SACRAMENTO

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SEDIMENT STUDY
OF
RALSTON AFTERBAY RESERVOIR

FINAL REPORT

SUBMITTED
TO
PLACER COUNTY WATER AGENCY

BY
GEOTECHNICAL AND HYDRAULIC ENGINEERING SERVICES
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EXECUTIVE SUMMARY

An investigation into the feasibility of implementing a Sediment Pass-Through concept for the Ralston Afterbay Reservoir is presented in this report. Since Ralston Afterbay Dam and Powerhouse were completed in 1966, the Placer County Water Agency has experienced continuing problems with accumulation of sediment in the reservoir that has curtailed operation of both Oxbow and Ralston Powerhouses. We believe that the key to development of a viable approach to managing the sediment problems at Oxbow and Ralston Powerhouses is the use of reservoir drawdown and operation of the low-level outlet to bypass sediment during moderate and high flow events. This approach is referred to as the Sediment Pass-Through concept. At the outset, we need to answer two very important questions, first, "what is the Sediment Pass-Through concept", and second, "how will this concept benefit operation of the Ralston and Oxbow powerhouses?

Basically, the Sediment Pass-Through concept is a <u>change</u> in the way that the spillway gates and low-level outlet at Ralston Afterbay Dam are operated during floods that will permit more sediment to pass through the reservoir than would be possible with the present operating procedures for the gates and low-level outlet. Thus, the concept is to change operating procedures so that <u>more</u> sediment passes through the reservoir, and <u>less</u> is deposited in the reservoir.

It is extremely important to recognize that the Sediment Pass-through concept is <u>not</u> a sluicing or flushing operation. Sluicing or flushing is a method that attempts to remove more sediment from the reservoir than comes in. Our analytical work shows that sluicing or flushing is not possible at Ralston Afterbay Dam unless major structural modifications are made to the low-level outlet. We are not proposing any structural changes to the low-level outlet. Therefore, sluicing is not possible. All we are trying to do is to reduce the amount of sediment that is deposited in the reservoir during floods. We can rearrange the material within the reservoir, and we can reduce the amount of material that the reservoir would trap during a flood, but we cannot remove more sediment than comes in.

If we are not sluicing the reservoir, what, then, is the advantage of the Sediment Pass Through operation? We cannot sluice the reservoir because the Rubicon River transports material that is composed of gravel, cobbles and boulders which are too large to pass through the reservoir without major structural modifications to Ralston Afterbay Dam. The principal advantage of the Sediment Pass-Through operation is to significantly reduce the amount of material that would be trapped in the reservoir and thereby greatly reduce the need for periodic dredging to keep the backwater effects from raising the tailwater at Ralston Powerhouse and curtailing power production. We cannot eliminate the need for dredging, but we can significantly reduce the quantity of dredging and the number of times that dredging will have to be done at minimal cost to the Placer County Water Agency.

The fundamental principal involved in the Sediment Pass-Through concept is to open the spillway gates and low-level outlet at the beginning of a flood event and to draw the reservoir down well before the peak flood flow occurs. This is in contrast to the present operating procedures, which keeps the reservoir level as high as possible throughout the flood event to maximize power production at Oxbow Powerhouse. Drawing the reservoir down increases the flow velocity through the reservoir and promotes transport of materials further down into the reservoir. It also provides for passage of suspended sediment in the inflow that under present operating procedures would have settled out and become trapped in the reservoir. This procedure reduces the deposition of material in the upper reaches of the reservoir which, in turn, causes a rise in tailwater and corresponding reduction in power generation at Ralston Powerhouse.

The Sediment Pass-Through concept is feasible at Ralston Afterbay for the following reasons:

1. The reservoir is essentially a run-of-the-river reservoir, is small, and can be readily drawn down at the beginning of a flood. Similarly, it can be refilled rapidly after the peak flood discharge has occurred.

2. The reservoir is long and narrow. Consequently, lowering the reservoir water level results in a significant increase in flow velocities through the reservoir, and increases the capability of transporting material further into the reservoir.

3. There is a low-level outlet that will reduce the accumulation of material directly in front of the dam by providing an outlet for sediment-laden flows below the spillway crest during floods. The low-level outlet will remain operable as required for dam safety.

Thus, the configuration of the reservoir, the size of the reservoir, and the large spillway capacity all favor the use of a Sediment Pass-Through scheme.

The HEC-6 computer model "Scour and Deposition in Rivers and Reservoirs" was used to simulate the long-term trends of scour and deposition in Ralston Afterbay Reservoir. A twenty-five year sequence of inflows to Ralston Afterbay was developed from the available hydrologic data. Sediment size distributions were obtained from previous studies and confirmed by sampling conducted for this study. The computer model was calibrated by varying the size gradation and quantity of sediment inflow so that the model matched the observed historical sediment deposition in the reservoir. Excellent agreement was obtained by starting with the 1966 reservoir profile and predicting the 1986 reservoir profile. The model was then validated by adjusting the sediment inflows to account for dredging operations between 1986 and 1995 and predicting the 1995 reservoir profile starting with the 1986 profile.

With the computer model successfully calibrated to simulate the past deposition in the reservoir, it was then used to predict future deposition for the following two cases:

1. The reservoir is operated just as it has been in the past (the "do nothing option")

2. A Sediment Pass-Through concept is implemented

The results showed that if present operating procedures continue (the "do nothing" approach) then deposition of sediment in Ralston Afterbay Reservoir will make it impossible to operate Ralston Powerhouse after about 15 years. If the SPT concept is implemented, then Ralston Powerhouse will continue to operate throughout the twenty five years of simulated deposition. Furthermore, the deposition at the end of the 25-year simulation period indicates that the powerhouse should continue to operate for considerably longer.

The SPT concept will not, however completely solve the sediment problem because we cannot pass all of the material that comes into the reservoir through the reservoir. There is a large quantity of cobbles and boulders transported by the Rubicon River that cannot be passed through and will deposit in the reservoir. Consequently, the need for reservoir dredging can be delayed significantly, but inevitably, some dredging will be necessary. Our results thus show that the need for periodic dredging can be reduced significantly, and that this benefit can be achieved at relatively little cost to the Placer County Water Agency.

Several options were considered to supplement the SPT concept, including

1. Installation of a tailwater depression unit at Ralston Powerhouse
2. Construction of a sediment training wall at Ralston Powerhouse
3. Installation of a guard gate for the low-level outlet at Ralston Afterbay Dam

We concluded that if the SPT concept were implemented, the periods when the tailwater depression unit is needed would be so short that the cost of installation could not be justified. The training wall at Ralston Powerhouse also proved to be very costly. In addition, the recent installation of turbine pit gates at Ralston Powerhouse provides an additional method for controlling deposition in the turbine pit. We therefore concluded that operating experience with the SPT concept should be used to determine if a training wall warrants further consideration.

We also concluded that installation of a guard gate for the low-level outlet at Ralston Afterbay Dam, was mandatory for implementation of the SPT concept. Past experience has shown that operation of the gate on the upstream side of the dam can result in debris jamming the gate. Since the operation of the low-level outlet is an essential part of the SPT concept, a guard gate must be installed to ensure that this outlet can remain operational and that it can be repaired easily should debris become lodged in the inlet. Conceptual layouts and a cost estimate for this guard gate are presented in Section 4.

The principal conclusion of this study is that implementation of the SPT concept at Ralston Afterbay Dam is a viable approach that can be used to significantly reduce the need for periodic dredging of Ralston Afterbay Reservoir. The changes in operating procedures required to implement this concept are not complicated. The concept will keep Ralston Powerhouse operational for a much longer period of time than under present operating procedures and will not result in adverse environmental impacts downstream from Ralston Afterbay Dam.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. The SPT concept is a viable and economical approach to managing the sediment problem at Ralston Afterbay Reservoir.

2. The analytical studies show that the implementation of the SPT concept can significantly reduce the need for periodic dredging in Ralston Afterbay Reservoir.

