up to 2 miles wide. Elevation of the valley floor ranges from 320 to 400 feet above mean sea level, while the foothills separating the valley from the Sacramento Valley reach a maximum elevation of 1,300 feet. Elevations along the west side of Antelope Valley increase rapidly with several peaks within 2 miles of Antelope Valley above 2,000 feet.

The Colusa Cell area is also between the Sacramento Valley to the east and the mountainous portion of the Coast Range on the west. The proposed reservoir would inundate alluvial valleys associated with both Hunter and Logan Creeks. Topographic relief within the inundation area is more varied than within Sites Reservoir and numerous small to moderate sized islands would be created from hills greater than 520 feet elevation. Inundation of the Colusa Cell would result in a reservoir approximately 10 miles long and 3 miles wide with a maximum depth of 260 feet. The foothills separating the Colusa Cell from the Sacramento Valley are substantially lower in elevation than those found at Sites, with only a single peak in excess of 1,000 feet elevation. Development of this project would entail construction of numerous saddle dams as areas along the eastern edge of the project are less than 520 feet elevation.

Newville Reservoir would be located in a large circular depression along the North Fork Stony Creek. Topographical relief within the inundation area of Newville Reservoir is that of gently rolling terrain ranging in elevation from 630 feet to 975 feet elevation. A single steep ridge (Rocky Ridge) separates the Newville Reservoir site from low, rolling foothill areas to the east. Rocky Ridge runs north and south with several peaks above 1,300 feet elevation. The western boundary of the project area is formed by steep rugged mountains (elevations up to 3,000 feet) within 2 miles of the reservoir boundary. The diversion on Thomes Creek would be made at a low dam in a steep, narrow, confined reach below Thomes Creek canyon at approximately 1,035 feet above mean sea level.

The Red Bank Project area is highly dissected, rugged, mountainous terrain. The primary drainages (and associated valleys) run from west to east. Linear alluvial terraces are associated with the major drainages and stream gradient is much greater than that found in the other three proposed reservoirs. Topographical relief within the inundation area of the Red Bank Project varies from small amounts of relatively flat alluvial terraces to gently rolling terrain to very steep hillslopes ranging in elevation from 780 feet to 1,200 feet elevation.

Climate and Hydrology

The climate of the watersheds draining into the western Sacramento Valley is typical Mediterranean. Winters are rainy and relatively mild with occasional freezing temperatures at lower elevations, and summers are comparatively dry and hot. The rainy season normally begins in September and continues through March or April. Rains may continue for several days at a time, but are usually gentle. Summer rains are rare, as are thunderstorms and hailstorms. Thunderstorms occur about ten days per year in the Sacramento Valley, occasionally producing high intensity rainfall of short duration. Most precipitation is associated with migrant storms that move across the area during winter. Snow is the dominant form of precipitation above 5,000 feet elevation. Snow persists on north- and east-facing slopes into the early summer.

High temperatures occur during July, August, and September. Temperatures in excess of 100 degrees Fahrenheit frequently occur during the summer. Fog of varying density and duration is common within the Sacramento Valley during winter. However, due to the physical topography, dense or persistent fog is much less common in the project areas. Winds occur seasonally, with dry north winds common during the summer and fall, while winds from the south are frequently associated with winter storm events. Winds in excess of 60 miles per hour may occur; however, these events are relatively uncommon and of short duration. Average wind speed at Red Bluff is 8.8 miles per hour, with the strongest winds reported during the winter months. Gross evaporation, the depth of water lost to the atmosphere, is approximately 70 inches per year in the foothill region.

Average annual precipitation within the general Sites and Colusa Reservoir Project area is approximately 18 inches and occurs almost exclusively in the form of rain. (Average annual precipitation in the Colusa Cell area is slightly higher, with 18 to 22 inches per year.) Snow occurs annually at slightly higher elevations and occasionally within the reservoir areas. Some areas within western Glenn County that range in elevation from 5,000 to 7,000 feet frequently receive between 60 and 75 inches of precipitation per year, primarily in the form of snow. Mean annual temperature is approximately 61.5 degrees F. Summer temperatures in excess of 115 degrees F have been documented. The project area generally experiences approximately 220 frost-free days per year while, nearby areas in the Sacramento Valley receive 260 frost-free days per year.

Average annual precipitation in the Thomes-Newville Project area is approximately 20 to 24 inches, primarily in the form of rain. Annual precipitation averages 23.5 inches at Paskenta. The wettest year on record at the Paskenta monitoring location (1982-1983) was 48.4 inches and the driest (1938-1939) was 8.6 inches. The project area generally receives between 220 and 250 frost-free days per year. The average date of the last spring freeze is April 1 at Paskenta. Summer temperatures in excess of 90 degrees F occur approximately 97 days per year and summer temperatures in excess of 100 degrees F occur annually.

Due to the slightly higher elevation of the Red Bank Project area, average annual precipitation is 25 inches. Snowfall occurs more frequently than at the other proposed reservoir locations, but seldom persists for long or contributes significantly to the total annual precipitation. Approximately 175 to 200 frost-free days per year occur in the project area, with the last frost of the spring on or about May 1. Temperature ranges are similar to those described for the other three proposed reservoirs.

A limited amount of surface water quantity and quality information has been collected within the proposed reservoir areas. Streams draining the proposed Sites Reservoir, Colusa Cell, and Newville Reservoir are ephemeral with little or no flow from July through October. However, these streams tend to respond rapidly to significant rainfall events. Flash flooding with substantial overland flow has been observed. Flow recorded at the stream gage on Stone Corral Creek near Sites is representative of the flow variability in these small ephemeral streams. Annual discharge varied from zero in 1972, 1976, and 1977 to 39,930 acre-feet in 1963 and averages 6,500 acre-feet. Monthly flows in excess of 15,000 acre-feet have been documented.

Flows in the Thomes Creek watershed fluctuate seasonally with summer low flows frequently measured at less than 4 cubic feet per second, while winter flows often exceed 4,500 cubic feet per second. The range of flows recorded at Paskenta range from zero in 1977 to 37,800 cubic feet per second during December 1964. The December 1964 runoff event was triggered by a major rain-on-snow storm. Periodic large floods (like 1964) can result in tremendous bedload movement.

Streamflows within Red Bank and South Fork Cottonwood creeks are much greater and less flashy than those within the other three proposed reservoirs. Red Bank Creek stream gaging (measured near Red Bluff) indicates an average annual discharge of 35,377 acre-feet with annual extremes ranging from 138,775 acre-feet in 1983 to 988 acre-feet in 1976.

The surface water quality of streams draining eastward from the Coast Range is generally poor. These streams generally have very high suspended sediment loads due to the metavolcanic bedrock and schist formations which produce clays that stay in suspension during turbulent flow conditions. Soil disturbance within these watersheds can accelerate erosion and sedimentation processes and lead to increased metal and nutrient concentrations. High concentrations of metals and nutrients are commonly present during both low flow and storm runoff events. These concentrations frequently exceed water quality criteria established for the protection of beneficial use or the maintenance of aquatic life. Water is generally warm in streams flowing through the proposed reservoir sites. Total phosphorus concentrations are at stimulatory levels for algae.

Little groundwater quantity or quality information has been collected at any of the four proposed reservoir locations. The immediate area of the candidate projects has very few groundwater resources. The area is underlain by the Great Valley Sequence rocks and locally by Quaternary terrace deposits. Groundwater is found in fractures in the Great Valley Sequence and in the sands and gravels in the terrace deposits. Springs occur where the terrace deposits terminate or where water-bearing fractures encounter the surface. A number of springs also occur in the Great Valley Sequence rocks where faults create subsurface dams that cause groundwater to reach the surface. Not all fractures or faults contain groundwater. Nor do all terrace deposits have groundwater. Most fractures and faults, because of overlying rock weight, are closed at depths greater than about 150 feet. This makes the Great Valley Sequence rocks essentially non-water bearing below about 150 feet.

There are about 280 Well Completion Reports on file with the Department of Water Resources for the general area of the candidate offstream reservoir projects. Sixty percent of these wells are used for domestic purposes. Irrigation wells and stock watering wells make up 10 percent each. About 20 percent of the wells are classified as "other" and are used for monitoring, test wells, or the use is unknown. Most of the irrigation wells are just east of the Tehama-Colusa Canal outside the area of the Sites and Colusa Projects and have reported depths and yields of about 250 feet and 750 gallons per minute respectively. The few wells in or close to the reservoir inundation areas obtain their yield from the Great Valley Sequence rocks. These wells are about 50 feet deep and yield less than 10 gallons per minute.

Few of the 170 reported domestic wells are within any of the proposed reservoir inundation areas. The wells in the general area average about 200 feet deep and yield an average of about 10 gallons per minute. These wells are only perforated down to about 150 feet and the rest of the hole depth is apparently used for water storage. The stock wells are shallower and average about 125 feet deep and also yield an average of about 10 gallons per minute. Most of the yield comes from fractures in the Great Valley Sequence rocks.

Department of Water Resources' Bulletin 118 identifies only one groundwater basin within the immediate area of the proposed projects: the Chrome Town Area adjoining the Thomes-Newville Project. This is not a true groundwater basin, but a groundwater area. It consists of Quaternary terrace deposits up to about 50 feet in thickness, which is unusual because terrace deposit thickness in the range of 10 to 20 feet is more common. Most wells in the area obtain their water from either the gravels in the terrace deposits at the contact with the underlying Great Valley Sequence rocks or from the fractures in the Great Valley Sequence rocks. Well yields up to 10 gallons per minute are all that can be expected from this area. Dry wells are not uncommon.

Landowners within the northern portion of Sites Reservoir and the Colusa Cell report the presence of shallow salt water deposits. Limited sampling of the springs which feed Salt Pond in the northeast portion of Sites Reservoir show extremely elevated levels of electrical conductivity (194,100 umhos/cm), dissolved calcium (22,000 mg/L), dissolved sodium (25,600 mg/L), dissolved chloride (32,800 mg/L), dissolved boron (33.7 mg/L), total aluminum (8,140 ug/L), total copper (615 ug/L), total iron (35,400 ug/L), total lead (14 ug/L), total nickel (241 ug/L), and total manganese (32,200 ug/L). The depth and extent of these highly mineralized groundwaters is unknown. The flow from these springs is very limited.

Geology and Soils

The rocks underlying the proposed dam sites are part of the Great Valley geologic province, mostly sandstone, mudstone, and conglomerate. The Great Valley geologic province is bounded to the west by the Coast Ranges province, to the north by the Klamath Mountains province, to the northeast by the Cascade Range province, and to the east by the Sierra Nevada province.

Along the west side of the Sacramento Valley, rocks of the Great Valley province include: Upper Jurassic to Cretaceous marine sedimentary rocks of the Great Valley Sequence; fluvial deposits of the Tertiary Tehama Formation; Quaternary Red Bluff, Riverbank, and Modesto formations; and Recent alluvium.

Water gaps in the sandstone and conglomerate ridges form the dam sites for all four proposed projects. The Great Valley Sequence formed from sediments deposited within a submarine fan along the continental edge. Sources of the sediments were the Klamath Mountains and Sierra Nevada to the north and east.

The mudstones of the Great Valley Sequence are typically dark gray to black. Generally the mudstones are thinly laminated and have closely spaced and pervasive joints. When fresh, the mudstones are hard, but exposed units weather and slake readily. Mudstones generally underlay the valleys.

The sandstones are light green to gray. They are considered to be graywackes in some places because of the percentage of fine-grained interstitial material. Sandstone beds range from thinly laminated to massive. In many places, the sandstones are interlayered with beds of conglomerates, siltstones, and mudstones. Massive sandstones are indurated and hard with widely-spaced joints, forming the backbone of most of the ridges.

The conglomerates are closely associated with the massive sandstones and consist of lenticular and discontinuous beds varying in thickness from a few feet to over

100 feet. Conglomerate clasts range in size from pebbles to boulders and are composed primarily of chert, volcanic rocks, granitic rocks, and sandstones set in a matrix of cemented sand and clay. The conglomerates are similar to the sandstones in hardness and jointing.

Tertiary and Quaternary fluvial sedimentary deposits unconformably overlie the Great Valley Sequence. The Pliocene Tehama Formation is the oldest. It is derived from erosion of the Coast Ranges and Klamath Mountains and consists of pale green to tan, semiconsolidated silt, clay, sand, and gravel. Along the western margin of the valley, the Tehama Formation is generally thin, discontinuous, and deeply weathered.

The Quaternary Red Bluff Formation consists of reddish poorly sorted gravel with thin interbeds of reddish clay. The Red Bluff Formation is a broad erosional surface, or pediment, of low relief formed on the Tehama Formation between 0.45 and 1.0 million years ago. Thickness varies up to about 30 feet. The pediment is an excellent datum to assess Pleistocene deformation because of its original widespread occurrence and low relief. Red Bluff Formation outcrops occur just east of the dam sites.

Alluvium is a loose sedimentary deposit of clay, silt, sand, gravel, and boulders. Deposits include landslides, colluvium, stream channel deposits, floodplain deposits, and stream terraces. Quaternary alluvium is a major prospective source of construction materials. Colluvium, or slope wash, consisting mostly of soil and rock, occurs at the face and base of a hill. Landslide deposits are similar but more defined and generally deeper. Landslides occur along the reservoir rim but are generally small, shallow debris slides or debris flows. These deposits may be incorporated as random fill in dam construction.

Stream channel deposits generally consist of sand and gravel. Potential construction material uses include concrete aggregate, filters, and drains. Floodplain deposits are finer grained and consist of clay and silt. Floodplain deposits may be used for the impervious core and for random fill.

The stream terraces form flat benches adjacent to and above the active stream channel. Up to nine different stream terrace levels have been identified. Terrace deposits consist of several to 10 feet of clay, silt, and sand overlying a basal layer of coarser alluvium containing sand, gravel, cobbles, and boulders. Four terrace levels have been given formational names by the U.S. Geological Survey (Helley and Harwood 1985) -- the Upper Modesto, Lower Modesto, Upper Riverbank, and Lower Riverbank -- and they range in age from 10,000 to several hundred thousand years old.

Terraces are valuable for evaluating the age and activity of faults that trend across them. A number of investigators have applied soil-stratigraphic, relative, and absolute age dating techniques, together with geomorphic analysis, to date and correlate terrace deposits. Evidence of faulting across the terrace deposits constrains the time of last movement. Additional information on area geology can be found in Chapter 5.

Soils of the Coast Range and western Sacramento Valley are highly diverse. Mountain soils are generally shallow to deep, well drained to excessively well drained, and mostly steep to very steep. Foothill soils are formed from hard, unaltered sedimentary rock and softly consolidated siltstone of the Tehama Formation. Soils of older alluvial fans and terraces are well drained to poorly drained and have moderate to low permeability. Interior valley basin soils are generally fine textured, poorly drained with very slow runoff.

Predominant soil associations within the Colusa and Sites Reservoir sites are the Altamont and Contra Costa clay loam series. These are young, eroded and shallow, well to excessively drained clay to clay loam soils that have developed in place over hard sandstone and shale. Runoff is slow to moderate. Erosion is slight to severe depending on slope and relief. Terrain is nearly level to steep and in many areas the surface yields many outcrops of the parent material.

The general soil associations of the Newville Reservoir area are the Millsholm and Lodo series. The Millsholm series are shallow, well drained, moderately coarse to moderately fine textured clay-loam soils that are formed from sandstone, mudstone, and shale. Terrain is hilly to steep with numerous outcrops found scattered throughout the landscape. In this area, outcrops occur on 30 to 50 percent slopes where runoff is medium to high, permeability is moderate, and erosion potential is severe. Lodo series are shallow, somewhat excessively drained, shaley-clay loam soils that formed in weathered, hard shale and fine-grained sandstone. In this area, the soils occur on mountainous terrain with slopes ranging from 30 to 65 percent. Runoff is medium to high, permeability is moderate, and erosion potential varies from moderate to severe depending on slope and relief.

Predominant soil associations within the Schoenfield Reservoir site are the Maymen-Los Gatos-Parrish series and to a lesser extent, the Sheetiron-Josephine association. The Maymen-Los Gatos-Parrish series are shallow to moderately deep, gravelly to rocky clay loam soils that are formed in hard sandstone and shale and in some areas, in hard mica schist. These soils occur on slopes ranging from five to 100 percent. Terrain is steep with deep canyons and narrow ridges. Most soils are well drained to excessively drained, and runoff is rapid to very rapid. Permeability is moderately slow to slow in the Parrish component, moderate to moderately rapid in the Maymen component and moderate in the Los Gatos component. The Sheetiron Josephine associations are well drained, shallow, gravelly loam soils found in strongly sloping to very steep terrain and are formed in altered sedimentary and extrusive igneous rock. This series comprises a very small portion of the area.

The general soil associations within the Dippingvat Reservoir are the Millsholm and Lodo series. The Millsholm series are shallow, well drained, moderately coarse to moderately fine textured clay-loam soils that are formed from sandstone, mudstone, and shale. Terrain is hilly to steep with numerous outcrops found scattered throughout the landscape. In this area, they occur on 30 to 50 percent slopes where runoff is medium to high, permeability is moderate, and erosion potential is severe. Lodo series are shallow, somewhat excessively drained, shaley-clay loam soils that formed from weathered, hard shale and fine-grained sandstone. In this area, the soils occur on mountainous terrain with slopes ranging from 30 to 65 percent. Runoff is medium to high, permeability is moderate, and erosion potential varies from moderate to severe depending on slope and relief.

Land Use

The watersheds draining the east slope of the Coast Range are subject to a variety of land use practices. Upper elevations are primarily commercial forest lands and managed for timber production, outdoor recreation, and grazing. Foothill areas are currently managed primarily for livestock grazing. Some foothill valleys support dryland grain or orchard production. Extensive mineral extraction activities have historically occurred throughout foothill and mountain areas. Sacramento Valley portions of the watersheds support a wide variety of agricultural uses including livestock grazing, irrigated grain and truck-crops, and orchards.

Land use within the proposed Sites Reservoir area is dedicated primarily to livestock production. Both year-round and winter/spring cattle grazing is the dominant land use while a small amount of both horse and sheep grazing also occurs. Other agricultural land uses include minor amounts (200 to 300 acres) of dryland grain production. Some residential land use also occurs within the small community of Sites (population 20) and on 10 to 14 scattered ranch sites. A small commercial rock quarry is present near proposed Sites Dam site. Limited commercial firewood harvesting has occurred within and adjacent to the inundation area.

Land use within the proposed Colusa Cell area is almost exclusively dedicated to livestock production. Both year-round and winter/spring cattle grazing is the dominant land use. No other agricultural land use practices have been identified. Only one occupied ranch homesite has been identified within the inundation area and no other residential or commercial developments are present.

Land use practices within the Thomes-Newville project area are dominated by seasonal and year long livestock cattle grazing. However, limited horse and sheep grazing also occur. At least 20 occupied ranch sites are found within the reservoir area. Limited firewood harvest has occurred in some areas.

Land use within the Red Bank Project area is similar to that at the other three proposed reservoirs. Both year-round and winter/spring cattle grazing is the dominant land use. Other agricultural land uses include a small walnut orchard and a few acres of irrigated pasture. Several landowners operate hunting clubs and at least one landowner operates a fee-for-fishing business.

Vegetation

The watersheds of the streams flowing in the west side of the Sacramento Valley contain a variety of vegetative communities. These include white fir, Klamath mixed conifer, Douglas fir, ponderosa pine, closed-cone pine-cypress, montane hardwood-conifer, montane hardwood, blue oak woodland, valley oak woodland, blue oak-foothill pine, montane riparian, valley foothill riparian, montane chaparral, mixed chaparral, chamise-redshank chaparral, annual grassland, and cropland.

Vegetation within the four proposed reservoir locations is varied due the influence of local soils, geology, microclimate, hydrology, aspect, elevation, as well as other physical and biological factors. All four reservoir sites contain at least some annual grassland habitat. This upland plant community of herbaceous annual grasses and herbs is characteristically composed of many non-native species and a limited number of native species. Species composition is highly variable among stands and throughout the growing season. Vernal pools and swales within the annual grassland community support unique assemblages of native wetland plant species.

Chaparral communities occur at or near each of the proposed reservoir locations in varying amounts. These stands frequently occur in a continuous canopy with little or no understory. Other shrub and tree species including poison oak and manzanitas may form a mosaic in some chaparral stands.

Riparian vegetation is associated with both intermittent and permanent drainages. Common riparian overstory species include Fremont's cottonwood, willows, and Mexican elderberry.

Two types of oak woodland were identified within the four proposed reservoir locations: valley oak woodland and blue oak woodland. Valley oak woodlands are found along the major tributaries and valley bottoms in the reservoir sites. This vegetative community may include other native tree and shrub species. Blue oak woodland occurs at or near each of the proposed reservoirs. Blue oak is the dominant or sole canopy species in these woodlands. An annual grassland understory is common and a shrub layer comprised of manzanitas and wedgeleaf ceanothus can occur. Blue oak woodlands primarily occur on moderately rocky to well-drained slopes. Limited amounts of wetlands occur within the proposed reservoirs. For additional information on wetland resources see Chapter 5.

Foothill pine woodland is the most common vegetative community within the Red Bank Project area. This woodland is dominated by foothill pine and frequently contains a well-developed blue oak understory. The foothill pine community is most common on well-drained uplands.

Annual grasslands (89 percent of the surface area) dominate the proposed Sites Reservoir. Blue oak woodland occurs around the fringe of the reservoir area. Approximately 923 acres (7 percent of the surface area) of blue oak woodland are present within the project area. Relatively small amounts of chaparral, riparian, wetlands, cultivated grain, and non-vegetated areas comprise the remaining 4 percent of the inundation area. As elevation increases above the western edge of the reservoir boundary, the foothill pine community becomes dominant with large chamise chaparral stands present on shallow soils and southern exposures.

Ninety-nine percent of the Colusa Cell area is dominated by an annual grasslands community. The remaining one percent of the land area is divided between blue oak woodland, riparian, emergent wetlands, and non-vegetated areas. No chaparral, blue oak/gray pine woodland, or cultivated grain is present within the project area. As elevation increases above the western edge of the reservoir boundary, the blue oak savanna community becomes dominant.

The Newville Reservoir area is dominated (85 percent) by annual grasslands. Oak woodland comprises an additional 11 percent of the inundation area. A limited amount of chaparral, emergent wetland, and riparian habitat were also mapped within Newville Reservoir. No foothill pine or cultivated grain was mapped within the reservoir footprint.

Foothill pine woodland dominates 61 percent of the Red Bank Project area. Oak woodland habitat was identified and mapped in about 20 percent of the area. Annual grasslands are present on about 12 percent. Limited amounts of chaparral, riparian, and wetlands are also present.

No State or federally threatened or endangered plants were found in the four potential reservoir areas during the two-year study. Populations of federal Species of Concern were identified in the Thomes-Newville and Red Bank alternatives. Several rare or limited distribution species were also found in all of the alternative reservoir areas. The Thomes-Newville and Red Bank sites yielded the greatest number of populations of sensitive plant species. A more detailed description of vegetative communities and rare plant survey methodologies and results can be found in Chapter 5.

Fish and Wildlife Resources

The watersheds of the north Coast Range draining east toward the Sacramento Valley contain native and non-native species, warm water and cold water species, and anadromous and resident fish species. At least 24 species of fish are present in these watersheds. Several State or federally listed fish species occur in the region including steelhead, and various runs of Chinook salmon. Cold water habitats are present in the upper watersheds of the major streams including Cottonwood Creek, Red Bank Creek, and Thomes Creek. However, natural and human made fish passage barriers may prevent anadromous species from reaching suitable cold-water rearing habitat.

Fishery evaluations performed at Antelope, Stone Corral, and Funks Creeks within the footprint of Sites Reservoir indicated the presence of several native and non-native species. A single spring-run Chinook salmon (federal threatened species) was also observed in Antelope Creek within the inundation area. All of these streams are ephemeral within the reservoir area. They do not provide cold water habitat. And most are degraded with extensive downcutting and little riparian vegetation. Habitat surveys indicate that the stream reaches above the reservoir do not provide suitable rearing habitat for anadromous species.

Fishery evaluations were performed on three ephemeral streams within the Colusa Cell footprint (Logan, Hunters, and Minton creeks). Survey results indicate the presence only one native species and several introduced warm-water species. All of these streams are ephemeral upstream from the proposed dam sites and do not provide cold-water habitat. No State or federally listed fish species were identified within the reservoir area. Habitat surveys indicate that the stream reaches above the reservoir do not provide suitable rearing habitat for anadromous species.

Survey of the ephemeral streams within the Newville Reservoir footprint resulted in capturing California roach, Sacramento pike minnow, Sacramento sucker, and green sunfish. Rainbow trout are present in the perennial headwater areas of Salt and Heifer Camp Creeks above the proposed reservoir inundation area. Thomes Creek watershed contains a diverse fish assemblage that includes runs of fall-run, late fall-run, and spring-run Chinook salmon and steelhead.

DFG conducted studies in lower Cottonwood Creek (below the North Fork confluence) and in the South Fork of Cottonwood Creek in 1976. They found ten resident game and 13 nongame species of fishes. The 1976 DFG survey also found runs of fall-run, late fall-run, and spring-run Chinook salmon in lower Cottonwood Creek and spring-run Chinook salmon and steelhead in the South Fork Cottonwood Creek. A more recent survey on the South Fork Cottonwood Creek and Red Bank Creek within the Red Bank Project area located four species of resident game fishes and four species of non-resident game fishes. Steelhead were identified within the Red Bank Creek watershed. Additional information concerning fish survey methods and results can be found in Chapter 5.

A wide variety of wildlife species utilize areas in and around the four proposed reservoir areas either seasonally or year-round. Surveys are ongoing of the proposed reservoir sites for the presence of State and federally listed species. However, substantially less information has been collected on non-listed species density and distribution.

Some general statements about relative wildlife species diversities can be made based on the variety of habitat types and successional stages present within each of the proposed reservoir locations. The Colusa Cell is strongly dominated by annual grasslands with little habitat or structural diversity. This monotypic habitat would not support the same diversity of wildlife species that would be expected at the other proposed reservoir locations where a greater diversity of habitats are present. Sites Reservoir contains a greater diversity of habitat types than found within the Colusa Cell.

Thomes-Newville and Red Bank Project areas support a greater diversity of habitat type than the Sites and Colusa Cell areas. This increased habitat diversity should provide habitat for a number of wildlife species not found within the Colusa Cell. Although the Red Bank Project area is the smallest of the four proposed reservoir locations, it contains the greatest diversity of habitats and seral stages of habitats and should support the highest diversity of vertebrate wildlife.

State or federally listed wildlife species have been studied and documented at or near each proposed reservoir location. Wintering bald eagles (State endangered, federal threatened) occur in low numbers at each proposed reservoir. Both wintering sandhill cranes (State threatened) and a migrating bank swallow (State threatened) have been detected at or near the proposed Colusa Cell. Extensive surveys of the proposed Sites and Colusa Cell project areas failed to detect any California tiger salamanders, red-legged frogs, or giant garter snakes. One red-legged frog (federal threatened) has been reported within the Red Bank project area. Numerous federal species of concern, California Species of Special Concern, federal Migratory Nongame Birds of Management Concern, or candidate species occur within each of the proposed reservoirs. Additional information concerning these species occurrence can be located in Chapter 5.

Several DFG harvest species occur within the proposed reservoirs. Upland game includes black-tailed deer, black bear, feral pig, gray squirrel, wild turkey, California and mountain quail, and morning dove. Waterfowl use is limited within each of the proposed reservoirs and generally restricted to winter use of stock ponds and small lakes. Limited wood duck and mallard nesting also occurs within stock ponds and along the stream channels where adequate brooding water exists. Relatively high winter deer use of portions of the Thomes-Newville and Red Bank Project areas has been reported. Substantially less deer use has been observed within the Sites Reservoir area and no use has been noted within the Colusa Cell area. Observations indicate that feral pigs occur in low to moderate numbers within each of the proposed reservoirs, with the greatest use within the Red Bank Project area. Wild turkeys are relatively common in portions of the Red Bank Project area and Newville Reservoir area.

According to the California Wildlife/Habitat Relationship System database several federally listed invertebrate species may occur within the four proposed reservoir sites. These species include valley elderberry long-horn beetle, vernal pool fairy shrimp, Conservancy fairy shrimp, and vernal pool tadpole shrimp.

Elderberry bushes with stems greater than 1-inch diameter at ground level are considered habitat for the valley elderberry long-horn beetle. Survey of reservoir inundation areas identified mature elderberry bushes at each of the proposed reservoir locations. These bushes primarily occur adjacent to riparian habitat. However, several small stands of elderberry bushes were located in upland habitat within each of the proposed reservoir areas. A small number of beetle emergence holes were observed in elderberry stems at both Sites and Newville Reservoirs.

Surveys designed to detect federally listed fairy or tadpole shrimp have not yet been conducted. Potential vernal pool fairy and tadpole shrimp habitat is present within annual grassland habitat at Sites, Colusa Cell, and Newville Reservoir sites, but absent within the Red Bank Project area. For additional information on State or federally listed species see Chapter 5.

Cultural Resources

Surveys of cultural resources within the Sites Reservoir project area recorded a total of 41 historic and prehistoric sites. At least 17 appear to be significant because they provisionally meet the criteria for eligibility to the National Register of Historic Places. Prehistoric settlement in the project area was constrained by the limited food and fuel resources and the scarcity of water; however, the area would have been important for seasonal hunting and gathering forays. The larger and more permanent villages were situated along the lower reaches of the bigger streams and on the knolls and natural levees along the Sacramento River.

Historic sites, features, and standing structures are significantly underrepresented in the site totals. These resources were not recorded because they are associated with working ranches, occupied buildings, and the town site of Sites. A future survey of historic resources may yield other significant historic sites in addition to the Historic District of the Town of Sites. Moving the large cemetery associated with Sites and several smaller cemeteries would be costly and present special problems, but there is precedent when associated with a major public works project.

Results of the record search indicated that the footprint of the Colusa Cell had never been surveyed for cultural resources and that there were no site records in the files of the State database. A field survey found greater scarcity of subsistence resources than in the Sites Reservoir area and the ephemeral nature of the water supply were not suitable for extensive use or habitation during the prehistoric past.

A total of three sites was recorded, two historic ranches and one site with a prehistoric and an historic component. The significance of the sites is undetermined. The assessment of eligibility to the National Register could not be made on the basis of surface indications. Additional studies would be necessary to complete the evaluation.

A comprehensive survey of prehistoric sites within Thomes-Newville Project area was completed in 1983. A total of 117 sites was recorded within the footprint of the proposed reservoir, representing a more complete prehistoric settlement pattern that includes evidence of permanent or semi-permanent villages, seasonal campsites, and special resource procurement and use sites. The presence of perennial streams and availability of fuel and subsistence resources accounts for the more intensive use of the project area during prehistoric times.

As with the Sites Reservoir, moving the historic cemeteries within the footprint of the Thomes-Newville Project would be costly and present special problems.

Results of the record search for the Red Bank Project indicated that the project area had not been surveyed for cultural resources and no site records were present in the State database. The prior survey and excavations for the Red Bank Project conducted in the early 1950s was for a Sacramento River diversion project near Red Bluff that had the same name. The surveys completed in 1994 for the U.S. Corps of Engineers' Cottonwood Creek Project were downstream of the project described here, with no overlap of the footprints.

A total of 31 sites were recorded within the footprints of the Red Bank Project. Twenty-eight sites are prehistoric and three are historic. The prehistoric sites in the Red Bank Project area were generally small and the artifact distribution relatively sparse. The sites were probably associated with seasonal upland hunting, fishing, and gathering activities. The larger permanent settlements were situated further downstream on the banks of the perennial streams and along the Sacramento River.

Transportation

The proposed Sites Reservoir is approximately 14 miles west of U.S. Interstate 5. East to west access through the project area is via the Colusa County Maxwell/Sites Road. This county road receives relatively heavy volumes of traffic, especially on weekends, because it provides access to East Park Reservoir and the southwest portion of the Mendocino National Forest as well as the communities of Stonyford and Lodoga. Other Colusa County roads include Peterson Road which extends approximately 4 miles north from the community of Sites, and Huffmeister Road which extends south and west from the community of Sites to the community of Leesville. The closest airport is approximately 17 miles away at the community of Willows.

The Colusa Cell is approximately 7 miles west of Interstate 5. Access to the reservoir area is via Glenn County roads 60 and 69. These gravel/paved roads receive relatively little traffic. No public access currently exists within the reservoir footprint. Ranch roads within the reservoir inundation area are very limited and access is severely restricted during winter and spring due to a high number of unimproved stream crossings. The closest airport is approximately 12 miles away at the community of Willows.

The Thomes-Newville Project area is accessed via Newville Road west from Orland or Corning Road west from Corning. The project area is approximately 18 miles west of Interstate 5. Round Valley Road connects to both Newville and Corning Roads in the northern end of the proposed reservoir. Round Valley Road continues west from the reservoir and provides access to the central portions of the Mendocino National Forest. The southern part of the proposed reservoir area can be accessed via Elk Creek Road and State Highway 162. The closest airport is approximately 18 miles away at the community of Orland.

The Red Bank Project is approximately 17 miles west/south-west from Interstate 5 at Red Bluff. Access to the project area is provided by a variety of Tehama County roads that travel west from Red Bluff including Red Bank Road, Reeds Creek Road, Pettyjohn Road, Johnson Road, and Balis-Bell Road. Red Bank Road provides public access through the Schoenfield Reservoir. Balis-Bell Road follows Clover Creek and provides public access into Blue Door Reservoir. No public access currently exists into the Lanyan or Dippingvat Reservoir areas. However, several private ranch roads provide some access into both of these proposed reservoirs. The closest airport is approximately 17 miles away at the community of Red Bluff.

Air Quality

The respective County Air Pollution Control Districts monitor air quality within Colusa, Glenn and Tehama Counties. Each county monitors similar contaminants including ozone and particulate matter. Detailed site-specific air quality information is not available. Tehama County is considered a moderate non-attainment area for both ozone and particulates (PM10) under the California Clean Air Act. However, levels of both contaminates are within federal criteria. Glenn County air quality meets both State and federal air quality standards for ozone and PM10. Colusa County is a non-attainment area for both PM10 and ozone under both State and federal criteria.

Recreation

Recreational activities within watersheds of the stream flowing through the project areas include hiking, hunting, fishing, camping, boating, mountain biking, and off-road vehicle use. Most of these activities occur primarily on public lands on the Mendocino National Forest and associated private timberlands. Little public access into the foothill private grazing lands occurs. However, large public recreational areas are present within the foothill portion of the Stony Creek watershed at Black Butte and at Stony Gorge. Waterfowl and upland game bird hunting are the primary recreational use activities within the Sacramento Valley portions of these watersheds.

Recreation use and opportunity are currently very limited within the footprint of the proposed project areas. Almost all lands within the proposed reservoir areas are privately owned and posted against trespass, thus preventing general public access. Recreational activities that do occur are primarily by landowner families, their friends, and employees. This level of recreation use probably amounts to only a few hundred recreation-hours per year per reservoir site. On these agricultural lands, hunting is the most common recreational activity. Upland game birds (dove, quail, and pheasant), black-tailed deer and feral pigs are the most commonly hunted species within the proposed reservoir areas. Commercial hunting operations for feral pig, black-tailed deer, wild turkey occur within the Red Bank Project area and may operate on individual landholdings within the other reservoirs as well. Fishing is an infrequent activity because of the intermittent nature of the streams in Sites, Colusa Cell, and Newville Reservoir areas. Numerous stock ponds within the project areas are large enough to support bass, catfish, and sunfish. It is unknown how much angling pressure these ponds receive, but it appears to be generally low. At least one fee-for-fishing recreational operation is currently in business on a small lake within the Red Bank Project area.

Chapter 3. Project Description and Alternative Evaluation

As part of their Phase II evaluation, CALFED compiled a list of 52 potential surface storage project alternatives. They also compiled engineering, cost estimate, and environmental information on these alternatives. An interagency group of specialists was established to review available data and screen out non-practicable alternatives and those with greatest negative environmental impact. Onstream projects were excluded because of their greater potential for negative environmental impacts. This screening process is ongoing, but CALFED has narrowed the number of potential sites for future consideration to twelve. Four of these are offstream storage projects located north of the Delta, namely Sites, Colusa, Thomes-Newville, and Red Bank. Study of these projects was initially authorized under the Safe, Clean, Reliable Water Supply Act of 1996, but is continuing under yearly appropriations through the State budget. Evaluation of these projects is expected to continue for the next several years and will result in preparation of a project feasibility report, environmental documentation, and permits. This chapter describes in detail each project alternative and summarizes project alternative evaluations conducted to date.

Alternative Projects Description

The four projects assigned to DWR are located in the same geographic region on the west side of the Sacramento Valley generally west of Maxwell to Red Bluff as shown on Figure 2.1. Comparative project statistics are shown on Table 3.1.

All of these projects have been investigated to varying degrees in the past. Our task now is to update and augment these past studies as needed to make them adequate for comparative evaluation. Each of these projects is described individually in more detail below.

Sites Project

Consideration of a Sites Project was first documented in a December 1964 Bureau of Reclamation report titled *West Sacramento Canal Unit*. This report documented results of a small Sites Project (1.2 maf) study as part of a plan to extend the Tehama-Colusa Canal south into Solano County. This study did not evaluate the potential of Sites as a stand-alone project to help serve statewide multiple water needs. The larger (1.8 maf) Sites Project was not considered by either DWR or USBR until the mid-1970s. The larger Sites Project was sized at the maximum elevation considered practicable at this site. The Sites Project was never investigated at more than a reconnaissance level; however, competing projects such as Thomes-Newville were carried to near feasibility level.

Table 3.1. Comparative Project Statistics for the Sites, Colusa, Thomes-Newville and Red Bank Projects

Project Feature	Sites	Colusa	Small Thomes-Newville	Large Thomes-Newville	RedBank[1]
Storage (ac-ft)					
Gross	1,800,000	3,000,000	1,900,000	3,000,000	360,000
Dead	40,000	100,000	50,000	50,000	27,000
Drainage Area (mi^2)	85	115	63	63	S 39 D 132
Reservoir Surface Area (ac)	14,000	28,000	14,000	17,000	4,000
Dam Height (ft)/Volume (1000 yd^3)					
Sites	290/3,800	290/3,800	---	---	---
Golden Gate	300/10,600	300/10,600	---	---	---
Prohibition	---	230/11,300	---	---	---
Owens	---	260/11,700	---	---	---
Hunters	---	260/24,700	---	---	---
Logan	---	270/30,600	---	---	---
Newville	---	---	325/16,000	400/33,000	---
Burrows Gap (Largest Saddle Dam)	---	---	75/600	150/2,000	---
Schoenfield (RCC)	---	---	---	---	300/467
Dippingvat (RCC)	---	---	---	---	250/367
Lanyan (RCC)	---	---	---	---	75/19
Bluedoor (RCC)	---	---	---	---	115/55
Saddle Dams (Number/Max. Height)	9/130	7/140	None	4/75	4/85
Reservoir Elevation (ft)					
Normal	520	520	905	980	S 1,017 D 1,205
Minimum	320	320	685	685	S 830 D 1,103
Avg. Annual Natural Reservoir Inflow (ac-ft)	15,000	20,000	20,000	20,000	S 16,000 D 96,400
Reservoir Evaporation (ac-ft)					
Average Annual	40,000	80,000	50,000	60,000	10,000
Total Critical Period	220,000	440,000	300,000	360,000	50,000
Pumping (ft)					
Static Lift from T-C Canal					
Maximum	320	320	655	730	---
Minimum	120	120	435	435	---
Capacity					
Maximum (1000 ft^3/s)	5 to 8	5 to 8	2	2 to 5	---

1. For Red Bank Project, D refers to Dippingvat Dam and Reservoir, S refers to Schoenfield Dam and Reservoir

The Sites Project site is located about 8 miles west of Maxwell in Antelope Valley, which is drained by Stone Corral and Funks Creeks. The drainage area of these watersheds totals 85 square miles. Two sizes of reservoirs were investigated in the past -- 1.2 million acre-feet at 480 foot normal water surface elevation and 1.8 million acre-feet at 520 foot normal water surface elevation. However, due to its greater water supply yield, Large Sites appears the more favorable project. Therefore, our investigation to date has focused mainly on Large, rather than Small Sites. Two main dams -- Golden Gate on Funks Creek and Sites on Stone Corral Creek -- and nine saddle dams along the northern edge of the project are required to form the reservoir. Large Sites Reservoir would occupy a maximum area of 14,000 acres.

The Large Sites Reservoir would be formed by a 290-foot-high Sites Dam on Stone Corral Creek. A 300-foot-high Golden Gate Dam on Funks Creek and nine saddle dams ranging up to 130 feet high would be built along the reservoirs northern boundary to prevent water from spilling over the ridge into Hunters Creek. Presently a 40-foot-high (Funks) dam forms a 2,000 acre-foot reservoir 1 mile downstream of the Golden Gate Dam site. This reservoir was constructed by the Bureau of Reclamation and is part of the Tehama-Colusa Canal System. It serves as a "surge reservoir" to stabilize flows down the canal as water diverters come on and off-line suddenly. Either this or an enlarged Funks Reservoir would serve as a forebay/afterbay to the Sites or Colusa Project. Imported water entering or leaving Sites or Colusa Reservoir would pass through Funks Reservoir; therefore, it is the terminal location for all of the alternative water conveyance routes to these reservoirs derived from sources to the east of the reservoir. Some small amount of water might also be derived from Upper Stony Creek by diverting it via tunnel and conveying it directly into the reservoir without passing through Funks Forebay. However, this water would flow through Funks Reservoir when it was released to meet downstream water demands.

If daily pumpback operations (pumping at night when power costs are low and generating during the day when they are high) were incorporated into either project, then Funks Reservoir would need to be enlarged to around 8,000 af. This operation scenario will be evaluated further as the study progresses.

The Sites or Colusa Project water control features (appurtenances) include water intake and outlet structures, a pumping and generating plant, and emergency spillway located at the Golden Gate Dam site on Funks Creek. Sites Dam will have a low-level outlet structure to release stream maintenance flows into Stone Corral Creek.

The operation of the Sites and Colusa Projects would be similar. Water would be diverted to the reservoirs from the Sacramento River and some tributaries mainly in winter months. During the irrigation season, releases from these reservoirs would be made back to the irrigation canals to provide local irrigation water in exchange for water that would otherwise be diverted from the Sacramento River. The exchanged Sacramento River water could remain in Shasta Lake for release later in the summer, partially to aid cooling of the upper river for fishery maintenance purposes. This water would be consumptively used downstream for agricultural, environmental, and urban purposes. This operating scenario requires modification of the Tehama-Colusa and Glenn-Colusa Canal intakes to allow large-scale winter diversions of water from the Sacramento River without adversely affecting the river fishery or other biologic resources. Current combined diversion capacity of these two facilities would not exceed 5,000 cfs. A new canal diverting 5,000 cfs from Sacramento east of Maxwell is also being considered. Colusa drain floodflows can also be diverted to this canal for conveyance to Sites Reservoir. High winter flows diverted into these canals would flow to Funks Reservoir from where it would be lifted into Sites or Colusa Reservoir. Other alternative locations and sources of water supply are being evaluated and will be discussed later. When water is released from the reservoir it will be routed through generators to reduce the net use of power. Estimates to date indicate that the economic value of power used to supply the reservoirs will be largely offset by the value of power generated, even though the quantity of power used exceeds that produced. This is due to the project's ability to emphasize the accumulation of reservoir water during periods of lower power prices and the release of water during periods of higher power costs.

Neither Sites nor Colusa Reservoirs would disturb much existing development. Fewer than 100 people live in the reservoir area. And only about 5 miles of county road and a roughly equivalent length of residential power lines would have to be relocated around the reservoir.

