River Basin is combined with Shasta releases to dilute these toxins. Water diverted from the Trinity River Basin has historically been an important component in providing dilution flows. Again, however, reducing the amount of interbasin transfers from the Trinity River Basin to the Sacramento River Basin will lead to an increased reliance on Shasta Lake water supplies to meet dilution flow requirements.

Adverse Effects

Potential adverse effects associated with raising the dam vary, depending on the geographic area. For purposes of evaluating potential adverse environmental impacts, the basin can be divided into three areas: (1) upstream from Keswick Dam, (2) the Sacramento River below Keswick Dam, and (3) the Sacramento-San Joaquin Delta and Bay. The environmental issues associated with each of these geographic areas are discussed below.

Upstream of Keswick Dam

Shasta Lake and its tributary streams support coldwater and warmwater fisheries. The gamefish species are rainbow trout, brown trout, smallmouth bass, largemouth bass, black crappie, bluegill, green sunfish, channel catfish, white catfish, brown bullhead, landlocked white sturgeon, and landlocked silver salmon. Nongame species include hard head, golden shiner, threadfin shad, and Sacramento squawfish.

The proposed dam raise project could have both beneficial and adverse effects on the fishery resources. Whether the effects are beneficial or adverse will depend primarily on project operations. Enlarging the reservoir would, in general, improve the reservoir fishery. Nutrient leaching in newly inundated areas would improve reservoir production during the first years following the enlargement. However, the inundation under a large raise (elevation 1280) would inundate about 42 miles of stream habitat, including 6 miles of the McCloud River, 16 miles of the Sacramento River, and a portion of Squaw Creek. Inundation of these areas would adversely affect trout production. Since the stream gradients on the upper tributaries are relatively constant, inundation effects are expected to be generally proportional to the raise in dam elevation.

The potential for inundating old mines, thereby increasing acid mine drainage wastes in the reservoir and the Sacramento River, is of particular concern. A preliminary review of mining claims and holdings in the vicinity of Shasta Dam indicates that, even under the largest dam raise alternatives, flooding of actual mine sites would not occur. At about elevation 1100, a raise in the maximum water surface elevation of about 30 feet, partial or complete inundation of the old Bully Hill Refinery site would occur on a seasonal basis. However, since this is only a refinery site and not an actual mining area, the materials of concern would be old spoils heaps and surficial site contaminants, not the more extensive deposits of a mine itself. A feasibility-level study would investigate the

toxicity of these deposits. Sporadic flooding and exposure of the refinery site could possibly be mitigated by either burial or removal of the tailings and surficial materials.

Also of concern is the presence of cultural resources. These can be divided into two major categories: (1) archeological and ethnographic sites, and (2) historic sites. Archeological and ethnographic sites include Indian villages, locations where ceremonies were held, burial grounds, and a number of other types of sites. Large portions of the Sacramento, McCloud, and Squaw Creek watersheds were known to have populations of the Wintu Tribe. Detailed surveys of known sites have not been made, but sites are known to occur (some with very well-preserved features) within the inundation zones of the high and intermediate raise options. Known sites are found in areas bordering the Low Option fringes. Historic sites include historic buildings and lodges and historic hiking and fishing trails. On the McCloud River, a private fly-fishing club has been in operation since 1904. Its lodges date from the 1860s. Some lodges are likely eligible for inclusion in the registers of National and State historic structures. The Intermediate and High Options would inundate these buildings. The Low Option could adversely affect their use, depending on ultimate reach of the reservoir level.

The predominant vegetation types in this area are northern yellow pine forests, Sierra montane forests, and blue oak-digger pine forests. The lower elevation areas are dominated by shrub and scrub oak. The

The McCloud River above Shasta Lake.

project area supports nearly 200 species of birds and 55 species of mammals, reptiles, invertebrates, and amphibians. Typical species include owl, raven, gray squirrel, black bear, deer, hummingbird, swallow, elk, ducks, and geese. Lower elevation areas in the McCloud River Sacramento River, Pit River, and Squaw Creek drainages are winter ranges for deer. Elk winter range is located in the McCloud and Pit River peninsulas.

The inundated area under the elevation 1280 alternative is about 60,500 acres. This is an increase of about 30,500 acres over the existing reservoir. The increase in inundated area for the elevation 1180 alternative is about 15,500 acres, and for the elevation 1084 alternative, about 2,000 acres. The adverse effects to wildlife habitat are relatively proportional to the increase in area inundated.