3. If present operating procedures are continued without dredging, then the middle reach of Ralston Afterbay Reservoir will become silted up and render Ralston Powerhouse inoperable in about 15 years. If the SPT concept is implemented, then the need for dredging can be delayed for more than 25 years.

4. It is not necessary to increase the capacity of the existing low-level outlet to implement the SPT concept.

5. It is mandatory that a guard gate be installed on the existing low-level outlet to permit safe, reliable operation during SPT operations.

6. The recommended discharge at Ralston Afterbay Dam to initiate reservoir drawdown and the SPT operation is 3,500 cfs. This discharge may be changed after monitoring the results of the SPT operations.

7. The number of days that operation at Ralston Powerhouse is curtailed by high tailwater is small if the SPT operation is implemented. Therefore, installation of a tailwater depression system at Ralston Powerhouse is not recommended.

8. The tailrace gates at Ralston Powerhouse should be closed whenever the powerhouse is shut down for any reason during an SPT event. The tailrace must be inspected for sediment deposits in front of the tailrace gates prior to returning Ralston Powerhouse to service.

9. The existing powerhouse training wall may be sufficient to keep large material from depositing in front of the tailrace gates at Ralston Powerhouse. We therefore recommend that a tailrace training wall not be constructed at this time. Operating experience with the SPT concept should be evaluated to determine if a training wall should be constructed in the future.

10. Oxbow Powerhouse should remain in service as long as practicable during SPT operations. When the Oxbow turbine is shut down, the bypass valve must be opened to maintain flow through the Oxbow Intake for the duration of the SPT operations.

11. The material passing through Ralston Afterbay Reservoir during SPT operations is material that would be trapped if the SPT concept is not implemented. This material is generally fine sand (D50= 0.18 mm) and smaller. It will travel down the Middle Fork of the American River just as it would have prior to construction of Ralston Afterbay Dam, and will not result in adverse environmental impacts in the river downstream from the dam.

12. Operation of the low-level outlet for SPT operation will not result in discharge of highly turbid water downstream from Ralston Afterbay Dam. Conservative operating procedures have been established that ensure against the possibility of such discharges. Consequently, the operation of the low-level outlet will not have adverse environmental effects on the reach of river downstream from the dam.

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1. INTRODUCTION

Ralston Afterbay Dam is located on the Middle Fork of the American River in Placer County, California about four air-miles from the town of Foresthill CA. as shown on Figure 1. The dam serves as a re-regulating reservoir for Ralston Powerhouse, an 86 MW facility which is located on the Rubicon River at the head of Ralston Afterbay Reservoir. The reservoir also impounds water for Oxbow Powerhouse, a 6 MW facility located near Ralston Afterbay Dam, as indicated on Figure 2. Since Ralston Afterbay Dam was completed in 1966, the Placer County Water Agency has experienced problems with sediment that have curtailed operation of the two powerhouses, and have required periodic dredging to keep the backwater from the reservoir from interfering with the operation of Ralston Powerhouse.

In accordance with the scope of work outlined in Bechtel's proposal to the Placer County Water Agency (PCWA) we conducted a study of the sediment problems at Ralston Afterbay Reservoir with the following principal objectives:

1. To review previous studies of the system and provide a general assessment of the sediment problem

2. To present and evaluate alternatives for management of the sediment at Ralston Afterbay Dam and recommend a preferred alternative.

3. To provide an analysis of the feasibility of the selected alternative

4. To develop a feasibility level cost estimate and conceptual layouts for the proposed modifications required to implement the selected alternative.

On the basis of our review and analysis of the sediment problem at Ralston Afterbay, we recommend that the Sediment Pass-Through Concept described in more detail in the Executive Summary be implemented. The studies which led to this recommendation were conducted in three Phases:

Phase 1. A field reconnaissance, assessment of channel geomorphology, review of previous studies, evaluation of alternatives, and recommendation of the Sediment Pass-Through concept

Phase 2. Analytical studies to evaluate the feasibility of the Sediment Pass-Through Option

Phase 3. Development of conceptual layouts for modifications required to implement the Sediment Pass-Through option, and preparation of a feasibility-level cost estimate

Each of these three phases are described in detail in subsequent sections of this report.

2. PHASE 1 STUDIES: PRELIMINARY ANALYSES

2.1 RALSTON AFTERBAY DAM, RESERVOIR AND POWERHOUSE

Ralston Afterbay Dam is located on the Middle Fork of the American River about 6,000 feet downstream from the confluence of the Middle Fork of the American River and the Rubicon River. The confluence is now located within the backwater from Ralston Afterbay dam, as shown on Figure 3. Figure 3 also shows Ralston Powerhouse which is located on the Rubicon River about two miles upstream from Ralston Afterbay Dam. The principal features of the dam and Powerhouse are as follows:

Ralston Afterbay

Normal Ralston Afterbay water level (W. L.)	El. 1175.0 ft.
Gross storage volume (El. 1183):	2782 ac-ft (4.5 million yd^3)
Five 30'(H) x 40'(W) radial gates:	Q = 20,000 cfs/gate at El. 1175.0
One 72-inch diameter sluice gate:	Centerline Elevation 1108 ft; $Q_{capacity}$ = 1200 cfs

Oxbow penstock intake (Centerline Elevation. 1146 ft) is located about 500 feet north of the low-level outlet

Current practice is to maintain Ralston Afterbay at the normal operating level for as long as practicable during a flood event by operating the spillway gates to maximize generation at Oxbow Powerhouse. The low-level outlet is normally closed during floods.

Ralston Powerhouse and Tailrace

Turbine Type:	Impulse
Center of the Runner:	El. 1186.0
Tailrace Outlet Elevation:	E. 1164.0 ft. (**Excavated** from pre-project condition of about El. 1170)

It appears that the construction of Ralston Powerhouse in 1966 resulted in about a 35% reduction in the width of the river channel at the powerhouse site, and a reduction in the bottom slope in the tailrace area.

The operating constraints for the Pelton turbine at Ralston Powerhouse due to high tailwater conditions contained in a letter entitled "Maximum Possible Ralston

Powerhouse Generation Under High Flow Conditions" from S. Jones to S. Hui, dated January 10, 1996 are:

Table 2-1 Tailwater Constraints on Operation of Ralston Powerhouse

Power Generation	Max. Allowable Tailrace W. L.	Remarks
(MW)	(ft.)	
86	1177.0	normal
75	1177.9	
55	1178.5	
30	1179.5	
20	1180.0	
0	1181.0	shutdown

Notes:

1) First operating problem since 1966 occurred on 1/23/69, when the maximum peak flow at the dam was about 17,500 cfs.

2) Five radial gates were operated as needed during high flows. In the past, the recorded high flows exceeding 24,000 cfs (at dam site) including the storms occurred on 1/14/70 (Q =24,200 cfs), 1/12/80 (Q=46,900 cfs), 2/18/80 (Q=?) and 2/14/86 (Q=63,900 cfs).

3) During the 1986 storm, the maximum tailwater level at Ralston Powerhouse tailrace was estimated to be at El. 1193.

2.2 SEDIMENT INFLOWS

Surveys and reservoir profiles were obtained in 1966, 1986, and 1995. The PCWA also dredged the reservoir after the 1986 flood and at intervals after the 1986 flood. These sediment data were summarized in a report by EA Engineering, Science, and Technology (1990). Based on the EA (1990) study and a recent aerial and underwater survey completed by S & E Engineering in December 1995, the history of the sediment inflow and removal in Ralston Afterbay Reservoir is as shown in Table 2-2.

Table 2-2. History of Sediment Inflow and Removal, 1996-1995

1966-1987 period:	Total removal:	170,000 yd^3
	Total remaining sediment (1987):	1,027,000 yd^3
	Total inflow:	1,187,000 yd^3
	Inflow Rate: (1966-1987):	57,000 yd^3/yr
1987-1995 period	Total removal (1987-1995):	112,000 yd^3
	Total remaining sediment (1995):	1,205,000 yd^3
	Total inflow (1966-1995):	1,487,000 yd^3
	Total net inflow (1987-1995):	290,000 yd^3
	Inflow Rate (1987-1995):	36,250 yd^3/yr
	Average inflow rate (1966-1995):	51,300 yd^3/yr

It is interesting to note that the sediment inflow rate of 57,000 yd^3/yr to Ralston Afterbay for the first 21-year (1966-1987) period is considerably greater than the 36,250 yd^3/yr calculated for the more recent 8-year (1987-1995) period.