Hydrology of Alternative Water Supplies

The flow of various nearby streams was evaluated to determine the quantity of water that could potentially be diverted to Sites, Colusa, or Newville Reservoirs. The Red Bank Project, unlike the others, has only one major potential source of water (South Fork Cottonwood Creek) which was also analyzed. A complete description of this work is contained in the DWR May 1999 report titled *Hydrology and Water Supply for Offstream Reservoirs.*

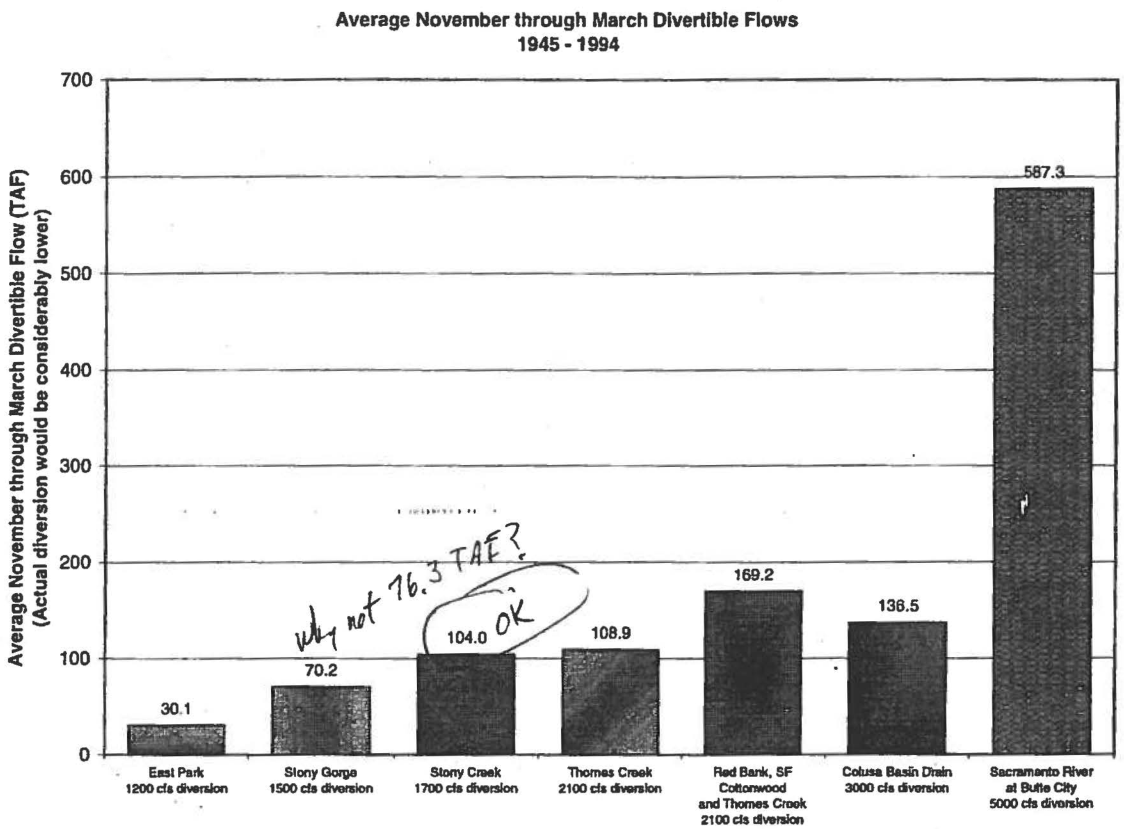
Potential sources of water to the Sites and Colusa Reservoirs are essentially identical except that a greater quantity of water may be needed for Colusa because of its larger capacity. The nearby streams analyzed for water supply potential are the Sacramento River, Stony Creek, Thomes Creek, the Colusa Basin Drain, Grindstone Creek, South Fork Cottonwood Creek, and Red Bank Creek.

To minimize the diversion impacts on the Sacramento River ecosystem, initial project formulation assumed that it might be advantageous to divert water from tributary streams before it reached the Sacramento River. However, further investigation revealed that the impact on the Sacramento River may not be significantly different, and that essentially all stream diversions would have to be screened for fish the same as diversions from the river. Therefore, at this time the tributary streams do not appear to present a more favorable scenario in terms of environmental impacts and costs associated with diversion screening. All of the project water diversions would be made during periods when high flows exceed the needs of the local watershed, river, and Delta. The basic operating criteria used in diversion studies is that diversions will not be made until surplus conditions exist locally, at the Wilkins Slough Navigation Control Point near Tisdale Bypass, and in the Delta. Also, all fish maintenance instream flow needs identified in future studies must be met.

To estimate availability of water for diversion to offstream storage, the hydrologic models were run on a daily basis for the months of November through April for the 50-year period from 1945 through 1994. Operating criteria usually limited the allowable diversion period to November through April to prevent any conflict with existing water rights. However, we occasionally extended this theoretical diversion period into May to determine what the impact on project water supply would be recognizing that this could only be done during years of unusually high spring flows.

These are simplified hydrologic models and their main purpose is to estimate the amount of water potentially available from the Sacramento River and local streams for diversion to the offstream storage reservoir. A summary of divertible water from various streams is shown in Figure 3.1.

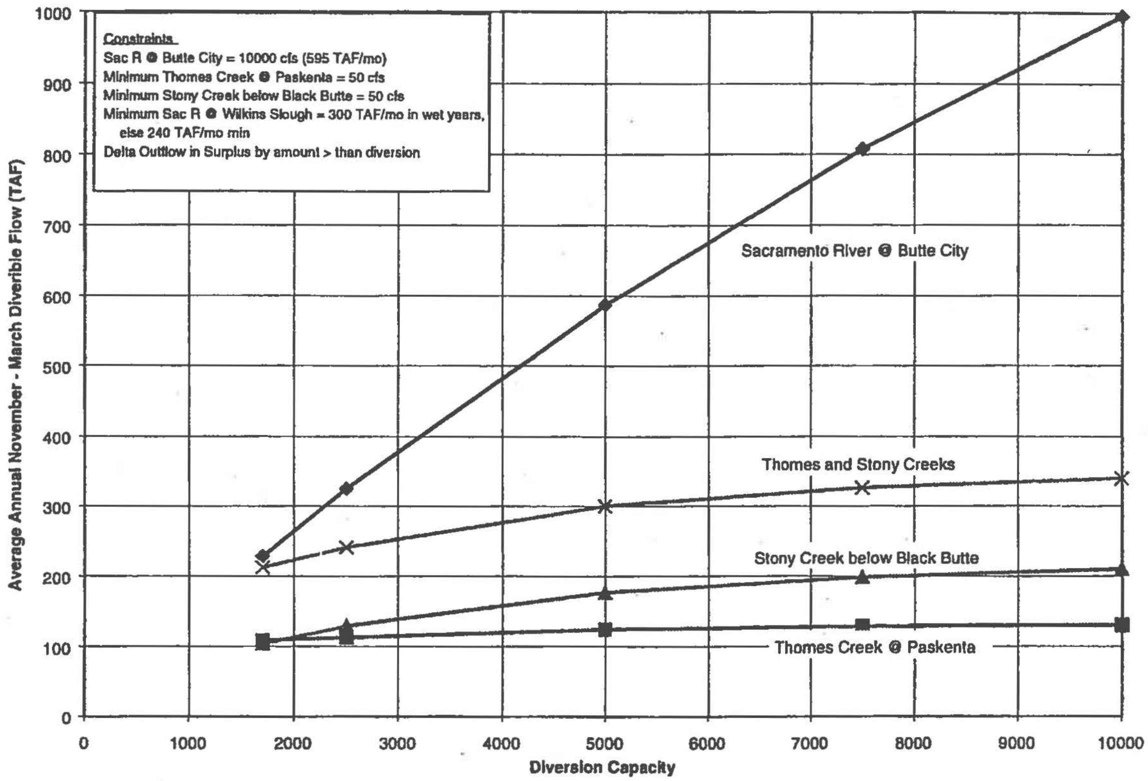
Figure 3.1. Potential Alternative Water Supply Sources for Offstream Storage Projects



The Sacramento River has by far the greatest supply capability of any streams considered. It is followed by the Colusa Basin Drain, Thomes Creek, and Stony Creek. Diversions from Stony Gorge and East Park Reservoirs through a gravity tunnel diversion were initially considered, but are presently being refined to determine their feasibility because of their small water supply potential and high costs. Also, a small supply reservoir on Grindstone Creek, a Stony Creek tributary, was rejected because of high estimated cost compared to supply. This dam site also has seismic and other geologic problems.

Figure 3.2 illustrates that on Sacramento River tributary streams, such as Stony and Thomes Creeks, the increments of additional divertible flow are relatively minor once diversion capacity reaches about 5,000 ft^3/s. Also, the total volume of divertible water is relatively low. However, on the Sacramento River, divertible flow potential continues to increase as diversion capacity exceeds 10,000 ft^3/s. This is because the river carries much greater and more stable flows than any of the tributary streams. More work must be conducted on water supply hydrology in response to additional information on instream diversion limitations. Studies of impacts resulting from diversions on the Sacramento River ecosystem are currently under way.

Figure 3.2. Comparison of Divertible Flows from Sacramento River and Thomes and Stony Creeks (1945 – 1994)



Project Operation Studies

To most project beneficiaries the two most important characteristics of a surface water project are its increased water supply, and the cost of this additional supply. The new or additional (above existing projects) yield that a proposed project could generate is predicted by conducting operation studies. This is an accounting process over a historic period using recorded or estimated streamflows. This accounting includes all water hypothetically supplied to, stored in, lost to seepage and evaporation, and released from the reservoir. This is accomplished by using a computer-based hydrologic simulation model. DWR's model is titled DWRSIM (or the recently established CALSIM) and operates a project under investigation simultaneously with other major reservoirs such as the Central Valley Project reservoirs, and the State Water Project over a historic period of 74 years. The water is assumed released on a schedule estimated to represent project water demands at some point in the future (in our case the year 2020). The difference between the total system water supply with and without the project under investigation is considered to be the water supply attributable to the subject project. The model is run using average monthly flows; whereas, the availability of water supplies from various streams is developed using average daily flow data. This creates some inaccuracy in the model but it is refined enough to generate relative water yield acceptable for making comparisons between competing alternatives.

For the first phase of the offstream storage investigation, 24 operation model studies have been run. These studies include 9 for Sites Reservoir, 9 for Colusa Reservoir, and 6 for Newville Reservoir. These studies include various alternative sources of water and conveyance facilities for filling the reservoirs so as to identify the better alternatives.

For Sites and Colusa Reservoirs, seven possible diversion locations were considered as sources of water to fill the reservoir. The Sacramento River at Red Bluff Diversion Dam; the Sacramento River at the Glenn-Colusa Irrigation District pumps; the Sacramento River at mile 158.5 (opposite Moulton Weir); the Colusa Basin Drain; Stony Gorge Reservoir; lower Thomes Creek at the Tehama-Colusa Canal crossing; and lower Stony Creek at the Glenn-Colusa Canal crossing.

For Newville Reservoir, five possible diversion locations were considered: Thomes Creek about 5 miles upstream from Paskenta; Stony Creek at Black Butte Reservoir; the Sacramento River at the Red Bluff Diversion Dam; the Sacramento River at the GCID pumps; and lower Thomes Creek at the Tehama-Colusa Canal crossing.

The DWRSIM Model used for the 25 operation studies:

- Runs on a monthly basis for years 1922 through 1994
- Uses estimated 2020 level of development
- Uses a surrogate demand based on estimated State Water Project demands (surrogate demand is used in place of actual estimated demand and the beneficiaries of the offstream reservoir yield, which is presently unknown). An estimated actual demand schedule will replace the surrogate in later operation study runs.
- Models flows of both the Sacramento and San Joaquin River systems, with coordinated operation of CVP and SWP reservoirs.
- Generates data to estimate water supply, power use and power generation, fishery maintenance flows, recreation use, and Delta flow requirements compliance

The computation of yield is the most useful output from an operation study. Yields are computed by subtracting total system-wide (includes all projects in the

DWRSIM Model) deliveries for a given operation study to the deliveries under a base study. The base study is the same study in all ways but without the addition of the project under investigation. Table 3.2 summarizes the yields for studies done to date.

Table 3.2. Estimated Increase in System Deliveries Resulting from New Projects

STUDY NUMBER	STUDY PERIOD 22-94	28-34	87-92	CONVEYANCE SYSTEM CAPACITY- CFS T-C CANAL	GCID CANAL	NEW CANAL	COLUSA DRAIN	STONY GORGE	LOWER STONY	THOMES CK
	YIELD TAF/YR									
1.8 MAF SITES										
A-LS-763	254	229	208	2,100	1,700					
B-LS-764	281	232	246	3,300	1,700					
C-LS-656	287	249	278	2,100	1,700		3,000			
D-LS-657	313	250	291	3,300	1,700		3,000			
E-LS-659	238	258	241				3,000		1,700	2,100
F-LS-658	324	254	297			5,000	3,000	1,500		
G-LS-761	180	195	159							
H-LS-762	196	200	171	3,300	1,700		3,000			
I-LS-824	232	222	199			5,000	3,000	1,500		
3.0 MAF COLUSA										
J-C-765	360	286	346	2,100	1,700					
K-C-766	389	322	368	3,300	1,700					
L-C-660	407	344	428	2,100	1,700		3,000			
M-C-846*	486	333	437	2,100	1,700		3,000			
N-C-671	427	346	452	3,300	1,700		3,000			
O-C-681	443	389	481			5,000	3,000	1,500		
P-C-682	341	327	393				3,000		1,700	2,100
Q-C-825	244	257	324	2,100	1,700		3,000			
R-C-826	265	277	349	3,300	1,700		3,000			
1.9 MAF NEWVILLE										
S-SN-683	195	207	168						3,000	5,000
T-SN-684	307	274	272	2,100					3,000	5,000
U-SN-827	263	234	200	2,100					3,000	5,000
3.0 MAF NEWVILLE										
V-LN-685	420	352	431	2,100					3,000	5,000
W-LN-686	464	452	487	3,300	1,700				3,000	5,000
X-LN-828	353	360	408	3,300	1,700				3,000	5,000

Shaded studies assume that river flows must reach a minimum of 60,000 cfs (trigger flow) before any water is diverted. All other studies assume that any Sacramento River flows above a minimum fish maintenance instream flow of 10,000 cfs can be diverted. Study M-C-846* assumes that the proposed Trinity River instream flow release schedule is approved by the Secretary of the Interior.

The difference in water supply for various runs under each criteria is due mainly to the water supply source and conveyance capacity. For the 1.8 maf Sites Reservoir, the potential average annual increased water supply over the 1922 through 1994 study period range from 238 taf to 324 taf. If a 60,000 cfs trigger flow is assumed, annual yield range drops to 180 to 232 taf.

In addition to the project yield, the impacts on flows of the Sacramento and Feather Rivers, and on storage at Shasta and Oroville Lakes, have been computed. Detailed information on these impacts can be found in the September 1999 Progress report *Offstream Storage DWRSIM Model Results.*

Water Conveyance Alternatives

This study investigated alternative conveyance systems to move water from its source in creeks or the river to offstream storage projects. For Sites and Colusa Reservoirs, the alternatives considered are identical and consist of the following combinations: (1) the existing Tehama-Colusa and/or Glenn-Colusa Canals (either as is, or modified to increase capacity); (2) a new canal from the Colusa Basin Drain and/or the Sacramento River near Moulton Weir; and (3) a new diversion on the river near Chico Landing, and a canal intertie to the Tehama-Colusa or Glenn-Colusa Canals. These three primary alternatives were combined in different ways and resulted in the variations described below and shown on Figure 3.3. A detailed description of each of these facilities, as well as the various alternatives is contained in the *September 1999 Summary Report-Sites Reservoir Conveyance Study.* The conveyance system alternatives investigated in this study are:

Alternative

I. Would use the existing Tehama-Colusa and Glenn-Colusa Canals from their diversions near Red Bluff and Hamilton City respectively to a terminal location near Funks Reservoir. A short section of new canal and pumping plant would connect the Glenn-Colusa Canal to Funks Reservoir. The capital cost of this alternative is estimated as $110 million, mostly for the new canal section and pumping plant. This alternative could deliver a maximum of 3,900 cfs from the Sacramento River to Funks Reservoir.

II. Is the same as alternative I except that both canals would be enlarged slightly to carry 2,500 cfs each for a total of 5,000 cfs from the river to Funks. The total cost would double to $220 million, while the carrying capacity increased only 28 percent. Under this alternative the costs of pumping plants and other facilities would be approximately equal.

This alternative would use the existing 2,100 cfs capacity in the Tehama-Colusa Canal and 2,900 cfs capacity in an enlarged Glenn-Colusa Canal, combined with 3,000 cfs from the Colusa Basin Drain. The drain water would be conveyed via a new canal and two pumping plants to the Glenn-Colusa Canal for transfer to Funks Reservoir by way of the same connector used in the last two alternatives. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated capital cost would be $486 million.

IVA. This alternative uses the enlarged Glenn-Colusa Canal to carry 5,000 cfs plus 3,000 cfs from the Colusa Basin Drain via the new canal. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated capital cost $549 million.

IVB. Same as Alternative IVA, but with a new 2,100 cfs diversion near Chico Landing connecting to the Glenn-Colusa Canal instead of an increase in pumping capacity at the existing Hamilton City pumping plant. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated capital cost $496 million.

V. Would consist of a new 5,000 cfs river diversion opposite Moulton Weir combined with a 3,000 cfs diversion from the Colusa Basin Drain. Both sources of water would be conveyed to Funks Reservoir via the New Canal. The total diversion capacity to Funks Reservoir would be 8,000 cfs and the estimated capital cost $585 million.

VIA. Uses existing 2,100 cfs Tehama-Colusa Canal combined with new 2,900 cfs Sacramento River diversion and canal opposite Moulton Weir, plus 3,000 cfs from the Colusa Basin Drain. Total diversion capacity to Funks Reservoir is 8,000 cfs and the estimated capital cost $471 million.

VIB. Same as VIA except the capacity of the Glenn-Colusa Canal is reduced to the presently existing 1,800 cfs and the new Sacramento River diversion is increased to 3,200 cfs. Diversion capacity remains the same at 8,000 cfs and the total cost is reduced to $450 million.

VIIA. New 5,000 cfs Tehama-Colusa Canal diversion and canal expansion to Funks Reservoir plus 3,000 cfs from the Colusa Basin Drain via the New Canal. Total diversion capacity to Funks Reservoir is 8,000 cfs and the estimated capital cost is $866 million

VIIB. Same as above except that the Tehama-Colusa Canal water is diverted at Chico Landing via new diversion. Diversion capacity is the same and estimated capital cost is $732 million.

VIIIA. Includes 1,500 cfs tunnel diversion from Stony Gorge Reservoir combined with the existing 2,100 and 1,800 cfs diversions via the Tehama-Colusa and Glenn-Colusa Canals respectively. The total diversion capacity to Sites or Colusa Reservoirs is 5,400 cfs and the estimated capital cost is $____ million.

VIIIB. Same as VIIIA except that Stony Creek water would be diverted from East Park Reservoir via a 1,200 cfs tunnel. Total diversion capacity to Sites or Colusa Reservoirs would be 5,100 cfs and the estimated capital cost $____ million.

In addition to the above conveyances, new or enlarged river diversion and canal pumping plants would be required in all of the conveyance alternatives. Pumping plant capacities would range from approximately 1,100 to 6,100 cfs, with pumping heads of approximately 20 to 110 feet (excluding the final Funks to Sites Reservoirs lift).

No decision on the preferred conveyance alternative has been made yet. Future investigation of the environmental impacts associated with these alternatives will greatly aid the selection process.

Power Generation and Potential Pumpback Operation

The DWR State Water Project Analysis Office performed a cursory study of power consumption and generation, as well as related costs and revenues associated with operation of the Sites Project. This work is documented in a November 1999 report titled *Sites Offstream Storage Project Power Costs Study.* The pumpback power generation potential of other projects will be evaluated later.

The November 1999 study estimates power costs associated only with the transfer of water between existing or enlarged Funks Reservoir and a 1.8 maf Sites Reservoir. It did not include costs associated with any additional pumping/generating plants required to transport water from the river or other water supply sources to Funks Reservoir. Nor does the study include the cost of energy required to initially fill Sites Reservoir.

Two categories of alternative operations were considered:

- Operation with no increased storage at Funks Reservoir, referred to as **minimal operation**
- Operation with an enlarged Funks Reservoir of around 6,000 acre-foot capacity to maximize power operations referred to as **optimized operation.**

Figure 3.3. Sites Reservoir Conveyance Alternatives

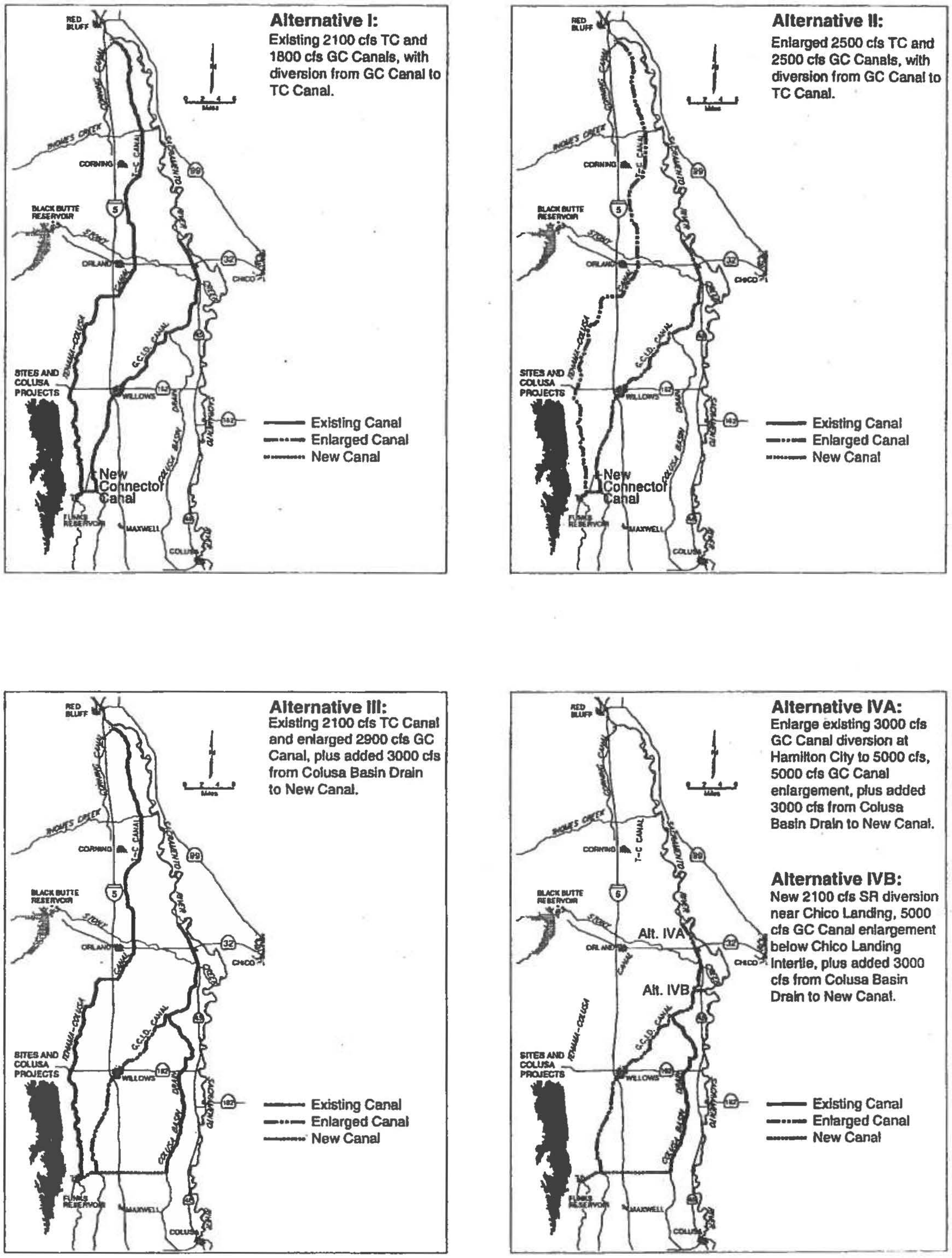
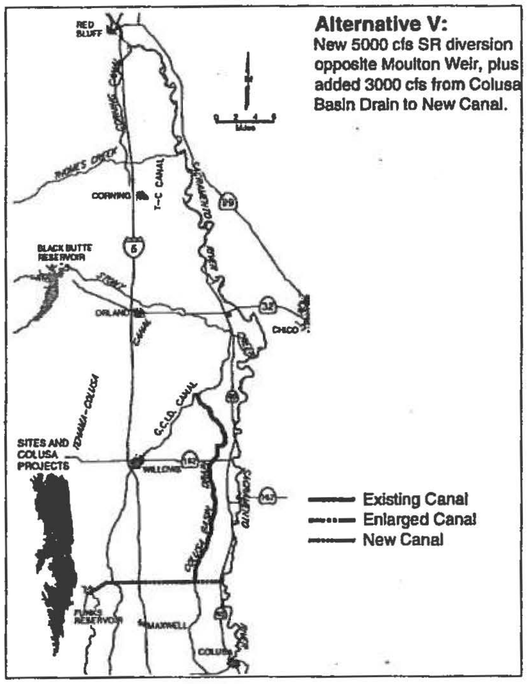
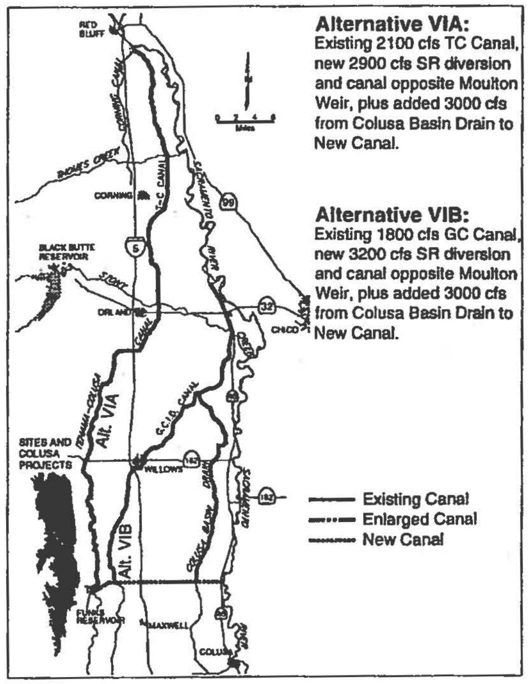
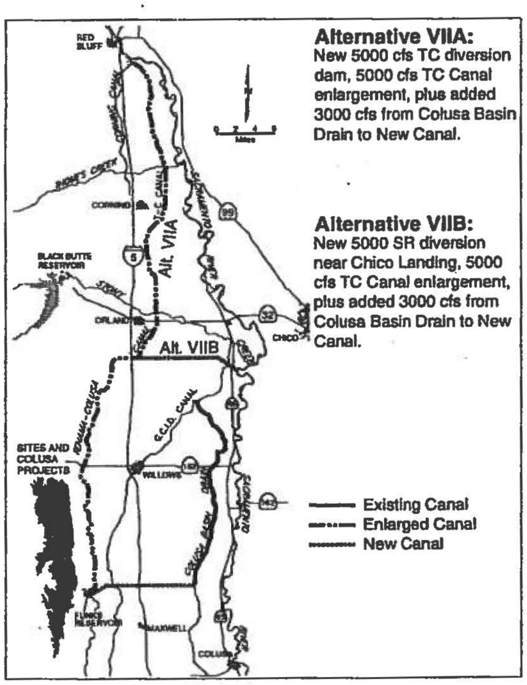
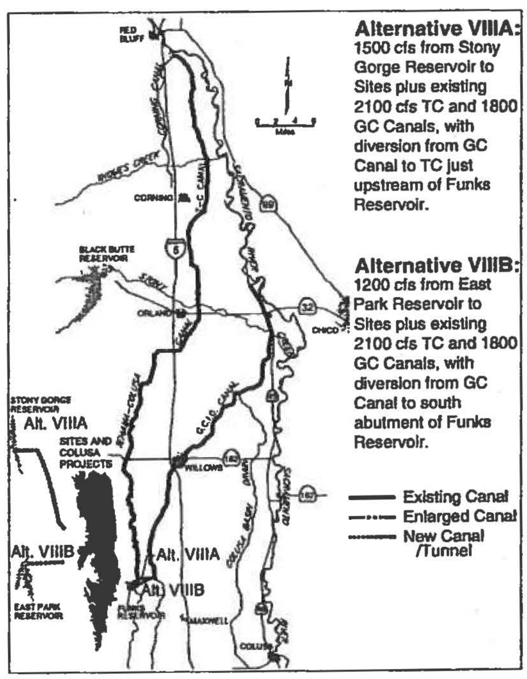


Figure 3.3. Sites Reservoir Conveyance Alternatives (continued)









For these two categories the following alternative operation modes were evaluated as summarized in Table 3.3.

- Minimal Seasonal Operation. No additional forebay storage beyond that in existing Funks Reservoir would be required for this operating option. It would simply pump water into the Sites Reservoir for storage on a 24-hour per day schedule as required during the winter and release water through Funks Reservoir for irrigation on the same continuous schedule during the summer. Pumping and generation would occur on a 24-hour basis regardless of hourly or daily power cost fluctuations. The average annual net power cost (cost of power consumed minus revenue from sale of power produced) resulting from this operation is estimated at around $723,000, or approximately $11.4 million in present worth net power cost over the life of the project (50 year period of analysis, 6 percent discount rate).

- Optimum Seasonal and Pumpback Operation combined. This option would require construction of a larger Funks or similar forebay (to around 6,000 acre-feet) and another pumping plant to raise water from the Tehama-Colusa Canal into the enlarged forebay. It would take advantage of pumpback opportunities whenever economically advantageous by pumping at night when power costs are lowest, and generating (by releasing reservoir water) during the day when power values are highest. After the project pumped or released the desired amount of water for seasonal operation, any remaining time could be used for full pumpback operation, where water is just transferred back and forth between Sites and Funks Reservoirs for the sole purpose of generating net power revenues. This would only be done when the difference between peak and off-peak power rates was large enough to more than offset the cost of power consumed by system inefficiencies and the operation, maintenance, and replacement costs. In other words, pumpback would only be implemented at times when substantial net revenues would be realized. The average net power revenue benefits which could result from this operation were estimated at around $2,481,000 per year or approximately $39 million over the life of the project.

Net revenues from pumpback operation must be balanced against major additional pumpback storage costs, which fall in the following categories: (1) constructing and maintaining a 6,000 acre-foot forebay; (2) constructing and maintaining an additional pumping plant to lift water from the Tehama-Colusa Canal to the new enlarged forebay; and (3) increased pumping/generating capacity, maintenance, and replacement. Although, we do not know the exact costs of these items, it will be substantial, possibly exceeding the $39 million present worth of pumpback storage power benefits. More work will be performed on this potential project feature as the OSI investigation continues. However, from this analysis it doesn't appear that pumpback storage offers a major advantage to a project whose overall cost will substantially exceed $1 billion. Therefore, pumpback power operations appears to be a relatively inconsequential factor in determining project feasibility, and may not be justified.

Table 3.3. Summary of Pumpback Operation Cost and Revenues
(Only pertains to water conveyed between Funks and Sites Reservoirs)

MINIMAL OPERATION (No Enlargement of Funks Reservoir)

		Annual Operation				
Mode of Operation	72 Year Period	Energy Consumption (1000 MWH)	Energy Production (1000 MWH)	Energy Cost ($1000)	Energy Revenue ($1000)	Revenue Minus Cost ($1000)
Seasonal	Max	350	261	8,991	6,331	-2,660
	Min	0	0	0	0	0
	Avg	107	75	2,657	1,925	-732

OPTIMIZED OPERATION (Enlargement of Funks Reservoir to around 6,000 acre feet)

Combined Seasonal pumpback	Max	800	625	15,032	18,363	3,331
	Min	223	167	3,771	4,861	1,090
	Avg	554	418	9,892	12,373	2,481

(a) The study this table summarizes was based upon assumption of a very efficient schedule with no environmental restrictions. This cannot be achieved in actual operation; therefore, this table represents the maximum power revenues potentially available.

(b) Costs of maintenance and wear on the units and replacement costs are considerable and may affect the decision to use pumpback operation when the onpeak/offpeak price differential is small.

Sites Reservoir Recreation

The recreation use potential of Sites Reservoir is substantial. Though limited somewhat by steep terrain and widely varying reservoir elevations. The nearby, but much smaller, Black Butte Reservoir received an average of 335,000 recreation user days annually since 1985. The potential at Sites Reservoir may be higher because of its larger size and proximity to population centers. There are several potential developable recreation areas around Sites Reservoir as shown in Figure ?(Not prepared yet.). These sites were identified in an initial recreation use study completed by DWR in July 1999 and documented in the report titled *Sites Reservoir-Recreation Requirements and Opportunities.*

Five major potential recreation areas around Sites Reservoir were identified in this study. They are described below:

- Stone Corral Recreation Area (225 acres) is located immediately north of Sites Dam. It could support approximately fifty campsites and possibly a two-lane boat ramp. Shoreline fishing would be good due to deep water and the area offers excellent views because of its higher elevation. A trail system and interpretive displays would be suitable.

- Saddle Dam Boat Ramp (600 acres) is located at the north end of the reservoir adjacent to several of the project saddle dams. This area is mildly sloping and suitable for boat ramp construction and associated parking. Also, this area would be readily accessible if the Maxwell-Lodoga Road was relocated around the north-end of the reservoir. Day-use facilities could be located on the slopes surrounding a boat ramp, but no campsites are proposed at this location due to its lack of vegetation and exposed character.

- Peninsula Hills Recreation Area (325 acres) is located on the west shore of Sites Reservoir on what would be a large peninsula. This area contains a series of small coves that would be excellent for fishing and hiking. It is suitable for a large campground of around 200 sites that could be completed in stages. There are two potential boat ramp locations. Access would be from the relocated Sites-Lodoga Road, but about 2 miles of additional new road would have to be constructed.

- Lurline Headwaters Recreation Area (200 acres) is located over the ridge forming the southeast shore of Sites Reservoir. It is characterized by an open meadow surrounded by oak grassland and steep hills overlook the reservoir. It could support both camping and day-use activities such as hiking to a nearby 1,282 foot high peak with outstanding views. Approximately 50 campsites, one or two group sites, and numerous picnic sites could be constructed on the 50 acres of relatively level land in this area. However, this area would not have vehicle access to the shoreline, or a boat ramp, because of the steep terrain. About two miles of rough existing road would need to be upgraded to access this area.

- Dunlap Island Boat-In Facilities (50 acres) could be located near the southwestern shore across form the Sites Townsite. This island would provide boaters a camping area near a secluded bay. Only enough suitable land exists to support construction of approximately a dozen primitive campsites with sanitation facilities, but with no treated water supply.

Other recreation features that could become a part of Sites Reservoir are:

- Sites Reservoir Loop Trail for hiking, biking, and equestrians extending around the reservoir and connecting all the shoreline recreation areas. Much of it would run along the crest of Logan ridge that provides outstanding views of the Sacramento Valley and surrounding mountain ranges.

- Fishing access points could be constructed at numerous locations along the relocated Sites-Lodoga Road.

- Pre-project fishing enhancement could be accomplished by stocking the numerous existing ponds in the reservoir area with brood-stock fish to accelerate development of a reservoir recreational fishery.

- A Stone Corral Creek coldwater fishery could be developed immediately below Sites Dam.

This estimate of recreation potential at Sites Reservoir is only adequate for comparative planning purposes. Considerable additional work would be required to bring it up to project feasibility level.

Colusa Project

The Department's interest in the Colusa Project began in the 1960s as part of a Klamath-Trinity River Development alternative conveyance system that would terminate at Colusa Reservoir. The November 1981 Bulletin 76-81 concluded that "data indicates that the incremental cost of storage at Colusa would be excessive in comparison to the storage costs of Sites Reservoir."

Colusa Reservoir, at the maximum water surface elevation of 520 feet, occupies all of the 14,000 acres immediately north of Sites Reservoir as shown on Figure ?. The Colusa Project adds 1.2 maf of storage to Sites, for a total of 3.0 maf. However, four more major dams along Logan's Ridge -- Prohibition, Owens, Hunters, Logan Dams -- and seven saddle dams are required to form the reservoir. There is approximately a four to one ratio between the dam volume of Colusa compared to Sites at the maximum 520 foot water surface elevation.

The Colusa Project, like Sites, would be filled by winter water, surplus to downstream needs from the Sacramento River and/or tributaries. Project appurtenances including inlet, outlet, spillway, pumping/generating plants, and forebay at Golden Gate Dam would be the same as for the Sites Project. However, with the larger Colusa Reservoir capacity, the size of most of these appurtenances would be increased proportionately. Considerable engineering and geologic work has been performed at Sites; Colusa is not as well defined and requires additional work to bring it up to an equivalent status. This work will be performed in the near future.

There are no major roads (state or county) and only one known permanent resident within the additional reservoir area required to form the Colusa Project. Also, the only known utilities are those that service the residents; therefore, the relocation of people and structures for Colusa will be essentially the same as for Sites. Colusa will flood a primary potential road relocation route for Sites. This will probably result in the Maxwell-Lodoga Road being located around the south end of Colusa Reservoir.

Alternative Sources of Water

Colusa at 3.0 maf can take advantage of a greater water supply and produce a larger yield than Sites at 1.8 maf. However, the potential sources of supply for Colusa are the same as that for Sites. Only the size of the diversion and conveyance system can be increased to expand the supply. Determination of the near optimum match between reservoir capacity and conveyance size is made by comparing water yields (from operation studies) with the estimated project costs to generate these yields. This sizing selection process will be emphasized toward the end of our investigation. More operation studies covering numerous sizing options and feasibility level cost estimates are needed to determine optimum project size. At this point in the investigation, the same alternative sources and sizes of water conveyances are under consideration for both the Sites and Colusa Projects. Continued project formulation studies will evaluate the optimum conveyance sizing compared to reservoir size.

Project Operation Studies

The results of the nine Colusa Project Operation Studies run to date are shown in Table ?. The 1922 through 1994 period average annual project yield estimated by studies ranged from 341 taf to 486 taf when any Sacramento River flows above 10,000 cfs could be diverted. These yields dropped to around 250 taf when a 60,000 cfs river trigger flow was required (river flow must reach 60,000 cfs each year before diversions can be made). For the 10,000 cfs river flow criteria the Colusa yields using identical conveyance systems range from 40 percent to 50 percent larger than Sites. This correlates reasonably with the fact that Colusa Reservoir is 66 percent larger than Sites. Additional operation studies will be run in the future for Colusa using a more refined model and more finely focused operational criteria.

Water Conveyance Alternatives

The potential Colusa Reservoir water conveyance alternatives are identical to those for Sites but the higher capacity options may be a better match for Colusa due to its larger capacity. Future operation studies and cost comparisons will further refine this understanding. Earlier studies of Colusa located the inlet/outlet and pumping/generating facilities at Logan Dam instead of Golden Gate Dam. This was done to shorten the conveyance system distance from the Tehama-Colusa and Glenn-Colusa Sacramento River diversions. However, for our comparative study to determine relative project feasibility, we have designated Golden Gate Dam as the water inlet/outlet location for both projects based on the following logic:

1. The two feeder canals are much closer together near Golden Gate and a connector canal between them would be less expensive to construct.

2. Golden Gate is a superior input location for water from the Colusa Basin Drain and the Sacramento River below Chico Landing because it would collect more water farther down the basin and the canal alignment would not pass through sensitive public waterfowl areas.

3. Considerably more study effort would be required to evaluate another inlet/outlet location and the probability that it would impact project feasibility is small.

4. If after further study the Colusa Project is determined to be superior to Sites, further consideration can be given to the relative merits of locating inflow/outflow facilities at Hunter instead of Golden Gate Dam.

Colusa Reservoir Recreation

Recreation Opportunities

Major recreational attributes of Newville Reservoir would include a large water surface that would be desirable for large motorboats, sailboats, and houseboats. The west shore islands would attract boat anglers and boat-in campers and would provide ideal houseboat anchorages. A hiking and riding trail would follow the crest Rocky Ridge along the eastern shore of the reservoir and offer attractive vistas and secluded fishing spots. Boat-in, hike-in, or ride-in camps on the west-shore could provide access to the reservoir or the backcountry of the Mendocino National Forest.

Fourteen recreation sites were identified around the reservoir that could accommodate up to 13 boat ramp lanes, 150 to 200 picnic sites, over 100 camp sites, over 1 mile of beach, and 5 to 10 miles of trail. If these areas are developed, they could support 500,000 to 1,000,000 recreation days annually, a typical level of use for this size project.

Thomes-Newville Project

The Thomes-Newville Project would include a 1.9 to 3.0 maf offstream reservoir located on the North Fork of Stony Creek. It is about 17 miles west of Orland and 6 miles upstream of existing Black Butte Reservoir. The water supply for this project could come from Stony Creek, Thomes Creek, and possibly the Sacramento River. The Thomes-Newville Project received extensive study by DWR from 1976 through 1982 and amajor department document titled *Thomes-Newville and Glenn Reservoir Plans Engineering Feasibility* reported on this work. The long and interesting history of water project planning in the Stony and Thomes Creek basins is summarized in Appendix F of this report. The current Offstream Storage Investigation is using this past work as a basis, but is incorporating substantial changes in water project planning criteria that have occurred since then. Because of the large amount of past engineering studies at this site and our concentration to date with investigation of the Sites and Colusa Projects, most Thomes-Newville Project information is based on historic work.

The basic components of the Thomes-Newville Project are: (1) a 300-foot to 400-foot Newville Dam at the historic Newville Townsite; (2) an 80-foot to 180-foot high saddle dam at Burrows Gap; (3) a southern saddle dam at Chrome for normal water surface elevations greater than 920 feet; (4) a pumped diversion and conveyance system from Black Butte Reservoir; 5) a small diversion dam and gravity diversion from Thomes Creek; and 6) a pumped diversion and conveyance system from the Tehama-Colusa and/or Glenn-Colusa Canals if needed for larger reservoir sizes.

In addition, several low saddle dams may need to be constructed along Rocky Ridge, the eastern boundary of the reservoir, depending on the selected reservoir elevation. The road through the reservoir to Paskenta, Round Valley, and Elk Creek would be rerouted around the eastern and northern boundary of the reservoir.

From a topographic perspective, Newville Reservoir is very efficient. It requires a relatively small volume of dam embankment material per unit of water stored (8 yd^3/af at 2 maf storage level). Also, the reservoir bottom is relatively wide, long, and flat so that the reservoir area only increases around 20 percent (14,000 to 17,000 acres) between the capacities of 1.8 and 3.0 maf. In comparison, the Colusa Project at 3 maf capacity occupies 28,000 acres, or 65 percent more area.

The main challenges of the Thomes-Newville Project are providing an adequate water supply from nearby streams and mitigating for environmental impacts which have not all been evaluated yet.

Alternative Reservoir Capacities

The most recent (1980) DWR Report on the Thomes-Newville Project examined three sizes: 1.4 maf at normal water surface elevation of 868 feet to 1.7 maf normal water surface elevation of 887 feet, and 1.9 maf at normal water surface elevation of 905 feet. For the CALFED Offstream Storage Investigation, a reservoir size up to 3 maf, is also included. Such a reservoir size analysis is based on studies performed by DWR around 1966. A 3.0 maf Newville Reservoir would be created at a normal water surface elevation of 975 feet. These older studies will be updated and modified in the future along with feasibility level engineering analysis at the Sites Project.

The primary sources of water for a Thomes-Newville Project up to 2 maf capacity are Stony Creek at Black Butte Reservoir, and Thomes Creek above Paskenta. For a reservoir size above 2 maf, additional water from the Sacramento River would be needed to fill the reservoir in a reasonable period (less than 10 years).

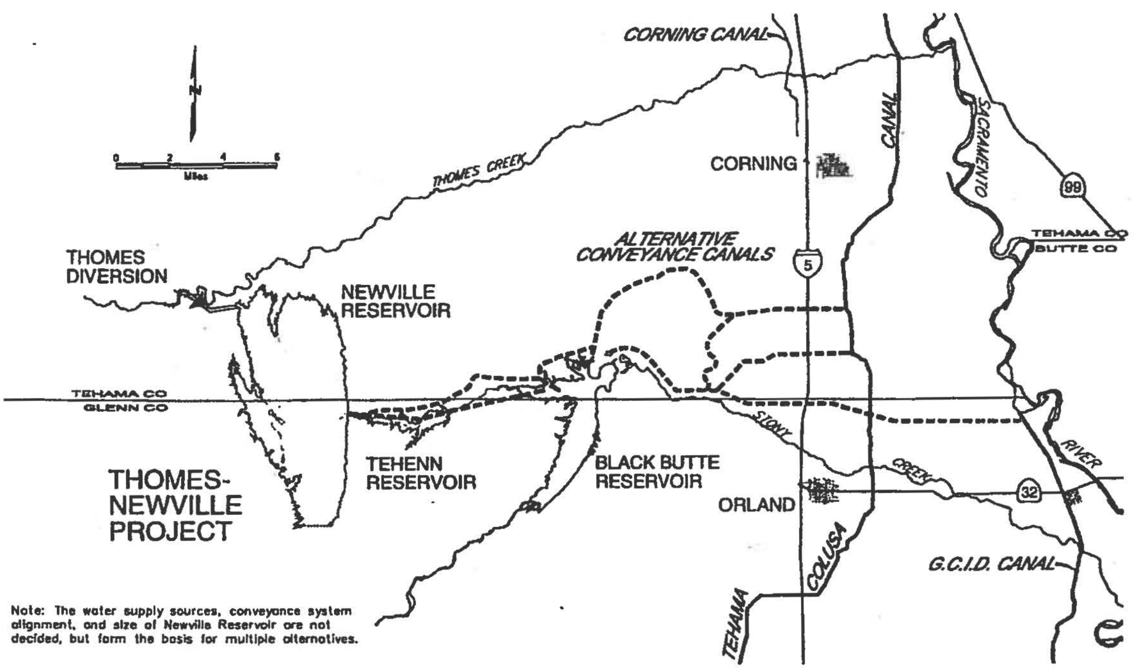
Diversions from Stony and Thomes Creek for reservoir sizes less than 2 maf are evaluated in the 1980 Engineering Feasibility Report. Stony Creek water from Black Butte Reservoir would be conveyed westward via an excavated deepening of the channel of North Fork Stony Creek and pumped into a small reservoir named Tehenn. This small dam and reservoir was planned for location on the North Fork about midway between Black Butte Reservoir and Newville Dam site. The 32,500-af Tehenn Reservoir at elevation 610 feet. would be formed by a small dam 112 feet high and 2,500 feet long. Because this reservoir would flood a cemetery of historic importance, future studies will evaluate other conveyance alternatives.