Eleven fish and wildlife species have been designated as rare, threatened, endangered, or sensitive in the Shasta Lake/Keswick Reservoir area. Among these are the bull trout (State endangered), the Shasta

salamander (State rare), and *Arnica venosa* (Federal sensitive plant). Other special status species include the bald eagle, the northern spotted owl, and the American peregrine falcon. The project would inundate habitat used by some of these species. Enlarging the lake would result in the loss of about 5 percent of the habitat used by the Shasta salamanders. Further surveys are required to determine if the *Arnica venosa* plant species is actually present.

Shasta Lake is home to the largest concentration of nesting bald eagles in California. In any given year, 18 pairs of bald eagles may nest within 0.5 mile of the reservoir shoreline. The lake supports up to 38 nesting and breeding individuals and over 50 wintering individuals. Habitat for the resident bald eagle population should increase.

The California Wild and Scenic River Act (Public Resources Code Sections 5093.50) was reviewed as part of this reconnaissance effort. Under Section 5093.542(b), the free-flowing stretches of the McCloud River are protected under State law. Under the act, the State legislature makes the finding that "maintaining the McCloud River in its free-flowing condition to protect its fishery is the highest and most beneficial use of water" under the State Constitution. The act prohibits the construction of dams, reservoirs, diversions, or other water impoundment facilities on the McCloud River from the location of the present confluence of the McCloud River with Shasta Reservoir (McCloud Bridge) throughout and beyond the areas affected by the Low, Intermediate, and High Options. State legislation, such as this act, would not preclude Federal action and could not prevent the Bureau of Reclamation from raising Shasta Dam. Subsection 5093.542(c) does, however, with the exception of certain designated activities by the California Department of Water Resources, prohibit any State department or agency from assisting or cooperating with any agency of the Federal, State, or local government in planning or constructing any facility that could have an adverse effect on the free-flowing condition of the McCloud River or on its wild trout fishery.

The areas potentially affected by the Low, Intermediate, and High Options are also protected by an agreement known as the McCloud River Coordinated Resource Management Plan ("McCloud River CRMP"). Participants in and signatories to the McCloud River CRMP include agencies of the Federal, State, and local governments; private landowners in the McCloud watershed; industry; and environmental groups.

One of the principal objectives of the McCloud River CRMP is to protect the free-flowing nature and natural condition of the McCloud River. The effect of this agreement upon the State and Federal signatories is unknown and should be considered during any further studies.

State Wild and Scenic River Act issues and issues related to the McCloud River CRMP agreement will likely continue to be issues

which will require close attention and consideration during any further studies.

Sacramento River Downstream from Keswick Dam

Along this 300-mile reach, the Sacramento River collects flow from nine major creeks and the Feather and American Rivers. Water quality is generally good along the upper half of the reach, except when toxic mine releases occur near Keswick. The upper half of the reach is good trout and salmon habitat. Along the lower half of the reach, agricultural drain water reduces water quality by increasing water temperature and turbidity. Warmwater fish populations increase below Red Bluff.

The Sacramento River supports a wide variety of resident and anadromous fish. Effects to these resources are described below.

Chinook Salmon.—Commercially, the most important anadromous fish is the chinook salmon. The Sacramento River and its tributaries support spring, fall, late fall, and winter races. There are adult and juvenile chinook in the river during every month of the year. The fall chinook run is the largest. Most fall-run spawning occurs in the mainstem Sacramento River between Hamilton City and Keswick Dam. Late fall- and winter-run chinook spawn primarily in the mainstem above Red Bluff. Genetically pure spring-run salmon spawn in a few tributaries, but spring-fall hybrids spawn in the mainstem.

The project could beneficially or adversely affect chinook salmon, depending on operations. Flow changes are of primary concern. How any operations are carried out will determine the positive or negative effects of any enlargement. Flow changes affect chinook spawning habitat by altering water depths and velocities. Flow changes can also affect rearing habitat availability and juvenile outmigration success. Mainstem flow reductions could reduce the dilution of tributary stream inflows, increasing the concentration and duration of turbidity sources. A deeper reservoir may also affect dissolved oxygen concentrations in releases from the deeper reservoir. These pollution and turbidity changes could adversely affect egg and juvenile chinook survival rates.

The other major concern associated with operations is temperature conditions within the Sacramento River. Any of the proposed raises should augment the size of the coldwater pool and should enhance the ability to meet water temperature standards through use of the existing temperature control device.