The 36% reduction in sediment inflow to the reservoir for the recent 8-year period may be explained by several factors: (a) After the Hell Hole Dam failure in 1964, some residual coarse material may have remained in the reaches of the Rubicon River upstream from the powerhouse and contributed to high sediment inflow rate in the earlier 1966 - 1987 period, (b) two major storms which occurred in 1980 and 1986 may have transported a large amount of this coarse material into the reservoir, and (c) no major storms similar to the 1980 or 1986 storms occurred in the 1987-1995 period. It appears that the apparent decrease in sediment inflow is a reflection of the rather short period of record, and the lack of major floods during this period. We therefore conclude that the average sediment inflow to Ralston Afterbay for the 1966-1995 period of about 50,000 yd^3/yr is probably representative of long-term conditions.

2.3 REVIEW OF PREVIOUS STUDIES

The following summarizes our review of the previous geological, morphological, hydrological and sedimentation studies for Middle Fork of the American River System which were obtained from the Placer County Water Agency.

(1) Scott, K., and Gravlee Jr., G. (1968) "Flood Surge on the Rubicon River, California - Hydrology, Hydraulics and Boulder Transport" USGS, Paper 422-M, 1968.

In December, 1964, a flood resulted in the failure of the partially-completed embankment for Hell Hole Dam on the Rubicon River about 32 miles upstream from Ralston Afterbay reservoir. This paper documents the hydrology, hydraulics and boulder transport following this failure. During this event, about 700,000 cubic yards of rockfill material from the breached dam embankment was washed downstream. Ralston Powerhouse is located about 2 miles upstream from Ralston Afterbay Dam and about 30 miles below Hell Hole Dam. The average channel bottom slope for the reach upstream from Ralston Powerhouse is about 2.1%. Figure 4a, taken from this reference, shows the profile of the Rubicon and Middle Fork of the American Rivers from Hell Hole Dam to Folsom Lake. The changes in river bed profile upstream and downstream from Ralston Afterbay Dam are evident on Figure 4a. The average flow velocity due to the dam break flood wave was about 22 fps. The fine materials and the gravel contained in the embankment could have easily been transported downstream and may have contributed to the aggradation in the headwaters at Ralston Afterbay Reservoir, as shown in Figure 4b (1966 profile).

(2) Alpha Geotechnical Consultants, Inc. (1988) "Exploration of Reservoir Sediments, Ralston Afterbay", January, 1988.

The results of near-surface sediment samples obtained in Ralston Afterbay Reservoir on October 22, 1987 are presented in this report. Ten backhoe test pits (TP) from 3.5 ft. to 6.5 ft deep were obtained, and four bulk surface samples from area inaccessible to exploration equipment were taken. The location of the relevant test pits is shown on Figure 3. Analysis of only eight test pit samples and two bulk samples were reported. The variation of the median size sediment, d_{50}, with distance from the dam is shown in Figure 5. The results show that the size variation is as follows:

- Lower Reservoir (lower 4,500 ft): fine to medium sand (d_{50} = 0.1 mm - 0.6 mm)
- Upper reservoir (upper 4000 ft.): fine gravel to cobbles (d_{50} = 20 mm - 80 mm)

Bed material larger than 80 mm was found at a location about 6,000 feet upstream of the dam at the confluence of the Middle Fork River and the Rubicon River.

(3) Sierra Hydrotech, (1988) "100-year Flood Elevation Analysis for Middle Fork American River Below Ralston Afterbay" August, 1988.

The 100-year peak discharges at the Ralston Afterbay and at a gauge location (#433300) about 1.6 miles downstream from the dam were estimated. They are:

- Q_{100} (near Foresthill about 1.6 miles downstream of Ralston Dam) = 127,800 cfs
- Q_{100} (immediately below Ralston Dam) = 104,200 cfs

The 100-year flood level for the reach of river located 1.6 miles below Ralston Dam was delineated in the study.

(4). EA Engineering, Science, and Technology (EA) (1990) "Preliminary Feasibility Analysis of Alternative Sediment Management Options for Ralston Afterbay Reservoir", December 1990.

The EA study is the most comprehensive previous study of the reservoir sedimentation to date. This study recommended the following six alternatives to solve the problems of sediment deposition in the reservoir and high tailwater level at Ralston Powerhouse:

Alternative 1: Continue small to medium scale sediment removal operations

Alternative 2: Change the operation pattern of Ralston Afterbay to utilize available storage space within the reservoir to accommodate additional sediment inflow

Alternative 3: Install a tailwater depression system at Ralston power house to control the tailwater level under the runner

Alternative 4: Construct a training wall along the Ralston Powerhouse tailrace to divert and prevent sediment from entering the powerhouse tailrace

Alternative 5: Relocate the cooling water intake for the Oxbow powerhouse

Alternative 6: Raise the intake for the Oxbow powerhouse.

2.4 ASSESSMENT OF THE SIX EA ALTERNATIVES

Our general comment on the six alternatives that EA (1990) presented in their report is that these alternatives address the symptoms of the problem, but do not try to manage the deposition of sediment in the reservoir, which is the root cause of the problems at Oxbow and Ralston Powerhouses. Taken individually, therefore, we do not think that any one of the proposed alternatives will adequately address the sediment problems in Ralston Afterbay Reservoir. However, a combination of these alternatives in conjunction with a program of reservoir drawdown and operation of the low-level sluices does, we believe, offer the best alternative for addressing the sediment problem. This concept is the Sediment Pass-Through concept which is presented in Section 2.7. In this section we will assess briefly EA's six alternatives.

Alternative 1. Continue small to medium scale sediment removal operations consistent with past practices: Past experience shows that this approach is only a reaction to the sediment deposition caused by moderate to major floods on the Rubicon. It does not provide any assurance that either Ralston or Oxbow powerhouse can be operated during the flood, nor does it provide any assurance that Ralston Powerhouse will be operable after the flood occurs. Removal operations are expensive, and storage space for the dredge spoils is at a premium in this area. As discussed in Section 3.10.3, it may not be possible to avoid dredging altogether, but a solution should be found that delays dredging for as long as possible so as to optimize the use of the remaining storage space for dredge spoils.

Alternative 2. Change the operation pattern of Ralston Afterbay to utilize storage space within the reservoir: This alternative proposes the use of reservoir drawdown to improve the sediment transport capacity within the reservoir and transport more material from the upper reaches to the lower reaches of the reservoir. It could reduce the sediment accumulation in the middle and upper reaches of the reservoir, thereby alleviating backwater effects and excessive tailwater levels at Ralston Powerhouse. However, it could exacerbate problems at the Oxbow Intake, since more material would now be transported to the lower reach of the reservoir. Unless there is also some sediment bypass operation using the low-level outlets, this alternative by itself would not be a viable alternative.

Alternative 3. Install a tailwater depression system at Ralston Powerhouse to reduce the tailwater elevation at the powerhouse tailrace: The operation of Ralston Powerhouse is quite sensitive to tailwater elevations above El. 1178, as indicated in Table 2-1 in Section 2.1 of this report. Installing a tailwater depression unit would permit operation at higher tailwater levels than presently possible. However, this does not address the fact that as sediment accumulates in the reservoir, the depression system becomes less and less effective. It also does not address the potential for accumulation of sediment in the tailrace chamber as occurred in the 1986 flood. It does show promise when used in combination with other measures.

Alternative 4. Construct a training wall along the Ralston Powerhouse Tailrace to divert and prevent sediment from entering the tailrace chamber: Some of the sediment deposition effects at Ralston Powerhouse are local effects. We believe that installation of such a training wall may ultimately be necessary as part of a complete program to manage the sediment problem. Since it only addresses a local problem, it is not, by itself, a satisfactory solution.