Three potential diversion dams on Thomes Creek to convey water through the low divide to Newville Reservoir have been investigated in studies around 1980. Because the lower two dams were higher and flooded more land critical to local deer herds, the uppermost and lowest dam was considered most desirable. Also, a low dam is easier to pass migrating fish around. Therefore, the dam site farthest upstream is still the favored alternative, but it will have to be redesigned to include a fish ladder and screen. We are not sure at this time how effective or expensive the redesigned diversion will be, but fishery issues do have the potential to create a significant problem at this diversion. After diversion, the Thomes Creek water (minus required instream flows) would be conveyed to Newville Reservoir via a two and one-half mile canal.

If additional water is needed due to larger reservoir sizes or an inability to divert water from Thomes Creek, it could be obtained from the Sacramento River by diverting from Tehama-Colusa and/or Glenn-Colusa Canals. This water could be conveyed via new facilities, shown on Figure 3-4. Periodic lift pumps would be required. Several alternative conveyance system alignments have been investigated at an initial level and the results are contained in the report titled *Sites Reservoir Conveyance Study.* Considerable additional design and cost estimating work needs to be done on the Thomes-Newville Project before a reliable cost estimate is developed.

The estimated amounts of water available from Stony Creek, Thomes Creek, and the Sacramento River for various conveyance capabilities derived from our hydrology report is shown in Figure ?. The sizing of these conveyances has not been determined yet.

Figure 3.4. Thomes-Newville Project Alternatives



Operation Studies

To date, a total of six operation studies have been run for Newville Reservoir, three at the 1.9 maf size and three at the 3.0 maf size as shown on Table 3.1. The average annual new water supply of these projects for the 1922 through 1994 period ranges from 195 taf to 307 taf for the 1.9 maf size, and 353 taf to 464 taf for the 3.0 maf size. Many more operation studies will have to be run in the future as project sizing and conveyance features become more defined. For the present, these operation studies indicate that the Thomes-Newville Project has roughly the same new water supply capability as comparable sizes of the Sites and Colusa Projects.

The operation of Thomes-Newville would be very similar to that of Sites and Colusa, in that winter water surplus to needs and rights in the watershed would be diverted and stored for release mainly during the irrigation season. The water released would be used entirely within the Colusa Basin in exchange for Sacramento River water that would otherwise have been diverted to serve this area. This river exchange water would remain as storage in Lake Shasta until released on a schedule designed to serve a combination of urban, environmental, and agricultural purposes.

Red Bank Project

The Red Bank Project would be located on the South Fork of Cottonwood Creek and on Red Bank Creek approximately 20 miles west of Red Bluff. This project would be formed by two main dams, Dippingvat on Cottonwood Creek and Schoenfield on Red Bank Creek, and two saddle dams, Lanyan and Bluedoor, on small tributaries of Red Bank Creek. The saddle dams facilitate conveyance of water from Cottonwood Creek to Schoenfield Reservoir.

With a total storage of 350 taf, the Red Bank Project is by far the smallest of four alternatives evaluated. Its main advantage is its capability to supply water directly to the entrance to the Tehama-Colusa Canal in lieu of diverting this water from the Sacramento River. This capability could allow the Red Bluff Diversion Dam gates to be raised for a longer period; thus further reducing the dam's effect on the Fishery.

The Red Bank Project was investigated by DWR in the late 1980s through the early 1990s and is documented in several DWR reports. The Red Bank Project is not a typical offstream storage project, in that one of the two major dams blocks access to approximately 132 mi^2 of South Fork Cottonwood Creek watershed which contains substantial anadromous fishery habitat. Also, cost of the project steadily increased as the study progressed and the water supply decreased as downstream fishery flow needs were identified.

We recently investigated the possibility of lowering and modifying Dippingvat Dam to allow fish passage above it, but our cursory evaluation indicated that this would increase cost and decrease yield without ensuring unhindered fish passage. Even though the size and cost of Dippingvat Dam would be reduced, savings would likely be more than offset by greater conveyance system costs, the addition of fish ladder and screen construction, and the large reduction in reservoir capacity linked to flood control and water supply benefits.

Because of the Red Bank Project's relatively recent evaluations, small size, and potential for adverse fishery impacts little additional engineering work on this project has been conducted. At this point, it seems likely that CALFED may defer additional work on this project in favor of emphasis on the Sites, Thomes-Newville, and Colusa Projects. However, an extensive inventory of environmental resources is being completed which will determine the environmental feasibility of this project.

Alternative Sources of Water

Unlike the other three alternative projects, the Red Bank Project's only sources of water are the watersheds above the two main dams. Over 70 percent of the 135 taf/yr average annual water supply comes from South Fork Cottonwood Creek, and most of the remainder comes from Red Bank Creek. In contrast, around 70 percent of the reservoir storage would be located in Schoenfield Reservoir on Red Bank Creek. Therefore, South Fork Cottonwood Creek provides the main water supply, and Red Bank Creek provides the main storage area. No water would be conveyed from any other sources, including the Sacramento River.

Operation Studies

We have not run any new operation studies for the Red Bank Project during this study because similar studies were performed in 1993. The 1993 study was for a stand-alone project not coordinated with other existing water supply projects. A coordinated study should be performed at a later date if the project survives future screening analysis. Instream fishery flow needs in South Fork Cottonwood Creek ranging from 30 cfs in the summer to 60 cfs in the winter with a couple of 120 cfs flushing flows of eight days duration each were incorporated into the study. A 70 taf flood control reservation in Dippingvat Reservoir was also included. The firm new water supply for an agricultural demand schedule estimated by this operation study is 43 taf/yr. This yield estimate could change considerably if different assumptions were made concerning fish releases, flood control reservation, water demand schedule, or other project criteria. No water from this project would be released directly to the Sacramento River because of concerns over the impacts of its warm summer temperature.

One potentially significant issue that past studies have not addressed is percolation to groundwater along 16 miles of Red Bank Creek if water is released from Schoenfield Reservoir to the Tehama-Colusa Canal via this channel. This factor should be addressed if this project is considered in the future.

Recreation Opportunities

The recreation potential at Schoenfield Reservoir is much greater than at Dippingvat due to the flatter terrain around the reservoir and the less severe drawdowns required for flood control. Schoenfield Reservoir could be developed for fishing, camping, picnicking, boating, hiking and hunting. Earlier estimates indicated that the entire Red Bank Project has the potential to provide an average of around 100,000 recreation days annually.

Project Formulation

Project formulation is a critical component of surface water storage investigations. The objective of project formulation is to formulate a project which 1) will have least environmental impacts, and 2) will optimize the project benefits by selecting the most feasible location, size, and configuration for the various project features such as storage, conveyance, and diversion structures. Many combinations of these separate facilities are possible but the cost effectiveness of different configurations varies widely.

At its heart, the project formulation process is technically rigorous and requires the analysis of numerous options. However, in practice the complexity of the process is reduced by making simplifying assumptions and developing reasonable criteria, and by the limitation of practical realities. Some of these potentially limiting factors include environmental considerations, hydrology and water supply availability, water demand projections, projected power demands and costs, and the level of development in and around the project. Evaluating these and other factors requires as much art (subjective analysis) as science and therefore, the process may rely on existing project operations, and experiences. For example, many reservoirs have different operating rules applied to them over their life. The trend today is to operate most major water projects as a unit (together) in order to maximize total combined water supply benefits; whereas, in most cases, they were planned using a stand-alone operating strategy. This tendency for water management operations of reservoirs to change over time is now considered beneficial and is considered adaptive management. It is a strong motivator for building maximum flexibility into current project formulations. Our project formulation studies attempt to combine engineering possibilities with cost and financial considerations, biologic impacts (environmental), and public acceptability.

The first step in project formulation is to identify reservoir site alternatives, water supply sources, and possible conveyance facilities. Alternatives not practicable or environmentally not promising are then screened out. The next step of the project formulation is to perform a series of initial project operation studies for remaining alternatives. These operation studies estimate the relative level of water supply (sometimes called yield) that could result from construction of various sized reservoirs, water conveyance systems, and water supply sources for various project alternatives. After feasibility-level cost estimates are made, formulation studies combining various sizes of reservoirs and water systems in comparison to their costs will be made. Also, opportunities for maximizing power revenues will be explored in greater detail. Increasingly refined project formulation studies will continue to be performed throughout the entire duration of these studies.

At this point in the study, the project formulation analysis for this project has just begun and much work remains to be done on two levels. First the project formulation of all four alternatives must be refined concurrently until a preferred alternative is identified and approved. Then the preferred alternative must be evaluated at a higher level to optimize its reservoir size and conveyance capacities size and configuration in order to reduce the cost per unit (af) of water as much as possible. This requires that many additional iterative operation studies be run to "test" each revised project formulation for its new water supply for comparison to the reformulated project cost. Essentially, this process continues throughout the entire study period until the final feasibility-level report on the preferred project is finalized.

Chapter 4. Geology and Geotechnical Studies

Regional Geology

The four proposed projects are in the western foothills along the edge of the Sacramento Valley. The rocks underlying the dam sites are part of the Great Valley geologic province, mostly sandstone, mudstone, and conglomerate. The Great Valley geologic province is bounded to the west by the Coast Ranges province, to the north by the Klamath Mountains province, to the northeast by the Cascade Range province, and to the east by the Sierra Nevada province.

Along the west side of the Sacramento Valley, rocks of the Great Valley province include Upper Jurassic to Cretaceous marine sedimentary rocks of the Great Valley sequence, fluvial deposits of the Tertiary Tehama Formation, Quaternary Red Bluff, Quaternary terrace deposits, and Recent alluvium.

Rocks of the Great Valley Sequence form a series of northwest-trending, east-dipping ridges of sandstone and conglomerate separated by valleys underlain by siltstone and mudstone. Notches in the sandstone and conglomerate ridges formed by seasonal creeks, called water gaps, form the dam sites for all four proposed projects.

The mudstones of the GVS are typically dark gray to black. In general, the mudstones are thinly laminated and have closely spaced and pervasive joints. When fresh, the mudstones are hard, but exposed units weather and slake readily. Mudstones generally underlay the valleys because of the stone's minimal resistance to weathering and erosion.

Sandstones are light green to gray. Sandstone beds range from thinly laminated to massive. In many places, the sandstones are interlayered with beds of conglomerates, siltstones, and mudstones. Massive sandstones are indurated and hard with widely-spaced joints, forming the backbone of most of the ridges.

The conglomerates are closely associated with the massive sandstones and consist of lenticular and discontinuous beds varying in thickness from a few feet to more than 100 feet. Conglomerate clasts range in size from pebbles to boulders and are composed primarily of chert, volcanic rocks, granitic rocks, and sandstones set in a matrix of cemented sand and clay. The conglomerates are similar to the sandstones in hardness and jointing.

Tertiary and Quaternary fluvial sedimentary deposits unconformably overlie the GVS. The Pliocene Tehama Formation is the oldest. It is derived from erosion of the Coast Ranges and Klamath Mountains and consists of pale green to tan, semi-consolidated silt, clay, sand, and gravel. The Nomlaki tuff member occurs near the bottom of the Tehama Formation and has been age-dated at about 3.3 million years. The Nomlaki is a slightly pink to gray pumice outcropping and a single massive bed about 30 feet thick. Along the western margin of the valley, the Tehama Formation is generally thin, discontinuous, and deeply weathered.

The Quaternary Red Bluff Formation consists of reddish, poorly sorted gravel with thin interbeds of reddish clay. The Red Bluff Formation is a broad relatively flat deposit that covered much of the Tehama Formation between 0.45 and 1.0 million years ago. Thickness varies up to about 30 feet. The surface of the Red Bluff Formation is an excellent datum to assess Pleistocene deformation because of its original widespread occurrence and low relief. Red Bluff Formation outcrops occur just east of the dam sites.

The terrace deposits form flat benches adjacent to and above the active stream channel. Nine different stream terrace levels have been identified. Terrace deposits consist of several to 10 feet of clay, silt, and sand overlying a basal layer of coarser alluvium containing sand, gravel, cobbles, and boulders. Four terrace levels have been given formational names by the U.S. Geological Survey (Helley and Harwood 1985): the Upper Modesto, Lower Modesto, Upper Riverbank, and Lower Riverbank. These levels range in age from 10,000 to several hundred thousand years old. Terrace deposits may be used for the impervious core and random fill for the embankment of the proposed dams.

Terrace deposits are also valuable for evaluating the age and activity of faults that trend across them. A number of investigators have applied different types of age dating techniques, together with geomorphic analysis, to date and correlate terrace deposits. Lack of evidence of faulting across the terrace deposits constrains the time of last movement.

Recent alluvium is a loose sedimentary deposit of clay, silt, sand, gravel, and boulders. Deposits include landslides, colluvium, stream channel deposits, floodplain deposits, and terrace deposits. Recent alluvium is the major source of construction materials.

Colluvium, or slope wash, consisting mostly of soil and rock occurs at the face and base of a hill. Landslide deposits are similar, but are more defined and generally deeper. Landslides occur along the reservoir rim, but are generally small, shallow debris slides or debris flows. These deposits may be incorporated as random fill in dam construction.

Stream channel deposits generally consist of sand and gravel. Construction material uses include concrete aggregate, filters, and drains. Floodplain deposits are finer grained and consist of clay and silt. Floodplain deposits may be used for the impervious core of a dam and for random fill.

Faulting and Seismicity

Recent work by numerous researchers indicates that an active tectonic boundary between the Sierra Nevadan basement and the Coast Ranges lies buried beneath the entire western edge of the Great Central Valley from Bakersfield to Red Bluff. This system of faults is generally referred to as the Great Valley thrust fault system or the Great Valley fault. The boundary is not a line but a complex geologic region, and the exact location of this fault in the study area is not known.

Activity along this complex zone is characterized by a number of types of faulting, and is considered to be the source of the two 1892 Winters-Vacaville earthquakes (magnitude 6-7), and the 1983 Coalinga earthquake (magnitude 6.7). Many small to moderate earthquakes have also occurred along the full length of the boundary. These include a magnitude 5.8 in 1866 and a magnitude 5.9 in 1881 west of Modesto, and a magnitude 6.0 in 1889 near Antioch. The deeper faulting manifests itself on the surface as low hills on the west side of the valley like Corning and Dunnigan Hills.

Since no definitive surface faulting exists, the analysis of microseismic data becomes an important tool to define the extent of the fault and its seismic potential. Wong et al. (1988) believes that a magnitude 7 earthquake could possibly occur anywhere along the boundary.

The Working Group on Northern California Earthquake Potential and other workers have divided the Great Valley fault into about 14 segments that act independently of each other. The segments of interest to this study are designated by the working group as GV01, with the source near the Salt Lake fault and Sites anticline, and GV02 outside the project area to the south, centered on the Cortina thrust (USGS 1996). GV01 has been assigned a magnitude of 6.7 with a recurrence interval of 8,300 years and a slip rate of 0.1 mm per year.

In the Phase I Fault and Seismic Hazards Investigation (Appendix O), DWR concluded that the design earthquake was a maximum credible earthquake of magnitude 7.0 occurring directly under the Sites, Golden Gate, Hunters, Logan, or Newville Dam sites at a depth of about 6 miles on the Great Valley Fault. This earthquake would have a duration of about 26 seconds, a peak horizontal acceleration of 0.7 gravity, and a period of 0.32 seconds. We believe this to be a conservative estimate. The earthquake data on the four projects are shown in Table 4.1.

Earth Sciences Associates (1980) concluded that all the faults near the Thomes-Newville Project's principal engineering structures are pre-Quaternary in age (over 1 million years old) and surface offsets need not be considered in project feasibility studies. We will revisit this conclusion during our Phase II Fault and Seismic investigation.

The Salt Lake fault is believed to be a surface feature related to the Great Valley fault. It begins near the town of Sites, trends within a mile or two of the Sites, Colusa, and Thomes-Newville Dam sites, and appears to terminate in the general area east of Newville. It is also possible that the edge of the subducting Gorda plate underlies the Newville area. Table 4.1 shows the seismic parameters, except for the Gorda plate at Newville that has not yet been evaluated.

Table 4.1. Draft Preliminary Design Parameters for the Proposed Projects.

Project	Maximum Credible Earthquake (Mw)	Distance (km)	Depth (km)	Peak Acceleration (g)	Duration (seconds)	Period (seconds)
Sites and Colusa	7.0	0	10	0.70	26	0.32
Thomes-Newville	7.0	0	10	0.70	26	0.32
Red Bank	8.3	0	35	0.72	28.5	0.42

Note- Preliminary design parameters subject to change as new information becomes available.

The Salt Lake fault follows the axis of the Sites anticline on the west side of Logan Ridge. The anticline and the Fruto syncline to the west extend at least 40 miles and possibly farther. The Salt Lake fault is believed to be a near vertical fault that developed adjacent to the axis of the anticline (DWR 1978). Salt water springs, gas seeps, and sag ponds on the fault trace suggest the possibility of recent fault activity. In several locations, however, the fault is concealed in a few places by unbroken Pliocene Tehama Formation, suggesting that the latest movement occurred prior to deposition of the Tehama Formation (3.3 million years ago) (USBR 1969) in these areas.

William Lettis and Associates are currently working on the Phase II investigation, which includes trenching and detailed seismic analysis of the dam sites. Their results are preliminary and incomplete at this time. They found that the faults are typically expressed within bedrock as well-defined, narrow (2 to 5 feet wide) zones of moderately to highly fractured rock with less than 1 to 2 feet of fault gouge.

The Quaternary stream, terrace, and slope deposits provide preliminary constraints on the activity of the faults. Detailed soil profiles in the trenches suggest that deposits within all trenches are roughly correlative and probably early Holocene to latest Pleistocene in age (8,000 to 15,000 years old). No surface rupturing events have occurred on these faults during this time. scientists continue to look for deposits that have been disturbed by faulting. This will help determine the actual age of last fault movement.

Sites Project

Both DWR and the U.S. Bureau of Reclamation have conducted geologic studies for Golden Gate and Sites Dam sites. Geologic data gathered to date suggest that the foundation is adequate for the proposed structures. The majority of the construction material is readily available locally, but riprap, filter, transition, and concrete aggregate may have to be brought in from distances exceeding 50 miles. Open joints on the abutments will require more grouting and foundation preparation work.

Golden Gate Dam Site Geotechnical Studies and Findings

There are three proposed axial alignments for Golden Gate Dam. These are the upstream straight alignment, the downstream curved alignment, and the downstream straight alignment.

Bedrock

The Golden Gate Dam site consists of northwest trending and steeply northeast dipping interbedded sandstone and mudstone of the Boxer and Cortina formations. The overall composition is about 70 percent sandstone and 30 percent mudstone.

Rock Strength

USBR and DWR (Appendix Q) have measured compressive strengths of foundation rocks. Compressive strengths of the sandstone and conglomerate generally range from 9,000 to 12,000 pounds per square inch. The mudstone generally varies from 3,000 to 6,000 psi. However, these samples are not fractured or jointed. Overall strength of the foundation rock will vary depending on the amount of jointing, fracturing, and faulting. For comparison purposes, general purpose concrete has compressive strengths from 3,000 to 5,000 psi.

Surficial Deposits

Quaternary to Recent deposits include colluvium, alluvium, landslide, and terrace. Stream gravel deposits are minor and range in thickness to about 5 feet. Colluvium typically ranges from 5 feet to about 15 feet at the base of slopes. Several landslides have occurred; one small recent one on the right abutment and a larger older deposit on the left abutment. Terrace deposits are the most extensive, mostly Upper Modesto and possibly Lower Riverbank Formations. These average 15 to 20 feet thick, but may reach a thickness in excess of 25 feet. The composition is variable, but generally consists of an upper layer of silt and soil, and a thin lower layer of clayey gravel and cobbles.

Structure

Several faults cross the foundation area. Faults GG-1 and GG-2 were mapped by Brown and Rich (1961). GG-2 extends from the right abutment, crosses the channel slightly upstream of the axis, crosses the left abutment, and then extends an additional 2 miles in a northwest direction before it ends or is lost in the mudstones to the east. Apparent right lateral displacement is estimated to be in the range of 0.3 miles

Fault GG-1 is much smaller and extends across the left abutment of the upper dam site, then trends northeast and misses the left abutment of the lower dam site foundation by about one-fourth mile. Apparent right lateral displacement is estimated to be about 50 feet.

GG-3 was also mapped by Brown and Rich (1961). It is parallel to GG-2 but about 4,000 feet farther to the south.

William Lettis and Associates, the Phase II contractor, dug trenches across all three faults and found no evidence of faulting within the surficial deposits.

The Salt Lake fault is less than 1 mile to the west. Although the fault is considered potentially active at this time, it does not cross the dam foundation. We believe that the fault is a surface expression of the deep-seated Great Valley fault.

Exploration

USBR drilled and water pressure tested three diamond core drill holes at the upstream straight alignment and one hole at their powerhouse location. DWR drilled an additional four diamond core holes and three auger holes at the downstream straight alignment. Three of the core holes were along the axis and the fourth was an angle hole in the channel oriented to intercept fault GG-2. Seven seismic refraction lines were surveyed at the dam site and outlet structure, totaling 1,000 feet in length. William Lettis and Associates excavated three trenches across fault GG-1, three trenches across GG-2, and two trenches and three test pits across GG-3.

At the Golden Gate outlet facilities, two diamond core holes were drilled along the tunnel alignment, one hole each along both proposed spillway alignments, and one hole at the pumping plant location.

Three shallow (up to 34 feet) auger holes were completed along the canal alignment from Funks Reservoir and the pumping plant. In addition, eight auger holes were completed to facilitate trench locations for the regional fault investigations.

Permeability and Grouting Requirements

Preliminary analysis of the water pressure test data indicates that grout takes should be mostly low to moderate, with some areas of high take. Abutment holes at the Golden Gate Dam site reveal moderate to high permeabilities averaging 0.26 feet per day, with higher values and grouting requirements on the right abutment. Channel hole permeabilities are lower, averaging 0.15 feet per day.

Foundation Preparation, Clearing, and Stripping

Both abutments and the channel are covered by grass with no brush or trees and require no clearing. The upper 22 feet of alluvium and terrace deposits in the channel should be easily stripped using common methods. An additional 7 to 20 feet of weathered bedrock may need to be blasted and removed.

The upper 5 feet of soil, colluvium, and intensely weathered bedrock on both abutments may be stripped using common methods. Another 20 feet of moderately to slightly weathered bedrock may need to be blasted and removed.

Construction Materials

Construction materials required for Golden Gate Dam are similar to Sites and more information can be found in Appendix P. Impervious core material is available in terrace deposits within 1 mile of the dam site. Excavation for the spillway, powerhouse, and canal will provide much of the required random fill and rock fill. Additional material is available directly upstream or downstream, depending on which dam alignment is selected. Concrete aggregate, riprap, and filter material sources are the same as for Sites.

Sites Dam Site Geotechnical Studies and Findings--Foundation Conditions

There is basically one dam alignment for Sites Dam. It is the same alignment as the one USBR chose. The only difference is that the embankment would be higher.

Bedrock

Sites Dam site was mapped by both USBR and by DWR. The foundation consists of steeply northeasterly-dipping interbedded sandstones and mudstones of the Upper Cretaceous Boxer and Cortina Formations. Overall, the Sites Dam site area consists of about 45 percent sandstone and 55 percent mudstone, mostly interlayered in beds typically ranging from less than 1 inch to tens of feet.

Surficial Deposits

Quaternary to Recent deposits include colluvium, alluvium, terrace deposits, and landslide deposits. Minor alluvium consisting mostly of sand and gravel occurs in the stream channel. Terrace deposits are the most abundant, occurring both above and below the dam axis. The terrace deposits typically range in depth from 15 to 30 feet and consists mostly of silt, sand, and clay. Colluvium averages about 5 feet on the abutments but may reach depths of 15 feet at the base of the slope. Several small landslides occur on the left abutment and a larger slide occurs on the right abutment. This landslide deposit is probably about 30 feet thick at the base but thinner at the top. It is approximately 200 feet high and 75 feet wide at the base.

Structure

Possible faults at the Sites Project include Lineament S-1 and Fault S-2. S-2 was mapped by Brown and Rich (1961) and extends from near the vicinity of the town of Sites. Then it trends northeast through the right abutment, crosses the channel near the axis, and extends downstream on the left abutment. The fault is about 5 miles long.

The fault was trenched this fall. The trenches showed no disturbance in the overlying alluvial deposits. The age of the alluvial deposits is presently unknown, but is believed to be 8,000 to 15,000 years old.

Lineament S-1 was not mapped by Brown and Rich (1961) or by the USBR (1969). It is a lineament, or suspected fault, that crosses the left abutment, then the channel near the axis, and trends to the southeast across the right abutment. Drill hole LC-3 intersected gouge and fractured rock believed to be associated with a fault. There is a possibility that the lineament is a southward extension of the Salt Lake fault, which is shown by Brown and Rich (1961) to terminate about 2 miles north of the dam site. The presence of this possibly active fault near Sites Dam site is a concern, and will therefore be considered further in the Phase II field investigation.

Bedding of the bedrock units trend approximately north-south and dip 50 to 60 degrees to the east. Joints generally trend parallel and perpendicular to the bedding. Both joint sets are of concern on the abutments because of a tendency for the joints to open where streams cross the ridge. This may result in deeper stripping and more grouting.

Exploration

The USBR investigated Sites Dam site in the 1960s and the 1980s and drilled three diamond core holes in the foundation. DWR has recently completed mapping, trenching, auger drilling, diamond core drilling, and geophysical surveys. Four holes totaling 740 feet were drilled during the summer of 1998. Two diamond core drill holes, LC-1 and LC-3, were drilled in the channel to intercept a northeast-trending fault. Two additional holes, LC-2 and LC-4, were drilled to intercept a north-northwest trending lineament. Two of the four holes were water pressure tested. Three auger holes, totaling 41 feet, were drilled to estimate depth to bedrock. William Lettis and Associates excavated three trenches across Fault S-2, several miles northeast of the dam site.

Permeability and Grouting Requirements

Preliminary analysis of water pressure test data indicates that grout takes should be mostly low to moderate, with some high. The average permeability of the four channel holes is a relatively low 0.15 feet per day. USBR drilled the abutments in 1976. Review of their data shows that the left abutment has an overall average permeability of 0.541 feet per day. The right abutment has a higher average permeability of 1.29 feet per day, possibly due to the fault crossing the right abutment. Grouting analysis was not performed, but it would most likely be moderate to high.

Foundation Preparation

The channel section has a sparsely vegetated riparian zone with scattered fig trees, willows, cottonwoods, and other species. Vegetation is mostly grass with a few blue oaks on the left abutment. The right abutment is mostly blue oaks and grass. The tree density is light except for colluvial and landslide deposits near the base of slopes.

The upper 15 feet of alluvium and terrace deposits in the channel area can be removed by common methods. An additional 3 to 10 feet of weathered bedrock may need to be blasted and removed. Soil, loose boulders, and weathered bedrock may be removed by common methods on the abutments to depths ranging from 1 foot to 10 feet. Landslides and colluvium at the base of the slopes probably range in thickness from a few feet up to 30 feet. These deposits must also be removed prior to construction. An additional 10 to 15 feet of weathered to moderately weathered and fractured bedrock will probably have to be removed by blasting.

Construction Material

Construction materials for the proposed embankment dam include impervious fill for the core, random or rock fill for the shell with riprap at the surface, filter and drain material, and aggregate for concrete structures. Construction materials for Sites Dam are described in Appendix P.

The sources of the impervious core material are terraces along Antelope and Stone Corral Creeks. The field classification of this material is silty clay to clayey silt with a slight amount of gravel in the stream channel, and it appears to be suitable for the impervious fill zone. In spring 1998, terrace samples were collected and analyzed at seven different locations where the terrace is exposed in the stream bank of Funks and Stone Corral Creeks. Fifteen test pits were dug into the various terrace deposits in the Sites Reservoir area during the second week of June 1999. Generally, three samples were collected from each test pit for future laboratory analysis.

Rockfill and random fill will be mined from the existing Sites quarry in the Venado sandstone downstream of the dam site and the terrace deposits. Material stripped from the foundation can be re-used in this zone.

Preliminary indications are that the crushed quarried rock would probably not be suitable for the filter and drain material because of a lack of durability. During spring 1998, Bryte Laboratory analyzed 10 3-inch cube samples of the quarry rock. During March 1999, approximately 5 cu. yds. each of the weathered and unweathered sandstone were crushed and taken to the Bryte Laboratory for further testing. During May 1999, 10 rock cores each of the weathered and unweathered sandstone from the

Sites quarry were collected and analyzed. The most likely replacement source would be commercial gravel pits near Willows and Orland.

Crushed quarried sandstone also may not be suitable for use as concrete aggregate. The commercial gravel pits near Willows and Orland would also be a source for concrete aggregate.

Quarried sandstone has been considered marginal for the use as rock riprap on the dam shell. Riprap is available on the east side of the Sacramento Valley near Deer Creek, a distance of about 70 miles.

Sites Saddle Dam Sites Geotechnical Studies and Findings

The proposed DWR alignment closely follows the earlier USBR alignment and consists of nine separate saddle dams at reservoir elevation 520 feet (SSD-1 through SSD-9). The saddle dam sites have been mapped by USBR and DWR.

Bedrock

The Boxer Formation, at the saddle dams' sites, consists mostly of mudstone with some interbedded sandstone and conglomerate. SSD-1 is underlain by mostly mudstone. SSD-2 is underlain by the Salt Lake fault, an 1,800 foot-wide zone of fractured, folded, and faulted mudstone with interbedded sandstone. The SSD-3 saddle area is underlain by stream alluvium and colluvium in the channel area, and Boxer on the abutments. SSD-4,-5,-7,-8, and –9 are all underlain by mudstone with some interbedded sandstone. SSD-6 is underlain by conglomerate.

The rock strengths of these units are described under the Sites Dam site description. It is expected that the rock strength within the Salt Lake fault zone will be considerably less.

Surficial Deposits

Surficial deposits consist of stream channel alluvium and terrace deposits, mostly at SSD-3. Colluvium covers the slopes and collects at the slope base.

Structure

The upturned Upper Cretaceous sedimentary rocks consist of north-south trending mudstone, sandstone, and conglomerate. The degree of dip and direction is variable because of deformation along the Salt Lake fault and the Sites anticline.

The Salt Lake fault trends north across the saddle dam alignment at Saddle Dam SSD-2. The fault zone is locally about 1,200 feet wide, mostly consisting of folded and fractured mudstone. Numerous springs and small mudflows mark the trace of the fault.

The Sites anticline trends across the saddle dams in about the same area as the Salt Lake fault. The anticline trends north from the town of Sites along Antelope Valley for about 24 miles. The folding is believed to be a result of movement on buried blind thrusts. The Fruto syncline is near the western part of the saddle dam alignment, where the beds dip at a shallow angle to the east.

Exploration

Only preliminary geologic mapping has been completed at the saddle dam sites. Additional evaluation, including subsurface geological exploration, is needed to investigate overall formation permeabilities. USBR drilled and water pressure-tested 13 diamond core drill holes along the saddle dam alignments, generally in the wind gap portions of the saddle dams. In 1999, DWR 's Northern District drilled two angle holes at SSD-3 and one vertical hole at SSD-6.

Permeability

DWR has not conducted any pressure testing to date. USBR conducted water pressure testing in most of their 13 shallow drill holes. The data shows that permeability is generally low to moderate.

Foundation Preparation

The saddle dam areas are covered by closely cropped non-native grasses and no clearing is required. Rough estimates range from several feet up to 25 feet of colluvial overburden that needs to be stripped and removed. An average stripping estimate for the dam sites includes 11 feet of overburden and several feet of weathered bedrock.

Grouting requirements have not been developed, but a preliminary review of USBR permeability data indicate that the amount of grouting needed will be minor.

Construction Materials

The saddle dams will be embankment-type structures, either earthfill or rockfill. The same sources as for Golden Gate Dam are available. Terrace deposits for the impervious core can be found within several miles of each of the saddle dams. The random fill or rockfill parts of the embankment may include material stripped from the foundation, quarried sandstone, and terrace deposits. The source of the rockfill would be the sandstone ridge north of Golden Gate Dam site.

Colusa Project

Limited geologic data have been gathered at the Hunters and Logan Dam sites. The data that has been gathered show that there probably is no geologic reason for not building the dams.

Colusa Reservoir Hunters Dam Site Geotechnical Studies and Findings

The dam site consists of a singular dominant ridge along the entire alignment. Total length of the dam site exceeds 14,000 feet. The dam would mantle the ridge and cross three water gaps: Prohibition Creek to the south, Owens Creek in the center, and Hunters Creek to the north.

Bedrock

Hunters Dam site consists of northwest trending and steeply northeast dipping interbedded sandstones and mudstones of the Upper Cretaceous Boxer and Cortina Formations of the Upper Cretaceous Great Valley Sequence. In general, the bedrock units consist of 60 percent sandstone with 40 percent interbedded mudstone and some minor conglomerate.

Laboratory results from the drill holes at Owens water gap shows a variation in compressive strength from less than 1,000 to over 17,000 psi. The results are shown in Appendix Q.

Surficial Deposits

Only limited preliminary mapping has been done at this dam site. Alluvial deposits occur in all three water gaps, consisting of stream channel deposits and terrace deposits. Alluvial deposits are less extensive than at Golden Gate Dam site. Several shallow mudflows and debris slides occur in the water gaps and along the ridge.

Structure

The sandstone, mudstone, and conglomerate strike approximately north-south and dip 55 to 75 degrees east. The Salt Lake fault and the Sites anticline, described previously, are less than 1 mile to the west.

Two northeast-southwest trending vertical faults cross the ridge, one just north of the Prohibition water gap and one about a quarter mile north of the Hunters water gap. Estimated offsets are 75 to 100 feet; recent movement is not apparent. As the studies progress, these faults will be evaluated.

Water pressure data showed high takes in places. This is caused by open joints both parallel and perpendicular to the bedding.

Exploration

Reconnaissance mapping at the dam site has been completed. Four diamond core holes were drilled and water pressure tested in the Owens water gap. No subsurface exploration has occurred at Prohibition or Hunters water gaps. No fault investigations have been completed to date.

Permeability

The abutment holes have higher permeabilities than the abutments at Golden Gate, averaging 0.63 feet per day. Weathering, jointing, and fracturing account for the higher permeabilities and associated high water takes during the drilling.

Foundation Preparation

The dam site is covered by closely cropped non-native grasses. A limited number of trees (2 to 10) grow in each water gap. Clearing requirements are minimal.

Rough estimates of stripping range up to 20 feet of colluvial overburden on the abutments, and up to 20 feet of alluvium plus up to 25 feet of terrace deposits in the channel. It is estimated that grouting requirements will be low in the channel areas, but moderate to high on the ridges and abutments.

Construction Materials

The geologic investigation of construction materials is described in Appendix P. Terrace deposits were mapped in the Hunters, Logan, and Minton Creeks and other unnamed drainages. The mapped area of the valley floors occupied by the deposit is 960 acres with an estimated volume of 15,550,000 cubic yards. The terrace deposits along the drainages in the Colusa Reservoir area are not as extensive as along Funks and Antelope Creeks. The field classification of the terrace material exposed in the incised stream channels is silty clay to clayey silt with some gravel.

The volume of impervious fill required for the Hunters and Logan Dams and the Colusa saddle dams is 13,200,000 cubic yards, or about 820 acres. Some quality material may have to be imported from the Sites Reservoir area. Haul distances of 3 or more miles will be required to transport this material to the dam sites. Nearly all of the terrace deposits inside the reservoir footprint will be required. Another potential source of impervious fill material is the deposits of weathered Boxer Formation mudstones that occur in the area. Some of these deposits have been observed with thicknesses of 12 or more feet. As studies proceed, laboratory tests will need to be conducted on these deposits.

A source for the random or rockfill has not yet been identified. The required volume of material is approximately 60,000,000 cu. yd. This volume of Venado sandstone is not available within the reservoir footprint. The ridges of Venado sandstone upon which the Hunters and Logan Dams are based are single ridges, not double ridges like the Golden Gate and Sites Dam sites. Using the analogy of a ridge quarry of 300 by 300 feet, a ridge over 3 miles long would be required to supply the required volume of material. Some of the rockfill may have to be brought in from the Golden Gate quarry and some may be available from spillway excavation.

Transition, drain, filter, and rock riprap construction material sources are the same as for Sites and Golden Gate dam sites.

Colusa Reservoir Logan Dam Site Geotechnical Studies and Findings

The dam site consists of a single dominant ridge along the entire alignment. The total length of the dam is about 7,200 feet.

Bedrock

In general, the bedrock consists of tilted Upper Cretaceous sedimentary rocks made up of dominant sandstone and interbedded silty mudstone with some conglomerate.

Surficial Deposits

Surficial deposits of stream channel alluvium and terrace deposits occur in the channel area. Landslide deposits and colluvium occur along the base and side of the ridge.

Structure

The conglomerate, sandstone, and mudstone strike north-south, and dip 55^0 to 75^0 to the east.

Two tentative northeast-southwest trending vertical faults occur across the left abutment with an estimated offset of 50 to 75 feet; recent movement is not apparent. The Logan Creek water gap does not exhibit evidence of faulting.

Exploration

Preliminary mapping has been completed at Logan Dam site, but no subsurface investigations have been instigated.

Foundation Preparation

Closely cropped non-native grasses cover the dam site. A limited number of trees (less than 30) grow in the Logan Creek water gap. Clearing requirements are minimal. Rough stripping estimates range from up to 20 feet of colluvial overburden on the abutments, and up to 20 feet of alluvium and terrace deposits in the channel.

Water pressure testing at Owens water gap suggests that the channel area will have low grouting requirements, but the abutments will have moderate to high requirements. This is because of the open joints that have developed on the ridges and abutments.

Construction Material

Construction materials for Logan Dam site are the same as Hunters Dam site.

Thomes-Newville Project

DWR and the USBR have conducted all of the geologic studies for the Thomes-Newville Project.

Newville Dam Site Geotechnical Studies and Findings

USBR's "Paskenta-Newville Unit, Engineering Geology for Feasibility Estimates, Lower Trinity River Diversion, North Coast Project, California", was the first major work done at Newville Dam site. This was followed by DWR's work from 1978-1982. Most of DWR's work is documented in three reports:

1. "Thomes-Newville and Glenn Reservoir Plans Engineering Feasibility Report", November 1980
2. "Engineering Geology of the Newville Dam and Burrows Gap Saddle Dam Sites, Glenn County, California", December 1982
3. "Thomes-Newville Unit – The 1980-1982 Construction Materials Investigations", December 1982

Bedrock

Newville Dam would be founded on sandstone, mudstone, and conglomerate of the Jurassic to Cretaceous Stony Creek Formation (?) and Cretaceous mudstones of the Lodoga Formation.

Rock Strength

The sandstone and conglomerate are massive and strong, but in places have open fractures near the ground surface. The conglomerates and sandstones have unconfined compressive strengths that range from 5,000 to 26,000 psi. The mudstone slakes readily when exposed, and ranges from weak to moderately strong and hard depending on freshness, bedding, and fracturing.

Surficial Deposits

Colluvium, stream channel deposits, and terrace deposits cover about 20 percent of the foundation area. Alluvial depths in the channel average 5 feet and consist of silt, sand, and gravel. The colluvium consists of gravelly clay averaging about 5 feet thick. Terrace deposits occur upstream and downstream, and cover part of the foundation in the channel. These consist of 5 to 20 feet of sandy clay overlying 3 to 15 feet of silty, clayey sand and gravel. Small areas of older terrace deposits occur on the abutments.

Structure

Conglomerate, sandstone, and mudstone beds strike north-south and dip 50-80 degrees to the east.

There are five faults crossing the foundation area. These are roughly parallel, striking N50E across the regional bedding. Mapping and drilling show that the faults dip steeply and offset bedrock units. The faults range in width from a few feet to over 40 feet and typically consist of highly fractured rock with seams of gouge. A zone of fractured and broken rock is generally associated with the fault plane. Some faults have been cemented with calcium carbonate.

Two sets of joints are prevalent. One set strikes northeast and dips near vertical; the second set strikes parallel to the ridge and dips east or west at zero to 45 degrees. Joint spacing is widest in the conglomerate beds (2 to 7 feet) and somewhat more closely spaced in the sandstone (less than 1 to more than 5 feet). Joints in the mudstone are generally closely spaced.

Exploration

USBR mapped the dam site and then drilled and water pressure tested 10 core holes. Twelve bucket auger holes were drilled near the dam site to investigate construction materials. DWR drilled and water pressure tested 11 core holes and opened ten trenches to explore the foundation. DWR also ran 18 geophysical survey lines to explore the subsurface.

Permeability

The foundation rocks are essentially impermeable, but faults, fractures, and joints contribute to local leakage. Water pressure testing of ten channel holes showed low water takes. Grout takes should be low except locally where takes could be moderate to high where large fractures occur.

Foundation Preparation

Clearing will be minimal at this dam site. Scattered oaks and brush occur on both abutments. Some riparian growth occurs in the channel area.

Exploration drilling, trenching, and geologic mapping indicate that the rock on both abutments is intensely weathered to a depth of about 5 feet and fresh rock is found at about 15 feet. Soil depth is generally less than 3 feet. Alluvium depths in the channel average 5 feet and an additional 20 feet of weathered rock overlie fresh rock.

Average depths of stripping under the outer shells are estimated to be about 10 feet on the right abutment, 20 feet in the channel area, and 10 feet on the left abutment. Under the impervious core, the average stripping depth would be about 15 feet on the abutments and 40 feet in the channel. Additional excavation would be required in more weathered areas, along faults, and in lenses of poorly cemented conglomerate.

Construction Materials

Materials are available nearby for construction of the various features, but more work is needed to evaluate their quantity and quality. Local sandstone and conglomerate appear to be weaker and less durable than the usual quarried rock for use in dams. The dam could be designed to accommodate this, but it would probably prove more economical to use stream gravel for transition zones and basalt for riprap. The stream gravel would come from Stony Creek and the basalt from the east side of the Sacramento Valley.

There are several adequate and tested sources of construction materials for an embankment-type Newville Dam. These are:

- There is over twice the required volume of good quality impervious material for Newville Dam and Burrows Gap Saddle Dam within the reservoir. About 90 percent of the needed pervious material can be found in Stony Creek between Julian Rocks and the Grindstone Indian Rancheria and in Grindstone Creek east of the Coast Range front. Dewatering will be needed for some of the impervious deposits and all of the pervious.
- Tehama Formation deposits for the impervious core located 5 miles east of the dam site.
- Terrace and slopewash deposits for the core and random fill portions of the embankment, located in the reservoir area and adjacent to the dam site.
- Stream gravel for filters and concrete structures, located within 7 to 12 miles of the dam site.
- Quarried sandstone and conglomerate from the Great Valley Sequence for the rockfill and random zones of the embankment. The potential borrow sites nearest the dam site are of limited extent and contain large percentages of weathered rock. The most promising borrow area, with 21 million cubic yards of material, lies 3 miles north of the dam site. Preliminary laboratory tests show that the less than normal

strength and durability would require more conservative embankment slopes than are customary in high rockfill dams. The quarry source may also be used for riprap, but laboratory tests show that the rock is marginal for this use. Other possible better quality sources occur on the east side of the Sacramento Valley.

Several potential quarry sites have been identified and some drilling and laboratory testing have been completed on sandstone and conglomerate deposits from Rocky Ridge north of Newville Dam site. At the conclusion of the studies in 1982, a test fill was recommended to evaluate the conglomerate from Rocky Ridge as a rock source.

Burrows Gap Dam Site Geotechnical Studies and Findings

The Burrows Gap Saddle Dam would be a homogeneous earth embankment with an internal filter and drain. It would function as a saddle dam for reservoir levels above 780 feet. The dam would be about 60 feet high and 450 feet long and would span a low saddle in Rock Ridge 3 miles south of the Newville Dam site.

Bedrock

The rock units at Burrows Gap are part of the Stony Creek Formation. They are nearly identical to the conglomerate, sandstone, and mudstone units found at Newville. The main section of the dam would be founded on conglomerate and sandstone. The upstream section of the embankment would be founded partially on mudstone.

Structure

The conglomerate and sandstone beds strike north-south and dip 60 degrees toward the east. Burrows Gap is a faulted saddle in Rocky Ridge. The northeast-trending fault zone that passes through the gap is considered to be inactive (ESA 1980). The fault appears to be 3 to 10 feet wide.