Wildlife Habitat Along the River.—There are four main wildlife habitat areas adjacent to this reach of the Sacramento River: the Sacramento River riparian zone, the Butte Basin, the Colusa Basin, and the Yolo Basin. Wildlife habitat in these areas includes agricultural lands, riparian zones, permanent marshes, seasonal marshes, and uplands. Any proposed enlargement project could adversely affect wildlife populations, depending on the amount of flooded land areas. Managed wetland habitats should not

be harmed. Of concern is the threat of conversion of riparian zones to agricultural zones posed by reduced flooding. Separate ongoing efforts are addressing these problems, and any future analysis of these potential effects would have to be coordinated with those efforts. Also of concern is the effect on riparian habitat of reduced flood releases during the winter and higher flows other times of the year. Reduced flooding could also reduce the amount of habitat that supports diverse populations of wildlife through a reduction in water supplies to the riparian zone.

Special species of concern that inhabit the riparian zone in this reach include the bald eagle, peregrine falcon, yellow-billed cuckoo, and giant garter snake. In addition, the California red-legged frog, western spadefoot toad, sharp-tailed snake, and Pacific pond turtle inhabit this reach.

The Delta

The Sacramento-San Joaquin Delta is the point of convergence of the Sacramento, San Joaquin, Mokelumne, and Cosumnes Rivers. Functionally, it is part of the San Francisco Bay Delta ecosystem, consisting of sloughs and islands that are subject to tidal influences.

The most significant fish species in the delta are anadromous species including chinook salmon, steelhead trout, white sturgeon, non-native striped bass, and American shad. These species use the delta as a passage to upstream spawning areas and as juvenile rearing areas. Another significant species is the delta smelt.

Important factors that affect the delta fishery and ecosystem in general are adequate circulation and dispersion of nutrients and upstream fish losses at diversions. Water circulation and nutrient dispersion are influenced by watershed runoff, upstream water storage, and delta area diversions that reduce freshwater outflows. Delta outflows affect the various zones within the area that form the areas of highest biological activity in the estuary. Adequate outflows are also required to prevent saltwater intrusion into the delta and to flush pollutants from the area. Saltwater intrusion can adversely affect food availability for delta fish and wildlife.

Also of concern is the potential for fish losses at diversions and the delta area export facilities operated by the California State Water Project and the Federal Central Valley Project. The potential for increased exports in dry years under any enlarged Shasta proposal could result in increased losses of fish eggs, fry, and fish food organisms caused by the pumping facilities.

Mitigation Strategies

Potential mitigation strategies for adverse effects associated with any enlarged dam proposal may include, but are not limited to, any of the following actions:

Upstream from Keswick Dam.—

- Leave natural vegetation or install artificial fish cover in the reservoir drawdown zone.
- Improve stream habitat in the project area and other critical habitat locations away from the project.
- Initiate land acquisition and management efforts to focus on improving deer, elk, and other wildlife habitat.
- Restrict jet ski, houseboat, and other motorized craft access to the upper reaches of the McCloud, Sacramento, and Pit River arms above the reservoir, to the extent this is permissible and feasible under existing laws of navigation.
- Avoid cultural resource sites and historic structures to the extent possible.

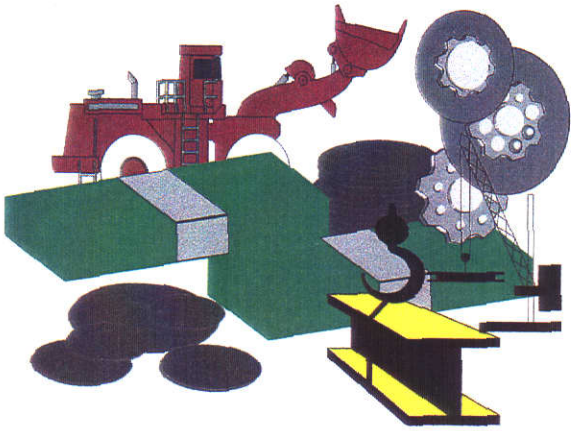
Sacramento River Downstream from Keswick.—

- Improve fish passage and habitat on the Sacramento River and its tributaries.
- Release water to enhance fish production and riparian habitat.
- Monitor salmon habitat to ensure maintenance of quality fish habitat.
- Maintain releases to dilute Spring Creek acid mine wastes.
- Control predation on salmonids.
- Manage meander belt zones to protect and enhance wildlife habitat.

Delta.—

- Modify flow management and provide additional fish protection facilities.

Many ongoing programs are addressing resource issues associated with some of the potential strategies identified above. Any future development of a mitigation program would have to be carefully coordinated with these ongoing programs.