Alternative 5. Relocate the cooling water intake for the Oxbow Powerhouse: Since the PCWA has installed strainers in the cooling water system, the problem with the cooling water has been resolved, and this alternative need not be considered further.

Alternative 6. Raise the intake for Oxbow Powerhouse: We believe that this alternative is impractical, and far too expensive to implement. It should not be given further consideration.

Although EA's Alternatives 1 through 4 do not address the sediment problem for the entire river system, we believe that a combination of these alternatives together with reservoir drawdown and operation of the low-level sluice offers the most promising solution to the sediment problem. Therefore, we shall not consider EA's alternatives separately but only in concert with our recommended alternative as appropriate to the development of the preferred alternatives for managing the sediment problem at Ralston Afterbay.

2.5 FIELD TRIP, OBSERVATIONS, AND COLLECTION OF ADDITIONAL SEDIMENT DATA

2.5.1 Helicopter

Bechtel engineers conducted a field reconnaissance study on January 8 and 9,1996. The field trip included a helicopter flight, and observations by car and on foot.

The helicopter flight included an overflight of the reaches of the Middle Fork of the American River System upstream and downstream of the Ralston Afterbay Dam. The flight downstream from the dam covered a reach for at least 10 miles. The upstream flight included reconnaissance of the Rubicon River, Long Canyon (tributary of the Rubicon) and the Middle Fork of the American River downstream of Interbay Dam. A summary of our observations include:

- Reach downstream of Ralston Afterbay: The Middle Fork of the American River in this reach is a meandering stream with many large sand and gravel bars. The channel slope is much flatter than upstream from the dam, and the channel morphology is significantly different from the Rubicon and the Middle Fork upstream from the confluence with the Rubicon.

- Rubicon River: The river between Ralston Afterbay Dam and Hell Hole Dam is generally located in a very steep canyon. In the lower reach, the canyon is forested with oak, while at the higher elevations, it is forested with fir. The slopes of the canyon are composed of loose, weathered rock, and easily erodible soils. There are numerous slides located within the canyon, with more slides in the lower reach between Ralston Afterbay Dam and the confluence with the South Fork of the Rubicon River. The river channel flows over bedrock in the upper reaches with a cobble and gravel bed generally confined within the canyon, so that the channel boundaries appear rigid and stable.

- Long Canyon: The upper reaches of Long Canyon are heavily forested with fir which extends to edge of the stream. There is logging activity in the watershed. However, reforestation practices appear to have controlled potential erosion problems. The lower reaches of Long Canyon exhibit characteristics similar to the lower reaches of the Rubicon River. The lower reach of the Long Canyon consists of a steep-walled canyon covered with oak and a few fir trees. The slopes are more erodible than the upstream reaches. In the lower reach, the stream banks are rigid and stable.

- Middle Fork between the Ralston Afterbay and Interbay Dam: This river reach is very similar to the Rubicon River upstream from Ralston Powerhouse

2.5.2 Automobile and on Foot

The field observations included the Ralston Afterbay Dam and Reservoir and its adjacent area, Ralston Powerhouse and its adjacent areas, an 800-foot long reach of the Middle Fork river upstream of the confluence with the Rubicon River, and a reach of the Rubicon River upstream from Ralston Powerhouse. The trip was made to obtain a first hand impression of the characteristics of the stream, such as the river bed and the stability of the banks. The observations confirmed the general impressions obtained from the helicopter flight, i. e., that the Rubicon streambed is covered with very coarse gravel, cobbles and boulders with almost no sand bars. Observations from both the helicopter flight and on foot indicate that the stream has formed hydraulic control sections at many narrow sections.

2.5.3 Additional Sediment Data Collection

The stream bed was observed to be primarily covered with very coarse gravel, cobbles and boulders. However, the sediment samples taken by Alpha Geotechnical Consultants (1988) indicated that the median size of the sediment inflow could vary from medium sand to very coarse gravel. Therefore, it was important to obtain sediment samples in the stream which could indicate what is currently deposited in the reservoir. With this mind, four samples were taken, two each from the Rubicon River and the Middle Fork. The samples were taken from selected small sand or gravel bars. The medium size, d_{50}, varied from about 0.5 mm to about 10 mm which confirms the sediment data sampled in the lower reach of the reservoir by Alpha Consultants Inc.

2.6. ASSESSMENT OF NEED FOR A GEOMORPHOLOGIC STUDY

2.6.1 Introduction

The objective of a geomorphologic study is to establish baseline conditions from which the potential impacts of the various sediment management schemes can be evaluated. A geomorphologic study generally includes:

1) A characterization of the river and its sediment transport characteristics

2) Evaluation of sediment sources and sediment production

3) Evaluation of controls and sediment storage within the system

An understanding of the dynamics of the system provides the basis for development of viable methods of managing the sediment problem for Ralston Afterbay Dam.

On the basis of our review of previous studies conducted for the project, and our field trip of January 8 and 9, 1996, we have concluded that a detailed geomorphologic study is not warranted. The fundamental reason for this conclusion is that the field observations and previous studies provide a sufficient understanding of the dynamics of the sediment transport characteristics of the system so that development of sediment management alternatives for the project can proceed without further geomorphologic study. The background for this conclusion is as follows.

2.6.2 Characterization of the River and Sediment Transport Characteristics.

2.6.2.1 Description of River System

Ralston Afterbay Dam is located on the Middle Fork of the American River about 6,000 feet downstream from the confluence of the Middle Fork of the American River and the Rubicon River. The confluence is now located within the backwater from Ralston Afterbay dam, as shown on Figures 2 and 3. The reach of the Middle Fork that is of interest as far as reservoir sedimentation is concerned is the 10 mile reach between Ralston Afterbay Reservoir and Interbay Dam, while the reach of interest on the Rubicon is the 32 mile reach between Ralston Afterbay Reservoir and Hell Hole Dam. The river system layout is depicted in Figure 2.

The Rubicon is the principal source of sediment for Ralston Afterbay Reservoir. Ralston Powerhouse is located on the Rubicon at the head end of the Ralston Afterbay reservoir (Figure 3) where reservoir sediment deposition has affected the tailwater at Ralston Powerhouse and has interfered with operation of the Pelton Unit. The Rubicon has two major tributaries located between the powerhouse and Hell Hole Dam. The first is Long Canyon, and the second is the South Fork of the Rubicon.

2.6.2.2 Rubicon River

The Rubicon River is characterized by a step-pool and boulder-step channel morphology. This means that much of the river is essentially a series of pools and riffles. On the average, the river slope between Hell Hole dam and the reservoir is about 110 ft/mile, or about 2%. This is indeed a very steep slope for a river. The pools may be formed by local expansions and contractions which occur due to local bedrock controls, tributary alluvial fans, or by landslides. Such channel morphology indicates a supply-limited stream. What this means is that the sediment transport capacity of the stream exceeds the sediment supply. This characteristic is quite different from lowland streams where the channel gradient is much less and the supply of material along the river is much greater than the ability of the stream to transport it.

In general, the channel is incised in bedrock, with a few areas that are locally wider where there are some gravel and cobble bars on which riparian species of vegetation have taken hold. The stream bed is generally paved with large cobbles and boulders. The cobble and gravel bars do contain coarse to fine sands which are the result of accumulations from overland erosion of the steep canyon slopes.

The cobble, boulder and gravel material which is present indicates clearly that significant transport of material can take place only during major floods. This is typical of steep mountain streams. Consequently, although computing yearly average sediment accumulation in the reservoir can provide an approximate estimate of the average rate of sediment inflow, this value should be used with caution, because in reality the majority of the sediment is transported during only the major flood flows. The annual flood flows will transport the small material that has washed down the steep canyon slopes during normal rains, but cannot mobilize the bed material since it is protected by an armor layer of material that is in the 2 to 6 inch and larger sizes.