Exploration

The geology at the site was mapped by DWR in 1961 and by USBR in 1966. This mapping was field-checked and revised by DWR in 1982. One angled core hole, drilled to a depth of 275 feet, and two geophysical survey lines provide the only subsurface information at the site.

Foundation Preparation

Stripping the foundation will consist of removing soil and weather rock under the embankment area and excavating a key trench.

Soil, colluvium, and intensely weathered rock should be about 5 feet deep on the left abutment. In the saddle and on the right abutment, it will average 10 to 12 feet.

The rocks that make up the foundation are essentially impervious below 50 feet. However, the east-west-trending joints and fractures related to the fault zone could contribute to leakage beneath the dam. There is a seep near the downstream embankment toe, which is probably caused by the damming effect of the fault. This leakage should be controllable with a single-line grout curtain under the foundation and a filter drain.

Construction Materials

The same sources of construction materials as the Newville Dam are available.

Red Bank Project

The Red Bank Project, located west of Red Bluff, was initially envisioned as two large embankment structures - Dippingvat Dam and Schoenfield Dam – but was switched to roller-compacted concrete. Advances in the use of roller compacted concrete created renewed interest in the project.

Dippingvat Dam Site Geotechnical Studies and Findings

The geologic studies conducted at the dam sites and along the conveyance routes did not find any geologic conditions that would prohibit the proposed structures being constructed.

Bedrock

The dam site lies within the Great Valley Sequence along the west boundary of the Sacramento Valley. The foundation bedrock consists mostly of Upper Cretaceous sandstone, with lesser amounts of interbedded mudstone and minor conglomerate, and with bedding thickness varying from less than one inch to tens of feet. The sandstone forms prominent ridges in the area.

The sandstone is medium green, hard, and well indurated. The mudstone is dark gray to gray, and generally finely laminated to thinly bedded. It is generally closely fractured and slakes where exposed to air and moisture. The conglomerate only occurs in one layer interbedded with the sandstone. It is also hard and well indurated.

Superficial Deposits

Colluvium and stream channel deposits are at the dam site. Terrace deposits occur 150 feet upstream of the proposed dam axis. The colluvium, stream channels, and terrace deposits cover bedrock locally up to 10 feet.

Structure

The conglomerate, sandstone, and mudstone beds trend northwest and dip about 60 degrees to the east.

Three faults are in the foundation. All were intersected during the drilling. Associated with the faults are zones of gouge and sheared bedrock from two to ten feet wide. Mapping showed no evidence to confirm or deny Quaternary to Recent displacement. No trenching or subsurface investigations were conducted across these faults.

Exploration

The geology was investigated by DWR (1990, 1992) between 1987 and 1992. Six diamond core holes were drilled and water pressure tested at the dam site. No additional geologic field work has been done.

Permeability

Dental work on the foundation includes a grout curtain to about 150 feet deep under the abutments and 70 feet under the channel which should be sufficient to control foundation seepage. There is some concern that open joints and fractures in the right abutment conglomerates may be difficult to treat. Grout takes are expected to be low except for some zones with moderate to high takes.

Foundation Preparation

Foundation preparation should include the stripping of about 24 feet of colluvium, soil, and loose weathered bedrock from the left abutment, 13 feet from the right abutment, and several feet from the channel. Another 10 feet of fractured and moderately weathered bedrock may have to be removed by blasting. Some dental work along the fault crossing the axis is expected, including the excavation of a trench about 20 feet wide and 50 feet deep.

Construction Materials

Aggregate construction material for the roller-compacted concrete dam is available about one-half mile downstream. The sandstone is interbedded with some mudstone, which will be removed before crushing.

Schoenfield Dam Site Geotechnical Studies and Findings

The geology is similar to Dippingvat Dam site. The dam site is on the Great Valley Sequence mudstone, conglomerate, and sandstone.

Surficial Deposits

Patches of Quaternary stream alluvium cover the channel locally to depths up to 9 feet. Several levels of scattered terrace deposits occur upstream within 600 feet of the dam axis. The terraces consist of 1 to 3 feet of clayey silt overlying 3 to 5 feet of cobbly gravel perched on a bedrock bench about 5 feet above the present channel level. Colluvium wedges occur at the base of the slopes in depths approaching 10 feet or more. The colluvium consists of a mixture of soil and angular rock fragments.

Structure

The major structural feature is the northwest-trending, homoclinally east-dipping bedding of the Cretaceous Great Valley Sequence. Bedding attitudes trend northwest and dip northeast about 45 degrees and joints are common.

There are two mapped faults and several smaller faults that intersect the foundation. Both faults are roughly perpendicular to the regional strike of bedding. Mapping showed no evidence of Quaternary to Recent movement. No trenching was conducted across the faults.

Permeability

In general, the rocks in the foundation were hard, well indurated, and of sufficient strength for the proposed dam. Water pressure data showed that water takes were generally low to moderate, with some zones of higher takes. The rocks have little primary permeability. Instead, zones of high water take are associated with extensive fractures or jointing. The conglomerate has the highest take because of regular, open fractures. The zones of fracturing associated with faulting exhibit local increases in permeability.

Foundation Preparation

Foundation preparation of the abutments will consist of the removal of brush with interspersed oak and pine. About 10 to 16 feet of soil, colluvium, and intensively weathered bedrock can be removed with common methods. An additional 5 to 10 feet of moderately to slightly weathered bedrock will probably have to be blasted. An average of about 5 feet of stream alluvium and up to about 10 feet of weathered bedrock needs to be removed from the channel. The two fault zones crossing the dam site will have to be excavated in trenches about 12 to 20 feet wide to an indeterminate depth and then backfilled with concrete.

Grout take, based on water pressure testing, is expected to be moderate overall, but with zones of high grout take in places.

Construction Material

The construction material initially selected for the roller compacted concrete structures is from a sandstone quarry site located one-half mile downstream. The quarry consists of one sandstone bed about 100 feet thick and a number of thinner beds. Two diamond core holes were drilled and samples sent to the laboratory for analyses. In addition, a series of mixes of sandstone aggregate, cement, and pozzolan were tested for compressive strength. The testing showed that the sandstone aggregate was adequate for the previously proposed seismic loading criteria.

Bluedoor and Lanyan Dam Sites, Geotechnical Studies and Findings

The geology, seismic considerations, construction materials, and foundation preparation for Bluedoor and Lanyan Dam sites are similar to Schoenfield Dam site. These two proposed roller-compacted concrete dams are small and less than 100 feet high. Four diamond core holes were drilled at Lanyan and five at Bluedoor. The drill holes intersected minor gouge and fractured rock at both dam sites. Each hole was then water pressure tested. Grout takes are expected to be low except for some zones of high grout takes

Chapter 5. Engineering Analysis

As summarized in the previous chapter, considerable engineering study of the four projects we are evaluating has been previously conducted. We used all this historic work to the extent possible, but most of it was performed at less than feasibility level and under planning guidelines that have changed substantially. Therefore, much additional engineering work remains to be done on each alternative. Our efforts to date have begun that process, and work must continue for several more years before feasibility level studies are complete.

The remainder of this chapter summarizes the engineering work performed as of December 1999. Major engineering work is required to complete feasibility level studies (Sites, Colusa, and Thomes-Newville Projects).

Sites Project

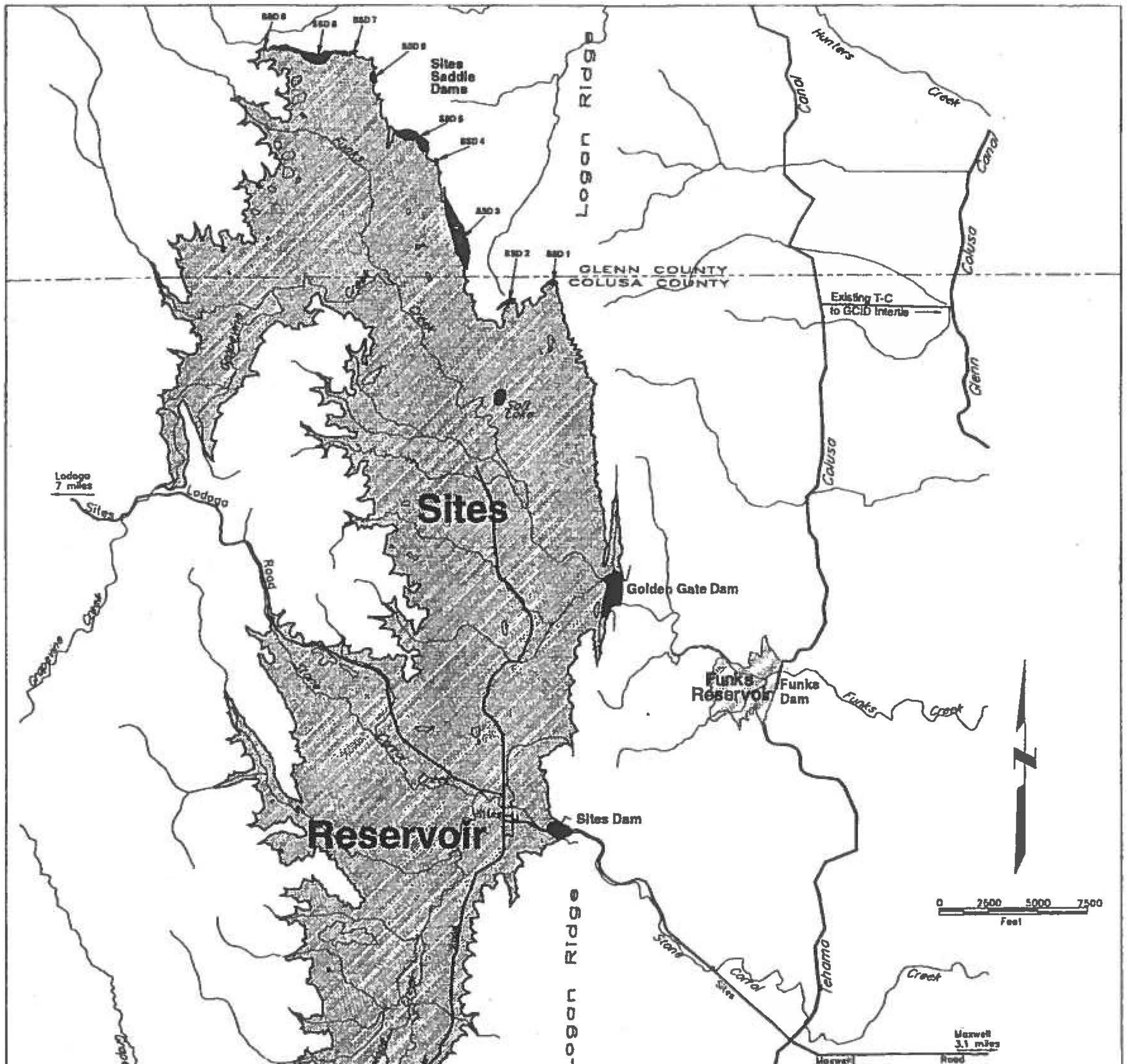
Sites Reservoir would be formed by Golden Gate Dam on Funks Creek, Sites Dam on Stone Corral Creek, and nine saddle dams (at 1.8 maf capacity) along the north ridge between Funks and Hunters Creeks, as shown in Figure 5.1. An area-capacity curve for Sites Reservoir is shown in Figure 5.2. The normal water surface elevation at Golden Gate Dam and Sites Dams would be 520 feet, inundating 14,000 acre for a total capacity of 1.8 maf. The minimum operating water surface elevation would be 320 feet.

Since the two small watersheds above the reservoir capture very little runoff (around 15,000 acre-feet average annual), Sites Reservoir would serve as off-stream storage, filled by diversions from the Sacramento River and tributaries using existing, new, or enlarged canals and pumping plants.

The existing 40-ft-high dam that impounds Funks Reservoir may remain or may be replaced with a larger dam to regulate the inflow and outflow from Sites Reservoir. For this study, it was assumed that no additional forebay or afterbay storage was required to meet project inflow or outflow regulation needs. The Tehama-Colusa Canal and the Glenn Colusa Canal are the main existing conduits through which the Sites Reservoir would be filled. The Tehama-Colusa Canal runs through Funks Reservoir. The Glenn Colusa Canal runs approximately 1 mile east and 80 feet lower than Funks Reservoir. Water from this canal could be pumped into Funks Reservoir through a new connector canal and pumping plant. A third conveyance alternative is a new canal running west from a new diversion point on the Sacramento River (possibly augmented with diversions from the Colusa Drain during periods of high runoff). Water from this new canal would be pumped into Funks Reservoir through the same Glenn Colusa Canal to Funks Reservoir connector canal mentioned previously. For this study it was assumed that the collective flow from the enlarged irrigation canals and the proposed new canal would not exceed 8,000 ft^3/s.

Reservoir inflow from various alternatives considered range from around 4,000 to 8,000 ft^3/s.

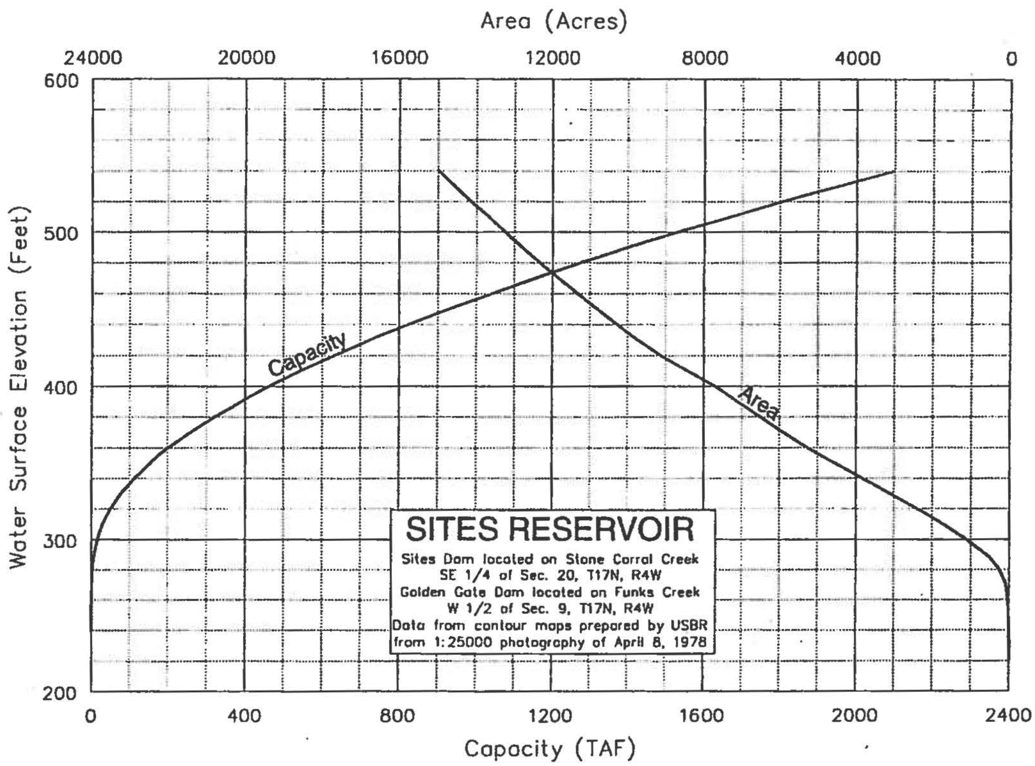
Figure 5.1. Sites Project and Statistics



STATISTICS

Storage (ac-ft)	
Gross	1,800,000
Dead	40,000
Drainage Area (mi^2)	85
Reservoir Surface Area (ac)	14,000
Dam Height (ft)/Volume (1000 yd^3)	
Sites	290/3,800
Golden Gate	300/10,600
Saddle Dams (Number/Max. Height)	9/130
Reservoir Elevation (ft)	
Normal	520
Minimum	320
Avg. Annual Natural Reservoir Inflow (ac-ft)	15,000
Reservoir Evaporation (ac-ft)	
Average Annual	40,000
Total Critical Period	220,000
Pumping (ft)	
Static Lift from T-C Canal	
Maximum	320
Minimum	120
Capacity	
Maximum (1000 ft^3/s)	5 to 8

Figure 5.2. Sites Reservoir Area-Capacity Curves.



A pumping/generating plant located at the base of Golden Gate Dam would lift water a maximum of 320 feet from Funks Reservoir into Sites Reservoir. During scheduled releases, the plant would be used to generate power. The plant would have maximum pumping and discharge capacities of around 8,000 ft^3/s.

The tunnel and penstock, located on the right abutment of Golden Gate Dam, would fill and evacuate Sites Reservoir through the pumping/generating plant under operation. A gated service spillway was sized at 59,000 ft^3/s to satisfy the Division of Safety of Dam's requirement that, during emergency evacuations, 10 percent of the maximum water depth must be released within ten days without including powerplant releases.

Contour maps of Sites Reservoir were scanned and digitized in 1997 by Northern District technicians. The original contour maps were prepared by the U.S. Bureau of Reclamation from 1:25000 photography BR-SVC-2, April 8, 1978. Ten-ft contours were interpolated from 5-meter contours. This digitized information was used for determining the most efficient facilities layout.

Golden Gate Dam

Golden Gate Dam, including its inlet/outlet works and pumping/generating plant (appurtenences), is the most complex structure necessary to form either Sites or Colusa Reservoirs. Its site is located on Funks Creek along Logan Ridge approximately 8 miles northwest of Maxwell. Depending on the alternative reservoir size of Sites or Colusa, the dam heights would range from 250 to 300 feet.

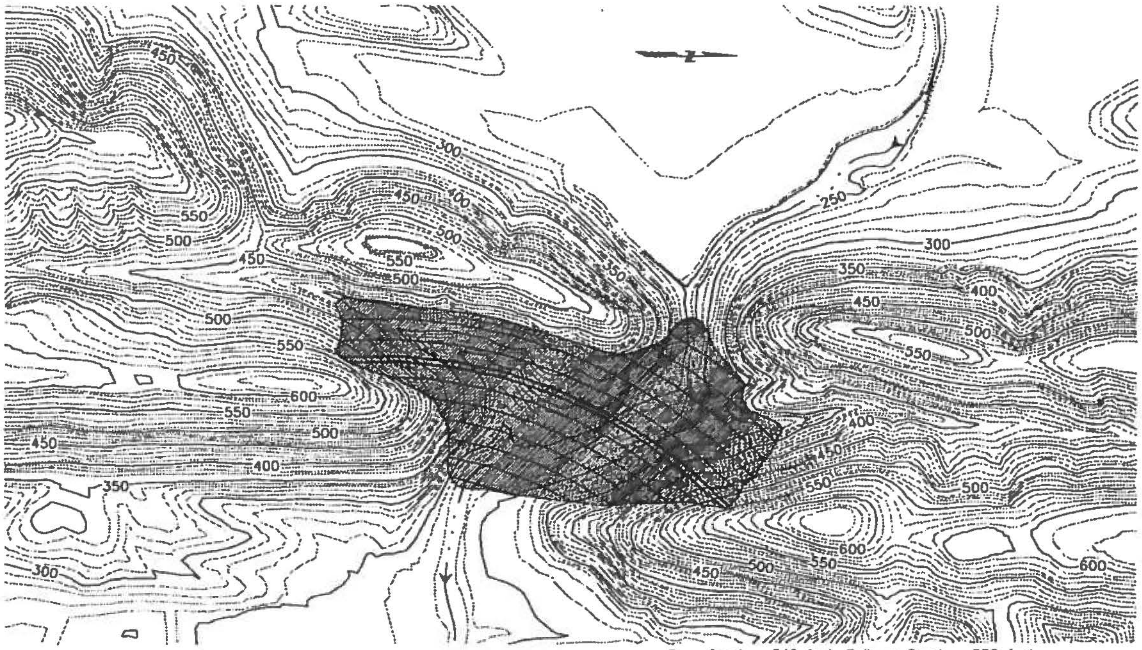
The design work to date has concentrated on the large 520-foot normal water surface elevation reservoir and the following discussion of Sites and Colusa Reservoirs deals only with this reservoir elevation. Much of the Sites Project engineering work has been done by DWR's Division of Engineering in Sacramento while most of the geology work has been performed by DWR's Northern District Geology Section. The Northern District Offstream Storage Investigation Branch directed the overall planning effort.

Embankment Design

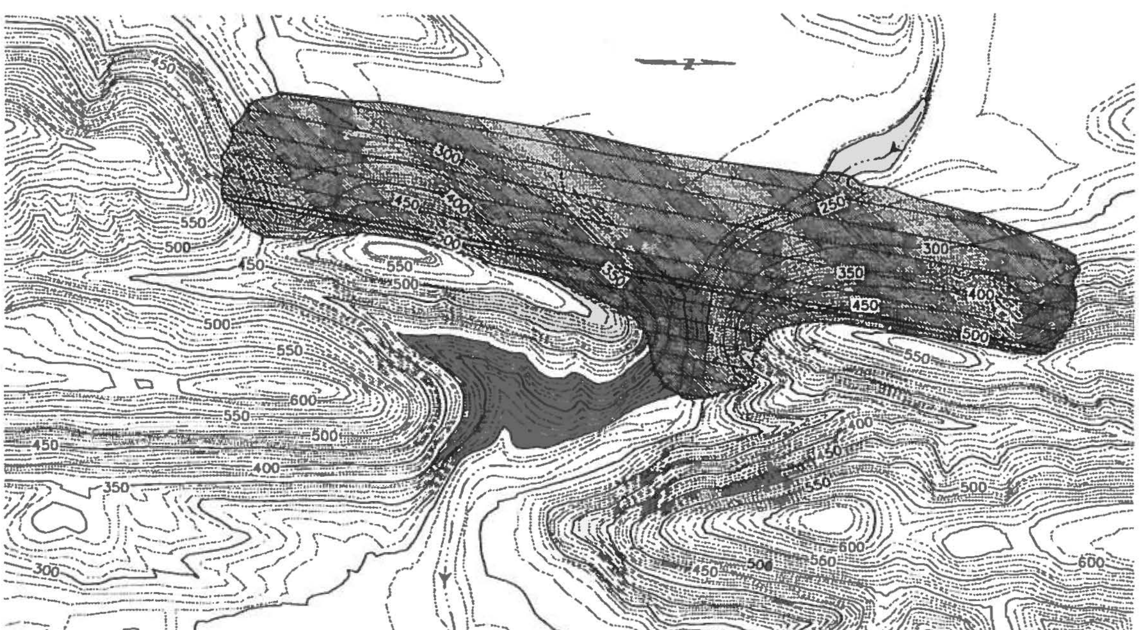
Golden Gate Dam would most likely be constructed as a zoned rockfill type dam. A roller-compacted concrete-type dam is also being evaluated as an alternative. Because of complex topographic and geologic conditions at the Golden Gate Dam site, two primary dam axis alignments were considered as shown on Figure 5.3. Golden Gate Dam would rise 300 feet above streambed elevation and be 2,000 to 5,000 feet long depending on which alignment is selected to achieve the target crest elevation of 540 feet. These alignments are discussed in detail in the February 2000 Dam Design Progress Report. The volume of embankment material would range from around 11 to 17 million yd^3 depending on axis alignment. The dam foundation is composed of sandstone and mudstone, which is generally strong and tight enough to provide an adequate foundation for both embankment and RCC-type dams. Foundation treatment to remove softer surface deposits in depths up to 20 feet will be required. Also, extensive grouting in some foundation areas will be required to reduce reservoir seepage to acceptable levels. At this stage of investigation the RCC-type dam appears more expensive than the earth-rock type dam. So, the remaining discussion concentrates on the earthfill embankment alternative.

The zoned embankment would have an impervious clay core with thin filter and drain zones on both sides to control seepage through the core. Materials testing indicates that adequate clay mixture soils exist in the reservoir area to supply the quantity of material required for the dam's impervious core. Random fill material for the downstream slope and lower upstream slope areas can be obtained from local siltstone and mudstone deposits. Sandstone is available locally for dam rock fill and shell material. Filter, drain, and concrete aggregate material would probably have to be hauled from locations as far away as 30 to 50 miles. Additional materials testing work will have to be performed to verify the location and quantity of suitable construction materials.

Figure 5.3 Golden Gate Dam Alternative Alignments



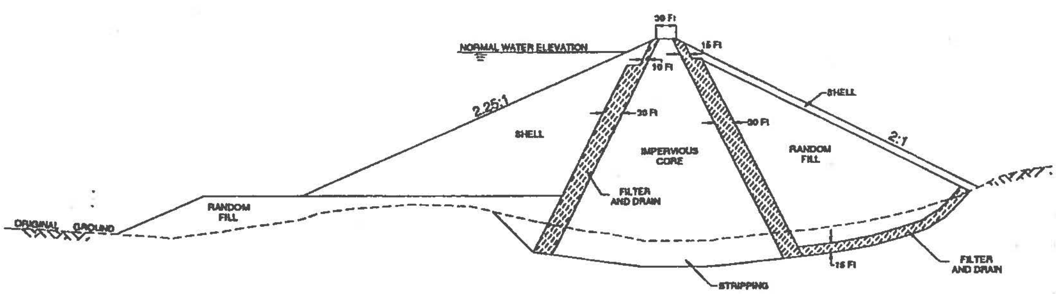
Downstream Curved



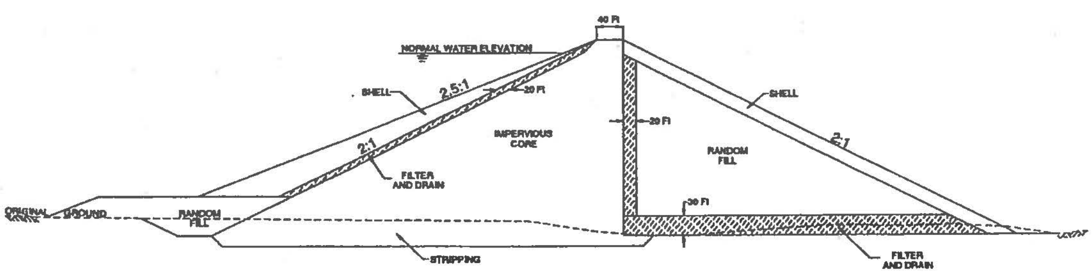
Upstream

The typical cross-sections of potential embankment dams at the Golden Gate and Sites locations are shown on Figure 5.4. Both static and dynamic (seismic) stability analysis were conducted on these potential embankment configurations and they yielded results that were considered adequate for the purpose of developing feasibility level designs and cost estimates. A significantly different embankment cross section was proposed for the upstream alignment as shown on Figure 5.4. In the static stability analysis evaluation under rapid drawdown conditions, the calculated factor of safety of 1.15 was less than the desired minimum of 1.25. This test will be run again after the construction materials testing program is completed and embankment design will be modified accordingly. Results from the seismic stability analysis test were high enough to warrant basing feasibility level cost estimates on this cross section.

Figure 5.4 Golden Gate and Sites Earthfill Dam Cross-Sections



Golden Gate Downstream and Sites Dam



Golden Gate Upstream

Spillways

The integrity of Golden Gate Dam would be protected against earthquake induced or overtopping by extreme event flooding by two types of spillways. The largest is a service (emergency outlet) spillway designed to carry a maximum of 59,000 cfs, and the smaller (flood relief) spillway designed to carry a maximum of 5,000 cfs. The service spillway must meet the Division of Safety of Dam's requirement of a 10 percent reduction of maximum head in less than 10 days. This criterion is designed to protect the dam's structural integrity in case of a large earthquake. This spillway can be controlled by a mechanical headgate structure.

The smaller emergency spillway is designed to meet the outflow requirements of the estimated probable maximum flood of around 5,000 ft^3/s generated in the watershed above into the reservoir. This spillway cannot be gated and must be open at all times, although no water will flow through it except at extreme reservoir elevations above 521 feet. Both of these spillway types were combined into a single structure as shown on Figure 5.5. Spillway statistics are contained in the June 1999 spillway design report titled "Golden Gate Dam Spillways".

- Excavation of the spillway would produce approximately 6.5 million cubic yards of construction materials that could be incorporated into Golden Gate Dam embankment.

Due to time limitations, only one of several potential spillway sites was investigated in this study. Others should be considered. Emergency releases through the service spillway would have significant widespread impacts downstream. A structure to safely convey this water to the Colusa Basin Drain should be designed as this study continues.

Pumping/Generating Plant and Inlet/Outlet Works

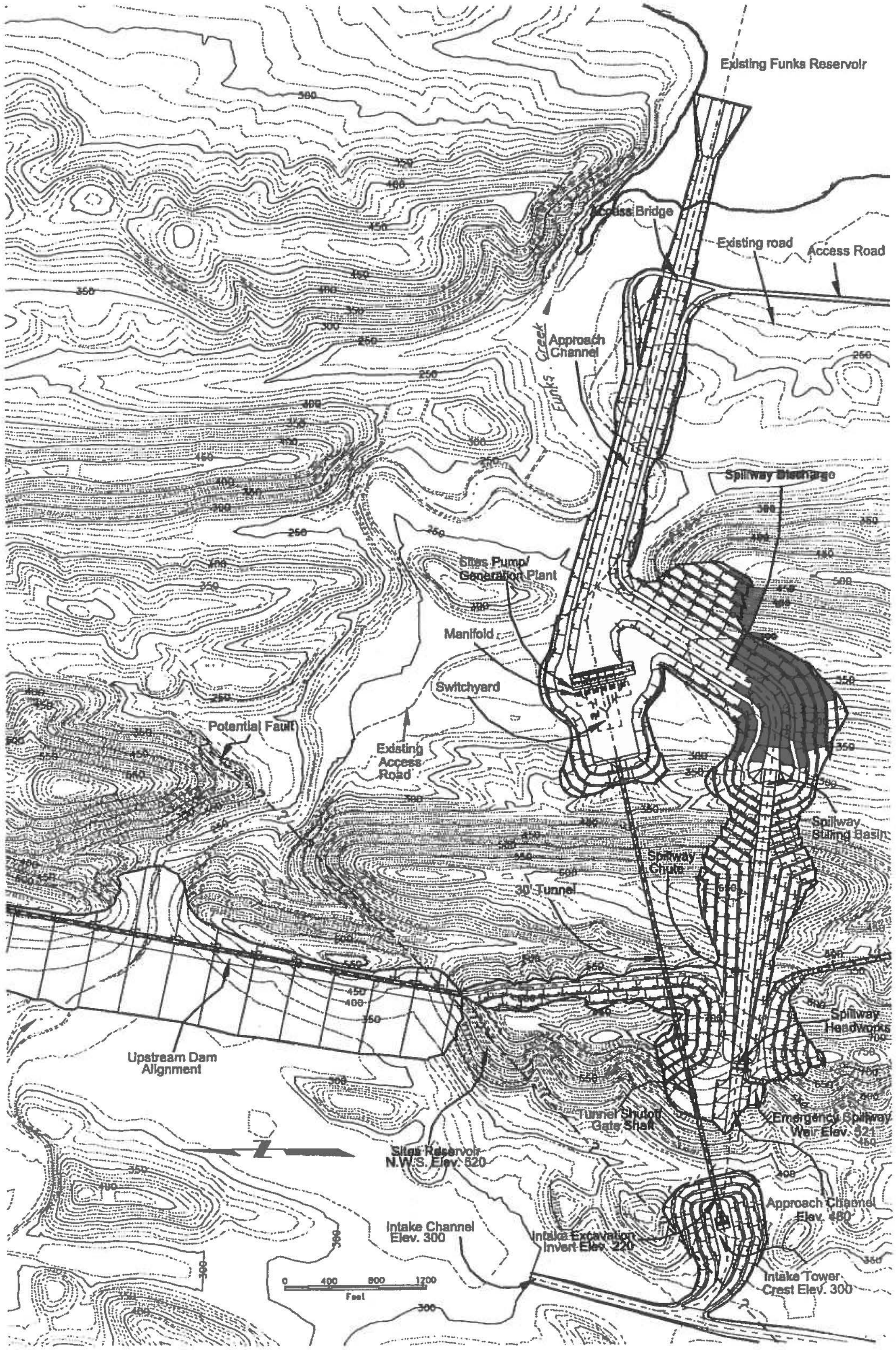
Almost all water entering Sites or Colusa Reservoirs will be diverted from the Sacramento River or its tributaries. The only water entering these reservoirs naturally is an average of 15 to 20 taf annually from the watersheds controlled by the dams. This natural inflow comprises less than half the water annually evaporating from the reservoirs. The diverted water will be conveyed to the existing or enlarged Funks Reservoir where it will be pumped into Sites or Colusa Reservoir. In order to recover much of the power required for pumping, generators will be included for recapturing power when reservoir releases are made.

Initial design and cost estimate studies of the facilities at Golden Gate Dam include facilities to convey water between existing Funks and potential Sites or Colusa Reservoirs. This work is documented in the January 2000 report titled "Sites Pumping/Generating Plant and Inlet/Outlet works".

Figure 5.5 shows the general layout of the pumping/generating plant selected as representative of the plant which will receive more detailed analysis in the future. It would pump between 5 and 8 thousand ft^3/s using from 10 to 15 pumping/generating units for initial design and cost estimating purposes a plant size at 7,500 ft^3/s using ten 630 ft^3/s and three 315 ft^3/s units was used. The plant would be a conventional indoor-type with an inline arrangement of thirteen vertical pumping/generating units. The total power output would be around 200 MW. Once a dam alignment is selected, the final plant location can be established.

Figure 5.5. Golden Gate Dam Upstream Alignment and Appurtenances

Note: Other alternative dam alignments are still under consideration.



For present planning purposes, the plant is located on a relatively low, flat bench immediately south of Funks Creek and less than a mile southeast of Golden Gate Dam site. If the existing Funks Reservoir is used as a forebay, the maximum excavation depth for the pumping/generating plant would be around 130 feet. This compares favorably with pumping plant excavations along the California Aqueduct that usually exceeded 140 feet. Much of the large quantity of material excavated to reach the required approach channel and plant depth would be used in constructing the embankment dam.

The inlet-outlet structure would convey between 5,000 and 7,000 ft^3/s between Sites Reservoir and the pumping/generating plant. This preliminary design set the capacity at 7,500 ft^3/s and the reservoir intake tower crest at elevation 300 feet; therefore, it could not selectively draw from water above this elevation. If future studies determine that multi-level outlets are required, this structure would have to be redesigned.

The reservoir intake structure would connect to a 30-foot inside diameter pressure tunnel, 4,000 foot long, running to the pumping/generating plant. This tunnel would be concrete lined for 3,000 feet on the end under the reservoir and steel lined for 1,000 feet on the pump/generating plant end. It is designed to carry a maximum velocity of 10 feet per second. A 30 foot by 20 foot water flow control gate would be located approximately 1,000 feet down-tunnel from the intake tower. It would allow dewatering of the lower tunnel for inspection. Tunnel inspection upstream of the gate shaft could be accomplished by covering the intake openings with bulkhead gates lowered from barges.

A steel penstock would run approximately 400 feet from the east tunnel portal and connect to a manifold feeding or receiving inflow from the pumping/generating plant. The penstock and manifold would be encased in concrete with anchor blocks to resist thrust forces at bends. The various branch diameters within the manifold were determined by setting maximum water velocity at 10 feet per second.

The connecting channel between Funks Reservoir and the pumping/generating plant would be a concrete lined trapezoidal section with a 100-foot bottom channel and 2 to 1 side slopes. The findings and recommendation for the Golden Gate Dam spillways, pumping/generating plant, and inlet/outlet works is contained in the January 2000 present report.

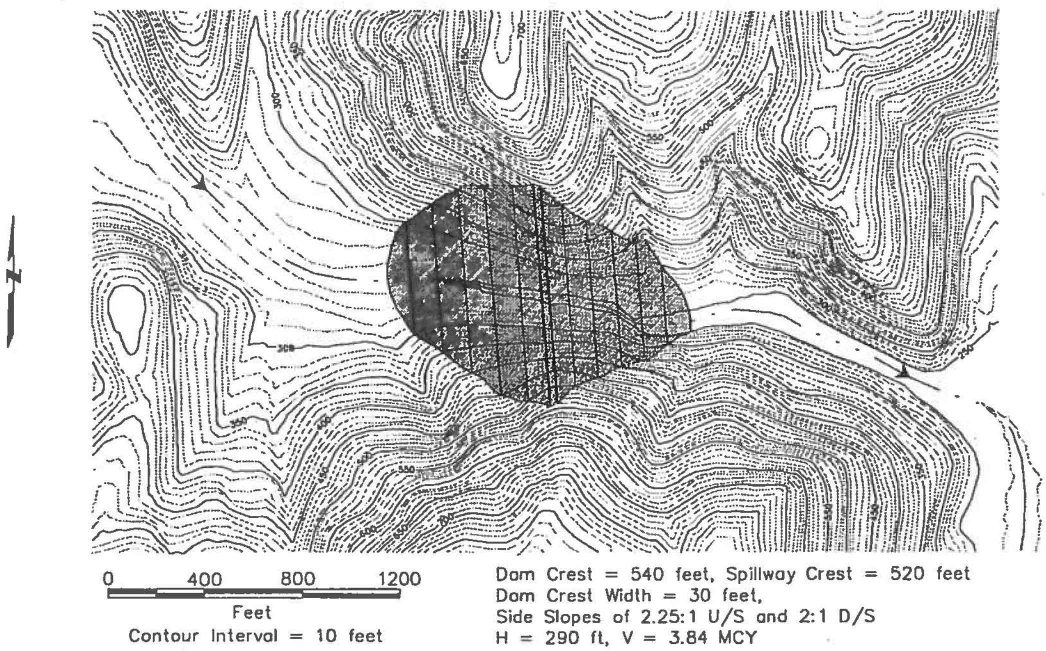
Based on available data, the proposed Sites/Colusa pumping/generating plant can be constructed using conventional methods.

Sites Dam

The second major dam required to form Sites Reservoir is the 300 foot high Sites Dam on Stone Corral Creek along Logan Ridge approximately 2 miles south of Golden Gate Dam site. This dam could be constructed either as a roller compacted concrete or earthfill/rockfill embankment structure. At this point, it appears that an earthfill/rockfill structure may be less expensive and the preferred alternative. Further study will be required to confirm this.

Sites Dam at 540 foot crest elevation would rise 290 feet above the streambed elevation. It would have a crest width of 30 feet with upstream and downstream slopes of 2.25 to 1, and 2 to 1 respectively as shown in Figure 5.6. It would require about 3.8 million cubic yards of embankment material. The only appurtenance required at Sites Dam is an outlet structure with control (not shown) to allow release of flows to Stone Corral Creek to maintain its fishery and riparian vegetation. Figure 5.6 shows a plan view of the dam embankment.

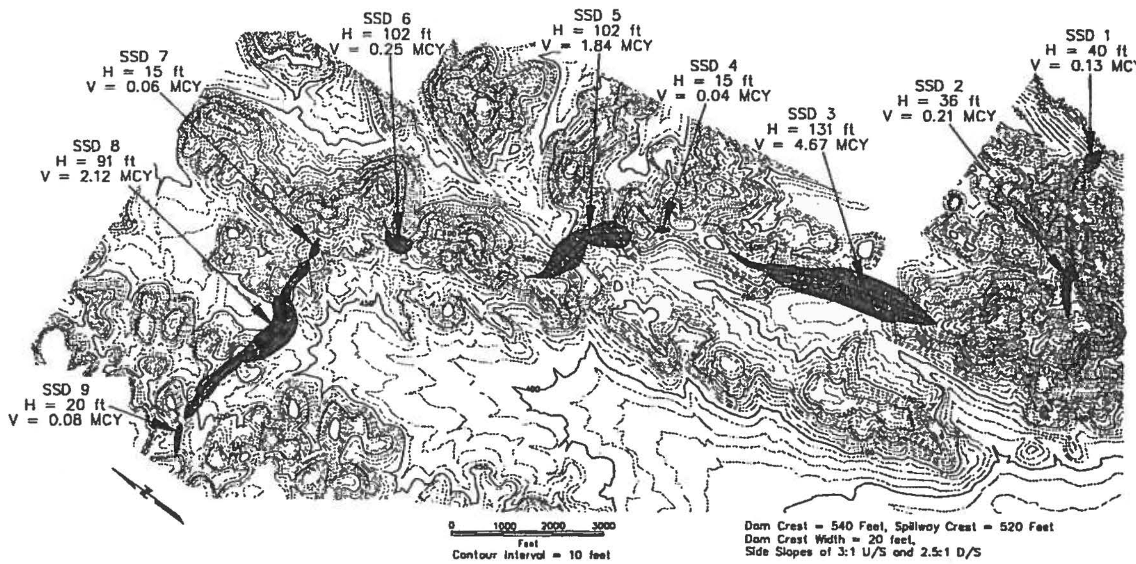
Figure 5.6. Sites Dam Plan View



Saddle Dams

The Large Sites Project will require the construction of nine saddle dams along the northern ridge dividing the Funks Creek and Hunters Creek drainages as shown in Figure 5.7. None of these dams has been designed or the cost estimated, but their embankment dimensions and volumes have been calculated. The total embankment volume of these saddle dams would be about 9.4 myd^3, and there would be no appurtenances associated with them. Design and cost estimation of these dams will be required before the total cost of the Sites Project can be accurately estimated.

Figure 5.7. Sites Project – Saddle Dams

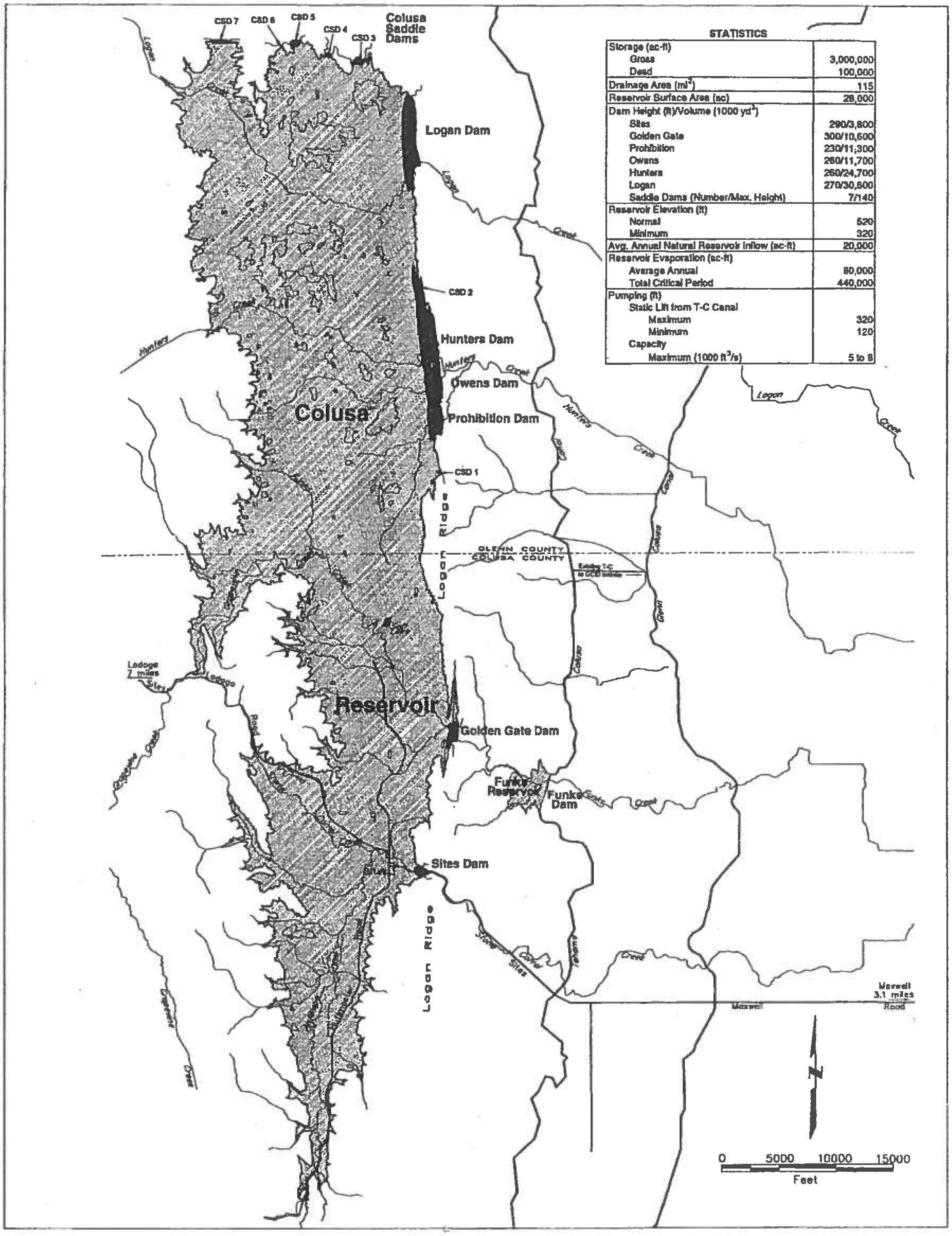


Colusa Project

The Colusa Project would entail expansion of the Sites Project to include the Hunters and Logan Creek drainages to the north. All of the large Sites Project facilities, except the saddle dams, would be constructed; although Colusa Reservoir requires seven saddle dams along its northern boundary totaling 7.58 myd^3. In addition, large dams would be built along Northern Logan Ridge to contain runoff from Hunters and Logan Creeks and form a reservoir with a maximum normal water surface elevation of 520 feet (same as Large Sites).