Detailed construction cost estimates based on current unit prices were prepared for the appraisal-level design features included in this study. These project features include the concrete dam overlay and RCC wing dams, spillway, river outlets, TCD modifications, selective-level intake, penstocks, new and existing powerplants, switchyards, cellular cofferdams, and reservoir dikes. Appraisal-level estimates include an allowance of 10 or 15 percent for unlisted items, depending on the feature, and an allowance of 25 percent for contract contingencies. The higher allowance for unlisted items of 15 percent was used for the concrete dam to cover a potential uncertainty in the concrete quantities, and a higher than usual mobilization cost (10 percent) was assumed for the extensive concrete batching and delivery systems required.

Past cost estimates for additional project features have been indexed to current price levels to provide an estimate of total project costs for each dam raise option. These features include the replacement of Interstate Highway 5 and the Union Pacific Railroad, potential modifications to Keswick Dam and Powerplant, resort and recreation facility relocations, acquisition of land rights, reservoir clearing, and Sacramento River seepage mitigation. In addition, a preliminary cost for a new Pit River Bridge (or Bridge Bay crossing) was developed for this study.

Cost Summaries

Estimated costs for the three dam enlargement options included in this appraisal-level study are summarized in table 10. The detailed cost estimate worksheets for each option are provided in appendix B.

Table 11 shows the cost per acre-foot of added storage. The cost per acre-foot of storage is shown both in terms of first costs and total investment costs. This cost per acre-foot of storage does not represent the cost per acre-foot of reservoir yield. These costs provide a basis of comparison to other storage options being considered in the CALFED process.

The total estimated field costs, first costs, and investment costs for each dam raise option are plotted in figure 9. At this appraisal level of analysis, these curves show a gradual, smooth increase in costs as the crest elevation increases. In reality, the cost curves can be expected to have discrete jumps, or discontinuities, in costs at various elevations where significant new features are required. For example, immediately above elevation 1084, relocation of the Pit River Bridge is required. Other significant physical features which would likely cause jumps in the cost curve at various elevations

Table 10.—Field cost summaries for Dam Raise Option

Description	Crest elevation 1084	Crest elevation 1180	Crest elevation 1280
Cofferdams	$ 0	$ 29,000,000	$ 29,000,000
Structure removal	7,200,000	11,000,000	11,000,000
Concrete dams	15,500,000	550,000,000	1,100,000,000
Spillway	[1] 22,000,000	17,500,000	24,000,000
River outlets	15,500,000	58,000,000	80,000,000
Existing powerplant	[2] 10,500,000	57,000,000	80,000,000
New powerplant	0	473,000,000	510,000,000
Switchyards	0	60,300,000	114,300,000
Reservoir dikes	0	28,900,000	98,000,000
Subtotal A	$ 70,700,000	$ 1,284,700,000	$ 2,046,300,000
Keswick Dam and Powerplant	0	0	253,000,000
Pit River Bridge	1,000,000	340,000,000	340,000,000
Interstate Highway 5 Replacement	0	181,190,000	235,050,000
Union Pacific Railroad replacement	0	353,000,000	455,000,000
Reservoir clearing	3,000,000	24,000,000	46,000,000
Resort/land rights	5,000,000	59,000,000	77,000,000
Recreation relocation	0	210,000,000	210,000,000
Recreation facilities	0	48,000,000	57,000,000
Seepage mitigation	3,000,000	43,000,000	86,000,000
Subtotal B	12,000,000	$ 1,258,190,000	$ 1,759,050,000
Total Field Costs	$ 82,700,000	$ 2,542,890,000	$ 3,805,350,000
Mitigation costs[3]	12,405,000	127,145,000	190,268,000
Engineering and design costs	8,270,000	178,002,000	266,375,000
Construction management	4,135,000	76,287,000	114,161,000
Total First Cost	$107,510,000	$2,924,324,000	$4,376,154,000
Interest during construction	14,771,000	965,405,000	1,434,773,000
Total investment Cost	$122,281,000	$3,889,729,000	$5,810,927,000
Average Annual Cost[4]	$9,001,000	$286,312,000	$427,725,000

1 Includes mass concrete in spillway crest (included in dam for other options).

2 Includes field cost of modifications to TCD.

3 Mitigation costs estimated at 15 percent for elevation 1084 option and 5 percent for elevation 1180 and 1280 options. Engineering and design costs estimated at 10 percent for elevation 1084 option and 7 percent for elevation 1180 and 1280 options. Construction management costs estimated at 5 percent for elevation 1084 option and 3 percent for the elevation 1180 and 1280 options.