This characteristic of the Rubicon is essential to the development of a sediment management scheme, because it means that whatever measures are undertaken must be implemented during major floods. There are some distinct advantages. First, the measures do not have to be undertaken very frequently. Second, if the measures do include sediment bypass operation and reservoir drawdown, the variations in sediment concentration which result from the bypass scheme will be small in comparison with the concentration of material caused by the major flood. Consequently, the impact of such measures on downstream reaches of the river will be insignificant. Finally, there would not seem to be any restriction on rates of drawdown and operation of spillway gates during major floods, which permits flexibility in the operational measures that can be considered.

Clearly an understanding of the dynamics of the system is essential to development of alternatives for sediment management. We believe that the necessary understanding of the characteristics of the Rubicon River as related to the task of managing the sediment problem has been obtained, and that a further detailed characterization of river reaches, river controls, locations of cobble and gravel bars, and a mapping of such features is not required to complete the task of developing alternatives for control and management of the sediment problem with Ralston Powerhouse.

2.6.2.3 Middle Fork of the American River

The Middle Fork of the American River has essentially the same morphological characteristics as the Rubicon. The river transports gravel, cobbles and some small boulders as evidenced by the deposition from the reservoir which has been progressing upstream. A gravel bar has formed adjacent to the picnic area near the confluence with the Rubicon which provides a clear picture of the type of material being transported. From our field inspection, the Middle Fork is not contributing significantly to the sediment problem in the Ralston Afterbay Reservoir, although the finer fraction of the material transported probably is exacerbating the sediment problems with the Oxbow Intake. Interbay Dam, located 10 miles upstream acts as a sediment trap, which accounts for the lesser role of the Middle Fork in comparison with the Rubicon in the reservoir sedimentation problem.

2.6.3 Evaluation of Sediment Sources and Sediment Production

The Rubicon River is located in a very steep-walled canyon consisting of weathered rock and overburden. It is heavily forested with oak at the lower elevations and fir at higher elevations. There is evidence of numerous landslides along both sides of the river canyon, with more landslide areas located between the reservoir and the South Fork of the Rubicon than in the reach between the South Fork and Hell Hole Dam. There is evidence of ancient slides in the large boulders located in the stream bed which form part of the pool and riffle system.

Moderate rainfall results in rills, and small channels on the canyon slopes which convey loose material, and fines to the river where it is deposited in bars during low and moderate flood flows. Major influxes of sediment do not occur unless there is a significant period of rainfall which may initiate slides, or cause transport of significant quantities of loose material. It is thus difficult to correlate sediment concentration with discharge, since the stream is clearly supply limited. However, we can use the transport capacity as the upper bound of the supply and calibrate with the measured sediment volumes of 1987 and 1995 in the reservoir to obtain a validated sediment inflow rating curve. The lower reaches of the tributaries of the Rubicon also share similar steep-walled canyons, and exhibit similar evidence of land slides . The Long Canyon watershed shows evidence of logging. However, replanting seems to have limited erosion on the logged areas.

The Middle Fork is also contained within a steep-walled canyon between Interbay Dam and the Ralston Afterbay Reservoir. In addition to slides, there is also a source of material in the tunnel spoil left from construction of the Ralston tunnel. The Middle Fork generally has sediment supply and production characteristics similar to the Rubicon.

The supply and production characteristics of the Rubicon seem to be well understood, and there does not seem to be any compelling reason to expend further effort in a detailed characterization of individual slides. Such an effort would not be of further value in developing alternatives for management of the sediment problems at Ralston Afterbay Dam.

2.6.4 Evaluation of Controls and Sediment Storage

The channel controls within the river system upstream from Ralston Afterbay Dam are certainly important in understanding the stream morphology. The channel controls result in areas of contraction and expansion, which leads to deposition of larger material upstream from the controls and finer material in the expanded areas downstream from the controls. Channel control may result from underlying bedrock, changing geologic units, landslides, and alluvial fans from tributary streams.

There are numerous channel controls on the Rubicon between Ralston Afterbay Dam and Hell Hole Dam. An understanding of the role of these controls leads to an understanding of the sediment transport characteristics of the stream. We do not see how a detailed catalog or survey of the river to locate these controls would aid in the development of alternatives for managing the sediment problems at Ralston Afterbay Dam.

There are gravel bars in some locally wider areas of the stream channel in both the Rubicon and Middle Fork of the American River. During low flood flows, the sand and small gravel fraction of the sediment load is deposited in these bars and in some of the overbank areas among the tree-lined banks. These bars act as storage areas for the fine material washed into the river during normal rainfall.

Mobilization of these bars occurs only during high flows, typically the 5 to 10-year floods. The presence of these bars helps to characterize the channel morphology and leads to a better understanding of the mechanism of sediment transport in steep streams. Again, we believe that a detailed catalog of these features does not materially aid in the solution of sediment problems with the Oxbow Intake and Ralston Powerhouse Tailrace.

2.6.5 Conclusions of Geomorphologic Assessment

A geomorphologic study of the Middle Fork of the American River provides a basic understanding of the sediment supply, production and transport characteristics of the system. It is our opinion that the previous studies conducted for this project coupled with a field reconnaissance has provided the necessary understanding of the geomorphology so that alternatives for management of the sediment problems at Ralston Afterbay Dam can be developed. Further detailed studies, analyses, characterization and cataloging of the channel geomorphology for the Rubicon and Middle Fork of the American River are not warranted.

The critical issue in the solution of the reservoir sedimentation problem is the estimate and the calibration of the sediment rating curve for the reservoir inflow, irrespective of the detailed geomorphology in the upstream watershed. If the sediment inflow and its associated gradation can be estimated, then the hydraulic analyses can be performed and the management alternative(s) to handle the sediment inflow and related high water levels near the powerhouse, and the sediment deposition near the Oxbow Intake can be developed and evaluated. The approach used in this study was therefore to develop a sediment rating curve based on calibration with the observed deposition in the reservoir and to then use this curve to investigate changes in deposition resulting from changes in reservoir operating procedures.

2.7 PRELIMINARY HYDRAULIC ANALYSIS AND ASSESSMENT OF SEDIMENT PROBLEMS

2.7.1 Gauging Stations and Flow Distribution

Before a hydraulic analysis of the Ralston Afterbay Reservoir and Rubicon River could be conducted, it was necessary to determine the proportion of the total reservoir inflow that enters the reservoir via the Middle Fork of the American River (MFAR) and the Rubicon River. This section describes the method used to determine the flow distribution into the reservoir for use in our HEC-2 studies of backwater and potential sediment transport capacity in the reservoir. It should be noted that a new version of HEC-2, called HEC-RAS, was issued by the U. S. Army Corps of Engineers Hydrologic Engineering Center during the course of this study. Therefore, references to HEC-2 and HEC-RAS are equivalent, for all practical purposes, and refer to the two versions of the same computer program.

There are two currently active and two de-commissioned gauging station located near Ralston Afterbay Dam as listed in Table 2-3.

The study by Sierra Hydrotech (1988) showed that two major storms occurred after the construction of Ralston Afterbay Dam, one in 1980 and the second in 1986, Therefore, the 1980 peak flow records at these four stations are a good indicator for the estimate of the flow distribution from the various drainage basins to the Ralston Afterbay. During the 1980 storm, the recorded peak discharges at stations 433300, 427770, 433260 and 444200 were 66,000 cfs, 9,900 cfs, 30,100 cfs and 37,000 cfs, respectively, as shown in Table 2-3.