A large cut or tunnel would be required between Funks and Hunters Creeks to allow free water transfer between the Sites and Colusa portions of the reservoir at all elevations above "dead storage" at elevation 320 feet. Colusa Reservoir at 500-foot elevation would contain 1.2 maf or 67 percent more water than the 1.8 maf Sites Reservoir at the same level. However, approximately four times as much fill material would be required to construct Colusa as Large Sites (101 myd^3 vs 26 myd^3). This will make a large difference in the cost of the two projects.

Figure 5.8. Colusa Project and Statistics



STATISTICS

Storage (ac-ft)	
Gross	3,000,000
Dead	100,000
Drainage Area (mi^2)	115
Reservoir Surface Area (ac)	28,000
Dam Height (ft)/Volume (1000 yd^3)	
Sites	290/3,800
Golden Gate	300/10,600
Prohibition	230/11,300
Owens	260/11,700
Hunters	260/24,700
Logan	270/30,600
Saddle Dams (Number/Max. Height)	7/140
Reservoir Elevation (ft)	
Normal	520
Minimum	320
Avg. Annual Natural Reservoir Inflow (ac-ft)	20,000
Reservoir Evaporation (ac-ft)	
Average Annual	80,000
Total Critical Period	440,000
Pumping (ft)	
Static Lift from T-C Canal	
Maximum	320
Minimum	120
Capacity	
Maximum (1000 ft^3/s)	5 to 8

Recent investigations conducted on the Colusa Project under the Offstream Storage Investigation Program focused on geotechnical studies. New estimates of embankment quantities have been made, but additional analysis of embankment design and materials will be needed if Colusa Reservoir is selected for continuing study. As presently configured there would be no major appurtenances located at the Colusa Project Dams, only low level outlet works to release stream maintenance flows to Hunters and Logan Creeks. This will greatly simplify the engineering evaluations required for this project. The water supply conveyance system for Colusa would be essentially the same as for Sites although a larger conveyance system capacity would be required to support Colusa's larger storage volume.

Figure 5.9. Colusa Reservoir Area-Capacity Curves

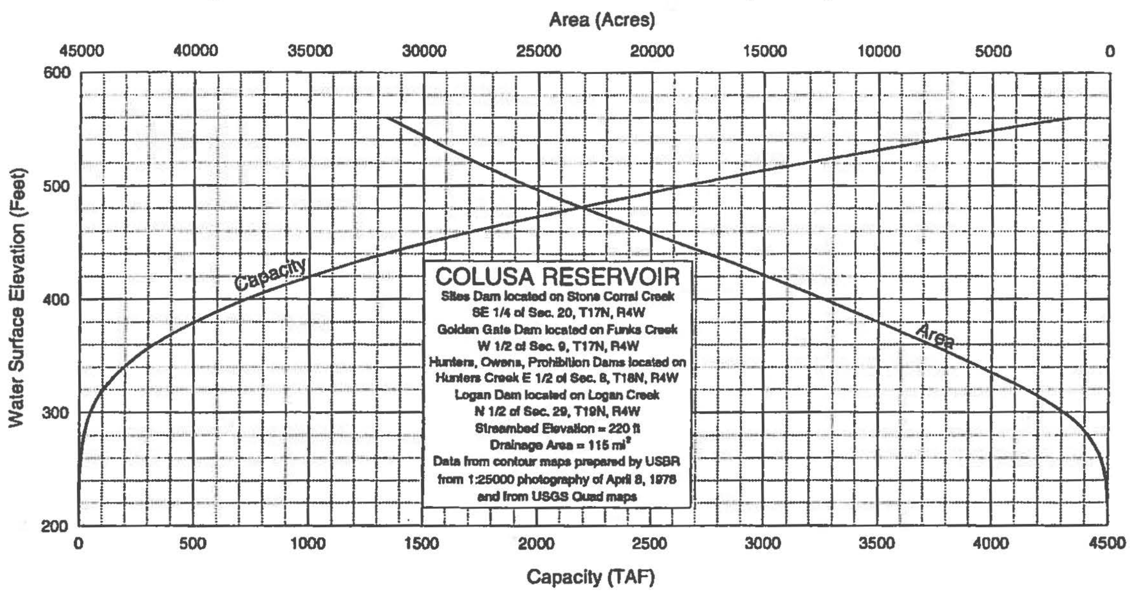


Figure 5.10. Colusa Reservoir – North Saddle Dams

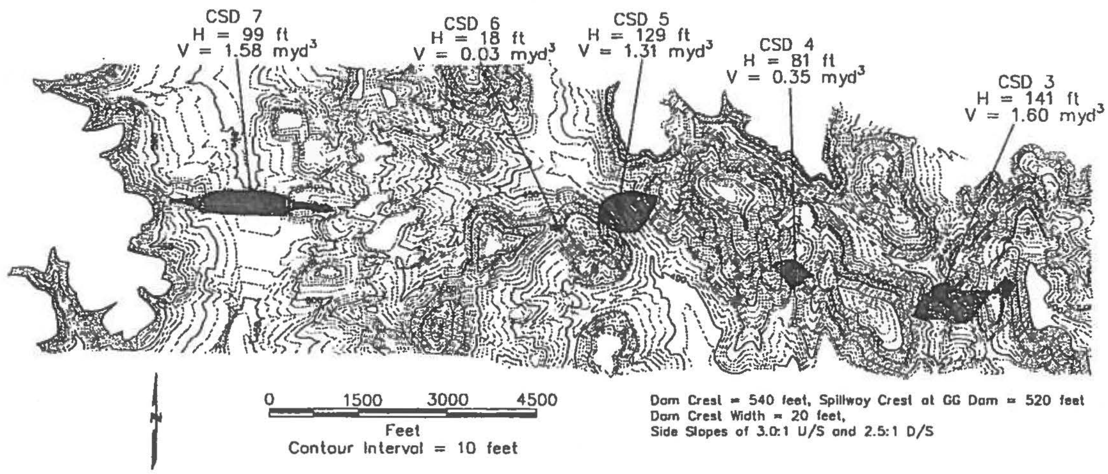


Figure 5.11. Colusa Reservoir – Hunters, Owens, Prohibition Dams

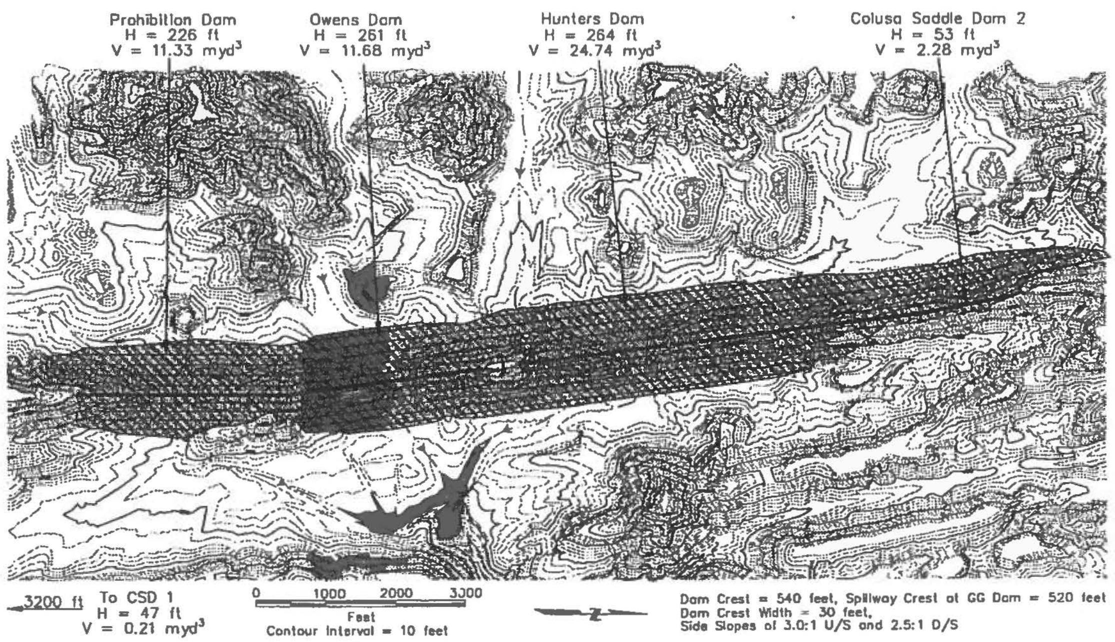
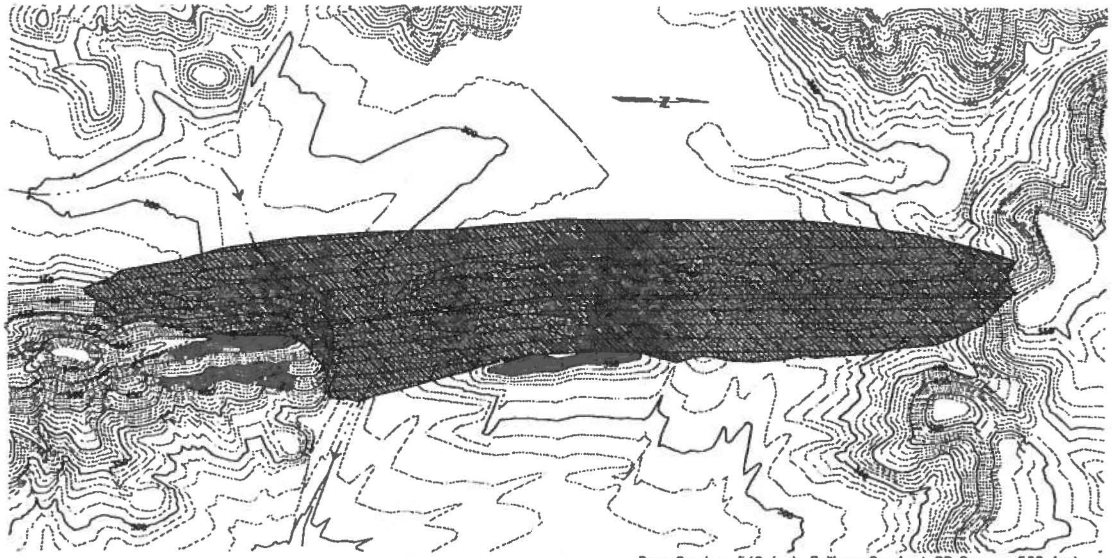


Figure 5.12. Colusa Reservoir – Logan Dam



Embankment Design

At this point it appears that the design of large-embankments (101 maf total) for the numerous long dams along northern Logan Ridge and the northern divide required to form Colusa Reservoir will be similar to that for Golden Gate and Sites Dams. The same types of materials are available for all these dams and the geology is similar. However, the actual design of these embankments is scheduled for the future after the requisite detailed geologic investigations are completed. Until then the detailed configuration of these embankments is somewhat speculative.

Road and Utilities Relocations

Both the Sites and Colusa Projects will inundate a portion of the Maxwell to Lodoga Road, which must be relocated. Alternative potential relocation routes under consideration are shown in Figure 5.13. A February 2000 Reconnaissance Report describing these alternatives is available. Basically, the relocated road must go either north or south of the reservoir. Presently a north route around Sites and a south route around Colusa appear most practicable, but considerably more investigation and public input is required before the preferred alternative can be identified.

Thomes-Newville Project

A feasibility-level evaluation of the Thomes-Newville Project conducted by DWR in the late 1970s and reported on in November 1980. This work was based on earlier studies conducted in the mid-1960s. Because of the extensive level of past studies, compared to the Sites and Colusa projects, the Thomes-Newville engineering reevaluation was judged to be of a lower priority for our initial study effort. One of the goals of this current study is to bring all the alternative projects up to an equivalent level of knowledge for screening purposes. Therefore, few recent engineering studies have been conducted at the Thomes-Newville Project and most of what we know about it is derived from the historic studies. However, this project will probably receive extensive additional study within the next couple of years.

The Thomes-Newville project and area-capacity curve are shown on Figures __ and __. Reservoir sizes under consideration range from 1.9 to 3.0 maf. The Thomes-Newville Project would consist of a reservoir created by Newville Dam on the North Fork Stony Creek and at least one saddle dam at Burrows Gap 3 miles south. North Fork Stony Creek has a limited drainage area and little surplus water; therefore, most of the water supply for Newville Reservoir would be diverted from Stony Creek, Thomes Creek, and the Sacramento River.

Diversion of surplus flows from the mainstem of Stony Creek would involve pumping from the existing Black Butte Reservoir to either a Tehenn Reservoir on the North Fork Stony Creek or a canal which would convey water to the toe of Newville Dam. Since the reservoir would flood a locally important cemetery, dating from the mid-1880s, future studies will emphasize the canal over the reservoir as a conveyance facility. Two pump lifts would be required with either the Tehenn Reservoir or canal conveyance alternative to transport water from Black Butte to Newville Reservoir. During reservoir releases, generators would recapture some of the energy required for pumping. Releases would probably flow down Stony Creek and be diverted, under an exchange agreement, to either the Glenn Colusa or Tehama-Colusa Canals. Because of water temperature concerns, no water would be released directly to the Sacramento River.

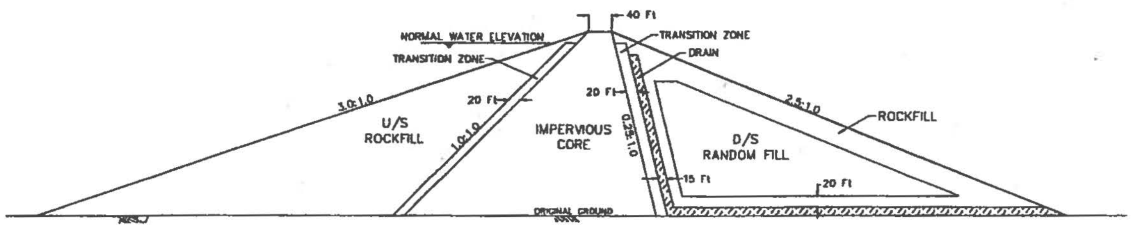
Surplus winter water from Thomes Creek would be conveyed by gravity flow from a low diversion dam. The short diversion canal would pass through a saddle on the drainage divide and discharge to the northwest corner of Newville Reservoir. When investigated in the 1970s, this appeared to be a rather conventional diversion, but current requirements to pass fish around the diversion dams and screen fish away from the diversion tunnel will greatly complicate this structure. This is made even more difficult by Thomes Creek's extremely large sediment load.

Investigations are ongoing as to how water from the Sacramento River could be diverted to the Thomes-Newville project using extensions to the Tehama-Colusa and/or Glenn Colusa Canals.

Newville Dam

Newville Dam would most likely be a conventional zoned earth-rock section dam with a section similar to that shown on Figure 5.13. For the range of reservoir capacities under consideration of 1.9 to 3.0 maf, the dam height above streambed would range from 325 to 394 feet and volume would range from 16 to 32 million cubic yards. The dam would have conservative upstream and downstream slopes of 3 to 1 and 2.5 to 1 respectively, a crest width of 40 feet, and a freeboard of 20 feet. Newville Dam would fill the gap in the north-south trending Rocky Ridge through which the North Fork Stony Creek flows.

Figure 5.13. Newville Reservoir – Earthfill Dam Section



Embankment Design

The dam would be composed of four major zones as shown on Figure 5.13 and described below:

- Impervious core using Tehama Formation clay mixture soils; transition and drain material composed of processed sands and gravels (transition zones prevent mixing of material in different zones); compacted processed rockfill; and random fill.

Most of the material for the dam would come from the Tehama foundation soils (for impervious zones) located in the reservoir area, stream gravels (for concrete and filter zones) from nearby streambed sources, and sandstone (for rockfill) from nearby Rocky Ridge. Some sand and gravel may have to be obtained from sources 30 to 50 miles distant. This is because little sand and gravel is available near the dam site and crushed sandstone from the site may not meet concrete and drain materials specifications.

The relative volume of each type of material composing the dam is: impervious - 25 percent, transition and drain – 10 percent, rockfill – 55 percent, and random fill – 10 percent. The embankment section was checked for stability under a range of static and seismic loading conditions and the resulting safety factors met the criteria for large dams.

As the dam height is increased beyond 325 feet corresponding with a 1.9 maf reservoir capacity, some additional design problems are encountered because of the limited thickness of the natural ridge (Rocky Ridge) which the dam abutments tie into. Therefore, for dams higher than 325 feet, a dam axis must be selected on the basis of protecting the upstream face of the abutments without excess embankment spillover on the downstream side. Also, as the reservoir normal water surface elevation increases, more saddle dams must be constructed along Rocky Ridge. These issues must be evaluated at feasibility level if this project is pursued in the future. The previous dam design will be modified using today's design criteria as the study continues.

Inlet/Outlet Structure

A single structure can convey water into the reservoir from the pumping plant and out of the reservoir to meet water supply demands. The outlet structure must also work in conjunction with the spillway to provide adequate capacity to meet emergency drawdown requirements. For Newville Reservoir, the emergency drawdown requirements would control the sizing of both the outlet works and the spillway. The outlet works should be able to selectively withdraw water from different reservoir levels to ensure high quality releases into the Black Butte Reservoir. This structure would also serve to divert creek flows around the dam site during the construction period.

Additional studies will be required to refine plans for this structure and modification will have to be made depending on the reservoir size ultimately selected. However, this preliminary design revealed no unusual design or construction problems associated with this structure.

Spillway

A conventional, gated, overpour spillway with concrete-lined chute and stilling basin on the right abutment was selected for planning purposes. Deep gates were incorporated to let the spillway help meet the emergency reservoir evacuation flow of around 33,000 cfs. This flow would increase substantially if the capacity of the reservoir is increased to near 3 maf.

Stony Creek Diversion Facilities

From one-third to one-half of the inflow to Newville Reservoir could be derived from main stem Stony Creek. Two plans are under consideration for conveying this water from Black Butte Reservoir to Newville Reservoir. The 32,500 acre-feet Tehenn Reservoir would be formed by a 112 foot high earthfill dam 2,500 feet long. A gravity canal would convey water from Black Butte to the base of Tehenn Dam, where the water would be pumped into the reservoir whose upper end terminates at the Newville Dam Pumping Plant. The total pumping lift would range from 210 to 470 feet, depending on the levels of Black Butte and Newville Reservoirs. The possibility of stabilizing the operation of Black Butte within a narrow range of fluctuation will also be investigated.

A second alternative was envisioned recently in response to local concerns that Tehenn reservoir would flood a historically significant cemetery. This alternative proposes a canal and pumping plant(s) to convey water from Black Butte reservoir to the Newville Pumping Plant. This alternative is only conceptual at present and design and cost-estimating work will be performed later. The 1980 Thomes-Newville Feasibility report contains an extensive discussion of the first (Tehenn) alternative.

Tehenn and Newville Pumping/Generating Facilities

The Tehenn plant would have to operate under variable level extremes of between 430 and 474 foot elevation for incoming water from Black Butte Reservoir. Water elevation in Tehenn Reservoir would normally be held at the spillway crest elevation of 610 feet. The plant would be located 2,000 feet downstream of Tehenn Dam in a 120 foot deep bowl on the north side of the creek. The plant would connect to the reservoir through a 16 foot diameter welded steel penstock. The plant would consist of two pumping units and one pumping/generating unit.

The Newville pumping/generating plant at the toe of Newville Dam would provide up to 370 foot lift from Tehenn to Newville Reservoir. The plant would be a 80 x 200 foot indoor facility with two pumping units, one pumping/generating unit, and a service bay.

Thomes-Creek Diversion Facilities

The nearly 200-square mile Thomes Creek watershed produces an average annual runoff of around 200,000 acre-feet. West of Paskenta, Thomes Creek passes within a half mile of a low saddle ridge separating its watershed from the Newville Reservoir drainage area. At this point, it would seemingly be relatively easy east to divert the floodflows of Thomes Creek to Newville Reservoir. However, under today's more stringent environmental requirements the major obstacles associated with such a diversion are: (1) preventing the diversion of fish; (2) allowing the free passage of fish in Thomes Creek;(3) passing the creek's extremely large sediment load; and (4) minimizing interference with the large deer herd that winters in this area. Any one of these problems in isolation would probably be manageable, but combined, they present a formidable design challenge. Therefore, considerable future work remains to be completed before this diversion can be considered acceptable under today's environmental requirements.

Saddle Dams and Dikes

For a Newville Reservoir of less than 2 maf capacity, only one saddle dam at Burrows Gap would be required. This saddle dam would be located approximately 3 miles south of the main dam and would fill a saddle along Rocky Ridge. A 70 foot-high earth-rockfill embankment type dam containing approximately 560,000 cubic yards of material and patterned after the Newville Dam section would likely be used. No unusual problems are anticipated in the design and construction of this relatively low dam.

If the capacity of Newville Reservoir was increased to 3 maf, Burrows Gap Saddle Dam would increase to a height of 144 feet and would require approximately 1.8

million cubic yards of embankment material. Also, as the maximum reservoir capacity increases, within the range of 2.5 to 3.0 maf, two to five additional small saddle dams are required along Rocky Ridge. The total volume of these additional saddle dams would be less than one myd^3. No appurtenances are proposed at any of the saddle dam locations.

Similarly, as the maximum reservoir capacity varies between about 2.5 and 3.0 maf, a 30 to 70 foot-high Chrome Dike would be required at the southern end of the reservoir. This dike would require from 0.25 up to 1.7 myd^3 of fill material.

Potential Diversions from the Sacramento River

Earlier work on the Thomes-Newville Project at reservoir capacities less than 2 maf concentrated entirely on diversions from Stony and Thomes Creeks. However, as larger reservoir sizes up to 3 maf are considered, or if diversion problems are encountered on Thomes Creek, then a diversion from the Sacramento River would be required.

Some initial investigation of potential diversions from the Sacramento River via extensions of canals has been conducted; but much work remains to be done. So far, several potential alignments have been identified and initial reconnaissance level cost estimates have been made. More exact estimates will be completed after environmental analysis of comparative alignments have progressed further. More information on alternative water supply conveyance systems is contained in the February 2000 report "Thomes-Newville Project – Sacramento River Conveyance Study".

Road and Utilities Relocations

There are about 8 miles of public roads within the prospective Newville Reservoir. The Paskenta-Round Valley route, a paved two-lane county road, passes through the north end of the reservoir for a distance of about 2 miles; and another county road crosses northwestward through the reservoir site from the dam site to connect with the Paskenta-Round Valley Road. The Glenn County portion of the road within the reservoir is about 2 miles long and is paved; the 4-mile portion within Tehama County is unpaved.

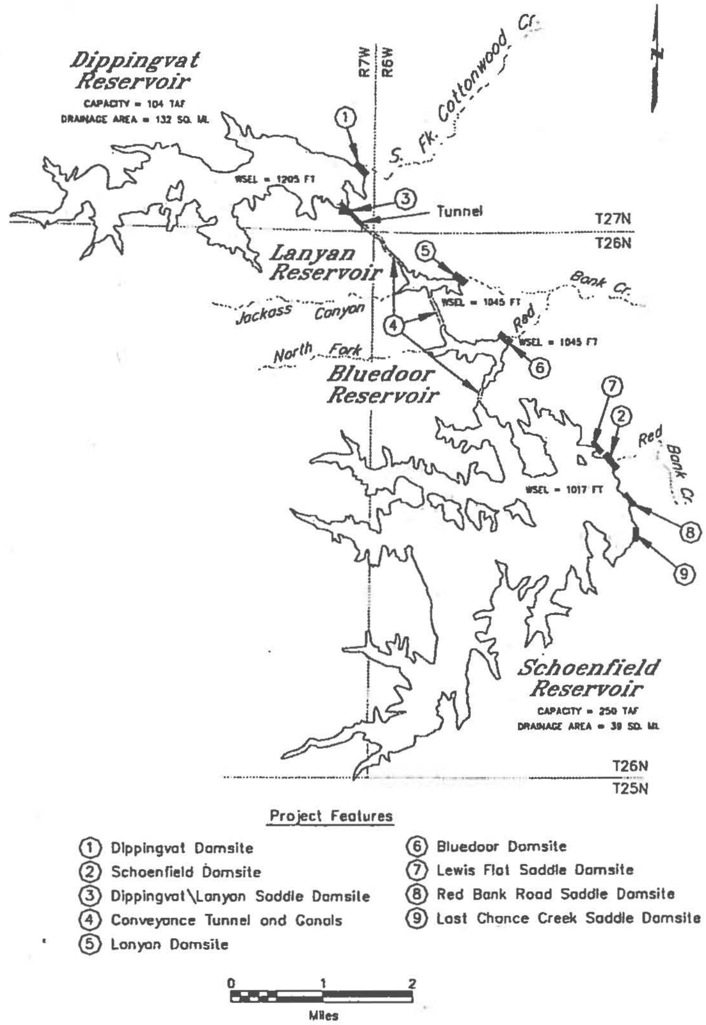
Both of these roads would be relocated and upgraded to current county paved-road standards. The Paskenta-Round Valley Road would be realigned around the north end of the reservoir and the other road would be routed along the east side of Rocky Ridge to link Newville Dam site to the town of Paskenta. The total length of new road construction would be about 10 miles. Any power lines or other utilities requiring relocation would follow the new road alignment whenever possible.

Red Bank Project

The Cottonwood Creek basin has been the subject of water development planning studies for over 50 years. Located within the 927 square mile watershed are two lower basin sites for large reservoirs - Tehama and Dutch Gulch – which were extensively investigated by the U.S. Corps of Engineers in the later 1970s and early 1980s for flood control and water supply. Higher in the watershed are located four smaller projects - Hulen, Fiddlers, Rosewood, and Dippingvat - which have also been extensively investigated. Of these numerous potential projects only Dippingvat appeared economically feasible in the late 1980s. It received continued low level investigation until 1993, when study was suspended due to escalating project cost estimates.

Interest in a Dippingvat Project combined with Schoenfield Reservoir on Red Bank Creek (known as the Red Bank Project) was renewed by CALFED around 1996 (Figure 5.14). This renewed interest was because of this project's capability to supply water to the entrance of the Tehama-Colusa Canal, thus allowing the Red Bluff Diversion Dam gates to be raised for a longer period. As a result, it was included as one of the four projects evaluated under the present Offstream Storage Investigation. The pre-feasibility design alternatives report completed on the Red Bank Project in 1993 determined that roller-compacted concrete dams would be considerably less expensive than equivalent earthfill dams at this location. Therefore, this progress report discusses only the roller-compacted concrete alternative. Additional future geologic investigations will be required to determine the ultimate suitability of this type of dam at this location.

Figure 5.14. Red Bank Project Features and Statistics



Dippingvat Dam

Dippingvat Dam site is located on South Fork Cottonwood Creek, in a deep narrow canyon one-half mile downstream of Dippingvat Flat Section 36, T27N, R7W as shown on Figure 5.14. The proposed dam would be 250 feet high and would create a 104 taf reservoir.

The average annual inflow to Dippingvat Reservoir is 104 taf captured by the 132 square mile upstream watershed. Dippingvat is an excellent dam site and Cottonwood Creek produces a substantial water supply, but the reservoir's capacity is too small to capture the majority of available water and also provide downstream flood control benefits. Therefore, a larger reservoir on nearby Red Bank Creek to help store excess Cottonwood Creek flows was thought desirable as part of the project.

Dam Structural Design

Dippingvat Dam would be a 250-foot high roller-compacted concrete (RCC) structure with a crest length of about 1,000 feet. The upstream face of the dam would be vertical and the downstream face would be sloped as shown in Figure 5.15. An earthfill dam was also evaluated at this location, but it presently appears much more expensive than the RCC alternative. However, future seismic investigations could determine that this site is not suitable for a RCC type dam.

Outlet Structure

Outlet works at both Dippingvat and Schoenfield Dams would be located through the dams near the centers, at approximately streambed elevation. The outlet would be used for diverting creek flows during construction. Discharge would be controlled by a dissipater valve at the end of each outlet as it transitions into the stilling basin. Maximum design velocity in the outlet pipe would be 35 ft/s.

Dippingvat Dam would have two outlets, a 15-foot diameter flood control outlet and a 2-foot diameter pipe to carry 60 ft/s for stream maintenance purposes. This outlet would draw from any of seven butterfly valves located along the upstream face of the dam for the purpose of controlling outlet water temperatures.

Spillway

Spillways at both Dippingvat and Schoenfield roller-compacted concrete dams would be constructed as an integral part of the dam face. Stepped concrete facing would line the spillway and help dissipate energy. Both spillways would have a crest length of 200 feet and would be controlled by an open ogee-type weir.

Figure 5.15. Dippingvat RCC Dam, Cross Section

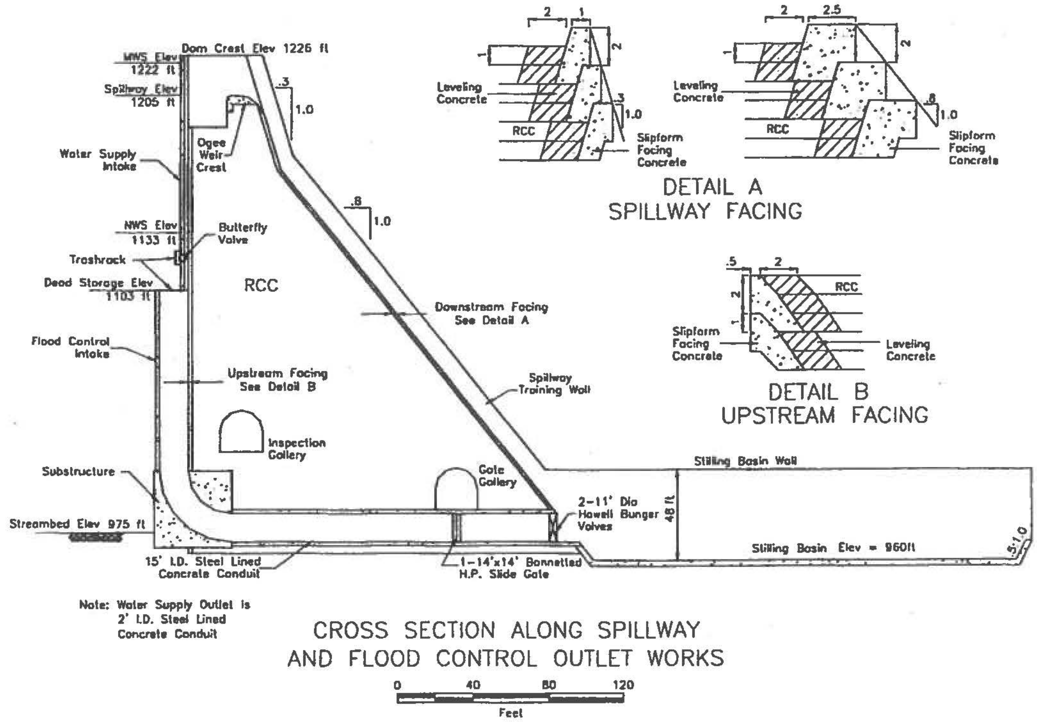
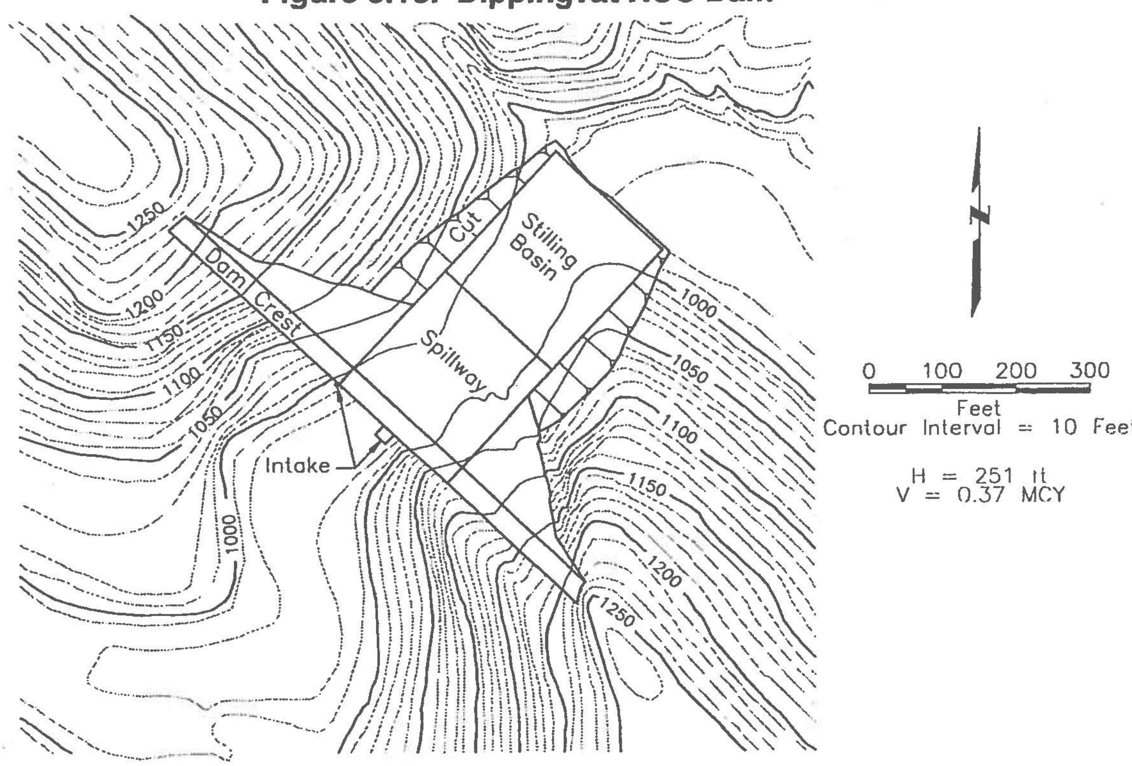


Figure 5.16. Dippingvat RCC Dam



Dippingvat Reservoir

At the spillway crest level, Dippingvat Reservoir would have a total storage of 104,000 acre-feet and cover an area of 1,260 acres. As planned in 1993, the reservoir would reach the spillway level only during major floods. Normally, the reservoir storage would be held at around 32,000 acre-feet to maintain a 72,000 acre-feet flood control reservation. These operating criteria could easily be modified in future studies if the level of flood control was changed.

Schoenfield Dam

Schoenfield Dam site is located on Red Bank Creek in a deep, narrow canyon in Section 16, known as the Narrows. This dam would form a 250 taf reservoir to help store runoff mainly diverted from South Fork Cottonwood Creek. Water would be conveyed from Dippingvat to Schoenfield Reservoir through three short canals and two low dams.

Schoenfield Dam would be a 300 foot high roller-compacted concrete structure approximately 900 feet long. About 540,000 yd^3 of concrete would be required to build the dam and the dam cross section would be similar to that for Dippingvat Dam. An earthfill dam at this location is still a possibility if future seismic investigations determine that the less expensive RCC dam is unsuitable.

Outlet Structure and Spillway

Schoenfield Dam would have a central overflow spillway constructed as part of the dam. The spillway crest length is limited to about 200 feet due to the narrow canyon floor at the downstream toe of the dam, which limits the width of the stilling basin. The maximum flow down the spillway resulting from the probable maximum flood is estimated at around 25,000 cubic feet per second.

Schoenfield Reservoir

At the spillway crest Schoenfield Reservoir would store 250,000 acre-feet of water and have a surface area of 2,770 acres. The natural average inflow into the reservoir is around 16,000 ac-ft per year and the releases would be made down Red Bank Creek to the Tehama-Colusa Canal. Only low level creek fishery maintenance releases would flow all the way into the Sacramento River.

Conveyance System

Much of the Cottonwood Creek water captured by Dippingvat Reservoir would be conveyed to the larger Schoenfield Reservoir for longer-term storage and ultimate release down Red Bank Creek. This water would be transported approximately 4 miles through three low ridges that separate the reservoirs. The conveyance system to accomplish this would consist of two small earthfill dams a short tunnel/canal and two other short canals as shown in Figure 5.16. No fish screen is presently planned for placement at the entrance of the conveyance system because anadromous fish could not pass Dippingvat Dam.

Water would be diverted from Dippingvat Reservoir into an 8-foot diameter one-half mile long concrete lined tunnel, capable of carrying 800 ft^3/s. A one-mile unlined canal would carry the water to 1,200 acre-foot Lanyan Reservoir formed by a 70 foot-high dam on Lanyan Creek. The water would then flow by gravity through a one-half mile canal from Lanyan Reservoir to 3,500 acre-foot Bluedoor Reservoir formed by 90-feet-high Bluedoor Dam on the upper North Fork Red Bank Creek. From here the water would be conveyed by a short canal through to Schoenfield Reservoir. Lanyan and Bluedoor Reservoirs would normally be held at their maximum storage level to facilitate gravity water conveyance. Water could only flow south through this system. The Lanyan and Bluedoor Dams were designed as conventional earthfill structures, but they could also be built as RCC structures.

Potential Future Studies

If study of the Red Bank Project continues, a canal-only conveyance alternative between the two major dams should be investigated. This would eliminate the need for Lanyan and Bluedoor Dams.

Also, a high dam on Cottonwood Creek would block migration of salmon to suitable habitat on areas upstream of the dam. This has raised recent interest in investigating a low dam on Cottonwood Creek, which could divert surplus flows to Schoenfield Reservoir while still allowing fish passage. While this may be possible, it would have major impacts on the project's water yield and benefits which would require considerable additional investigation to evaluate.

Another item which should be investigated if interest in the Red Bank Project continues is the potentially large flow reductions caused by percolation to ground water and consumptive use of water by vegetation along Red Bank Creek, in the approximately 30 stream miles between Schoenfield Dam and the Tehama-Colusa Canal entrance. This flow reduction could be considerable, particularly during the mid and late summer months.

Chapter 6. Environmental Studies

Potential environmental impacts associated with the storage, allocation, distribution, and use of water in California are complex. These actions must be carefully evaluated to document adverse impacts and identify mitigation measures to avoid or reduce impact to less than significant levels. Many environmental laws affect the State's major water supply programs and environmental concerns play a major role in water policy and planning. To begin to document fish, wildlife, and plant resources that could be affected by north-of-the-Delta offstream storage projects, environmental field surveys have been initiated. To date, surveys have focused on the footprint of the reservoirs. Future evaluations will target completing surveys within the reservoir footprints and on areas outside the reservoirs where conveyance facilities, roads, recreation facilities, and other structures will be located. This chapter will summarize the major laws influencing water supply facility planning, construction, operation, and include a summary results of the environmental surveys. Detailed information about these surveys can be found in various appendixes listed in the report.

Endangered Species Act

Under the federal ESA, an endangered species is one that is deemed to be in danger of extinction in all or a significant part of its range, and a threatened species is one that is considered likely to become endangered in the near future. The ESA is designed to preserve endangered and threatened species by protecting individuals of the species and their habitat and by implementing measures that promote their recovery.

The ESA sets forth a procedure for listing species as threatened or endangered. Final decisions on listings are made by USFWS and NMFS. Presently over 650 species have been listed in the United States, of which 110 are native to California---the largest number in any state.

Once a species is listed, Section 7 of the act requires that federal agencies, in consultation with USFWS or NMFS, ensure that their actions do not jeopardize the continued existence of the species or habitat critical for the survival of that species. The federal wildlife agencies are required to provide an opinion as to whether a proposed federal action would jeopardize the species. The opinion must consider reasonable and prudent alternatives to the action that would avoid jeopardizing the species' existence. Federal actions subject to Section 7 include issuance of federal permits such as the dredge and fill permit required under Section 404 of the federal Clean Water Act.

State and local agencies and private parties are subject to the ESA, if their proposed projects require a federal permit. In addition, Section 9 of the ESA prohibits the "take" of an endangered species and threatened species for which protective regulations have been adopted. "Take" has been broadly defined to include actions that harm or harass listed species or that cause significant loss of their habitat. Agencies and private parties are generally required to obtain a permit from USFWS or NMFS under Section 10(a) of the ESA before carrying out activities that may incidentally result in taking a listed species. The permit normally establishes conditions to avoid take of listed species and to compensate for habitat adversely impacted by the activities.

The ESA has been interpreted to apply not just to new projects, but also to ongoing project operation and maintenance. For example, maintenance activities along the California Aqueduct right-of-way may impact the San Joaquin kit fox, the blunt-nose leopard lizard, and the Tipton kangaroo rat, all species that have been listed as endangered. DWR initiated the Section 10(a) process to obtain a permit for the incidental take of species resulting from maintenance activities along the California Aqueduct. Another example is federal, State, and local operations in the Delta and upstream along the Sacramento River that are affected by biological opinions to protect winter-run salmon and Delta smelt.

California Endangered Species Act

The California Endangered Species Act is similar to the federal ESA and must be complied with in addition to the federal ESA. Listing decisions are made by the California Fish and Game Commission.

Dredge and Fill Permits

Section 404 of the federal Clean Water Act regulates the discharge of dredged and fill materials into waters of the United States, including wetlands. The term "discharge of dredged and fill material" has been defined broadly to include the building of any structure involving rock, sand, soil, or other construction material in waters of the United States. No discharge may occur unless a permit is obtained from the U.S. Army Corps of Engineers. Generally, the project proponent must agree to mitigate or have plans to mitigate environmental impacts caused by the project before a permit is issued. The U.S. Environmental Protection Agency has the authority to veto permits issued by the Corps for projects that EPA believes will have unacceptable adverse effects on municipal water supplies, fisheries, or recreational areas.

Section 404 requires that the project proponent demonstrate that a proposed project is the least environmentally damaging practicable alternative for meeting the project purposes. This requires an extensive and exhaustive evaluation of alternatives that may include non-structural alternatives. Mitigation of the proposed project is not even considered until this hurdle is passed.

Section 404 provides for the issuance of a general permit on a State, regional, or nationwide basis for certain categories of activities that will cause only minimal environmental effects. Such activities are allowed without an individual permit. Installation of a stream gaging station along a river levee is one example of an activity which falls within a nationwide permit.

The Corps also administers a permitting program under Section 10 of the 1899 Rivers and Harbors Act. Section 10 generally requires a permit for obstruction to navigable water. The scope of the permit under Section 10 is narrower than under Section 404 since the term "navigable waters" is more limited than "waters of the United States".

The majority of water development projects must comply with Section 404, Section 10, or both. For example, proposed facilities for North-of-the-Delta Offstream Storage, Phase II of the Coastal Branch for the SWP, Los Vaqueros for the Contra Costa Water District, as well as activities within Delta channels, are all subject to 404 jurisdiction and regulation.

Migratory Bird Treaty Act

This federal act implements various treaties for the protection of migratory birds and prohibits the "taking" (broadly defined) of birds protected by those treaties without a permit. The Secretary of the Interior is directed to determine conditions under which a taking may occur, and criminal penalties are imposed for unlawful taking or transportation of birds. Liability imposed by this act was one of several factors leading to the decision to close the Kesterson Wildlife Refuge.

National Environmental Policy Act

NEPA directs federal agencies to prepare an environmental impact statement for all major federal actions that may have a significant effect on the human environment. It states that it is the goal of the federal government to use all practicable means, consistent with other considerations of national policy, to protect and enhance the quality of the environment. It is a procedural law requiring all federal agencies to consider the environmental impacts of their proposed actions during the planning and decision-making processes. The content of an EIS is very similar to that required by the California Environmental Quality Act for a State environmental impact report.

California Environmental Quality Act

CEQA, modeled after NEPA, requires California public agency decision-makers to document and consider the environmental impacts of their actions. It requires an agency to identify ways to avoid or reduce environmental damage and to implement those measures where feasible. It also serves as a means to encourage public participation in the decision-making process. CEQA applies to all levels of California government, including the State, counties, cities, and local districts.

CEQA requires that a public agency carrying out a project with significant environmental effects prepare an environmental impact report. An EIR contains a description of the project; a discussion of the project's environmental impacts, mitigation measures, and alternatives; public comments; and the agency's responses to the comments.

NEPA does not generally require federal agencies to adopt mitigation measures or alternatives provided in the EIS. CEQA, on the other hand, does impose substantive duties on all California governmental agencies approving projects with significant environmental impacts to adopt feasible alternatives or mitigation measures that substantially lessen these impacts, unless there are overriding reasons why they cannot. When a project is subject to both CEQA and NEPA, both laws encourage the agencies to cooperate in planning the project and to prepare joint environmental documents.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act and related acts express the policy of Congress to protect the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources. Under this act, any federal agency that proposes to control or modify any body of water, or to issue a permit allowing control or modification of a body of water, must first consult with USFWS and State Fish and Game officials. This requires coordination early in the project planning and environmental review processes.

Public Interest Terms and Conditions

The California Water Code authorizes the State Water Resources Control Board to impose public interest terms and conditions to conserve the public interest, specifically the consideration of instream beneficial uses, when it issues permits to appropriate water. Frequently, SWRCB reserves jurisdiction to consider new instream uses and to modify permits accordingly.