4 Average annual costs based upon 7.125-percent interest over a 50-year period.

Table 11.—Average costs per acre-foot of storage
($)

Description	Crest elevation 1084	Crest elevation 1180	Crest elevation 1280
Total field cost	82,700,000	2,542,890,000	3,805,350,000
Total first cost	107,510,000	2,924,324,000	4,376,154,000
Total investment cost	122,281,000	3,889,729,000	5,810,927,000
Added storage (acre-feet)	290,000	3,920,000	9,340,000
Cost per acre-foot based on first cost	371	746	469
Cost per acre-foot based on total investment cost	422	992	622

include the elevation at which a new powerplant and switchyard would be required, the elevation at which recreation facilities would need to be relocated, the elevation at which a cofferdam is required rather than construction of a simple parapet wall, the elevation at which the Centimundi and Bridge Bay dikes are required, and the elevation at which modifications to Keswick Dam are required. At this appraisal level, however, the cost curves depicted in figure 9 provide a general relationship of costs versus elevation for comparison purposes.

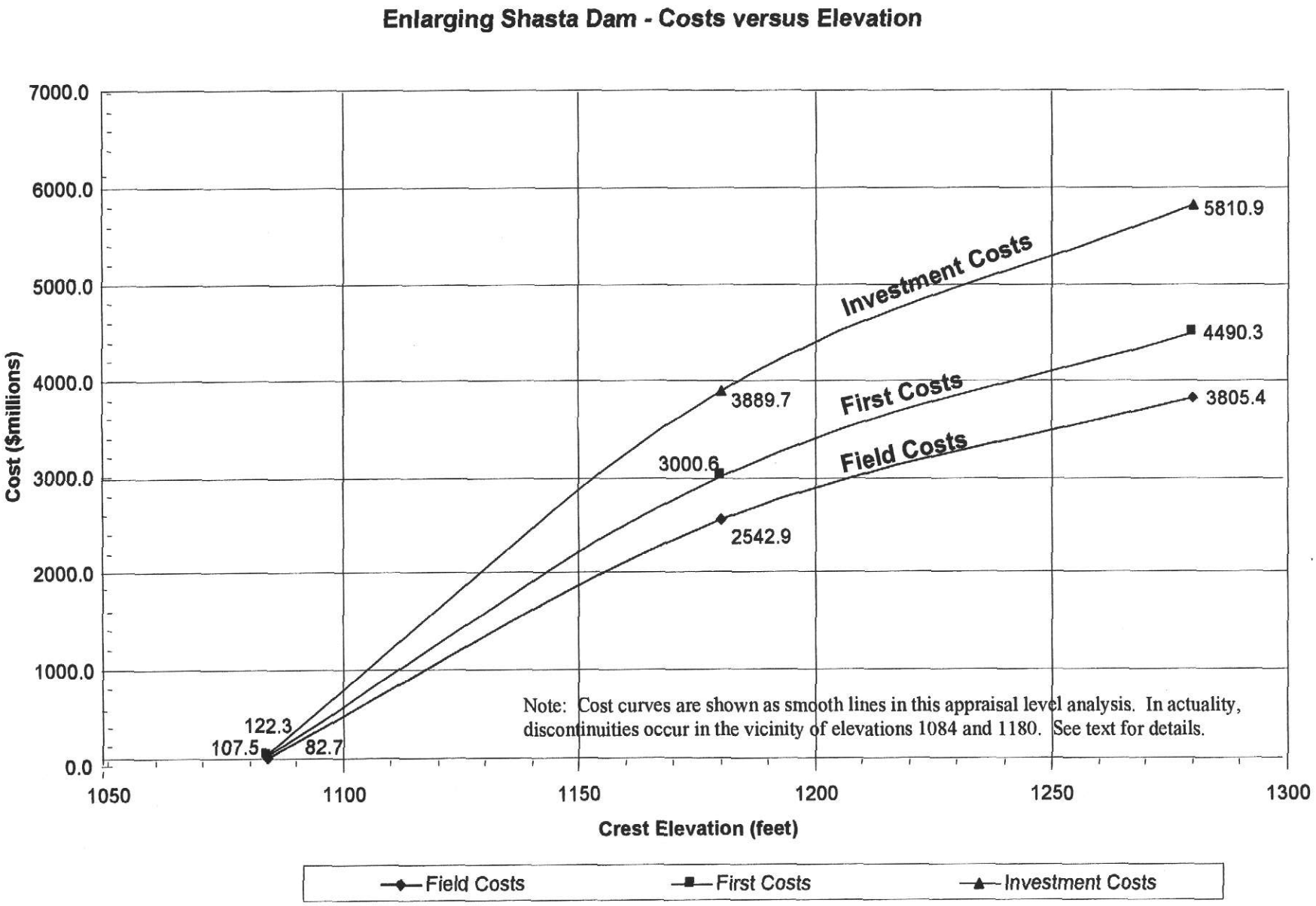


Figure 9 Cost Versus Elevation Curve