Table 2-3 Gauging Stations Used in the Analyses

Gauge No.	Location	Drainage Area (sq. miles)	Period of Service	1980 Peak Discharge (cfs)
433300	MFAR-1.6 mi. downstream from Oxbow Powerhouse	524	1958-Present	66,000
427770	Middle Fork - 500 ft downstream from Interbay Dam	89.1	1965-Present	9,900
433260	North Fork of MFAR-1.0 mi. d/s from El. Dorado Canyon	88.9	1965-1985	30,100
444200	Rubicon River-1.2 mi. u/s from Confluence with Middle Fork	315	1958-1984	37,000

. This implies that the peak discharges in the Rubicon River near Ralston Powerhouse, the Middle Fork of the American River downstream of the Interbay, and Ralston Afterbay are about 56.1%, 15% and 71.1% of the peak discharge at the Foresthill gauging station (#433300). Sierra Hydrotech's 1988 Study also estimated that the 100-year discharges at Foresthill gauging station (433300) and Ralston Afterbay are about 127,800 cfs and 104,200 cfs, respectively. Based on this flow data, the following flow distributions to the Ralston Afterbay were computed:

Table 2-4 Flow Distribution into Ralston Afterbay Reservoir

Flow Range at Dam	Q_{Dam}/Q_{Fh}	Q_{Rb}/Q_{Fh}	Q_{MF}/Q_{Fh}
(CFS)	(%)	(%)	(%)
Less than 50,000	71.1	56.1	15.0
More than 50,000	81.5	64.3	17.2

where Q_{Dam} - Discharge at the Ralston Afterbay
Q_{Fh} - Discharge at the Foresthill Station (#433300)
Q_{Rb} - Discharge of Rubicon River near Ralston Powerhouse
Q_{MF} - Discharge of Middle Fork of the American River

2.7.2 Hydraulic Analysis

The hydraulic analysis of Ralston Afterbay reservoir requires the input data of the channel geometry and the distribution of the inflow from Rubicon River and Middle

Fork. The flow distribution estimated in the previous section was used to determine the contribution from these two upstream tributaries. Based on cross-section data obtained from a survey conducted by S&E Engineering in October 1995 as shown on Figure 3, a HEC-2 computer model was established for the reach between the Ralston Afterbay Dam and Ralston Powerhouse. Since no topographic data was available for a reach about 1,400 feet downstream of the powerhouse, an extrapolation procedure was used to estimate the channel cross-sections for that portion of the stream. Additional topographic data shown on Figure 3 was obtained for the final analyses described in Section 3.

Flow rates of 10,000 cfs, 30,000 cfs, 50,000 cfs and 100,000 cfs at the dam site were investigated and conditions with and without reservoir drawdown were considered. Based on the spillway rating curve for the radial gates provided by the PCWA, the maximum possible reservoir drawdown for various flows at the dam site were estimated as follows:

Table 2-5 Maximum Reservoir Drawdown

$Q_{dam\ site}$	$Q_{per\ gate}$ (1)	Minimum Reservoir Elevation	Maximum Reservoir Drawdown Below El. 1175	Remarks
(cfs)	(cfs)	(ft.)	(ft.)	
100,000	20,000	1175.0	0.0	
63,900	12,780	1169.0	6.0	1986 flood
50,000	10,000	1166.5	8.5	
30,000	6,000	1161.0	14.0	
10,000	2,000	1153.0	22.0	

Note: (1) It was assumed that all five radial gates would be in operation, but the low-level outlet was not in service. The low-level outlet was considered in the final analysis described in Section 3.

The results show that:

(a) The maximum flood level at the Ralston Powerhouse location is relatively insensitive to the reservoir drawdown. This is because of several channel control sections which occur in the reaches between the powerhouse and the dam.

(b) When the discharge exceeds about 10,000 cfs, the maximum flood level at the powerhouse, based on the 1995 bed profile, would about be at El. 1178. This water level is the critical high tailwater level which could virtually shutdown the turbine unit. When the next major storm occurs, the additional sediment depositions would further increase the water level at the powerhouse. Therefore, it would be reasonable to expect that the existing powerhouse could suffer excessive tailwater levels whenever the peak flow at the dam site reaches about 10,000 cfs.

(c) Results of the HEC-2 model, using the 1986 peak discharge and the 1995 bed profile, show that the computed flood level at the tailrace was about El. 1192.7 which was almost the same as observed during the 1986 flood. As depicted in Figure 4b, the bed profiles of 1986 and 1995 are similar. The agreement indicates that the HEC-2 model does give water levels comparable to observed water levels. Consequently, the HEC-2 model which we have developed can be used with confidence to assess the hydraulic characteristics of the river system.

2.7.3 Sediment Transport Capacity and Critical Shear Stress

The critical shear stress for a given sediment size is the tractive force required to initially move the sediment. Based on the sediment size as obtained from samples in the reservoir, the required shear stress to initiate motion, shown in Table 2-6 varies from about 0.01 lb/ft^2 in the lower reservoir to 1 lb/ft^2 in the upper reservoir. The estimated available shear stresses and the critical shear stresses along the reservoir bed for flow rates at the dam site, with and without reservoir drawdown, ranging from 10,000 cfs to 100,000 cfs are presented in Table 2-6. As shown in Table 2-6, without the reservoir drawdown, the available shear stresses for a flow of 10,000 cfs would be less than 0.01 lb/ft^2 in the lower part of the reservoir, about 0.03 lb/ft^2 in the middle of the reservoir and about 0.8 lb/ft^2 in the upper reach of the reservoir near Ralston Powerhouse. The corresponding available shear stresses, with maximum reservoir drawdown condition in the lower, middle and upper reaches of the reservoir would be about 0.2 lb/ft^2, 0.6 b/ft^2 and 1.5 lb/ft^2, respectively.

Table 2-6 Critical Shear Stresses vs. Calculated Shear Stresses at Different Sample Locations

Sample Source Location	Distance (ft)	d_{50} (mm)	Shear Stress: With/Without Reservoir Drawdown (lb/ft^2)(Q (cfs) 100000	63900	50000	30000	10000	Critical Shear (lb/ft^2)
S-2	2370	0.13	0.44/0.44	0.32/0.22	0.27/0.14	0.22/0.05	0.15/0.01	0.0021
S-1	3140	0.52	1.18/1.18	1.21/0.53	1.22/0.33	1.62/0.12	1.14/0.01	0.0083
TP-10	4230	0.34	2.30/2.30	1.87/1.04	1.62/0.66	1.21/0.24	0.97/0.03	0.0054
TP-9	4790	46	2.35/2.35	1.84/1.15	1.56/0.74	1.12/0.28	0.60/0.03	0.559
TP-8	5180							
TP-7	5280	44	2.72/2.72	2.49/1.50	2.34/1.01	2.11/0.40	1.36/0.05	0.535
TP-6	510							
TP-5	6190	88	2.0/2.0	1.44/1.22	1.19/0.88	0.79/0.39	0.32/0.05	1.07
TP-4	6550	16	3.72/3.72	3.01/2.44	2.62/1.79	1.92/0.81	1.00/0.10	0.195
TP-1	6930	34	3.40/3.40	2.85/2.11	2.57/1.71	2.02/0.89	1.14/0.13	0.413
TP-2	7730	40	2.75/2.75	2.31/2.08	2.11/1.85	1.74/1.34	1.35/0.33	0.486
TP-3	8260	73	7.98/798	6.72/6.72	6.12/6.12	3.74/3.49	1.49/0.79	0.887

Notes: 1. Shear stresses are obtained form interpolated sections in the HEC-2 analysis
2. The reservoir water level was at El. 1175 before the drawdown

The principal result of this analysis is that with reservoir drawdown, the available shear stress is generally much higher that the critical shear stress, which implies that reservoir drawdown may be an effective means of moving material through the reservoir. The results of this analysis also imply that (a) without reservoir drawdown, sediment accumulation would continue in the lower and middle reaches of the reservoir, and (b) during a major flood with a peak discharge of 10,000 cfs or more, the sediment already deposited in the lower reach of the reservoir could be transported further downstream toward the existing low-level outlet, if the reservoir is drawn down to its maximum allowable limits. This implies that drawing down the reservoir can move material already deposited in the upper reaches of the reservoir into the middle part of the reservoir, and that reservoir drawdown has some potential as a means of managing the sediment in Ralston Afterbay Reservoir.

2.7.4 Assessment of Sediment Problems

Our review of the previous studies and our hydraulic analysis of the system led to the following general observations and assessment of the sediment problems:

- The sediment inflow to the Ralston Afterbay varied from 57,000 yd^3/yr in the earlier period from 1966 to 1987 to about 36,250 yd^3/yr for the recent period from 1987 to 1995. This variation is attributable to the shorter period of record and the lack of major storms in the 1987-1995 period.