Releases of Water for Fish

California Fish and Game Code Section 5937 provides protection to fisheries by requiring that the owner of any dam allow sufficient water at all times to pass the dam to keep in good condition any fisheries that may be planted or exist below the dam. In *California Trout, Inc. v. the State Water Resources Control Board* (1989), the court determined that Fish and Game Code Sections 5937 and 5946 require the SWRCB to modify the permits and licenses to the City of Los Angeles to appropriate water from Mono Lake tributaries to ensure sufficient water flows for fisheries purposes. In a subsequent case, the court of appeal ordered the Superior Court to set interim flow standards for the four tributaries that the City diverts. The Alpine County Superior Court entered a preliminary injunction prohibiting Los Angeles from diverting water whenever the Mono Lake level falls below 6,377 feet.

Streambed Alteration Agreements

Fish and Game Code Sections 1601 and 1603 require that any governmental entity or private party altering a river, stream, or lake bed, bottom or channel enter into an agreement with DFG. Where the project may substantially impact an existing fish or wildlife resource, DFG may require that the agreement include provisions designed to protect riparian habitat, fisheries, and wildlife. New water development projects and on-going maintenance activities are often subject to these sections.

Natural Community Conservation Planning

Adopted in 1991, California's Natural Community Conversation Planning Act establishes a program to identify the habitat needs of species before they become listed as threatened or endangered, and to develop appropriate voluntary conservation methods compatible with development and growth. This program is designed to preserve habitat for the variety of species that are dependent upon each other.

Participants in the program develop plans to protect certain habitat and will ultimately enter into agreements with DFG to ensure that the plans will be carried out. Plans must be consistent with endangered species laws. A pilot program has been established in Riverside, Orange, and San Bernardino Counties for the Coastal Sage Scrub, which exists in a habitat that has been diminishing. A number of endangered species, including the gnatcatcher, depend on this habitat. The Secretary of the Interior has endorsed this process, which may evolve into the approach of the future. Participation in these plans is not mandatory.

The Natural Conservation Planning Act is likely to play an important role in water development in the future. Water suppliers may participate in plans for habitat impacted directly by new water projects and indirectly in the areas that receive water supplies.

Need for Environmental Field Studies

Taken together, all of these environmental laws require that any agency proposing a major action such as construction of a large water project must conduct an extensive field evaluation of potentially affected natural and cultural resources.

The federal Endangered Species Act requires consultation with either USFWS or NMFS when any action threatens the continued existence of a species or its critical habitat. The State Endangered Species Act requires that a project proponent obtain a Section 2081(b) permit to authorize the incidental take of a State listed species. The Fish and Wildlife Coordination Act also requires consultation with USFWS and DFG to avoid damage to fish and wildlife resources. The federal Clean Water Act requires that a permit be obtained from the Corps, which can be obtained only after the affected resources are documented and plans are developed to mitigate any impacts. A complex set of federal and State laws and policies regulate preservation of historic and cultural resources, including cemeteries. Finally, NEPA and CEQA require disclosure of affected resources, potential environmental impacts, proposed mitigation measures, and alternatives.

At least 20 environmental permits would be required before a major water storage project could proceed. Each permit requires a detailed description of the potentially affected resources as the first step in determining what is affected, identifying measures to avoid impacts, and defining measures to mitigate for unavoidable impacts. The delineation of wetlands (identifying and mapping) is the first step of discussions with the Corps regarding the Clean Water Act and in consulting with the administering agencies regarding wetland species and the Endangered Species Acts.

This initial phase of the environmental evaluation focused on so-called "listed" species. These are species that are listed as threatened or endangered by the federal and State Endangered Species Acts. It also evaluated "sensitive" species; those that could become listed as threatened or endangered in the near future. In future studies, the potential impacts on more common species, such as migratory deer or resident fish, will be evaluated.

The following sections describe the surveys and inventories undertaken to date to identify the sensitive plants, fish, animals, and their potential habitats, and the cultural resources that could be affected by the water diversion and storage projects under consideration. For some species, the regulatory agencies have defined guidelines, or protocols, which describe how the surveys should be conducted. When protocols have been defined, they were followed in conducting these surveys.

Table 6-48, at the end of this chapter, lists species that could occur in the Counties in the west side of the Sacramento Valley where the proposed offstream storage reservoirs are located. The lists were based on a review of the California Natural Diversity Database, the Federal Register of Threatened, Endangered, and Special Status Species, and other references. The purpose of environmental field data collections and surveys is to verify the existence of these species in specific locations where offstream storage project facilities may be located. These are the species that determined the design of the various surveys and the species the survey teams were looking for in the field. Table 6-48 also shows the species that have been observed during two years of survey effort, and also the probability of other species that may be present in the area (based on preliminary habitat evaluations) but have not been observed to date.

Wetlands Delineation

This section summarizes a two-year survey of wetlands and other "waters of the United States" within the footprint of the four potential Offstream Storage Reservoirs. Detailed information about the wetlands delination can be found in Appendix B.

Stereo pairs of 1:12000 and 1:6000 scale color aerial photos were reviewed to identify wetlands and wetland vegetation prior to field studies. The aerial photography used in the wetland identifications was done in late spring 1998 in order to differentiate seasonal wetlands from annual grassland cover. Wetland types were identified on the photographs and representative types were selected throughout each reservoir area for field verification. Wetland delineations were made using the "routine method" as described in the 1987 "Corps of Engineers Wetland Delineation Manual". Results of the wetland delineations and field verifications were used to produce a draft map of jurisdictional wetlands.

Sites Reservoir

Seasonal wetlands account for over 76 percent of the jurisdictional wetlands identified within the Sites Reservoir footprint (Table 6.1). Most of the alkaline wetlands are also "seasonal" but are vastly different in the plant species composition. The alkaline wetlands within the Sites Reservoir are located along a linear zone of deformation potentially associated with Salt Pond Fault. A very small quantity (2 acres) of emergent wetlands was identified within the Sites Reservoir.

The riparian areas found in the Sites Reservoir area are rarely well developed or large in size. The largest concentration of riparian habitat is located within the southern portion of the Sites Reservoir.

Many of the vernal pools found within the Sites and Colusa Reservoir areas are "manmade" (e.g., drainages blocked by roads, stock ponds, or disturbed areas within heavy clay soils) and have very low plant species diversities. Pools occurring along the northeastern edge of the Sites Reservoir tended to be larger in size and higher in plant species diversity than elsewhere. One large pool with higher plant species diversity occurs within the Colusa Cell.

Colusa Cell

Seasonal wetlands account for over 84 percent of the Colusa Cell wetlands (Table 6.1). Most of the alkaline wetlands are also "seasonal" but are vastly different in the plant species composition. The alkaline wetlands within the Colusa Cell are located along a linear zone of deformation potentially associated with Salt Pond Fault. Emergent wetlands were present within the Colusa Cell in several small areas but these were not measurable using aerial photo interpretation.

The riparian areas found the Colusa Cell are rarely well developed or large in size.

Newville Reservoir

Seasonal wetlands dominate (74 percent) the wetlands of the Newville Reservoir site (Table 6.1). Some of the wetland areas are very large in size and may form complexes with other types of wetlands including riparian areas. This site also has significant quantities of other wetland types.

Riparian areas account for over 18 percent of the Newville Reservoir wetlands. Well-developed riparian habitat occurs along a number of the main tributaries, although patches of the invasive non-native *Ailanthus altissima* (tree of heaven) occur within some of these stands. Construction of the Newville Reservoir would result in the loss of 77 acres of good quality riparian habitat.

One small area of alkaline wetland was identified within the Salt Creek drainage. Other areas adjacent to Salt Creek and some of its tributaries supported alkaline species but were too narrow to map.

Vernal pool complexes, that is areas of concentrated pools and connecting swales, were found in several locations within the reservoir site. The pools of this reservoir alternative were of an overall higher quality when compared to the Sites and Colusa Reservoir areas.

Red Bank Project

Seasonal and emergent wetlands make up less than 9 percent of the wetland total for the Red Bank Project (Table 6.1). Many of these wetlands are located within or adjacent to small stockponds or are associated with saturated spring-fed areas. Clay soils are relatively rare within the steep terrain that dominates both the Schoenfield and Dippingvat Reservoirs.

Riparian areas dominate (92 percent) the wetlands of this area. Riparian areas can be found throughout the two reservoirs but are best developed along the South Fork of Cottonwood and Red Bank Creeks.

Table 6.1 Jurisdictional Wetlands and Waters of the U.S. Delineation

Wetlands Type	Acreage by Reservoir			
	Sites Reservoir	Colusa Cell	Newville Reservoir	Red Bank Project
Alkaline	19	35	3	0
Emergent	2	0	6	included with seasonal
Riparian	22	11	77	76
Seasonal	153	263	304	7
Total Jurisdictional Wetlands	201	312	413	83
Streams	159	111	165	118
Ponds	16	24	66	34
Other Waters	175	135	231	152
Total Waters of U.S.	376	447	644	235
Reservoir Area	14,162	13,664	17,073	4,905

Special Status Shrimp Habitat Surveys

This section describes the methods and results of the mapping of potential special-status shrimp habitat at the proposed Sites, Colusa, Thomes-Newville, and Red Bank potential offstream storage project areas.

Jones & Stokes Associates ecologists performed surveys of potential special-status shrimp habitat at these potential reservoir sites in 1998 and 1999. The 1999 surveys were conducted in an effort to verify potential special-status shrimp habitat mapped in 1998 and to survey in areas where access was unavailable in the previous surveys because of flooded creeks, washed-out roads, and issues with property owners.

The 1998 and 1999 results are summarized in the General Discussion section and in Table 6.2.

Special-status shrimp include species in the following categories:

- Shrimp listed or proposed for listing as threatened or endangered under the federal Endangered Species Act (50 CFR 17.11 for listed animals and various Federal Register notices for proposed species) and

- Other shrimp species meeting the definition of rare, threatened, or endangered species under the California Environmental Quality Act (State CEQA Guidelines, Section 15380).

The surveys focused on identifying potential habitat for the federally listed as threatened vernal pool fairy shrimp (*Branchinecta lynchi*); the federally listed as endangered Conservancy fairy shrimp (*Branchinecta conservatio*); the federally listed as endangered vernal pool tadpole shrimp (*Lepidurus packardi*); and the rare, non-listed "Mid-Valley" fairy shrimp. Three fairy shrimp species, which are not special-status species but are found in the same types of habitat, also have the potential to occur within the proposed project areas: *Branchinecta coloradensis, Branchinecta lindahli,* and *Linderiella occidentalis.*

Table 6.2 Total Acreage of Potential Special-Status Shrimp Habitat

Potential Reservoir Site	Total Extent of Potential Special-Status Shrimp Habitat (Acres)		
	1998 Survey	1999 Survey	Difference
Red Bank	0.0	0.0	0.0
Thomes-Newville	26	26	0
Sites	73	71	-2
Colusa Cell	12	12	0

The 1999 surveys were conducted between April 5 and May 21. A total of 28 days (56 person days) were spent in the field. Aerial photographs and existing data from the California Department of Water Resources and the 1998 survey results were used to select areas most likely to support special-status shrimp habitat. Potential habitat was mapped conservatively in an effort to be as inclusive as possible. Potential habitat surveyed included vernal pools, alkali flats, clay flats, ephemeral stock ponds, pools, and salt lakes. Therefore, it is likely that the results of this study represent a high estimate of habitat extent. In certain instances, such as clay flats and non-vegetated artificial habitats that had dried for the season, precise boundaries were difficult to define and were estimated using best professional judgment. Surveys conducted using the approved, more detailed USFWS protocol could result in identification of a lesser amount of actual special-status shrimp habitat.

Typical habitat for special-status fairy and tadpole shrimp in California include vernal pools, ponded areas within vernal swales, rock outcrop ephemeral pools, playas, alkali flats, and salt lakes. Other kinds of depressions that hold water of a similar volume, depth and area, and for a similar duration and seasonality, such as vernal pools and swales, also may be potential habitat. These other depressions, however, are typically artificial habitats and are unvegetated, yet bear an equal potential for supporting special-status shrimp.

Pool volume is important in determining potential shrimp habitat because deeper pools with a large surface area can more easily maintain their dissolved oxygen levels. Similarly, deep pools will pond long enough to allow the shrimp to complete their life cycle.

Common wetland plant species that typically co-occur with special-status shrimp species generally need the same hydrologic conditions (i.e., ponding depth, ponded surface area, ponding duration). Therefore, the presence of these plant species within a potential habitat would imply a greater potential for a population of these shrimp to be present.

Conversely, pools that are dominated by vernal pool plant species that tolerate only short inundation periods will have hydrology that cannot support shrimp species (i.e., ponding duration too short, pool area too small).

Similarly, wetland habitats that support plant species that need water year round cannot support special-status shrimp species because the shrimp's cysts must dry out before they can hatch.

Unvegetated potential shrimp habitats (e.g., clay flats, road ruts, and alkali flats) were mapped to the perimeter (i.e., where the vegetation begins) or to high-water mark indicators such as drift lines or dams.

Therefore, potential special-status shrimp habitat is defined as seasonal wetlands and other temporarily ponded areas of sufficient size (depth and area) and seasonality that may support specific vegetation. This vegetation indicates the potential for ponding for a sufficient duration to allow special-status shrimp species to complete their life cycles and to maintain cool water temperatures conducive to special-status shrimp species.

All habitats mapped during the 1998 survey effort were revisited, plus areas previously inaccessible were surveyed for additional potential special-status shrimp habitat. Habitats fulfilling these criteria were mapped on U.S. Geological Survey 7.5-minute quadrangle maps. The shape and dimensions of the habitat sites were drawn and described in field notes and used to calculate habitat extent in acres.

Sites Reservoir

Grasslands and vernal pools on heavy clay soils in basin terrain characterize the Sites Reservoir area, with low ridge lines near the valley margins. Clay slumps are common along the ridges and clay flats occur in low-lying areas. The land is currently used for cattle and sheep grazing. During the 1999 surveys, 1.5 acres of potential special-status shrimp habitat was determined to be incapable of supporting special-

Table 6.3. Acreage Estimates of the Dominant Vegetation Communities Mapped Within the Four Offstream Storage Reservoir Alternatives

VEGETATION[1]	ACREAGE BY RESERVOIR			
	SITES	COLUSA cell	THOMES/ NEWVILLE	RED BANK
Grassland	12,602	13,540	14,492	565
Woodland (oak)	923	20	1,839	899
Woodland (foothill pine)	0	0	0	2826
Chaparral	5	0	363	98
Riparian	52	37	64	73
Vegetated wetland	23	15	0	1
Cultivated grain	277	0	0	0
VEGETATION SUBTOTAL	13,882	13,612	16,758	4,462
Other	280	51	315	142
Total reservoir acreage	14,162	13,663	17,073	4,604

Notes:[1] Other classification refers to disturbed/developed acreage within the inundation elevations.

Red Bank Project

Foothill pine woodland is the dominant vegetation in the Red Bank Reservoir area. Oak woodland represents approximately 20 percent (899 acres) of the project area. The total amount of woodland habitat including foothill pine woodland and oak woodland comprises 83 percent of the vegetative cover. At this site, only 2 percent of the cover is chaparral scrub, and 12 percent (565 acres) is annual grassland. Potential habitat exists at this site for the chaparral, valley and foothill woodland, and valley and foothill grassland prioritized species. No vernal pool or alkaline wetland habitat was observed in the Red Bank Reservoir site. Ten prioritized plant species and 73 total populations were found in this project area; including 39 priority species populations and 34 populations of low priority species (Table 6.4).

Table 6.4. Summary of Prioritized Plant Species Found in the Offstream Storage Reservoir Project, 1998-1999

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

Notes:
[1] Nomenclature corresponds to Skinner and Pavlik 1994;
[2] Occurrences are defined per California Native Plant Society1999 as population findings separated by at least 0.25 miles;
[3] USFWS 1998:SC (Species of Concern); Skinner and Pavlik 1994;CNPS IB; (Plants rare, threatened or endangered in California and elsewhere); CNPS List 4 (Plants of limited distribution).

Valley Elderberry Longhorn Beetle Surveys

The valley elderberry longhorn beetle (VELB), *Desmocerus californicus dimorphus* Fisher, was listed by USFWS as threatened, with Critical Habitat on August 10, 1980 (Federal Register 45:52803-52807). Although there were no known VELB sites within the proposed reservoirs, habitat was known to exist within the project areas and known VELB locations were recorded nearby. The purpose of this survey was to identify and record the presence of VELB and its habitat (see Appendix C for more detail).

Surveys focused on identifying potential habitat for VELB, the number of elderberry stems found measuring one inch or more, and the presence of exit holes. All drainages and adjacent savannas were checked first with aerial photographs and then by field surveying all potential habitat.

Habitat for VELB occurs at each of the four proposed reservoir sites. VELB emergence holes were found within the proposed Sites and Newville Reservoir areas. No emergence holes were found within the proposed Colusa and Red Bank Project areas. No adult beetles were observed at any of the proposed reservoir sites. Six hundred seventy-two elderberry stems were counted within the Sites Project area. Emergence holes were found on 18 individual stems. Only one stand of elderberry was found within the Colusa cell consisting of 38 stems. Five hundred fifty-two stems have been counted in the Newville Reservoir area. Emergence holes have been found in 42 stems. A total of 1,001 elderberry stems were found within the proposed Red Bank Project area. Two hundred ten elderberry stems were found at the Dippingvat Reservoir site. Seven hundred ninety-one individual stems were counted at the Schoenfield Reservoir site. No emergence holes were found at either proposed reservoir area. No elderberry plants were found at either the Bluedoor or Lanyan Reservoir sites, however potential elderberry habitat does exist at both.

Areas not surveyed prior to this report, such as areas with restricted access, conveyance facility locations, and road relocations, will need to be surveyed. Analyses will also be needed to predict how possible changes in water regimes within the channels and associated savannas downstream will affect elderberry survival and distribution.

Avian Surveys

The purpose of the avian survey effort was to identify the occurrence, density, and distribution of State and federally "listed" species of birds that may occur within the proposed project areas. These data provide information to help evaluate and compare the potential project effects on State and federally "listed" avian species and their habitats at the four proposed reservoir locations. (See Appendix K for more detail).

A compilation of State and federal listed species, California Species of Special Concern, and federal Species of Management Concern which could potentially occur within the proposed reservoirs was developed from several sources including: Natural Diversity Data Base, California Wildlife Habitat Relationships Program, literature review, landowner interviews, USFWS lists, and consultation with species experts.

Three methodologies were used to determine presence, density, and distribution of State and federally listed bird species at the proposed reservoir locations including monthly avian line-transects, annual bank swallow surveys, and annual owl surveys using pre-recorded calls. The avian studies were primarily confined to the area of the reservoir footprint. However, line transects extended up to 2.5 miles from the reservoir footprints along key drainages. Surveys were initiated at the existing Funks Reservoir to document which State or federally listed avian species would utilize a reservoir within low elevation grassland habitats.

Line transects were established in representative habitat within proposed reservoir locations as access allowed using standard avian line transect methodology (Emlen, 1971). Transect length and initiation dates are identified in Table 6.5. Initial access for the transect surveys was obtained at different points in time, resulting in different numbers of transect repetition for each season at each of the four proposed reservoir locations. Sites Reservoir data are most comprehensive as the 12.5 mile transect has been surveyed monthly since March 1997. DFG conducted avian surveys between 1980 and 1983 within the Stony and Thomes Creek watersheds as part of the fish and wildlife studies of the proposed Thomes-Newville Project. The Newville Reservoir transect was established and sampled to supplement the information obtained in that effort.

Table 6.5 Avian Transect Lengths and Initiation Date

Reservoir Location	Transect Length	Date Initiated
Sites Reservoir	12.5 miles	March-97
Colusa Cell	11.0 miles	October-97
Newville Reservoir	19.5 miles	December-98
Red Bank Project	16.0 miles	April-98
Funks Reservoir (existing)	2.5 miles	October-97

Line transects were surveyed either by foot or from a vehicle at a rate of two to three miles/hour. All state and federally listed avian species, California Species of Special Concern, and federal Migratory Nongame Birds of Management Concern detected were recorded. The distance from the transect line at the point of detection was recorded using a Tasco Lasersite Rangefinder. Detections were recorded on to field data sheets in 100 yard increments. Maximum range of the rangefinder of 800 yards (either side of the transect line) was used as the outer limit of the transect. State and federally listed species detected outside of the 800-yard limit were noted (presence) but not included in density estimates. Both 10X40 binoculars and a 15X60 spotting scope were used for field identification.

Information recorded included species, number of individuals, and lateral distance from the transect line at the point of first sighting. Data analyses followed methods of Balph et al. (1977). This method of line transect data analyses allows the field data to be used to determine differences in detectability between species and within the same species at different points in their life cycle, resulting in greater precision in density estimates.

Monthly transect results were consolidated into seasonal groups for density analyses. Seasons were defined based on the dates used by the California Wildlife Habitat Relationships Program for seasonal bird reports (Zeiner et. al. 1990). These seasonal breakdowns are based on documented migration and residency patterns of California species. Avian surveys were not conducted during periods of precipitation, high wind, or reduced visibility (fog or smoke).

Bank swallow surveys involved walking all permanent and ephemeral stream reaches with downcut channels during the bank swallow breeding season (May through July). All vertical banks were inspected for the presence of bank swallow burrows. All foraging swallows were identified to species. And all detections of burrows or foraging bank swallows were recorded.

Owl surveys were conducted at night along the previously identified line transect routes during May or June. Sampling was initiated at dusk. Methodology involved broadcasting pre-recorded calls using a tape recorder with external speaker at half-mile intervals. Each species call (burrowing owl, short-eared owl, and long eared owl) was broadcast for 30 seconds followed by 30 seconds of silence to detect return calls. Three repetitions of each call/listen cycle were conducted for each species at each one-half mile interval along the line transects. All owl detections were logged. Owl surveys were not conducted during periods of high wind or precipitation.

Review of existing databases indicated that nine State or federally listed avian species may occur within Tehama, Glenn, or Colusa Counties. Three of these species were identified during avian transect sampling at or near the proposed reservoir locations: southern bald eagle, bank swallow, and sandhill crane (Table 6.6).

Sporadic wintering use by both adult and immature bald eagles has been documented at each of the four proposed reservoir locations. Wintering use was nearly an order of magnitude greater at Funks Reservoir than at any of the four proposed reservoir locations. Both fish and a large concentration of waterfowl are available as prey for bald eagles wintering at Funks Reservoir. Up to five bald eagles have been observed perched around the reservoir on one date. Extensive winter bald eagle surveys were conducted along Thomes Creek as part of the Thomes Reservoir studies in the 1980s. These studies confirmed extensive use of Thomes Creek by wintering bald eagles. No suitable nesting habitat is present in the vicinity of Sites, Colusa, or Newville Reservoirs. An adult and an immature bald eagle were observed together within the Red Bank Project during late-April 1998. No indication of nesting other than these two sightings of adult birds during the breeding season has been observed.

A single sighting of a bank swallow was made near the proposed Colusa Reservoir Cell during avian transect sampling. This sighting was made during late September 1998 approximately 2.5 miles east of the proposed Colusa Reservoir Cell. This sighting represents a transient or migrating bank swallow rather than a breeding season use. DFG surveys conducted at the proposed Thomes-Newville Reservoir in the early 1980s identified two small bank swallow colonies along Thomes Creek downstream from the project area. Both of these historic colony locations appear to be outside the footprint of the currently proposed reservoir.

Five sandhill cranes were observed flying over the Colusa Reservoir during November 1997. No actual habitat use was observed. This observation occurred on a date when the Sacramento Valley was fogged in while the adjacent foothill areas were fog free. Under these conditions sandhill cranes may set down and utilize foothill annual grasslands. No other sandhill crane observations at any of the other three reservoir locations were made during the course of the sampling effort. No sandhill crane use was recorded during the three years of intensive study conducted at Thomes-Newville Reservoir during the early 1980s.

Nesting habitat for peregrine falcon, northern spotted owl, yellow-billed cuckoo, greater sandhill crane and willow flycatcher is absent from the proposed reservoirs. Marginal Swainson's hawk nesting/foraging habitat is present at Sites, Colusa, and Newville Reservoir locations and absent at the Red Bank Project. Habitats within the proposed reservoirs offer very limited opportunity for wintering or migration use by Aleutian Canada goose, mountain plover, peregrine falcon, greater sandhill crane, and willow flycatcher.

Table 6.6. State and Federal Listed and Special Concern Avian Species Which May Occur At North-of-the-Delta Offstream Storage Reservoirs

Species	Status	Sites	Colusa	Newville	Red Bank	Funks
Aleutian Canada Goose	FT					
American bittern	MNBMC					X
American white pelican	CSSC					X
bank swallow	ST		X			
Barrow's goldeneye	CSSC					
Bell's sage sparrow	MNBMC					
Burrowing owl	CSSC, MNBMC	X	X	X		
California gull	CSSC	X				X
California horned lark	CSSC, MNBMC	X	X	X	X	
Common loon	CSSC, MNBMC					X
Cooper's hawk	CSSC	X	X	X	X	
double-crested cormorant	CSSC		X			X
Ferruginous hawk	CSSC, MNBMC	X				X
golden eagle	CSSC	X	X	X	X	X
Grasshopper sparrow	MNBMC		X			X
greater sandhill crane	ST		X			
hermit warbler	MNBMC					
lark sparrow	MNBMC	X	X	X	X	
Lawrence's goldfinch	MNBMC		X		X	X
least bittern	MNBMC					
Loggerhead shrike	CSSC, MNBMC	X	X	X	X	X
long-billed curlew	CSSC, MNBMC	X	X	X		X
long-eared owl	CSSC	X	X	X	X	
Merlin	CSSC	X		X	X	
Mountain plover	CSSC, MNBMC					
Northern goshawk	CSSC, MNBMC					
Northern harrier	CSSC	X	X	X	X	X
Northern spotted owl	FE, SE					
Osprey	CSSC				X	
Peregrine falcon	SE					
Prairie falcon	CSSC	X	X	X	X	X
Purple martin	CSSC					
Sharp-shinned hawk	CSSC	X	X		X	X
Short-eared owl	CSSC, MNBMC					X
Southern bald eagle	SE, FT	X	X	X	X	X

Table 6.6 continued	Status	Sites	Colusa	Newville	Red Bank	Funks
Sand hill Crane			X			
Swainson's hawk	ST					
Tricolored blackbird	CSSC, MNBMC	X	X	X		
Vaux's swift	CSSC, MNBMC					
Western snowy plover	CSSC, MNBMC					
Western yellow-billed cuckoo	SE, MNBMC					
White-faced ibis	CSSC, MNBMC					
White-tailed kite	MNBMC	X				X
Willow flycatcher	SE					
Yellow warbler	CSSC	X				
Yellow-breasted chat	CSSC					

KEY

CSSC=California Species of Special Concern
MNBMC=Migratory Nongame Birds of Management Concern (USF&WS)
SE=State Endangered
ST=State Threatened
FE=Federal Endangered
FT=Federal Threatened
FPT = Federal Proposed Threatened
X=Observed at reservoir site indicated.

Thirty-six avian species classified as either California Species of Special Concern or Migratory Nongame Birds of Management Concern may occur within Tehama, Glenn, or Colusa counties. Twenty-five of these species have been observed at or near one or more of the proposed reservoir locations including: American bittern, American white pelican, burrowing owl, California gull, California horned lark, common loon, Cooper's hawk, double-crested cormorant, ferruginous hawk, golden eagle, grasshopper sparrow, lark sparrow, Lawrence's goldfinch, loggerhead shrike, long-billed curlew, long-eared owl, merlin, northern harrier, osprey, prairie falcon, sharp-shinned hawk, short-eared owl, tricolored blackbird, white-tailed kite, and yellow warbler (Table 6.6).

Seasonal avian density estimates developed from line transect data for each of the four proposed reservoir locations are presented in Tables 6.3-6. Seasonal avian density estimates for the existing Funks Reservoir are presented in Table 6-7.

Table 6.7 Sites Reservoir Avian Transect Results

(Density in Birds/Square mile)

Species	Summer	Fall	Winter	Spring
Burrowing owl	0.24	0.05		
California horned lark	4.83	1.58	2.90	6.57
Cooper's hawk		0.03		0.06
Ferruginous hawk			0.12	
Golden eagle	0.23	0.20	0.26	0.32
Lark sparrow	NS	NS	0.47	1.46
Loggerhead shrike	0.93	1.60	1.17	0.47
Long-billed curlew			14.59	1.26
Northern harrier	0.05	0.50	1.53	0.58
Sharp-shinned hawk		0.40		0.03
Southern bald eagle			0.07	
tri-colored blackbird				5.38
White-tailed kite	0.12			0.12
Miles of transect per season	37.5	88.0	75.0	150.5
NS=Not Sampled				

Table 6.8 Colusa Cell Avian Transect Results

(Density in Birds/Sq. Mile)

Species	Summer	Fall	Winter	Spring
Bank swallow		0.14		
Burrowing owl		0.14		0.03
California horned lark	85.00	7.38	22.63	36.66
Cooper's hawk		0.14	0.27	
Double-crested cormorant				0.10
Golden eagle	0.22	0.32	0.24	0.30
Lark sparrow	NS	NS		0.80
Loggerhead shrike	0.89	2.15	1.84	2.82
Long-billed curlew				4.53
Northern harrier	1.00	0.67	0.87	0.50
Prairie falcon		0.14		
Sandhill crane		0.67		
Sharp-shinned hawk		0.14		
Southern bald eagle		0.04	0.03	0.10
tri-colored blackbird	41.50			20.32
Miles of transect per season	20.0	74.5	38.0	87.5
NS=Not Sampled				

Table 6.9 Newville Reservoir Avian Transect Results

(Density in Birds/Sq. Mile)

Species	Summer	Fall	Winter	Spring
Southern bald eagle	NS	NS	0.08	
California horned lark	NS	NS	0.52	0.75
Cooper's hawk	NS	NS	0.17	
Golden eagle	NS	NS	0.10	0.13
Lark sparrow	NS	NS	7.64	1.50
Loggerhead shrike	NS	NS	2.05	0.90
Merlin	NS	NS	0.04	
Northern harrier	NS	NS	0.15	0.06
Prairie falcon	NS	NS	0.05	0.12
tri-colored blackbird	NS	NS	0.69	2.41
Miles of transect per season			58.5	58.5
NS=Not Sampled				

Table 6.10 Red Bank Project Avian Transect Results

(Density in Birds/Sq. Mile)

Species	Summer	Fall	Winter	Spring
Southern bald eagle		0.11	0.05	0.26
Cooper's hawk		0.07	0.16	0.26
Golden eagle	0.09	0.25	0.30	0.32
Lark sparrow	NS	NS	0.18	4.79
Lawrence's goldfinch			0.36	0.78
Merlin				0.07
Northern harrier		0.08	1.07	0.26
Osprey				0.13
Prairie falcon			0.00	0.13
Sharp-shinned hawk		0.19	0.40	0.06
Miles of transect per season	25.5	53.0	55.0	68.0
NS=Not Sampled				

Table 6.11 Funks Reservoir Avian Transect Results (Existing Reservoir)
(Density in Birds/Sq. Mile)

Species	Summer	Fall	Winter	Spring
American bittern	0.84			
American white pelican		0.16	0.10	
California gull		0.32	1.84	0.43
Common loon				0.21
Cooper's hawk		0.48		
Double-crested cormorant	0.37	1.43	1.11	0.33
Golden eagle			0.13	0.05
Lark sparrow	NS	NS	8.18	
Loggerhead shrike		1.43	0.49	1.07
Long-billed curlew		4.20	17.73	
Northern harrier		0.53	3.89	0.75
Prairie falcon		0.09		
Sharp-shinned hawk			0.48	
Short-eared owl				0.43
Southern bald eagle			0.82	0.21
White-tailed kite			1.14	0.14
Miles of transect per season	6.0	21.5	18.0	20.5
NS=Not Sampled				

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Mammal Studies

A variety of field survey methods were used to sample the mammal populations at the four alternative sites. Preliminary research included general literature searches, consultation with agency and species experts, aerial photo habitat interpretations, and landowner interviews. In addition, DFG biologists reviewed the Natural Diversity Data Base; Wildlife Habitat Relationship System; the Federal Register of Threatened, Endangered, and Special Status Species; the 1983 *Thomes/Newville Status Report*; and the 1987 *Final Report on Reconnaissance Level Studies of the Fish and Wildlife Resources at the Dippingvat and Schoenfield Reservoir sites* to gather additional species information for each project area. A list was then compiled which included the following potentially occurring Special Status species of mammals. While the species listed below remain the focus of survey efforts, sampling has been designed to include the detection and assessment of all mammal species. (See Appendix E for more detailed information).

Table 6.12. Mammal Species Surveyed at Proposed North-of-the-Delta Offstream Storage Reservoirs

Species	Status
Yuma myotis *(Myotis yumanensis)*	FSCS, CSSC
Long-eared *(Myotis evotis)*	FSCS
Fringed myotis *(Myotis thysanodes)*	FSCS
Long-legged myotis *(Myotis volans)*	FSCS
Small-footed myotis *(Myotis ciliolabrum)*	FSCS
Western red bat *(Lasiurus blossivillii)*	SS
Spotted bat *(Euderma maculatum)*	FSCS, CSSC
Pale big-eared bat *(Corynorhinus townsendii pallescens)*	FSCS, CSSC, SS
Pacific western big-eared bat *(Corynorhinus townsendii townsendii)*	FSCS, CSSC, SS
Pallid bat *(Antrozous pallidus)*	CSSC, SS
Western mastiff bat *(Eumops perotis californicus)*	FSCS, CSSC
San Joaquin pocket mouse *(Perognathus inornatus inornatus)*	FSCS
Ringtail *(Bassariscus astutus)*	CFPS
Pine marten *(Martes americana)*	SS
Pacific fisher *(Martes pennanti pacificus)*	FSCS, CSSC, SS
American badger *(Taxidea taxus)*	CSSC

Key

CSSC = California Species of Special Concern
CFPS = California Fully Protected Species
FSCS = Federal Special Concern Species
SS = Sensitive Species

After the development of the species list, field surveys were designed to assess the presence, distribution, and, where possible, the relative abundance of the mammal species at the four alternative reservoir sites. Field investigation methods included small mammal live trapping, mist netting, acoustical surveys, roost and hibernacula searches, track plates, photo stations, spotlighting, general habitat measurements, walking transects, road transects, and incidental observations.

Small Mammal Trapping

H.B. Sherman live traps were used by DFG staff to inventory the small mammal (rodent) populations. The trap size used was 3 by 3.5 by 9 inches, the standard for conducting small mammal inventories. Traps were set for three consecutive nights and checked and closed every morning at sunrise. All captures were identified, measured, marked, recorded on data sheets, and released back in the field. Traps were baited with a mixture of birdseed and crushed walnuts each afternoon approximately one half hour before sunset. The initial surveys specifically targeted habitat areas identified from aerial photo habitat interpretations that appeared to have the greatest suitability for the target species. Those areas were ground checked and extensively surveyed with high densities of traps in an attempt to maximize capture success of Special Status species such as the San Joaquin pocket mouse.

During the current efforts, trapping grids were implemented for larger sampling areas. Trapping locations, or grids, were randomly selected from each of the habitat types and designed so that the number of samples represented the amount and coverage area for each of the habitat types on the alternatives, a technique known as stratified sampling.

The trapping grids consisted of 200 traps within a 100 by 100 meter square. The grids were established by field crews using a compass and 100 meter tape. Various colors of pin flags were used to mark the grids. One pin flag was placed every ten meters on the grid and two traps were set within two meters of each point (pin flag) on the grid.

Mist nets were the primary method of inventorying bat species. Nets were set over water sources (i.e., ponds, creeks, or water troughs), across draws or narrow canyons, in front of entrances of old buildings, in woodland or forest edges, and in small clearings within a woodland or forest. Various net sizes and configurations were used. Net configurations were primarily as simple as a single net, but often involved several single nets spaced throughout an area. Other net configurations included "joining" several nets together and arranging them to form V, L, and T shapes. These configurations were used primarily in areas where there was a lot of known bat activity, but where previous capture efforts failed.

All captures were removed from the nets immediately upon capture and placed in a handling bag for later processing. Processing was conducted at the conclusion of netting efforts or when bat activity became slow. This reduced the potential for counting individuals of any particular species multiple times. Captures were all identified, measured, recorded on data sheets, recorded on the Anabat Detector, and released back into the field.

The Anabat Detector and software (Anabat) with a laptop computer or tape recorder was used to conduct acoustical surveys for free-flying bat species. It is known that free flying bats can be difficult to survey and capture and the use of acoustical surveys can greatly increase the detection of bat species in a survey area (O'Farrell and Gannon, 1999). The Anabat was primarily used to record free flying bats at the net sites during the initial efforts. As the studies progressed, other survey techniques were implemented. These techniques included recording while night driving and/or walking and at stationary points. Walking and driving surveys helped field crews identify potential trapping sites. When bats were detected, crews stopped for one minute and continued recording. If bat activity continued, an additional five minutes of recording was conducted. Those areas with a great amount of bat activity were mapped for future trapping efforts since long periods of activity probably indicates either a foraging area or a roost location.

Visual surveys were conducted during the daytime hours in rock outcroppings, out buildings, tree cavities, woodlands, and snags for evidence of bat presence. Visual inspections with the aid of a flashlight if needed in a rock crevice or tree cavity enabled field personnel to locate potential and existing roosts. The location of the site was recorded and if the bat could be identified without much disturbance, the species was recorded. No bats were removed form the roost because of the potential of disturbing them to the point of roost abandonment.

Track plates were used to identify the presence of carnivores such as the marten and fisher. Track plates were set up in 3- to 4-foot square areas. The site was prepared by raking a relatively flat surface and placing an aluminum plate on the ground. The baits used included chicken parts or pieces or approximately one and one half ounces of canned mackerel.

Track plates were placed at intervals of approximately 1,000 meters. They were checked every morning by DFG field staff. Any tracks were measured, identified, photographed, and recorded on data sheets. In addition, clear tape was used to lift the tracks from the plates and transfer to data sheets.

Trailmaster Camera set-ups were used to survey for carnivores in a method similar to the track plates. Two types of Trailmaster sensors were used, infrared and motion sensors. When triggered, the sensors sent a signal to the camera, which then took a photograph. The area was baited with canned mackerel, commercial baits or scents, chicken, road kill deer, or fish.

Each event (detection by the sensor) was recorded in the sensor's memory, which also differentiated which events were photographed. The camera setups were checked each morning by field personnel and recorded on data sheets.

Spotlight surveys were conducted by two or three person crews using hand-held Q-beam spotlights (250,000 to 1,000,000 candle power) from a vehicle traveling between 10 and 15 miles per hour. When eye shine was detected, the vehicle was stopped and DFG personnel identified the species with the aid of binoculars or a spotting scope when possible. Eye shine characteristics such as color, body size, and general behavior of the animal were useful in identifying species (Morrel 1972). Information such as location, habitat, species, time, distance traveled on the route, and weather was recorded on data sheets each night. All accessible roads in the study areas were included in spotlight surveys. Surveys began approximately one-half hour after sunset and concluded at approximately midnight.

Field personnel conducted walking transects throughout the different habitat types on the project areas. This effort was designed and implemented specifically to detect badger denning sites and rodent burrow areas. Field personnel performed walking transects between ten and 50 meters (33 and 164 feet) apart depending on terrain and ground cover. All potential denning sites and burrow areas were measured, mapped, counted, and recorded.

Road transects were used along with small mammal trapping to determine the prey base available to carnivores and raptors using the project areas. The main prey species sampled was the California ground squirrel (*Spermophilus beecheyi*). The technique involved driving the roads throughout the project areas at approximately ten miles per hour and counting ground squirrels within 50 meters of the travel route.

Incidental observations were recorded by field personnel while conducting other, more formal surveys. Observations from field personnel conducting surveys for other disciplines such as botany, birds, fish, and herps were also reported to DFG and recorded. Reports from other field personnel were verified where possible.

Initial field investigations were designed and focused to detect the presence and distribution of Special Status species in the proposed reservoir areas in order to provide decision-makers with some baseline information that might assist with assessing potential mitigation requirements. As the studies progressed, modifications were made to determine the presence and distribution of all mammal species in the alternative reservoir areas in attempt to assess the cumulative potential impacts that would result from project construction.

General habitat measurements were made to assist with future efforts to conduct a Habitat Evaluation Procedure. Detailed vegetative inventories were conducted by DWR staff. DFG staff focused primarily on identifying habitat features such as snags, logs, burrows, and basic vegetation measurements such as plant heights and canopy cover while conducting other surveys such as trapping. This information was recorded and will be used in the future when the HEP Team is developed and begins the Habitat Suitability Index Model selection process.

As of August 13, 1999, six mammal species of Special Concern were documented at the four project areas (Table 6.13). The pallid bat (*Antrozous pallidus*) is the only species documented in all four of the project areas thus far in our efforts. The

American badger (*Taxidea taxus*) and Yuma myotis (*Myotis yumanensis*) were documented in three of the sites. The western red bat (*Lasiurus blossivillii*) and ringtail (*Bassariscus astutus*) were documented in two of the sites while the San Joaquin pocket mouse (*Perognathus inormatus inornatus*) was documented in only one of the sites.

Table 6.13. Sensitive Species by Project area

Species	Sites	Colusa	Thomes/Newville	Red Bank
Yuma myotis	X		X	X
Western red bat	X			X
Pallid bat	X	X	X	X
Ringtail	X		X	
American badger	X	X	X	
San Joaquin pocket mouse			X	

Studies designed to evaluate the potential impacts of each of the alternatives on small mammals are not complete. Some areas have been surveyed lightly or not at all because of lack of vehicular access. Future surveys will require access to all areas throughout the year to allow a uniform effort at each of the alternative reservoir sites, which will be needed to make comparisons between the alternatives.

Fish Surveys

The Department of Fish and Game surveyed fishes in streams in the area of proposed Sites-Colusa Reservoir as part of Offstream Storage Investigation. Those streams were inspected and sample stations were chosen. Stations were seined on all creeks within the reservoir area to determine fish species composition. In the Sites Colusa area there were thirty-six stations spread out among Hunter, Minton, Logan, Antelope, and particularly Stone Corral and Funks Creeks. (See Appendix D for more detailed information).

Sites Reservoir

Fish were caught by seining in 31 stations in Stone Corral, Antelope, and Funks Creeks within the reservoir footprint. Eight species of fishes were caught (Table 6.14).

Table 6.14. Names of Fishes Found at Proposed Sites Reservoir

Common Name	Scientific Name
Chinook salmon	*Oncorhynchus tschawtscha*
Sacramento blackfish	*Orthodon microlepidotus*
California roach	*Hesperoleucus symmetricus*
Hitch	*Lavinia exilicauda*
Sacramento pikeminnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentalis*
Mosquitofish	*Gambusia affinis*
Green sunfish	*Lepomis cyanellus*

Stone Corral Creek - Eleven stations were sampled on Stone Corral Creek between July 15, 1998 and January 6, 1999. Eight species of fish were found in Stone Corral Creek, including two species of game fish, green sunfish and bluegill.

The fish that occurred at the most stations was the Sacramento pikeminnow followed by the hitch (Table 615). The density of fish on Stone Corral was relatively low for all species at all stations. Hitch were the dominant species in terms of density 0.9 fish/m2 (Table 6.15).

Antelope Creek: Five stations were sampled on Antelope Creek between July 14, 1998 and November 25, 1998. Three species of fish were captured on Antelope Creek: green sunfish, hitch, and Sacramento pikeminnow (Table 6.16). Hitch were the most abundant fish with an average density of 3.8 fish/m^2. The Sacramento pikeminnow and the green sunfish both had a relative abundance of 0.2 fish/m^2 (Table 6.16). A single spring-run chinook salmon swam up Antelope Creek in spring and died in a pool in early summer. Habitat in Antelope Creek does not support salmon because the creek nearly dries up each summer. The remaining water is too hot to allow salmon to survive there.

Table 6.15. Species Caught and Average Abundance in Stations on Stone Corral Creek

Species	Station											Abundance (fish/m^2)
	1	2	3	4	5	6	7	8	9	10	11	
Hitch		X	X					X	X	X	X	0.9
Sacramento pikeminnow			X	X	X	X		X	X		X	0.2
California roach		X		X								0.02
Sacramento blackfish											X	0.2
Sacramento Sucker			X	X		X					X	0.02
Mosquitofish				X								0.002
Green sunfish			X					X	X	X	X	0.04
Bluegill				X								0.002

Table 6.16. Species Caught and Relative Abundance of Fishes Found in Antelope Creek

Species	Station Sampled					Abundance ($fish/m^2$)
	1	2	3	4	5	
Hitch	X	X	X	X	X	3.8
Sacramento pikeminnow				X	X	0.2
Green sunfish		X		X	X	0.2

Funks Creek: A total of fifteen stations were sampled on Funks Creek between July 22, 1998, and January 8, 1999. Funks Creek had the greatest diversity of fishes throughout the year in the study area. Funks Creek had five species of fish, including one introduced game fish, largemouth bass.

The most common fish in Funks Creek was the hitch, with an average density of 3.7 $fish/m^2$ (Table 6.17). Hitch were caught in 11 out of 13 stations seined (Table 6.17).

Table 6.17. Species Caught at Each Sample Station on Funks Creek

Species	Station Sampled															Abundance ($fish/m^2$)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Hitch			X	X	X	X	X	X	X	X	X	X	X			3.7
Sacramento pike-minnow					X	X			X				X			0.07
Sacramento Sucker					X	X			X	X			X			0.02
Sculpin														X		0.003
Largemouth bass									X			X				0.001

The most diverse sections of Funks Creek that were sampled were in the lower reaches, stations 5, 6, 11, 12, and 13. The upper reaches of Funks Creek that were sampled either lacked fish or only one species was found. Hitch densities varied widely throughout the creek, and no one area seemed to maintain a higher population.

Hitch were found in all the creeks in the Sites Project area. Hitch were also present in the greatest numbers. Stone Corral Creek had the greatest diversity of fishes throughout the year, eight species, including two species of introduced game fish, bluegill and green sunfish. However, fish densities were lower particularly for Hitch in Stone Corral than in other creeks.

Most fish that were captured during seining in the Sites Project area were minnows, members of the Cyprinid family. California roach are the only fish present that are adapted to spending summers in the remaining pools of intermittent streams (Moyle 1976). Very few fish found while seining, including game fish, were above 150 mm in lengths, suggesting that fish only rear in these areas.

Colusa Cell

Pools were seined at specific stations on all live streams in the Colusa Cell to determine species composition. In the Sites Colusa area there were 36 stations spread out among Hunters, Minton, Logan, Antelope, and particularly Stone Corral and Funks Creeks. Seven farm impoundment ponds in the Sites/Colusa area were also seined for fish.

Fish were sampled in Hunters, Logan, and Minton Creeks. Nine species of fishes were caught (Table 6.18). Four species were game fishes and five were nongame fishes.

Table 6.18. Fishes Caught in the Colusa Project Study Area

Common Name	Scientific Name
Hitch	*Lavinia exilicauda*
Sacramento pikeminnow	*Ptychocheilus grandis*
Sacramento sucker	*Catostomus occidentalis*
Mosquitofish	*Gambusia affinis*
Largemouth bass	*Micropterus salmoides*
Red ear sunfish	*Lepomis microlophus*
Bluegill	*Lepomis macrochirus*
Green sunfish	*Lepomis cyanellus*
Sculpin sp.	*Cottus sp.*

Hunters Creek- Three stations were seined on Hunters Creek between July 22, 1998 and August 3, 1998. Only two species of fish were found on Hunters Creek, mosquitofish, and green sunfish. Both species were found in two of the three stations (Table 6.19). Mosquitofish were found in a relative abundance of 4.5 fish/m^2, but they only occurred in abundance at one station. Green sunfish were found to have an average density of 2.7 fish/m^2 (Table 6.19)

Table 6.19. Species Caught and Average Abundance in Stations on Hunters Creek

Species	Station Sampled			Abundance (fish/m^2)
	1	2	3	
Mosquitofish		X	X	4.5
Green sunfish		X	X	2.7

Minton Creek- Minton Creek was sampled in two locations in August, 1998. Hitch were found in one of those stations, at a density of 0.6 fish/m^2.

Logan Creek-Four stations were sampled on Logan Creek in August 1998. Hitch were caught in stations 1 and 2. The average density of hitch on Logan Creek was 0.5 fish/m^2.

Ponds-Three game fish were found in the seven ponds that were seined: red-eared sunfish, bluegill, and largemouth bass. Red-eared sunfish were found in one pond, bluegill were found in abundance in two ponds, and largemouth bass were found in three ponds out of the seven seined.

Hitch were found in all the creeks in the Colusa Project area. Hitch were also present in the greatest numbers.

Most fish that were captured during seining in the Colusa Cell were minnows, members of the Cyprinid family. California roach are the only fish present that are adapted to spending summers in the remaining pools of intermittent streams (Moyle 1976). Very few fish found while seining, including game fish, were above 150 mm in lengths, suggesting that fish only rear in these areas.

Thomes-Newville Project

In the early 1980s, game and nongame fishes were sampled in Thomes Creek and Stony Creek at the request of the DWR to provide information for environmental documents required for Thomes-Newville Project planning. Seining for juvenile chinook salmon in Stony and Thomes Creeks was done over a period of three years, 1980 to 1982. Carcasses of chinook salmon were counted to estimate the number of adult salmon in Stony and Thomes Creeks. On June 13, 1979, August 18, 1980, and August 12, 1998, Thomes Creek was surveyed to enumerate spring-run chinook salmon and summer-steelhead. A fyke net was placed in the creek near the mouth of Thomes Creek to capture juvenile and larval Sacramento sucker and Sacramento pikeminnows migrating to the Sacramento River. Streams in the footprint of proposed Thomes-Newville Reservoir were sampled by electrofishing 1981 and 1982.

Anadromous Fish Surveys

Thomes Creek

Thirteen juvenile chinook salmon were captured by seining during the 1980 sample period (Table 6.20). These fish were caught in lower Thomes Creek from March 20 to May 24, 1980. Six juvenile chinook salmon were captured by seining during the 1981 sample period (Table 6.20).

Table 6.20. Juvenile Chinook Salmon Seined from Thomes Creek in 1980 and 1981

Sample Period	Number of fish		Average length of fish (mm)	
	1981	1982	1981	1982
March	5	5	71	105
April	8	1	70	59
Total	*13*	*6*		

In 1981, 162 juvenile chinook salmon were captured by fyke netting in Thomes Creek, 20 from the main stem and 142 from the Tehama-Colusa Canal discharge canal (Tables 6.21 and 6.22).

Table 6.21. Fyke Net Catches of Juvenile Chinook Salmon from Thomes Creek in 1981

Sample Period	Number of fish	Average length of fish (mm)
February	0	0
March	9	68
April	10	79
May	1	69
Total	20	

Table 6.22. Fyke Net Catches of Juvenile Chinook Salmon from the Tehama-Colusa Canal Discharge Channel in Thomes Creek in 1981 and 1982

Sample Period	Number of fish		Average length of fish (mm)	
	1981	1982	1981	1982
January	1	2	35	35
February	126	45	34	35
March	15	333	33	37
Total	*142*	*380*		

<u>1982 Emigration</u> – No juvenile chinook salmon or steelhead was captured by seining or fyke netting in the main stem of Thomes Creek during the 1982 sample period.

Three hundred eighty juvenile chinook salmon were captured by fyke netting in the Tehama-Colusa Canal discharge channel. The first fish was captured during the first week of January, but the bulk of the emigration did not occur until the third week of February.

Juvenile Steelhead - Seven juvenile steelhead were captured by seining in Thomes Creek in 1981.

An estimated 48 juvenile steelhead were caught in 1981 by electrofishing during the summer cool, shaded sections of Salt Creek and an estimated 7 were caught in Heifer Camp Creek.

Stony Creek

During the 1980 sample period, 181 juvenile chinook salmon were caught by seining. Salmon were first caught during the second week of February, while the last salmon was caught during the first week of May.

During the 1981 sample period, 73 juvenile chinook salmon were captured by seining. Fish were first captured during the third week of February while the last fish were captured during the second week of April. During the 1982 sample period, only four juvenile chinook salmon were captured by seining. Two fish were captured during January and two were captured during the first week of April.

Thomes Creek

1980-81 Fall-Run Estimate – Fifty-nine chinook salmon carcasses were tagged during 12 surveys of Thome Creek. Twenty-three of these carcasses were recovered. From these data we estimated that 155 salmon spawned in Thomes Creek during the sample period.

Live fish were first observed in the creek November 11, 1980, but the first carcass was tagged 9 days later. The last carcass was recovered on January 12, 1981.

Fifty-seven (97 percent) of the fish recovered were located in the Tehama-Colusa Canal outlet channel. Only two fish (3 percent) were recovered in the main stem. Observation of six redds and four live fish indicate the there was some spawning activity in areas below Henleyville.

1981-82 Fall-Run Estimates – Thirty-eight chinook salmon carcasses were tagged during 10 surveys of Thomes Creek. Twenty of these carcasses were recovered. From these data we estimated that 167 salmon spawned in Thomes Creek during our sample period. All of the fish recovered were located in the Tehama-Colusa Canal outlet channel. No live fish or redd was seen in the main stem.

1979-1980 Spring-Run Estimates – No adult anadromous salmonid was seen during the June, 1979 or August, 1980 spring-run chinook salmon surveys in Thomes

Creek. Numerous juvenile steelhead and brown trout were seen the in area of the survey which may indicate that habitat for spring-run chinook salmon or summer steelhead may exist.

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

1979 Late Fall-Run – The late spawning characteristics of a few chinook salmon indicate that they were of the late fall-run. Those that spawned in late December and January were salmon of this race.

Stony Creek

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

Most of the spawning activity was located in lower Stony Creek in the reach between Interestate 5 bridge and the North Diversion Dam. At least 35 redds and 29 carcasses were counted in this area.

Resident Fish Surveys

Newville Reservoir-Six species of fish, two game species and four nongame species, were captured in streams potentially inundated by the Newville Reservoir. Steelhead were captured in sections of streams above the inundation line where the water is cool and cover is abundant. California roach, Sacramento pike minnow, and Sacramento sucker, carp and green sunfish were captured in sections of streams below the inundation line. California roach, Sacramento pike minnows, and Sacramento suckers were more abundant species, while carp and green sunfish are relatively uncommon (Tables 6.23 and 6.24).

Table 6.23. Population Estimates for Fishes Caught in Selected Sections of Streams Within the Newville Reservoir Site in 1983

Species	North Fork Stony Creek	Salt Creek	Heifer Camp Creek
Steelhead	-	24	8
Hitch	4	546	120
Sacramento pikeminnow	12	24	85
Carp	1		
Sacramento sucker	≥ 2	45	6
Green sunfish	-	13	

Table 6.24. Average Biomass Estimates (g/m²) for Fishes Caught in Streams Within the Newville Reservoir Site in 1983

Species	North Fork Stony Creek	Salt Creek	Heifer Camp Creek
Steelhead	-	8.4	2.1
Hitch	0.1	47.9	8.1
Sacramento Pikeminnow	0.9	38.1	86.9
Carp	16.3	-	
Sacramento sucker	≥ .01	9.9	
Green sunfish	-	3.8	

Upper Salt Creek supports a population of wild steelhead. Nongame fishes were not found in this area and because of a waterfall, migratory Cyprinids cannot ascend the creek.

Stony Creek – Twenty-eight species of fishes were observed in Stony Creek (Table 6.25). DFG staff developed population and biomass estimates for 22 of these species (Table 6.26). Nine species were game fishes and 13 were nongame fishes. Largemouth bass and bluegill were the most abundant gamefishes below Black Butte Reservoir and channel catfish and white catish were the most abundant game fishes above the Sacramento River. Sacramento pikeminnows and suckers were found in all stations throughout Stony Creek and were the most abundant and had the highest biomass for all species of fish. Prickly sculpin were found in all sections but made up a very small portion of the total biomass.

Table 6.25. Fishes of the Stony Creek Drainage (excludes fishes within Newville Reservoir Site) (1983)

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

Table 6.26. Average Population Estimates and Biomass Estimates (g/m^2) for Fishes Caught in Stony Creek in 1982

Species	*Average Population Estimate*	*Average Biomass (g/m^2)*
Threadfin shad	2	0.1
Carp	5	7.0
Goldfish	8	3.8
Hardhead	9	2.7
Hitch	32	2.3
Sacramento pikeminnow	146	10.2
Roach	200	6.1
Speckled dace	318	4.7
Sacramento sucker	96	28.8
Channel catfish	57	5.3
White catfish	30	3.9
Mosquitofish	3	0.01
Threespine stickleback	3	0.006
Black crappie	8	1.1
White crappie	5	2.0
Green sunfish	7	0.3
Bluegill	19	0.9
Largemouth bass	13	1.3
Smallmouth bass	5	1.8
Tule perch	6	0.6
Prickly sculpin	57	1.3

Thomes Creek - Twenty-two species of fishes were observed in Thomes Creek (Table 6.27). DFG staff developed population and biomass estimates for 13 of these species (Table 6.28). Three species were gamefishes and 10 were nongame fishes. Steelhead were the most abundant fish above the Gorge, while Sacramento Sacramento pikeminnow, Sacramento suckers, hardhead, California roach, and speckled dace were the more common fishes below.

Table 6.27. Fishes of Thomes Creek in 1982

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

Table 6.28. Average Population Estimates and Biomass Estimates (g/m^2) for Fishes Caught in Thomes Creek in 1982

Species	*Average Population Estimate*	*Average Biomass (g/m^2)*
Hitch	1	0.05
Roach	41	1.2
Hardhead	47	5.3
Sacramento pikeminnow	337	10.0
Speckled dace	229	1.8
Goldfish	1	1.7
Carp	90	7.2
Sacramento sucker	143	1.8
Bluegill	3	0.5
Green sunfish	14	1.7
Largemouth bass	5	0.9
Tule perch	1	0.02
Prickly sculpin	1	0.2

The most significant findings of these studies are the presence of fall-run chinook salmon, late fall-run chinook salmon, spring-run chinook salmon, and steelhead in Thomes Creek, Salt Creek, and Heifer Camp Creek.

Red Bank Project

Biologists conducted fisheries surveys of Cottonwood Creek from the confluence of the North Fork to the mouth of Cottonwood Creek in 1976 to provide environmental documentation for reservoir planning. Observations were made by diving, seining, fyke netting, and electrofishing. Abundance estimates were made for fishes caught by electrofishing.

Sixteen stations were seined on Red Bank, Dry, and Grizzly Creeks in the Red Bank Project area in 1998. Electrofishing was done in the Red Bank Reservoir area in October and November of 1998. A type VII Smith-Root backpack electrofisher was used for surveys on Red Bank Creek.

Thirteen species of nongame fishes were observed in Cottonwood Creek (Table 6.29). No estimates of abundance were done for fish caught in fyke nets, therefore these fish were not included in the relative abundance tables.

The most common species of resident nongame fishes found were: hardhead (0.026 fish/m^2) and Sacramento pikeminnows (0.018 fish/m^2) (Table 6.30). Some Sacramento pikeminnows and Sacramento suckers also migrate to the Sacramento San Joaquin estuary to rear and return to Cottonwood Creek as adults to spawn.

DFG biologists sampled fish at 13 stations in Red Bank Creek within the footprint of the proposed project in summer 1998. Fish were captured by seining and electrofishing. Four species of nongame fishes were observed (Table 6.29). The most common species of nongame fishes found were California roach (0.71 fish/m^2) and Sacramento pikeminnow (0.19 fish/m^2)(Table 6.30).

Table 6.29. Nongame Fishes Observed in the Red Bank Project Area

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

Table 6.30. Relative Abundance of Nongame fishes (fish/m^2) Caught in Lower Cottonwood Creek, 1976, and in Red Bank Creek, 1998

Species	Cottonwood Creek	Red Bank Creek
Carp	0.003	
California roach	0.003	0.706
Hardhead	0.026	
Sacramento pike minnow	0.018	0.190
Sacramento sucker	0.007	0.109

Biologists observed 10 species of resident game fishes in the Cottonwood Creek system in 1976 (Table 6.31). The most common resident game fishes were bluegill (0.026 fish/m^2) and green sunfish (0.18 fish/m^2). Steelhead were common in the higher reaches of the Cottonwood system, but not common in the lower reaches, while green sunfish and bluegill were more common in the lower reaches surveyed. No estimates of abundance were done for fish caught in fyke nets, therefore these fish were not included in the relative abundance tables.

Biologists observed three species of resident game fishes in Red Bank Creek in 1998. The most common resident game fishes were largemouth bass (0.011 fish/m^2) and bluegill (0.001 fish/m^2) (Table 6.32).

Table 6.31. Game Fishes Observed in Cottonwood Creek, 1976, and in Red Bank, 1998

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

Table 6.32. Relative Abundance of Non-Salmonid Game Fishes (fish/m^2) Caught in Lower Cottonwood Creek, 1976, and in Red Bank Creek, 1998

Species	Cottonwood Creek	Red Bank Creek
Largemouth bass	0.003	0.011
Smallmouth bass	0.003	
Bluegill	0.026	0.001
Green sunfish	0.018	0.001
Brown bullhead	0.007	

Biologists found populations of juvenile steelhead in the South Fork of Cottonwood Creek in the Yolla Bolly Wilderness in the summer of 1976. No estimates of populations of juvenile steelhead were made. The Yolla Bolly Wilderness is well above the proposed Dippingvat Dam site. Adult steelhead were seined from the mouth of Cottonwood Creek in November, 1976.

The DFG estimates that Cottonwood Creek supports an average of 1,000 steelhead, based on the best estimates of biologists who were most familiar with Cottonwood Creek. Biologists found juvenile steelhead in the footprint of the proposed Schoenfield Reservoir in Red Bank Creek in 1998. They were found at a density of 0.002 fish/m^2. Steelhead were found in two of twenty-two stations sampled.

Fall-run chinook salmon ascend Cottonwood Creek and spawn in late October through November. They spawn in Cottonwood Creek from the mouth to the confluence of the North Fork of Cottonwood Creek. About 53 percent of fall-run chinook salmon spawn from the mouth of Cottonwood Creek to the I-5 highway bridge; 23 percent spawn from the I-5 highway bridge to the confluence of Cottonwood Creek and the South Fork of Cottonwood Creek, and 24 percent spawn in Cottonwood Creek between the confluence of the South and North forks. Their young begin migrating after they incubate in January. They migrate downstream from January through May. The DFG estimates that an average of 3,600 fall-run chinook salmon spawn in Cottonwood Creek.

Late fall-run chinook salmon migrate up Cottonwood Creek and spawn in January. Biologists observed them spawning at the mouth of the North Fork of Cottonwood Creek in January, 1976. Their young migrate downstream in May and June as much smaller fry than the fall-run at that time of year. Young late fall-run chinook salmon were caught in fyke nets near the mouth of Cottonwood Creek in May and June, 1976. DFG estimates that an average of 300 late fall-run chinook salmon migrate up Cottonwood Creek.

Spring-run chinook salmon migrate up Cottonwood Creek in April and spend the summer in deep pools in the South Fork of Cottonwood Creek, Beegum Gulch, and the

North Fork of Cottonwood Creek. Most are found in Beegum Gulch. Young spring-run chinook salmon migrate downstream from January through May. DFG estimates that an average of 500 spring-run chinook salmon run up Cottonwood Creek. Some young chinook salmon from the Sacramento River use the lower reach of Cottonwood Creek from highway I-5 to the mouth for rearing during the summer and fall.

The most significant findings of these studies are the presence of fall-run chinook salmon, late fall-run chinook salmon, spring-run chinook salmon, and steelhead in Cottonwood Creek. The presence of steelhead in Red Bank Creek is also a significant finding.

Amphibian Surveys

The Department of Water Resources requested the Department of Fish and Game to survey amphibians in the area of proposed Sites, Colusa, and Red Bank Project areas as part of the North-of-the-Delta Offstream Storage Investigation. All aquatic habitats were categorized as to type of water body; (e.g., pond, farm impoundment, vernal pool, or creeks). All ponds were measured for length, width, and depth during the initial assessment. (See Appendix E for more detailed information). A summary of survey findings is presented below.

Sites Reservoir

California Red-legged Frog. Surveys were conducted August 1997 to January 1998, and during the months of May through October 1998. All ponds and creeks in the study area were surveyed a minimum of four times during each of these periods. Both night and day surveys were conducted during this time, at least two of each for each habitat site. Day surveys were performed on clear, sunny days with minimal wind. Night surveys were conducted on warm still nights from an hour past sunset until midnight.

California Tiger Salamander. The historic range of California tiger salamanders was established using distribution records. Grasslands, vernal pools and farm pond impoundment's that contained water for only part of the year were examined as potential California tiger salamander habitat sites. All ponds and vernal pools, and the surrounding territory were examined for burrows, log debris, type of terrestrial vegetation, use of land and its current condition, embankments and surrounding topography. Each pond was then seined.

Transect and visual pond inspections were conducted at night, during storms that continued from the day into the night, when the air temperature was between 7-10 °C (45-50 °F) or warmer during the months of November and March for both the 1997-98 and 1998-99 seasons.

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

No California red-legged frogs or California tiger salamanders were found during any of these surveys.

Surveys of Common Amphibians. General herpetology surveys were done by ground searching near ponds and other habitats, transects, and night driving studies.

A total of 5,507 hours were spent in the Sites study area looking for amphibians. A total of five species were found during this survey (Table 6.33).

The most prevalent species found was the bullfrog, *Rana catesbieana*, with a catch per hour effort ratio of 4.2 for adults. Pacific chorus frogs had a catch per hour effort ratio of 1.2 individuals per hour, and western toads had a catch per hour effort ratio of 0.4. California slender salamanders and California newts were less common.

Table 6.33. Amphibian Species of the Sites Project Area

Common Name	Scientific Name
Bullfrog	*Rana catasbieana*
Pacific tree frog	*Hylla regilla*
California slender salamander	*Batrachoseps attenuatus*
California newt	*Taricha torosa*
Western toad	*Bufo boreas*

Three hundred and three hours were spent searching oak woodland habitat and 542 were spent searching farm ponds. Oak woodland and farm ponds were habitat where the greatest diversity of species was found. All five species of amphibians were found in this type of habitat (Table 6.34).

Table 6.34. Species Found in Each Habitat Type in the Sites Reservoir Area

Common Name	Riparian	Oak Woodland	Grassland	Farm Pond	Vernal Pool
Bullfrog	X	X	X	X	
Pacific chorus frog	X	X	X	X	X
California slender salamander		X		X	
California newt		X		X	
Western toad	X	X	X	X	
Western toad larvae	X			X	X

Four species of amphibians were also found in the oak woodland habitat. Pacific chorus frogs were found in all five habitat types.

A total of 4,662 hours was spent in ground searches. Searching was the most productive method of locating a variety of amphibians. Representatives of all species found during the study were located via ground searches. Dip netting and seining were particularly effective in capturing semi aquatic amphibians, and especially larval amphibians.

No threatened or endangered amphibians were found in this study. All species caught or observed are regarded as common.

Colusa Cell

All aquatic habitats within the Colusa Cell were categorized as to type of water body; (e.g., pond, farm impoundment, vernal pool, or creeks). Hunters, Minton, and Logan Creeks were measured for length and width. All ponds were measured for length, width, and depth. Preliminary surveys of ponds in the Colusa Cell area were done during the fall of 1997.

California Red-legged Frog. Surveys were conducted August 1997 to January 1998, and during the months of May through October 1998. All ponds and creeks in the study area were surveyed a minimum of four times during each of these periods. Both night and day surveys were conducted during this time, at least two of each for each habitat site. Day surveys were performed on clear, sunny days with minimal wind. Night surveys were conducted on warm still nights from an hour past sunset until midnight.

California Tiger Salamander. The historic range of California tiger salamanders was established using distribution records. Grasslands, vernal pools and farm pond impoundment's that contained water for only part of the year were all examined as potential California tiger salamander habitat sites. All ponds and vernal pools, and the surrounding territory were examined for burrows, log debris, type of terrestrial vegetation, use of land and its current condition, embankment and surrounding topography. Each pond was then seined.

Transect and visual pond inspections were conducted at night, during storms that continued from the day into the night, when the air temperature was between 7-10 °C (45-50 °F) or warmer during the months of November and March for both the 1997-98 and 1998-99 seasons.

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

No California red-legged frogs or California tiger salamanders were found during these surveys.

Surveys of Common Amphibians and Reptiles. General herpetology surveys were done by ground searching near ponds and other habitats, transects, and night driving studies.

A total of 751 hours were spent in the Colusa Project area looking for amphibians. A total of three species were found during this survey (Table 6.35).

The most prevalent species found was the bullfrog, *Rana catesbeiana*, with a catch per hour effort ratio of 9.1 for adults. Western toads had a catch per hour effort ratio of 0.6 individuals per hour, and California slender salamanders had a catch per hour effort ratio of 0.1.

Table 6.35. Amphibian Species Found in the Colusa Cell

Common Name	Scientific Name
Bullfrog	*Rana catasbieana*
California slender salamander	*Batrachoseps attenuatus*
Western toad	*Bufo boreas*

Two hundred and seventy one hours were spent searching farm ponds habitat and 370 hours were spent searching riparian habitat. One hundred and ten hours were spent searching grassland habitat Farm ponds had the greatest diversity of species. All three species of amphibians were found in this type of habitat (Table 6.36).

Table 6.36. Species Found in Each Habitat Type in the Colusa Cell

Habitat Type	Bullfrog	California Slender Salamander	Western Toad
Farm Pond	X	X	X
Grassland	X		X
Riparian	X		X

Two species of amphibians were also found in the grassland and riparian habitat. Bullfrogs and Western toads were found in all three habitat types.

A total of 700 hours was spent in ground searches. Searching was the most productive method of locating a variety of amphibians. Representatives of all species found during the study were located via ground searches. Dip netting and seining were particularly effective in capturing semi aquatic amphibians, and especially larval amphibians.

No threatened or endangered amphibians were found in this study. All species caught or observed are regarded as common.

Thomes-Newville Project

Surveys for amphibians at the Thomes-Newville Project were conducted by the Department of Fish and Game from April 1981 through May 1982 at the request of the Department of Water Resources to provide environmental information for water project planning. Amphibian surveys were done by ground searching ponds and transects, seining or night driving studies. Ground searches were done both day and night, but driving surveys were done only at night. Pitfall trapping was done in the Thomes-Newville Project area. A camera was used to photograph specimens for species verification and to maintain a general record of the find.

This survey produced observations of seven amphibian species that occur within the habitats in the project area and surrounding areas (Table 6.37). No estimate of population sizes was possible because of the small number of recaptures that occurred during the pitfall trapping.

Table 6.37. Amphibians Observed in the Thomes-Newville Project Area in 1982

Common Name	Scientific Name
Black salamander	*Aneides flavipunctatus*
California slender salamander	*Batrachoseps attenuatus*
Western spadefoot	*Spea hammondi*
Western toad	*Bufo boreas*
Pacific tree frog	*Hyla regilla*
Foothill yellow-legged frog	*Rana boylei*
Bullfrog	*Rana catesbeiana*

Western toads and Pacific chorus frogs were found in all habitat types. Some species such as black salamanders were much more limited in their distribution (Table 6.38).

Table 6.38. Amphibian Species Found in the Thomes-Newville Project Area in 1982 (X = found in this habitat type).

Species	Grassland	Chaparral	Oak Savannah	Pine-Oak Woodland	Riparian	Stream	Standing water
Black salamander				X			
California slender salamander	X	X	X	X			
Western spadefoot	X		X				
Western toad	X	X	X	X	X	X	X
Pacific tree frog	X	X	X	X	X	X	X
Foothill yellow-legged frog					X	X	X
Bullfrog					X	X	X

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

Pitfall traps tended to be selective for amphibians. This trapping method failed to provide any amphibian or reptile species not found by at least one other collection method.

Although no amphibian species listed as rare or endangered was found in the project area, three species were found that are considered of special concern by the State of California because of habitat losses. These species complete their reproductive cycle in both temporary and permanent ponds found throughout the inundation area. Spadefoot toads and foothill yellow-legged frogs occur in the streams coursing through the reservoir site. The presence of these species constitutes a significant finding.

Red Bank Project

DFG conducted one-year studies of the Red Bank Project in 1986 and in 1998. The major objectives of these surveys were to search for California red-legged frogs, which are listed as federally threatened and general herpetology surveys. One species listed as a federal and California species of special concern, the foothill yellow legged frog, was also searched for during the course of this survey.

Historic ranges of the species searched for were established. Physical observations of the present habitat, historic records, and the Natural Diversity Database of the California Department of Fish and Game were also used to establish the list of potential species that could occur in the Red Bank Project areas. The results of past surveys conducted in the Red Bank Project were also reviewed.

Surveys were conducted during the fall of 1997 and during the months of May through October 1998 for California red-legged frogs. Surveys were not conducted during the breeding or rearing period of the frogs in order to avoid disturbing breeding frogs, eggs, or larvae. All ponds and creeks in the study area were surveyed a minimum of four times during this five-month period in 1998. Both night and day surveys were conducted during this time, at least two of each for each habitat site. No site was sampled twice within a twenty-four hour period. Day surveys were performed on clear, sunny days with minimal wind. Night surveys were conducted on warm still nights from an hour past sunset until midnight. Photographs were also taken of the environment in which animals are found in order to confirm field notes and to document the state of the habitat at the time it was surveyed.

General amphibian surveys were done by ground searching ponds and transects, seining or night driving studies. Ground searches were done both day and night. Driving surveys were only done at night. Seining was done during the day.

General amphibian surveys were conducted year round throughout the Red Bank Project areas, when the weather was appropriate for amphibian and reptile activity.

Biologists spent about 100 hours searching the banks of Cottonwood Creek in the study area in 1986 and 425 hours searching in 1998. A threatened species, the California red-legged frog, was seen in 1986 and in 1998. One species listed as a species of special concern, foothill yellow-legged frogs (Table 6.39) was common and distributed throughout the study area.

During these studies five species of amphibians were found. The most common species of amphibians observed were foothill yellow-legged frogs (18.7/hr.) and Western toads (18.8/hr.).

Table 6.39. Relative Abundance of Amphibians Observed in the Red Bank Project Area

Species	Catch per Hour	
	Cottonwood Creek	Red Bank Creek
California red-legged frog		<0.01
Foothill yellow-legged frog	14.80	3.91
Bullfrog	0.02	1.06
Pacific tree frog	0.01	1.58
Western toad	13.10	5.65

The most significant find in the current investigation is the discovery of a California red-legged frog in Sunflower Gulch. Another individual was observed in the same location in 1986. Extensive searches failed to find other red-legged frogs in the study area. It is probable that the population of red-legged frogs is very small at the site of the proposed Red Bank Project.

Also significant is the finding of one species of special concern, the foothill yellow-legged frog It is plentiful throughout the study area. They were found in Red Bank Creek and the South Fork of Cottonwood Creek.

Reptile Surveys

DWR requested the California Department of Fish and Game to conduct studies of the reptiles in the proposed Sites, Colusa, and Red Bank Project areas. DFG biologists conducted the sampling in spring and summer of 1998 and 1999. The DFG initiated studies in 1997.

Sites Reservoir

Western Pond Turtle. Western pond turtles were looked for when biologists seined or spotted during daytime visual surveys. Carapaces of dead animals were also noted and measured. During periods of warm weather, watching the creek when possible while traveling to and from work stations yielded positive results in locating western pond turtles.

Surveys of Common Reptiles. General herpetology surveys were done by ground searching near ponds, transects, and night driving studies. Ground searches were done both day and night. While driving surveys were only done at night. Searching ponds was done during the day. General herpetology surveys were conducted year round throughout the area when the weather was appropriate for reptile activity.

Transects were walked by team members in a line, 5 meters apart. All logs, trees, burrows, rocks and crevices are inspected for animals. Transect areas included riparian, grasslands, vernal pools, and oak woodlands. Binoculars were used to scan ahead for animals such as turtles and frogs that dive under water when startled. Night transects were walked in the same manner using 6-volt flashlights for illumination.

Night driving surveys were conducted by driving a vehicle at speeds between 24 and 40 km/hr. Specimens found on the shoulder were identified and counted. Roads interior to the reservoir sites, and immediately surrounding the project areas were driven a total of eight times in 1997 in the Sites Reservoir area.

Results

A total of 2,400 hours were spent in the Sites area looking for reptiles. A total of 14 reptile species were found during this survey (Table 6.40). One species of special concern was found: the western pond turtle. These turtles are listed by the Natural Diversity Data Base as occurring in Colusa County.

Western fence lizards were the most common reptiles with a catch per effort ratio of 0.2 (Table 6.42).

Table 6.40. Reptile Species of the Sites Project Area

Common Name	Scientific Name	Status	
		State	Federal
Western pond turtle	*Clemmys marmorata*	DFG: SC DFG: Protected	FSC
Ring neck snake	*Diadophis punctatus*		
Gopher snake	*Pituohpis catenifer*		
Aquatic garter snake	*Thamnophis couchii*		
Common garter snake	*Thamnophis sirtalis*		
Western terrestrial garter snake	*Thamnophis elegans*		
Western rattle snake	*Crotalus viridus*		
Common racer	*Coluber mormon*		
Sharp tailed snake	*Contia tenuis*		
Common king snake	*Lampropeltus getula*		
Southern Alligator lizard	*Elgaria muliticoranata*		
Western skink	*Eumeces skiltonianus*		
Western Sagebrush lizard	*Sceloporus graciosus gracilis*		
Western fence lizard	*Sceloporus occidentalis*		

DFG: California Department of Fish and Game
SC: Species of special concern
FSC: Federal species of special concern

Seven hundred and fifty hours were spent searching riparian habitat. It was here that the greatest diversity of species was found. Fourteen of the 19 total species of reptiles and amphibians, all three species of frog species, and all but three reptile species were found in this type of habitat (Table 6.41). Bullfrogs and western toad larvae were also found in the pools of the riparian zone.

Table 6.41. Species Found in Each Habitat Type

Common Name	Riparian	Oak Woodland	Grassland	Farm Pond	Vernal Pool	Night Driving
Western pond turtle	X					
Ring neck snake					X	
Gopher snake	X	X	X	X	X	
Aquatic garter snake	X				X	
Common garter snake	X	X	X	X	X	
Western terrestrial garter snake	X	X		X		
Western rattle snake	X	X	X	X		X
Common racer	X	X				
Sharp tailed snake	X					
Common king snake	X		X	X		
Southern Alligator lizard	X	X	X	X		
Western skink		X				
Northern Sagebrush lizard		X				
Western fence lizard	X	X	X	X	X	

Fourteen species of reptiles were also found in the oak woodland habitat. Adults of all but five species reptile were found here. Gopher snakes, common garter, and western fence lizards were found in all four habitat types.

A total of 2,060 hours was spent in ground searches. Searching was the most productive method of locating a variety of reptiles and amphibians, with an overall catch per hour effort ratio of 8.1 (Table 6.42). Representatives of all species found during the study were located via ground searches. Dip netting and seining were particularly effective in capturing semi aquatic reptiles (Table 6.42).

Table 6.42. Catch Per Hour Effort for Each Survey Method

Common Name	Searching	Dip netting	Seining	Night Driving	Totals
Western pond turtle	0.0009	0	0	0	0.0008
Ring neck snake	0.0005	0	0	0	0.0004
Gopher snake	0.007	0.009	0	0	0.006
Aquatic garter snake	0.0005	0.009	0	0	0.0008
Common garter snake	0.02	0.04	0.02	0	0.02
Western terrestrial garter snake	0.05	0	0.02	0	0.04
Western rattlesnake	0.02	0.009	0.06	0.2	0.002
Common racer	0.0002	0	0	0	0.002
Sharp tailed snake	0.0005	0	0	0	0.0004
Common king snake	0.003	0	0	0	0.003
Alligator lizard	0.005	0	0	0	0.002
Western skink	0.006	0	0	0	0.005
Western Sagebrush lizard	0.0005	0	0	0	0.0004
Western fence lizard	0.17	0	0	0	0.2
Totals	8.1	45.6	12.1	0.2	10.0

Western pond turtles were found in the project area, as well as outside the reservoir footprint in both upstream and downstream. California red-legged frogs generally share a habitat preference with western pond turtles and they are frequently found occupying the same areas.

Colusa Cell

Western Pond Turtle. Western pond turtles were looked for when seining ponds or spotted during daytime visual surveys. Carapaces of dead turtles were also noted and measured. During periods of warm weather, watching creeks whenever possible while traveling to and from work stations yielded positive results in locating western pond turtles.

Surveys of Common Reptiles. General herpetology surveys were done by ground searching near ponds and searching transects in grassland areas. General herpetology surveys were conducted year round throughout the Colusa Cell area when the weather was appropriate for reptile activity.

Transects were walked by team members in a line, 5 meters (17 feet) apart. All logs, trees, burrows, rocks and crevices were inspected for animals. Transect areas included riparian, grasslands, vernal pools, and oak woodlands. Binoculars were used to scan ahead for animals such as turtlès and frogs that dive under water when startled. Night transects were walked in the same manner using 6-volt flashlights for illumination.

A total of 813 hours were spent in the Colusa area looking for reptiles. A total of nine reptile species were found during this survey (Table 6.43). One species of special concern was found: the western pond turtle. These turtles are listed as occurring in Colusa County by the Department of Fish and Game. Western fence lizards were the most prevalent reptiles with a catch per effort ratio of 0.138 (Table 6.44).

Three hundred and seventy hours were spent searching riparian habitat where the greatest diversity of species was found. All reptile species were found in this type of habitat. Searching farm ponds took 182 hours and 261 hours were spent searching grassland areas (Table 6.44).

Table 6.43. Reptile Species Found in the Colusa Cell Area

Common Name	Scientific Name	Status	
		State	Federal
Western pond turtle	*Clemmys marmorata*	DFG: SC DFG: Protected	FSC
Gopher snake	*Pituohpis catenifer*		
Common garter snake	*Thamnophis sirtalis*		
Western terrestrial garter snake	*Thamnophis elegans*		
Western rattle snake	*Crotalus viridus*		
Common racer	*Coluber mormon*		
Common king snake	*Lampropeltus getula*		
Southern Alligator lizard	*Elgaria mulitticoranata*		
Western fence lizard	*Sceloporus occidentalis*		

DFG: California Department of Fish and Game
SC: Species of special concern
FSC: Federal species of special concern

Table 6.44. Species Found and Catch Per Hour of Effort in Each Habitat Type

Common Name	Grassland	Farm Ponds	Riparian
Western pond turtle			0.003
Gopher snake		0.005	0.011
Common garter snake		0.005	0.046
Western terrestrial garter snake		0.011	0.173
Western rattlesnake		0.005	0.024
Common racer			0.008
Common king snake		0.005	0.005
Southern alligator lizard	0.009	0.005	
Western fence lizard	0.005	0.033	0.1

Seven species of reptiles were also found in farm ponds. Adults of all but two species of reptiles were found there. Only Western fence lizards were found in all three habitat types.

A total of 813 hours was spent in ground searches. Searching was the most productive method of locating a variety of reptiles. Representatives of all species found during the study were located via ground searches.

Western pond turtles were found in the project area. It is the only species of concern found within the reservoir footprint. Degraded habitat within the project footprint makes it unlikely that any other reptile species of concern would occur there.

Thomes-Newville Project

Surveys for reptiles at the Thomes-Newville Project were conducted from April 1981 through May 1982 at the request of the Department of Water Resources to provide environmental information for water project planning. Reptile surveys were done by ground searching ponds and transects, seining or night driving studies. Ground searches were done both day and night. Driving surveys were only done at night. Animals were identified using published identification keys. Pitfall trapping was also done in the Thomes-Newville Project area. A camera was used to photograph specimens for species verification and to maintain a general record of the find.

This survey produced observations of 15 reptile species that occur within the habitats composing the project area and surrounding areas (Table 6.45). No estimate of population sizes was possible because of the small number of recaptures that occurred during the pitfall trapping.

Table 6.45. Observed Reptiles in the Thomes-Newville Project Area in 1982

Common Name	Scientific Name
Western pond turtle	*Clemmys marmorata*
Sagebrush lizard	*Sceloperus graciosus*
Western fence lizard	*Sceloperus occidentalis*
Western skink	*Eumeces skiltonianus*
Western whiptail	*Cnemidophorus tigris*
Southern alligator lizard	*Elgaria multicarinata*
Western racer	*Coluber constrictor*
Sharp-tailed snake	*Contia tenuis*
Common kingsnake	*Lampropeltis getulus*
Striped racer	*Masticophis lateralis*
Gopher snake	*Pituophis malanoleucus*
Western aquatic garter snake	*Thamnophis couchi*
Western terrestrial garter snake	*Thamnophis elegans*
Common garter snake	*Thamnophis sirtalis*
Western rattlesnake	*Crotalus viridis*

Western toads and Western fence lizards were found in all habitat types. Gopher snakes and Western rattlesnakes were also found in most habitat types. Some species such as Western sagebrush lizards were much more limited in their distribution (Table 6.46).

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

Table 6.46. Reptile Species Found in the Thomes-Newville Project Area in 1982 (X = found in this habitat type)

Species	Grassland	Chaparral	Oak Savannah	Pine-Oak Woodland	Riparian	Stream	Standing water
Western pond turtle					X	X	X
Sagebrush lizard		X					
Western fence lizard	X	X	X	X	X	X	X
Western skink	X	X	X				
Western whiptail		X	X	X			
Southern alligator lizard	X	X	X	X	X		
Western racer	X	X	X		X		
Sharp-tailed snake	X	X					
Common kingsnake	X	X	X	X			
Striped racer	X	X					
Gopher snake	X	X	X	X	X		
Western aquatic garter snake					X	X	
Western terrestrial garter snake	X		X		X	X	X
Common garter snake	X				X	X	X
Western rattlesnake	X	X	X	X	X		
Total number of species observed	15	14	13	10	13	8	8

Pitfall traps tended to be selective for lizards and smaller snakes, such as the sharp-tailed snake. Larger snakes, because of their length, could easily avoid falling into the traps. This trapping method failed to provide any reptile species not found by at least one other collection method.

Although no reptile species listed as rare or endangered was found in the project area, one species considered of special concern by the State of California is found throughout the inundation area. The western pond turtle occurs in streams coursing through the reservoir site. The presence of this species constitutes a significant finding.

Red Bank Project

The objectives of these surveys within the Red Bank Project area were to search for two species listed as federal and California State species of special concern. These species are western pond turtles *Clemmys marmorata* and Western spadefoot toads *Spea hammondii.*

Historic ranges of the species searched for were established. Physical observations of the present habitat, historic records, and the Natural Diversity Database of the California Department of Fish and Game were also used to establish the list of potential species that could occur in the Red Bank Project areas. The results of past surveys conducted in the Red Bank Project were also reviewed.

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

Biologists spent about 100 hours searching the banks of Cottonwood Creek and Red Bank Creek in the study area in 1986 and 425 hours searching in 1998. One species listed as a species of special concern, the western pond turtle, was found (Table 6.47). They were distributed throughout the study area.

During these studies eleven species of reptiles were found. The most common species of reptiles observed were common garter snakes (0.42/hr.) and western pond turtles (0.26/hr.)(Table 6.47).

The most significant finding of these studies was the discovery of western pond turtles, a California species of special concern.

Table 6.47. Names and Abundance of Reptiles in the Red Bank Project Area

Common Name	Scientific Name	Cottonwood Creek	Red Bank Creek
		Catch per Hour	
Western pond turtle	Clemmys marmorata	0.17	0.09
Western skink	Eumeces skiltonianus	0.01	0.03
Western sagebrush lizard	Sceloperus graciosus gracilis	0.02	0.01
Western fence lizard	Sceloperus occidentalis	0.14	0.08
Southern alligator lizard	Elgaria multicarinata	0.02	0.01
Western racer	Coluber mormon		0.01
Common kingsnake	Lampropeltis getulus	0.01	0.01
Gopher snake	Pituophis malanoleucus	0.05	0.01
Western terrestrial gartersnake	Thamnophis elegans	0.15	0.13
Common garter snake	Thamnophis sirtalis	0.39	0.03
Western rattlesnake	Crotalus viridis	0.12	0.01

Cultural Resources

The objectives of the cultural resource surveys at Sites Reservoir, Colusa Cell, and Red Bank Project were to obtain information about the archaeological sites comparable to the data from the survey conducted at Thomes-Newville Reservoir site in 1982, and to determine if there are cultural resource issues serious enough to remove a reservoir project from further consideration. Many new sites were identified and documented during the surveys representing a varied array of site types and almost all of the previously recorded sites were found again and documented to current standards. Archaeological evaluations of the proposed reservoirs yielded a wide range of variability in numbers and types of sites between projects, from three sites in one reservoir basin to well over 100 sites in another.

The reservoir assessments were based on record searches and field surveys. Database files, maps, and reports were reviewed at the Northeast, Northwest, and North Central Information Centers of the California Historical Resources Information System, an adjunct of the State Office of Historic Preservation. The goal was to determine the extent of coverage of prior surveys within the project footprints and to obtain the records of any previously recorded sites. The field surveys concentrated on those areas with the highest potential for significant archaeological sites, such as stream terraces and level woodland flats, although areas of lesser sensitivity, such as steep hill slopes and arid plains, were also sampled.

Sites Reservoir

Parts of the Sites Reservoir area were surveyed in 1967 by a field class from the University of California, Los Angeles, and Chico State College, under agreement to the National Park Service. A total of 15 prehistoric sites was recorded at that time. No further work has been done within the reservoir footprint until the present study, which resulted in the discovery of 26 new archaeological sites. Of the total of 41 sites, at least 17 appear to be significant, in that they provisionally meet the criteria for eligibility to the National Register of Historic Places. Six of the sites are not eligible and 16 have undetermined status. An accurate assessment could not be made of these sites based solely on evidence visible on the surface. If further studies are warranted, a site testing program utilizing techniques such as small scale excavations, auger borings, and soil column sampling would be implemented to determine if the sites have archaeological values that meet the criteria for eligibility to the National Register.