- Since the remaining active storage volume at El. 1183 ft. is only about 2,800,000 yd^3, the reservoir could be filled up to the top of the dam in about 65 years if no preventive measures are taken soon. However, the crest of the spillway gate is located at El. 1149.0 ft. where the gross storage volume is about 1.1 million yd^3. Therefore, the reservoir would become inoperable much sooner than the computed value of 65 years.

- The water level at Ralston Powerhouse would reach about El. 1178 ft. when the peak discharge at the dam site reaches about 10,000 cfs. Therefore, the operation of Ralston Powerhouse would have to be curtailed during any major storm with peak discharge exceeding about 10,000 cfs.

- The deposition of sediment at the powerhouse tailrace area will likely continue, because of the channel excavation (from El. 1170 to 1162) during its construction in 1966. The lowering of the river bottom slope due to the construction of the powerhouse tailrace channel changed the river morphology and reduced the flow velocity in the area of the Ralston Powerhouse tailrace. The rise in tailwater level is further exacerbated by the backwater effects due to sediment deposition in the downstream reservoir.

- Sediment deposition in the reservoir can be expected to continue because the current reservoir operation procedures promote sediment deposition rather than encouraging sediment to pass through the reservoir as would be the case if reservoir drawdown and operation of the low level outlet were considered.

- Since about 33% of the total sediment inflow would be coarse material with sizes larger than fine gravel, a sediment bypass operation may not be capable of completely bypassing all the sediment inflow and thus it may not completely resolve the sedimentation problem in the reservoir.

2.7. RECOMMENDED ALTERNATIVE: SEDIMENT PASS-THROUGH CONCEPT

We believe that the key to the development of a viable approach to managing the sediment problems at Oxbow and Ralston Powerhouses is the use of reservoir drawdown and operation of the low-level sluice to bypass sediment during moderate and high flow events. This approach is referred to as the Sediment Pass-Through (SPT) method, and has been used on the Cowlitz Falls Hydroelectric Project on the Cowlitz River in the State of Washington. The method has also been proposed and thoroughly studied for

PG&E's Rock Creek and Cresta Projects on the North Fork of the Feather River in California. The basic concept is to use reservoir drawdown to enhance the sediment transport capacity through the reservoir, and to open the low-level sluice so that material transported to the lower reach of the reservoir can be passed through and out of the reservoir.

It is important to note that the SPT option as proposed here is not a sluicing or a flushing operation. Sluicing or flushing is a method that attempts to remove more material from the reservoir than comes in. As will be shown in our detailed studies described in Section 3, major structural changes would be required to provide enough capacity in the low-level outlet to achieve actual removal of more material than comes in. The objective is to change the operation of the spillway and low-level outlet so that material that would have settled out in the reservoir under present operating procedures will pass through the reservoir. Hence the name Sediment Pass-Through.

The analysis of shear stress using the HEC-2 computer model, as described previously in Section 2.7.3, demonstrates that drawing down the reservoir does provide a significant increase in sediment transport capacity, and that using reservoir drawdown is therefore a viable approach to managing sediment deposition in Ralston Afterbay Reservoir. The detailed analytical studies to investigate the viability of the SPT option using a moveable-bed computer model are presented in Section 3. Considerations of a tailrace training wall and tailwater depression for Ralston Powerhouse are also presented. Finally, effects on the operation of Oxbow Powerhouse are discussed, together with an evaluation of potential environmental effects of the SPT operation on the river downstream from Ralston Afterbay Dam.

3.0 ASSESSMENT OF THE SPT CONCEPT

3.1 GENERAL

The river system which was investigated to assess the feasibility and viability of the Sediment Pass-Through (SPT) concept included a reach of the Middle Fork of the American River from Ralston Afterbay Dam to the confluence with the Rubicon River and a reach of the Rubicon River from the confluence with to he Middle Fork to a point about 1400 feet upstream from Ralston Powerhouse. The objectives of the analyses were:

1. To investigate of reservoir drawdown procedures and operation of the low-level outlet and determine the efficacy of the proposed SPT operation

2. To recommend a preferred alternative or combination of alternatives to mitigate the sediment problems at Oxbow and Ralston Powerhouses

3. To assess the impact of SPT operation on power operation for the preferred alternatives(s)

4. To assess the potential environmental impact of the SPT operation on the river channel downstream from Ralston Afterbay Dam.

3.2. METHODOLOGY

The HEC-6 computer model, "Scour and Deposition in Rivers and Reservoirs", developed by the U. S. Army Corps of Engineers (1993)was used in this study. This computer model is a quasi-steady state, one-dimensional sediment transport model, and is designed to simulate the long-term trends of scour and deposition in a stream or reservoir that might result from modifying the frequency and duration of the water discharge and stage. The HEC-6 model was used to develop qualitatively the potential morphologic changes in the reservoir and along the river reaches due to sediment transport and deposition given the present geologic and hydraulic controls in the river system above Ralston Afterbay Dam.

3.3 DATA AND ASSUMPTIONS

Four sets of engineering data are required for the modeling of a reservoir using HEC-6. They are: (1) River channel geometric data, (2) Hydrologic data, (3) River sediment data, and (4) Reservoir operation procedures and downstream boundary conditions.

3.3.1 River Channel Geometric Data

In our preliminary study summarized in Section 2.7.2, a total of 22 river cross-sections were used in the HEC-RAS simulation. The lower 16 cross-sections from Sta. 0+00 to Sta. 82+10, shown on Figure 3, were taken from a survey conducted by S&E Engineering in October 1995 while the upper 6 cross-sections from Sta. 82+10 to Sta. 97+35 (about 1,400 feet downstream of Ralston Powerhouse) were estimated from an extrapolation procedure. The confluence of the Rubicon River and Middle Fork is located at l Sta. 67+50, about 2,950 feet downstream from Ralston Powerhouse. In this part of the investigation, a survey to obtain cross-sections for an additional 4,500 feet of river channel was conducted by the Placer County Water Agency (PCWA). The new survey included a 1,470-foot -reach between the reservoir headwater at Sta. 82+10 and Ralston Powerhouse at Sta. 96+80 and a reach beginning at Ralston Powerhouse and extending about 3,050 feet upstream of Ralston Powerhouse. A total of 20 cross-sections were selected from these newly surveyed reaches for the analysis. A total of 36 cross-sections was used in this phase of study, and are shown for reference in Appendix A. The location of the cross-sections up from the dam to Ralston Powerhouse are shown on Figure 3.

3.3.2 Hydrologic Data

There are two currently active and two de-commissioned gauging stations located near Ralston Afterbay Dam and Ralston Powerhouse. The active gauging stations are the Forest Hill station (#433300) located about 1.3 miles downstream from Oxbow powerhouse and the Middle Fork/Interbay Dam station (#427770) located about 500 feet downstream from Interbay Dam. These two stations have maintained daily flow data from 1966 to the present. The two de-commissioned stations are the North Fork Station (#433260) located about one mile downstream from El Dorado Canyon, and the Rubicon station (#444200) located about one mile upstream from Ralston Powerhouse. Daily flow data up to 1985 were maintained at these two stations. In addition, daily inflows to the Ralston Afterbay Reservoir and the daily outflow from Interbay to Ralston Powerhouse were also estimated by PCWA staff for the period from 1966 to the present (1996).

3.3.3 River Sediment Data

Sediment gradation data for the bed material at various locations in the stream as obtained by Alpha Geotechnical Consultants(1988) and Bechtel's field collection on January 8 and 9,1996 were used in this study. Alpha obtained ten sediment samples from backhoe test pits (TP) at a depth from 3.5 feet to 6.5 feet and four bulk surface samples from areas inaccessible to exploration equipment. However, only eight test pit samples and two bulk samples were analyzed and reported. The variation of the median size sediment, d_{50}, along the river referenced to the distance from the dam is shown in Figure 5. Four sets of gradation data (S2, TP9, TP5 & TP3) and two sets of Bechtel data are presented in Figures 6 and 7, respectively. The location of these pits is shown on Figure 3. The selected Alpha sediment data represents sediment deposition located in the lower, middle and upper reaches of the reservoir while the Bechtel data is indicative of the movable sediment material available in the Rubicon River.