Prehistoric settlement in the project area was constrained by the limited food and fuel resources and the scarcity of water; however, the area would have been important for seasonal hunting and gathering forays. The larger and more permanent villages were situated along the lower reaches of the bigger streams, in the Sacramento Valley, and on the knolls and natural levees along the Sacramento River.

Historic sites, features, and standing structures are significantly under-represented in the site totals. These resources were not recorded because they are associated with working ranches, occupied buildings, and the town site of Sites. A future survey of historic resources may yield an estimated 15-20 significant historic sites in addition to the Historic District of the Town of Sites. Moving the large cemetery associated with Sites and several smaller cemeteries would be costly and present special problems but there is precedent when associated with a major public works project. No cultural resource problems are known that would remove this reservoir project from further consideration.

Colusa Cell

The record search indicated that the footprint of the Colusa Cell had never been surveyed for cultural resources and that there were no site records in the files of the State database. The field survey indicated an even greater scarcity of subsistence resources than existed in the Sites Project area, and an ephemeral water supply that was not suitable for extensive use or habitation during the prehistoric past.

A total of three sites was recorded, two historic ranches and one site with a prehistoric and an historic component. The significance of the sites is undetermined. The assessment of eligibility to the National Register could not be made on the basis of surface indications. Additional studies would be necessary to complete the evaluation. The Colusa Cell has no cultural resource issues that would preclude reservoir construction.

Thomes-Newville Project

A comprehensive survey of prehistoric sites within Thomes-Newville Reservoir was completed by a consultant for the Department of Water Resources in 1983. A total of 117 sites was recorded within the footprint of the proposed reservoir, representing a prehistoric settlement pattern that includes evidence of permanent or semi-permanent villages, seasonal campsites, and special resource procurement and use sites. The presence of perennial streams and availability of fuel and subsistence resources accounts for the intensive use of the project area during prehistoric times. Approximately 60 sites meet the criteria for eligibility to the National Register and would therefore qualify for some level of mitigation effort.

Historic features, sites, and standing structures are underrepresented in the site totals. These resources are now given the same consideration as prehistoric resources; however, that was not the case in the early 1980s when the survey was conducted. Additional survey work would be necessary to determine the number, type, and significance of the historic resources that are present.

As at Sites Reservoir, moving the historic cemeteries within the footprint of the Thomes-Newville Project would be costly and present special problems but there are no cultural resource issues serious enough to remove this reservoir from consideration.

Red Bank Project

The record search for the Red Bank Project indicated that the project area had not been surveyed for cultural resources and no site records were present in the State database. The prior survey and excavations for the Red Bank Project conducted in the early 1950s by the University of California, Berkeley, for the National Park Service, was for a Sacramento River diversion project near Red Bluff that had the same name. The surveys completed in 1994 by California State University, Sacramento, for the Corps of Engineers, Cottonwood Creek Project, were downstream of the current proposed project, with no overlap of the footprints.

A total of 31 sites was recorded within the footprint of three of the four reservoirs comprising the Red Bank Project; no sites were found at one reservoir. Twenty-eight sites are prehistoric and three are historic. Nine sites appear to meet the criteria for eligibility to the National Register, 16 sites are of undeterminable significance without further work, and six sites are not eligible for listing on the National Register, and are therefore not significant.

The prehistoric sites in the Red Bank Project were generally small and the artifact distribution relatively sparse. The sites were probably associated with seasonal upland hunting, fishing, and gathering activities. The larger permanent settlements were situated further downstream on the banks of the perennial streams and along the Sacramento River.

No issues were identified as a result of the survey of the Red Bank Project that was serious enough to prevent construction of the reservoirs.

Table 6.48. Probability of Occurrence and Listing Status of Animal and Plant Species Evaluated

Species (Common Name)	Status[1]			Occurrence Probability within Reservoir Sites[2]				
	Federal	State	Other	Sites	Funks	Colusa	ThomesNewville	Red Bank
Invertebrates								
Desmocerus californicus dimorphus (valley elderberry longhorn beetle)	FT	none	none	X	X	X	X	X
Lepidurus packardi (vernal pool tadpole shrimp)	FE	none	none	*	*	*	*	-
Branchinecta lynchi (vernal pool fairy shrimp)	FT	none	none	*	*	*	*	-
Branchinecta conservatio (Conservancy fairy shrimp)	FE	none	none	*	*	*	*	-
Anthicus antiochensis (Antioch Dunes anthicid beetle)	FSC	none	none	-	-	-	-	-
Anthicus sacramento (Sacramento anthicid beetle)	FSC	none	none	-	-	-	-	-
Dubiraphia brunnescens (brownish dubiraphian riffle beetle)	FSC	none	none	-	-	-	-	-
Ochthebius reticulatus (Wilbur Springs minute moss beetle)	FSC	none	none	-	-	-	-	-
Paracoenia calida (Wilbur Springs shore fly)	FSC	none	none	-	-	-	-	-
Hydroporus leechi (Leech's skyline diving beetle)	FSC	none	none	-	-	-	-	-
Amphibian								
Ambystoma californiense (California tiger salamander)	FC	DFG	none	-	-	-	-	-
Rana aurora ssp. draytonii (California red-legged frog)	FT	CSC,DFG	none	-	-	-	X	X

Species (Common Name)	Federal	Status[1] State	Other	Occurrence Probability within Reservoir Sites[2] Sites	Funks	Colusa	ThomesNewville	Red Bank
(Foothill yellow-legged frog)								
Scaphiopus hammondii (western spadefoot toad)	none	DFG	none	*	-	*	X	*
Fish								
Lampetra tridentata (Pacific lamprey)	FSC	none	none	*	*	*	X	X
Mylopharodon conocephalus (Hardhead)	FS	CSC	none	X	X	X	X	X
Oncorhynchus mykiss (Steelhead)	FT	none	none	-	-	-	X	X
Oncorhynchus tshawytscha (Late fall-run Chinook salmon)	FPT	CSC	none	-	-	-	-	-
Oncorhynchus tshawytscha (Spring-run Chinook salmon)	FPE,FS	ST	none	X	-	-	X	X
Pogonichthys macrolepidotus (Splitail)	FE	SE	none	-	*	-	-	-
Reptile								
Clemmys marmorata ssp. marmorata (Northwestern pond turtle)	FSC	CSC,DFG	none	X	X	X	X	X
Phrynosoma coronatum ssp. frontale (California horned lizard)	FSC	CSC,DFG	none	*	-	*	*	-
Thamnophis gigas (Giant garter snake)	FT	ST,DFG	none	-	*	-	-	-
Avian Species								
Accipiter cooperii (Cooper's hawk)	none	CSC	none	X	X	X	X	X

Species (Common Name)	Status[1] Federal	State	Other	Occurrence Probability within Reservoir Sites[2] Sites	Funks	Colusa	ThomesNewville	Red Bank
(Northern goshawk)								
Accipiter striatus (Sharp-shinned hawk)	none	CSC	none	X	X	X	*	X
Agelaius tricolor (Tricolored blackbird)	none	CSC	SC	X	*	X	X	-
Ammodramus savannarum (Grasshopper sparrow)	none	CSC	CS	*	X	X	*	*
Amphispiza belli ssp. belli (Bell's sage sparrow)	none	CSC	SC	-	-	-	*	-
Aquila chrysaetos (Golden eagle)	PR	CSC,CFP	none	X	X	X	X	X
Asio flammeus (Short-eared owl)	none	CSC	none	*	*	X	*	*
Asio otus (Long -eared owl)	none	CSC	none	X	*	X	X	X
Athene cunicularia (Burrowing owl)	FSC	CSC	none	X	X	X	X	*
Botaurus lentiginosus (American bittern)	MNBMC	none	none	*	X	*	*	*
Branta canadensis ssp. leucopareia (Aleutian Canada goose)	FT	none	none	-	*	-	-	-
Bucephala islandica (Barrow's goldeneye)	none	CSC	none	-	*	-	-	*
Buteo regalis (Ferruginous hawk)	none	CSC	SC	X	X	*	*	-
Buteo swainsoni (Swainson's hawk)	none	ST	none	*	*	*	*	-
Carduelis lawrencei (Lawrence's goldfinch)	MNBMC	none	none	*	X	X	*	X
Chaetura vauxi	MNBMC	CSC	none	*	*	*	*	*

Species (Common Name)	Status[1] Federal	State	Other	Occurrence Probability within Reservoir Sites[2] Sites	Funks	Colusa	ThomesNewville	Red Bank
(Vaux's swift)								
Charadrius semipalmatus (Western snowy plover)	FT	CSC	none	-	-	-	-	-
Charadrius montanus (Mountain plover)	PLT	CSC	none	*	-	*	*	-
Chondestes grammacus (Lark sparrow)	MNBMC	none	none	X	X	X	X	X
Circus cyaneus (Northern harrier)	none	CSC	none	X	X	X	X	X
Coccyzus americanus ssp. occidentalis (Western yellow-billed cuckoo)	none	SE	none	-	-	-	-	-
Dendroica occidentalis (Hermit warbler)	MNBMC	none	none	*	*	*	*	*
Dendroica petechia (Yellow-warbler)	none	CSC	none	X	-	-	-	-
Elanus caeruleus (White-tailed kite)	none	none	none	X	X	*	*	*
Empidonax traillii (Willow flycatcher)	none	SE	none	-	-	-	-	-
Eremophila alpestris ssp. actia (California horned lark)	none	none	SC	X	X	X	X	X
Falco columbarius (Merlin)	none	CSC	none	X	*	*	X	X
Falco mexicanus (Prarie falcon)	none	CSC	none	X	X	X	X	X
Falco peregrinus (Peregrine falcon)	FE	SE	none	*	*	*	*	*
Gavia immer (Common loon)	MNBMC	CSC	none	-	X	-	-	*

Species (Common Name)	Status[1] Federal	State	Other	Occurrence Probability within Reservoir Sites 2 Sites	Funks	Colusa	ThomesNewville	Red Bank
Antrozous pallidus (Pallid bat) (Ringtail)	FS	CSC	none	X	NE	*	X	*
Corynorhinus townsendii ssp. pallescens (Pale big-eared bat)	FSC,FS	CSC	none	*	NE	*	*	*
Corynorhinus townsendii ssp. townsendii (Pacific western big-eared bat)	FS,FSC	CSC	none	*	NE	*	*	*
Euderma maculatum (Spotted bat)	FSC	CSC	none	-	NE	-	-	-
Eumops perotis californicus (Western mastiff bat)	FSC	CSC	none	-	NE	-	*	*
Lasiurus blossivillii (Western red bat)	FS	none	none	X	NE	*	*	X
Martes americana (Pine marten)	FS	none	none	*	NE	*	*	*
Martes pennanti ssp. pacificus (Pacific fisher)	FSC,FS	CSC	none	*	NE	*	*	*
Myotis ciliolabrum (Small-footed myotis)	FSC	none	none	*	NE	*	*	*
Myotis evotis (Long-eared myotis)	FSC	none	none	*	NE	*	*	*
Myotis thysanodes (Fringed myotis)	FSC	none	none	-	NE	-	*	*
Myotis volans (Long-legged myotis)	FSC	none	none	-	NE	-	*	*
Myotis yumanensis (Yuma myotis)	FSC	CSC	none	*	NE	*	*	X

Species Scientific and (Common Name)	Status[1] Federal	State	Other	Occurrence Probability within Reservoir Sites 2 Sites	Funks	Colusa	Thomes Newville	Red Bank
Perognathus inornatus ssp. inornatus (San Joaquin pocket mouse)	FSC	CSC	none	*	NE	*	*	-
Taxidea taxus (American badger)	none	CSC	none	X	NE	X	*	*
Plant Species								
Antirrhinum subcordatum (Dimorphic snapdragon)	none	none	1B	*	NE	*	X	X
Asclepias solanoana (Serpentine milkweed)	none	none	1B	-	NE	-	-	-
Astragalus rattanii var. jepsonianus (Jepson's milk-vetch)	none	none	1B	-	NE	-	X	X
Asrtagalus tener var. ferrisiae (Ferris's milk-vetch)	FSC	none	1B	*	NE	*	*	*
Atriplex cordulata (Heartscale)	FSC	none	1B	*	NE	*	*	*
Atriplex depressa (Brittlescale)	FSC	none	1B	*	NE	*	*	*
Atriplex joaquiniana (San Joaquin spearscale)	FSC	none	1B	*	NE	*	*	*
Atriplex persistens (Vernal pool saltbush)	none	none	1B	*	NE	*	*	-
Balsamorhiza macrolepis var. macrolepis (Big-scale balsamroot)	none	none	1B	*	NE	*	*	*
Brodiaea coronaria ssp. rosea (Indian Valley broadiaea)	FSC	SE	1B	*	NE	*	*	*
Chamaesyce hooveri (Hoovers spurge)	FT	none	1B	*	NE	*	*	-

Species (Common Name)	Federal	State	Status[1] Other	Occurrence Probability within Reservoir Sites 2 Sites	Funks	Colusa	ThomesNew ville	Red Bank
Cordylanthus palmatus (Palmate-bracted bird's-beak)	FE	SE	1B	*	NE	*	*	-
Cryptantha crinita (Silky cryptantha)	none	none	1B	*	NE	*	*	*
Delphinium recurvatum (Recurved larkspur)	none	none	1B	*	NE	*	*	*
Eleocharis quadrangulata (Four-angled spikerush)	none	none	2	*	NE	*	*	-
Eriastrum brandegeae (Brandegee's eriastrum)	FSC	none	1B	-	NE	-	*	X
Eschscholzia rhombipetala (Diamond-petaled California poppy)	FSC	none	1A	*	NE	*	*	*
Fritillaria pluriflora (Adobe lilly)	FSC	none	1B	*	NE	*	X	X
Gratiola heterosepala (Bogg's Lake hedge-hyssop)	none	SE	1B	*	NE	*	*	*
Hesperevax acaulis var. acaulis (Dwarf evax)	none	none	1B	*	NE	*	*	*
Hesperolinon drymarioides (Drymaria-like western flax)	FSC	none	1B	-	NE	-	*	*
Hesperolinon tehamense (Tehama Co. western flax)	FSC	none	1B	-	NE	-	X	*
Juncus leiospermus var. leiospermus (Red Bluff dwarf rush)	none	none	1B	*	NE	*	*	*
Layia septentrionalis (Colusa layia)	none	none	1B	*	NE	*	*	*
Legenere limosa (Legenere)	none	none	1B	*	NE	*	*	-
Lepidium latipes var. heckardii (Heckard's pepper-grass)	none	none	1B	*	NE	*	*	*

Species (Common Name)	Status[1]			Occurrence Probability within Reservoir Sites[2]				
	Federal	State	Other	Sites	Funks	Colusa	ThomesNewville	Red Bank
Lotus rubriflorus (Red-flowered lotus)	FSC	none	1B	*	NE	*	*	*
Lupinus milo-bakeri (Milo Baker's lupine)	FSC	ST	1B	*	NE	*	*	*
Lupinus sericatus (Cobb Mountain lupine)	none	none	1B	-	NE	-	*	*
Madia hallii (Hall's madia)	FSC	none	1B	-	NE	-	*	*
Madia stebbinsii (Stebbin's madia)	none	none	1B	-	NE	-	*	*
Microseris sylvatica (Woodland mocroseris)	none	none	3	*	NE	*	*	*
Myosurus minimus var. apus (Little mouse tail)	FSC	none	3	*	NE	*	*	-
Myosurus sessilis (Sessile mousetail)	none	none	3	*	NE	*	*	*
Neostaphia colusana (Colusa grass)	FT	SE	1B	*	NE	*	*	-
Orcuttia pilosa (Hairy Orcutt grass)	FT	SE	1B	*	NE	*	*	-
Orcuttia tenuis (Slender Orcutt grass)	PT	SE	1B	*	NE	*	*	-
Paronychia ahartii (Ahart's paronychia)	FSC	none	1B	*	NE	*	*	*
Sagittaria sanfordii (Sandford's arrowhead)	FSC	none	1B	*	NE	*	*	*
Silene campanulata var. campanulata (Red mountain catchfly)	FC	SE	1B	*	NE	*	*	*
Streptanthus morrisonii (Morrison's jewel flower)	FSC	none	1B	-	NE	-	*	-

Species (Common Name)	Status[1] Federal	State	Other	Occurrence Probability within Reservoir Sites 2 Sites	Funks	Colusa	ThomesNew ville	Red Bank
Trichocoronis wrightii var. wrightii (Wright's trichocoronis)	none	none	2	*	NE	*	*	-
Tropidocarpum capparideum (Caper-fruited tropidocarpum)	FSC	none	1B	*	NE	*	*	*
Tuctoria greenei (Green's tuctoria)	FE	CR	1B	*	NE	*	*	-
Viburnum ellipticum (Western viburnum)	none	none	3	-	NE	-	*	*

Foot note#1

Status Key

1A=Presumed to be extinct in California (California Native Plant Society)
1B=Rare, Threatened or Endangered in California and elsewhere (California Native Plant Society)
2=Rare,Threatened or endangered in California but more common elsewhere
3=More information is needed
CFP=Fully protected under California Fish and Game
CR=State Listed as rare (Section1904,DFG code 1994)
CSC=California Species of Special Concern
DFG=California Department of Fish and Game Protected

Status Key

FC=Federal Candidate Species
FE=Federally Endangered
FPE=Federally Proposed for listing as threatened
FPT=Federally Proposed as threatened
FS=Forest Service Sensitive Species
FSC=Federal Special Concern Species
FT=Federally Threatened
MNBMC=Migratory non-game bird of management concern (USF&WS)
PLT=Proposed for listing as threatened under ESA
PR=Protected under the Bald Eagle Act

PT=Federally Proposed,threatened
SB=Specified birds under California Fish and Game Code
SC=Other species of concern identified by CALFED
SE=State endangered
ST=State threatened

Foot note #2
X=Observed in the reservoir footprint or within one mile of it
*=Not observed to date but potential habitat exists in the reservoir footprint or within one mile of it
-=Not observed and not likely to occur in the reservoir footprint or within one mile of it
NE=Not evaluated in inundation area studies, see site 1-mile perimeter column for potential occurrence at Funk's reservior.

Chapter 7.

DWR began the North-of-the-Delta Offstream Storage Investigation in late 1997 as a two-year reconnaissance level study authorized by Proposition 204-the Safe, Clean, Reliable Water Supply Act, approved by voters in 1996. In early 1999, CALFED consolidated all storage investigations under a comprehensive program called the Integrated Storage Investigations. The North-of-the-Delta Offstream Storage Investigation was incorporated into one of seven ISI program elements and continues engineering, economic, and environmental impact analyses to determine the feasibility of four north-of-the-Delta storage projects.

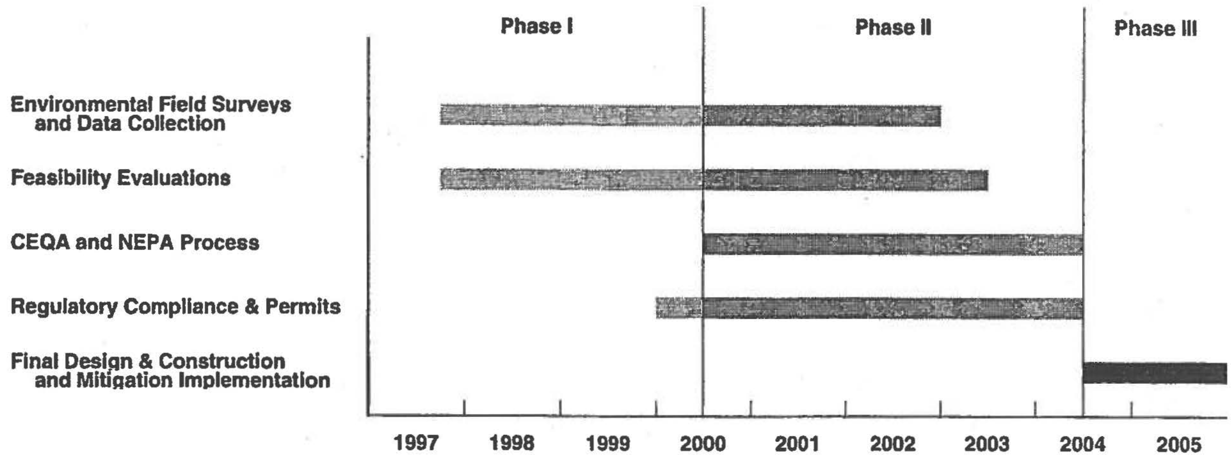
Phase I of this investigation, currently under way, includes preliminary field surveys of environmental and cultural resources; geological, seismic and foundation studies; and engineering feasibility evaluation. Phase II will start when CALFED's Record of Decision and Certification for the Programmatic EIR/EIS is filed and if additional north-of-the-Delta offstream storage is consistent with CALFED's preferred program alternative. Phase II will include completing the necessary fish and wildlife surveys, evaluating potential mitigation sites, preparation of project-specific environmental documentation, final project feasibility report, and the acquisition of permits necessary for project implementation. Phase III will consists of final design and construction, and mitigation plan implementation contingent on findings of Phase II investigations. Figure 7.1 shows the project timeline. A more detailed workplan is shown in Figure 1.2. Phase I studies are designed to:

- Collect field data to identify any potential fatal flaws in any of the project alternatives;
- Provide necessary field data for project feasibility evaluation;
- Gather information that will help the decision-makers to formulate a preferred alternative for the North-of-the-Delta Offstream Storage Program; and
- Provide field data for environmental documentation process, habitat evaluation procedure, mitigation planning, and regulatory agencies' permit decisions.

Studies conducted in Phase I will be valuable in the decision-making process of choosing a preferred alternative for the project and in helping to formulate a plan for the North-of-the-Delta Offstream Storage Program in an environmentally sensitive manner. Phase I studies have also provided basic information on the costs, benefits, and potential impacts of north-of-the-Delta offstream storage for consideration in CALFED's programmatic EIR/EIS.

Engineering studies conducted in the last two years focused on identifying major project features and alternative sources of water supply. Water supply studies, alternative conveyance facilities, geological exploration of dam sites, and initial design of dams, spillways, canals, stream diversions, pumping plants, and power generation facilities for Sites Reservoir have been the main activities. Table 7.1 shows a list of engineering activities to date.

Figure 7.1. Project Timeline



Biological studies were initiated to identify endangered, threatened, or sensitive plant and wildlife species that exist within the reservoir inundation areas, along with cultural resources studies. These studies consisted of reviewing past studies and existing databases, and conducting extensive field surveys. Table 7.2 is a list of environmental activities completed to date.

Reconnaissance-level surveys for potential special-status shrimp habitat at the potential reservoir sites were performed using aerial photography and existing data. DWR is initiating a process to work with USFWS and affected landowners to obtain incidental take permits and right-of-entry permits, respectively, to conduct shrimp surveys using Service protocol at the project areas. In addition to the shrimp surveys, environmental studies in Phase II will be extended to include areas outside of the reservoir footprint for project alternatives, along the alignment of conveyance facilities, and where other infrastructures associated with the project, including future road and recreation facilities, will be located.

Impacts of diversion from the Sacramento River on the ecosystem and fishery resources have been the subject of extended discussion. A series of studies to evaluate the potential impacts of project operation on fishery, riverine processes, and overall Sacramento River ecosystem is currently being initiated and will continue during the next two years. Table 7.3 is a list of studies planned for this program. Work on some of these studies has begun and will continue during Phase II.

The Phase II investigations will lead to the preparation of environmental documents to comply with the National Environmental Policy Act and the California Environmental Quality Act. NEPA directs federal agencies to prepare an environmental impact statement for all major federal actions that may have a significant effect on the human environment. CEQA, modeled after NEPA, requires California public agency decision-makers to document and consider the environmental impacts of their actions. It requires an agency to identify ways to avoid or reduce environmental damage and to implement those measures where feasible.

In addition to environmental documentation, federal and State laws require compliance with various laws protecting waters and wetlands as well as other aspects of the environment. Table 7.4 shows a list of major federal and State environmental permits and compliances related to project implementation.

The studies that have been conducted in the last two years have provided valuable engineering and biological data to the North-of-the-Delta Offstream Storage Investigation. These studies, along with the work over the next several years, will be instrumental in the decision-making process, CEQA and NEPA, and mitigation planning for the preferred alternative for north-of-the-Delta offstream storage program. The previous chapters in this report have summarized the work that has been completed to date. The following section lists the conclusions drawn and makes some recommendation as the program moves forward.

Conclusions and Recommendations:

- Four offstream storage alternatives are under investigation in the west side of the Sacramento Valley. Project formulation includes consideration of a water exchange program to use the water supply of the project for agricultural and wetland uses within the Colusa Basin in exchange for current diversions from the Sacramento River.
- North-of-the-Delta offstream storage can improve water supply reliability for all users. Potential project benefits include increased operational flexibility, improved water quality, reduced flooding, additional water supply to meet agricultural, urban, and environmental demands, cooler water for Sacramento River salmon, and ecosystem benefits.
- Engineering and geological investigations conducted at Golden Gate and Site dam sites indicate that these sites are suitable for construction of dams impounding a 1.8 maf Sites Reservoir.
- The dominant Natural Plant Community in the Sites, Colusa, and Thomes-Newville project areas is California annual grassland. The Red Bank Project area is dominated by blue oak, mixed oak, foothill pine, and chaparral. Sites Reservoir contains a greater diversity of habitat type and woodland than found in the Colusa Cell. Thomes-Newville Project area has more density and diversity of species than Sites Reservoir. Red Bank Project area, by far, has the most diversity of species than the other three alternative reservoir sites.
- Habitat for the valley elderberry longhorn beetle occurs at each of the four proposed reservoir sites. VELB emergence holes were found within the proposed Sites and Newville Reservoir areas. No emergence holes were found

within the proposed Colusa Cell and Red Band Project areas. No adult beetles were observed at any of the proposed reservoir sites.

- Jurisdictional wetlands and waters of the U.S. are present in all four reservoir areas. The Newville Reservoir area with 413 acres of jurisdictional wetlands and 231 acres of other water of U.S. has the most acreage of all four reservoir areas.
- Review of existing databases indicated that nine State and federally listed avian species could be found within the counties covering the west side of the Sacramento Valley and foothills. Three of these species were identified during field surveys including sporadic wintering use by both adult and immature bald eagles, which have been documented at each of the four reservoir sites. A single sighting of a bank swallow was made near the proposed Colusa site. Five sandhill cranes were observed flying over the Colusa Project area during November 1997. This observation occurred on a foggy day in the Sacramento Valley when the sandhill cranes may have flown over the project area in the foothills that were fog free to utilize the annual grasslands.
- The streams flowing through the proposed Sites Reservoir and Colusa Cell are warm water streams with poor water quality. These streams do not support habitat for anadromus fish, and are generally intermittent in nature. Sampling of game and nongame fishes within these streams found very few fish above 150 mm in lengths, suggesting that fish only rear in these areas. Hitch was the most abundant fish found in both reservoir areas.
- Thomes Creek was surveyed in 1980-81, 1981-82, and again in 1999 for the presence of salmon and steelhead. Fall and late fall-runs of salmon and steelhead were seen during these surveys. In the 1999 survey, one adult spring-run chinook salmon was also found.
- DFG staff estimates that Cottonwood Creek supports a good population of steelhead. Steelhead were also found in Red Bank Creek within the footprint of Schoenfield Reservoir. Fall-run and late fall-run chinook salmon were found by DFG staff in lower Cottonwood Creek from the mouth to the confluence of the North Fork Cottonwood Creek. Spring-run chinook salmon migrate upstream in April and spend the summer in deep pools in the south and north fork of Cottonwood Creek.
- No threatened or endangered amphibians were found within the Sites, Colusa, or Thomes-Newville project areas. A single California red-legged frog was found in the Red Bank Project area.
- Fish species found in Cottonwood Creek are more diverse than in streams flowing through other alternative reservoir sites. Spring run chinook salmon and steelhead were sampled in South Fork Cottonwood Creek where the proposed Dippingvat Reservoir would be located. Much more diverse habitat and species were also present within the Schoenfield Reservoir area.
- Hydrologic studies of Red Bank Creek indicate that without diversions from the Cottonwood Creek, Schoenfield Reservoir is not feasible. Therefore, it is recommended that the Red Bank Project studies be discontinued.

- The natural flow of Red Bank Creek at the proposed Schoenfield Reservoir averages about 16,000 acre-feet per year. This flow is not adequate to justify the construction of Schoenfield Reservoir without additional water supplies from South Fork Cottonwood Creek. Diversion of Cottonwood flood flow to Red Bank Project is not feasible without construction of a diversion dam on the South Fork Cottonwood Creek.
- Red Bank Creek is proposed to convey Schoenfield Reservoir water to the Tehama-Colusa Canal. Seepage of project water in Red Bank Creek may be excessive, making it an infeasible conveyance alternative.
- The embankment to storage ratio for the Colusa Cell is very high, increasing the project cost considerably. This is primarily due to the very large embankments required for construction of four main dams and seven saddle dams that would form the Colusa Cell. This disproportionately large embankment volume increases the cost of the project and unit cost of water considerably. Therefore, it is recommended that further studies of the Colusa Project be deferred until the completion of an economic feasibility study of the project. These studies may be continued later, if economic feasibility evaluations indicate that the Colusa Cell is feasible.
- The environmental documentation process for the North-of-the-Delta offstream storage project should start this year if additional north-of-the-Delta offstream storage is consistent with CALFED's preferred program alternatives as discussed in the Bay-Delta Program final programmatic EIS/EIR and Record of Decision.

Table 7.1 Completed Engineering Activities

- Preliminary Hydrology and Operation Studies for Each Reservoir
- Preliminary Fault and Seismic Evaluation for the Four Project Alternatives
- Preliminary Design Work for Conveyance Facilities to Sites
- Preliminary Cost Estimates for Various Conveyance Alternatives
- Aerial Photography and Topographic Mapping, including 2-Foot Contour at Sites and Golden Gate Dam Sites, of Conveyance Alignments
- Preliminary Evaluation of Earthfill Cross-Sections for Sites Reservoir
- Preliminary Design and Cost Estimates for Dams and Appurtenances at Golden Gate Dam Site
- Location and Characteristic of Dam Construction Materials for Sites Reservoir
- Preliminary Design and Cost Estimates for Pump/Generation Facilities from Funks Reservoir to Sites Reservoir
- Preliminary Road and Utilities Relocations Study for Sites and Colusa Reservoirs
- Foundation Mapping, Drilling, and Water Pressure Testing for Sites Reservoir and Partial Colusa Project
- Began Detailed Fault and Seismic Evaluation of Sites Reservoir

Table 7.2 Completed Environmental Activities for Reservoir Footprint

- Delineation of All Wetlands in All Reservoir Areas
- Preliminary Cultural Resources Inventory of All Reservoir Areas
- Complete 2-Year Survey of Threatened and Endangered Species in Reservoir Areas
- Complete 2-Year Botanical Survey of Reservoir Areas
- Complete Survey of Elderberry Plants in All Reservoir Areas
- Survey of General Species and Their Habitat as needed to complete the Habitat Evaluation Procedure
- Fairy Shrimp Habitat Survey and Mapping for Thomes-Newville and Sites/Colusa Reservoir Areas
- Preliminary Evaluation of Recreational Facilities Potential for Sites Reservoir

Table 7.3 Studies Planned for North-of-the Delta Offstream Storage Investigation

Work has begun on these activities

- Establish a process for proper coordination and consultation with resource agencies.
- Complete operation studies for project alternatives.
- Complete water quality investigation for project alternatives.
- Complete tributaries fish studies for project alternatives.
- Complete highway and utilities relocation studies for project alternatives.
- Complete recreation facility design for project alternatives.
- Complete Sites and Golden Gate Dams design and cost estimates.
- Complete geological investigation for Sites Reservoir including foundation and borrow materials investigation.
- Complete fault and seismic analysis for Sites Reservoir.

Work on these activities will begin in mid-2000

- Develop a water exchange program for project alternatives.
- Energy analysis and power transmission facilities for project alternatives.
- Evaluate impacts of diversions on Sacramento River ecosystem.
- Evaluate impact of diversions on Sacramento River fishery resources.
- Initiate special status shrimp surveys for project alternatives.
- Initiate and complete the following studies outside the footprint of the Sites Reservoir: Avian, Wetlands, Botanical Resources, Amphibians, Mammals, and Reptiles, and Valley Elderberry Long-Horn Beetle.
- Conveyance facilities design and cost estimates for Sites/Colusa Project.

- Embankment design and cost estimates for Golden Gate, Sites, and saddle dams.
- Update Newville Dam design and cost estimates.
- Update Newville Dam geological investigation including borrow materials and foundation investigation.
- Update embankment design and cost estimates for Newville Dam and saddle dams.
- Update Newville Dam fault and seismic analysis.
- Complete conveyance facilities for Thomas-Newville Project.
- Develop project formulation.
- Complete CEQA and NEPA process.
- Initiate Habitat Evaluation Procedure.
- Prepare mitigation plan.
- Acquire project permits.
- Complete economic feasibility of the project alternatives.
- Final engineering feasibility.
- Complete general mammal surveys.

Table 7.4 Major Environmental Permits and Compliance

Federal
- Clean Water Act 404 Permit for reservoir conveyance system, diversion structure
- Federal Endangered Species Act Compliance-Section 7 Take Permits
- National Environmental Protection Act Compliance
- Federal Energy Regulatory Commission Compliance
- National Historic Preservation Act Compliance
- Fish and Wildlife Coordination Act
- Rivers and Harbors Act Compliance
- Farmland Protection Act Compliance
- Executive Order 11988: Floodplain Management Compliance
- Executive Order 11990: Protection of Wetlands
- Clean Air Act Compliance
- Surface Mining Reclamation Act Compliance

State
- Regional Water Quality Control Board 401 Water Quality Certification
- Regional Water Quality Control Board Stormwater Permit

- Regional Water Quality Control Board Approval for Construction in Water Bodies and Discharge of Dewatering Water
- State Water Resources Control Board Water Rights Permits
- Department of Fish and Game 1600 Streambed Alteration Agreement
- Department of Fish and Game Dredge Permit (Section 5653 DFG Code)
- California Environmental Quality Act Compliance
- State Endangered Species Act Compliance
- Department of Water Resources Dam Safety Certification
- State Lands Commission Notification/Permit (Riverbed Modification)

North-of-the-Delta Offstream Storage Investigation
Progress Report -- List of Appendices

Glossary

A

active storage capacity the usable reservoir capacity available for seasonal or cyclic water storage. It is gross reservoir capacity minus inactive storage capacity.

afterbay a reservoir that regulates fluctuating discharges from a hydroelectric power plant or a pumping plant.

agricultural drainage (1) the process of directing excess water away from root zones by natural or artificial means, such as by using a system of drains placed below ground surface level; also called subsurface drainage; (2) the water drained away from irrigated farmland.

alluvial pertaining to or composed of alluvium

alluvium unconsolidated soil strata deposited by flowing water.

anadromous fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

aquifer a geologic formation that stores water and yields significant quantities of water to wells or springs.

average annual runoff for a specified area is the average value of annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

B

bedload the part of the sediment in a stream that is moved on or immediately abouve the stream bed usually consisting of boulders, pebbles, and gravel.

biota living organisms of a region, as in a stream or other body of water.

brackish water water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than sea water.

brooding water used by nesting waterfowl to rear their young.

C

California Species of Special Concern species designated by the California Department of Fish and Game as having declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction. The purpose of this designation is to halt or reverse their decline by calling attention to their plight and addressing issues of concern early enough to secure their long term viability.

candidate species species that have been petitioned to be listed as threatened or endangered based upon current information and data available. These species are under review and investigation through research for formal listing as threatened or endangered.

chaparral a major vegetation type in California characterized by dense evergreen shrubs with thick, hardened leaves.

colluvial overburden colluvium that is laying on hard rock which must be removed for construction to take place.

colluvium a general term applies to heterogeneous material of loose soil or rock fragments that is deposited at the base of a hill by rainwash or downhill creep.

compressive strengths the amount of pressure that can be applied to a rock, under certain conditions, before the rock breaks or is crushed.

conglomerate a sedimentary rock composed of rounded to subangular fragments larger than sand, surrounded by sand, silt, or clay. These fragments are usually cemented together.

conglomerate clasts the rock fragments that make up the coasrs-grained portion of a conglomerate.

conjunctive use the operation of a groundwater basin in combination with a surface water storage and conveyance system. Water is stored in the groundwater basin for later use by intentionally recharging the basin during years of above-average water supply.

cretaceous a geologic period that covers the geologic time scale from about 65 to 144 million years ago.

D

deep percolation percolation of (irrigation) water through the ground into the groundwater.

dissolved organic compounds carbon-based substances dissolved in water.

dissolved oxygen (DO) the amount of oxygen dissolved in water or wastewater, usually expressed in milligrams per liter, parts per million, or percent of saturation.

drainage area the area of land from which water drains into a river; for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called watershed or river basin.

DFG harvest species species managed by the Department of Fish and Game for public hunting opportunities. Species include but are not limited to deer, ducks, bear, and pigs.

E

electrical conductivity a measurement of how easily electricity flows through water. This correlates with the Total Dissolved Solids in water. The higher the TDS, the more easily electricity flows through the water, the higher the electrical conductivity.

emergent wetlands wetlands containing erect, rooted vegetation such as tules (not including mosses and lichens).

endangered species a species at high risk to extinction in the wild in the near future.

environmental water the water for wetlands, for the instream flow in a major river or in the Bay-Delta, or for a designated wild and scenic river

ephemeral a stream, pool, or lake that occurs for only the "wet" portion of the year. These bodies of water disappear during the summer months.

eutrophic said of a body of water characterized by a high level of plant nutrients, with correspondingly high primary productivity.

F

fault gouge soft, uncemented, pulverized clayey material filling or partly filling a fault zone or found along a fault.

fluvial of or pertaining to a river or rivers.

forebay a reservoir at the intake of a pumping plant or power plant to stabilize water levels; also a storage basin for regulating water for percolation into groundwater basins.

fry a recently hatched fish.

G

Geologic province a large region characterized by similar geologic history and rocks.

gradient the steepness of the slope of the land surface or river

gross reservoir capacity the total storage capacity available in a reservoir for all purposes, from the streambed to the normal maximum operating level. Includes dead (or inactive) storage, but excludes surcharge (water temporarily stored above the elevation of the top of the spillway).

groundwater water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated.

groundwater area an area where because of the nature of the geologic material, groundwater is found. Unlike a groundwater basin, the boundaries of a groundwater area are less definitive.

groundwater basin a groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir. In some cases, the boundaries of successively deeper aquifers may differ and make it difficult to define the limits of the basin.

groundwater recharge the natural or intentional infiltration of surface water into the zone of saturation (i.e., into groundwater).

groundwater table the upper surface of the zone of saturation, in an unconfined aquifer.

H

Habitat Evaluation Procedure a computerized method used to inventory habitats and assess impacts that combines habitat quality with habitat area to calculate Habitat Units. The Habitat Units are sensitive to changes in both amount and quality of habitat. The project consists of quantitative information for each species or suite of species evaluated.

Habitat Suitability Index Model species models that are used for habitat-based evaluation techniques.

Holocene a geologic epoch in the Quaternary that ranges from now to 10,000 years ago.

hydrologic basin the drainage area upstream from a given point on a stream.

I

instream use use of water within its natural watercourse. For example, the use of water for navigation, recreation, fish and wildlife, aesthetics, and scenic enjoyment.

irrigation return flow applied water that is not transpired, evaporated, or infiltrated into a groundwater basin but that returns to a surface water body.

J

jurassic a geologic period that covers the geologic time scale from 144 to 208 million years ago.

L

land subsidence the lowering of the natural land surface due to groundwater (or oil and gas) extraction.

lenticular a sedimentary deposit that is lense-shaped

lineament a linear feature on the earth's surface that is believed to reflect the earth's structure (i.e. fractures, faults, aligned volcanoes, and straight stream courses).

M

maximum contaminant level (MCL) the highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

maximum storage the maximum amount of water that can be stored in a reservoir

mean sea level the average height of the surface of the sea for all stages of the tide over a long period of time. Mean sea level is used as a datum plane for the measurements of elevations and depths.

metavolcanic an informal term of volcanic rocks that shown evidence of having been subjected to pressure and temperature after their deposition from volcanic activity.

ML

multipurpose project a project, usually a reservoir, designed to serve more than one purpose, and whose costs are normally allocated among the different functions it provides. For example, a project that provides water supply, flood control, and generates hydroelectricity.

N

National Pollutant Discharge Elimination System (NPDES) a provision of Section 402 of the federal Clean Water Act that established a permitting system for discharges of waste materials to water courses.

nonpoint source waste water discharge other than from point sources. See also point source.

normal pool elevation (or reservoir) the highest elevation at which reservoir water is normally stored. This is usually the spillway crest elevation.

nomlaki tuff member a tuff unit in the Pliocene rock units that has been given a formal name. It has been identified throughout the Sacramento Valley.

O

offstream storage a reservoir on a small stream that does not significantly contribute to the water supply of the reservoir. The water supply for the reservoir is diverted from a nearby river via one or more canals to the reservoir.

P

pathogens viruses, bacteria, or other organisms that cause disease.

pediment a broad, gently sloping surface caused by erosion.

permeability the capability of soil or other geologic formations to transmit water.

phytoplankton minute plants, such as algae, that live suspended in bodies of water.

pleistocene a geologic epoch that covers the geologic time scale from 10,000 to 1.6 million years ago.

pliocene a geologic epoch that covers the geologic time scale from 1.6 to 5.3 million years ago.

point source a specific site from which wastewater or polluted water is discharged into a water body.

pollution (of water) the alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

project yield the water supply attributed to all features of a project, including integrated operation of units that could be operated individually.

pumice a rock composed of volcanic ash. Its light weight many times will allow it to float on water.

pump lift the distance between the groundwater table and the overlying land surface.

pumped storage project a hydroelectric powerplant and reservoir system using an arrangement whereby water released for generating energy during peak load periods is stored and pumped back into the upper reservoir, usually during periods of reduced power demand.

pump-generating plant a plant which can either pump water or generate electricity, depending on the direction of water flow.

Q

quaternary a geologic period that covers the geologic time scale from now to 1.6 million years ago.

R

recent a geologic epoch in the Quaternary that ranges from now to 10,000 years ago. This epoch is sometimes referred to as the holocene.

recharge basin a surface facility constructed to infiltrate surface water into a groundwater basin.

recycled water urban wastewater that becomes suitable, as a result of treatment, for a specific beneficial use. Also called reclaimed water. See also water recycling.

return flow the portion of withdrawn water not consumed by evapotranspiration or system losses which returns to its source or to another body of water.

riparian located on the banks of a stream or other body of water. Riparian water rights are rights held by landowners adjacent to a natural waterbody.

runoff the volume of surface flow from an area.

S

salinity generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as an electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. See also total dissolved solids.

salmonid fish species belonging to the salmon family, including salmon and trout.

schist a metamorphic rock that readily splits into thin flakes.

seepage the gradual movement of a fluid into, through, or from a porous medium.

septic tank lechate the fluid that leaves a septic tank and usually percolates down to the groundwater table or moves laterally until it is used by vegetation or empties into a stream or lake.

service area the geographic area served by a water agency.

slake the crumbling or disintegration of rock upon exposure to air or moisture.

soil-stratigraphic unit a soil with physical characteristics and relationship with other soils that permit its consistent recognition and mapping.

soluble minerals naturally occurring substances capable of being dissolved.

submarine fan a fan-shaped deposit on the sea floor that is seaward of large rivers or submarine canyons.

surface supply water supply from streams, lakes, and reservoirs.

syncline a fold in sedimentary rocks that is concave upward.

T

tectonic boundary a boundary between two or more areas of similar faulting and folding.

tectonic scarps a line of cliffs producing by faulting

tertiary a geologic period that covers the geologic time scale from 1.6 to about 65 million years ago.

threatened species a species at high risk to extinction in the wild in the medium term future.

total dissolved solids (TDS) a quantitative measure of the residual minerals dissolved in water that remain after evaporation of a solution. Usually expressed in milligrams per liter. Abbreviation: TDS. See also salinity.

tuff a general term for all rock that is formed by volcanic material transported into place by air or water.

U

unconformity a gap or break in the deposition between two rock units. During this break in deposition, the lower rock unit has been eroded or weathered.

unimpaired flow the flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use.

V

vernal pools ephemeral wetlands forming in shallow depressions underlain by a substrate near the surface that restricts the percolation of water.

W

water gaps a deep pass in a mountain ridge, through which a stream flows.

water quality description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

water recycling the treatment of urban wastewater to a level rendering it suitable for a specific beneficial use.

watershed see drainage basin.

water table see groundwater table.

water transfers marketing arrangements that can include the permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; the sale or lease of a contractual right to water supply.

well completion reports reports of water wells constructed in California. The reports contain data about the well and the materials encountered in its construction.

wetlands delineations investigation of inundated areas to determine if hydrology, soils, and vegetation qualify the area to be subject to jurisdictional regulation.