3.3.4 Reservoir Operation Data

Present operating procedures are directed at maximizing power production. Thus, during a flood event, the spillway is operated to maintain the normal operating pool of El. 1175, as long as possible. This approach maintains the head on the Oxbow Power Plant for generating purposes. Development of a reservoir drawdown and rule curve to increase the quantity of sediment that passes through the reservoir therefore became a major part of the study.

3.3.5 Downstream Boundary Conditions

Downstream boundary conditions for the computer model are the operation of the five radial gates on the main spillway (crest El. 1149.0), the operation of the 72-inch diameter low-level outlet (Centerline El. 1108), and the operation of the Oxbow penstock intake (Centerline El. 1146.0) which is located about 500 feet north of the low-level outlet as indicated on Figure 3.

3.4 ESTABLISHMENT OF A 25-YEAR DAILY FLOW HYDROGRAPH

About 25 years of continuous daily flow data for the Rubicon River, the Middle Fork American River and the discharge from the Ralston Powerhouse are required to simulate the hydraulic and sediment transport into Ralston Afterbay Reservoir. At least 25-years of record is necessary to provide a sufficiently long period for assessment of the viability of a proposed sediment management program.

Based on the available hydrologic data, the following methodology was used to develop a 25-year daily inflow sequence to Ralston Afterbay for the period from 1966 to 1995:

(1) 1966-1985 Period:

Rubicon River Inflow: The recorded daily data at Rubicon gauging station were used.

Middle Fork/Interbay Inflow: A correlation analysis was performed to develop relationship between the daily flows at the Middle Fork/Interbay station and the Rubicon station, using the available concurrent historical data. It was found that the daily flows from the Middle Fork/Interbay is 24% of the daily flow from the Rubicon station for the period.

Ralston Powerhouse Discharge: The computed Interbay release estimated by the PCWA was used as the discharge from Ralston Powerhouse. The average flow rate is about 750 cfs.

(2) 1985-1995 Period:

Rubicon River Inflow: The daily flows for the Rubicon River are not available for this period. A correlation analysis was performed to develop a flow relationship between the daily flows at the Forest Hill station and the Rubicon station, using the concurrent historical data. The derived relationship was then used to reconstitute the daily flow at the Rubicon station for this period.

Middle Fork/Interbay Inflow: The same procedure as used for the 1966-1985 period was applied for the 1985-1995 period.

Ralston Powerhouse Discharge: The same procedure as used for the 1966-1985 period was applied to the 1985-1995 period.

The daily inflows to Ralston Afterbay for the period from 1966 to 1995 was then developed and is shown on Figure 8. These data were used as HEC-6 input for the calibration and prediction of sediment inflows to the reservoir.

Two sets of 25-year daily inflows were selected for the study, First, the 1966-1990 period and second, the 1970-1995 period. The hydrologic period which produced the more severe sediment deposition problem in the reservoir was selected for the final analyses.

It should be noted that during the major storms, the peak discharges are much greater than the corresponding daily flow rates. In this study, the peak discharges for 13 major storms in this period were obtained and included in the simulation. The corresponding hydrographs were also adjusted accordingly to preserve the total daily inflows.

3.5. ESTABLISHMENT AND CALIBRATION OF HEC-6 SEDIMENT MODEL

3.5.1 Establishment of the HEC-6 Model

The most critical aspect of an analysis of a reservoir sedimentation problem is the development and the calibration of the sediment rating curve for the reservoir inflow, irrespective of the detailed geomorphology in the upstream watershed. If the sediment inflow and its associated gradation can be established, then the next step is to develop a preferred management alternative to handle the sediment problems and the related tailwater level near the Ralston Powerhouse, and the sediment deposition near the Oxbow intake. The HEC-6 model was developed by incorporating the channel geometry from the HEC-2 model used in the preliminary studies, extending the river cross-sections about 3,000 feet upstream of Ralston Powerhouse, including the Ralston Powerhouse inflow, and including sediment data and reservoir operation rules.

3.5.2 Sediment Transport Equation(s)

As indicated by the sediment sampling in the reservoir (Figures 3 and 4), about 30% of the total sediment deposition is expected to be coarse material with a median size larger than fine gravel. Our literature review indicates that among the many published sediment transport equations, only equations from Parker (1982), Myer-Peter-Muller (1948), and Yang (1973) are among those few which are accepted by the sediment transport profession as suitable for application to coarse materials. The Parker equation is considered to be most suitable for use in the estimate of gravel transport. However, it was found that for application using HEC-6, Parker's (1982) method has the following deficiencies:

a) The format of his transport equation does not fit the pre-set format specified in the HEC-6 computer model

b) It only computes the gross transport capacity for the gravel size and does not give the individual transport capacity by fraction for different size of the coarse material

c) It does not compute the transport capacity of sand sizes.

It was also found that the transport capacity given by the Myer-Peter-Muller (1948) equation is far too conservative and that both Parker (1982) and Yang's (1973) equations result in a similar transport capacity for the coarse materials. Since Yang's equation is one of the built-in equations in the HEC-6 model, Yang's method was therefore used in this study.

3.5.3 Calibration of Sediment Inflows

From our review of the survey data, the average sediment volume deposited in the reservoir for various periods were estimated as shown in Table 3-1.

Table 3-1 Deposition of Sediment in Ralston Afterbay Reservoir

Period	Sediment Removal (yd^3)	Sediment Deposition (yd^3)	Average Deposition (yd^3/yr)
1966-1987	170,000	1,027,000	57,000
1987-1995	112,000	290,000	36,250
1966-1995	282,000	1,317,000	51,300

The measured bed profiles for 1966, 1987 and 1995 shown on Figure 4b provide the means for calibrating the model. Using the 1966 bed profile as the baseline condition, the calibration process involves two important objectives: (1) the selection of a representative sediment gradation which would result in sediment deposition that matches the historical sediment profile data obtained in the reservoir, and (2) the development of a sediment supply rating curve which after a 21-year sediment routing, would result in a deposition pattern and bed profile consistent with that surveyed in 1987.

With the fore-mentioned calibration objectives, a trial-and-error approach was then implemented to perform a sediment routing for the 1966-1987 period. It was determined that the average of the sediment data obtained in the lower, middle and upper reservoir constitutes a reasonable and representative set of sediment gradation data to simulate the sediment inflow from the watershed. Several combinations of gradation data from samples S2 (lower reach), TP9 & TP5 (middle reach) and TP3 (upper reach) were used for the calibration. For each combination of the assumed sediment gradation, the sediment transport capacities for different flow discharges were first computed for size fractions up to fine gravel and then extrapolated to material coarser than fine gravel. This computed sediment supply rating curve was used as the upper limit for the "trial-and-error" approach of HEC-6 runs. It was quickly found that the sediment supply is really governed by the sediment yield of the watershed. In other words, the river system is supply limited, just as our field observations indicated. A revised sediment supply was then adjusted downward until the resulting sediment deposition volume and its corresponding gradations at various locations within the reservoir were reasonably similar to those surveyed in 1987.

Table 3-2 Comparison of Bed Material, d_{50}, for Observed vs. Calibrated HEC-6 Results

Sample Location	Station	d_{50}	
		Observed	Computed
S-2	22+90	VFS	FS
TP-9	47+80	VCG	VCG
TP-5	61+30	SC	SC
TP-3	82+10	VCG-SC	SC

It was found that the 1987 bed profile and the corresponding bed material gradation was reasonably duplicated when the average gradation of the four sediment samples at S2, TP9, TP5 and TP3 was used. The computed and the measured bed profile at the end of 1987 is compared in Figure 9. The corresponding bed gradation at various locations of the reservoir are also compared in Table 3-2, which shows that the computed and measured values are in good agreement. The derived sediment rating curve corresponds to an average sediment supply of 63,000 yd^3/yr and a deposition of 58,000 yd^3/yr for the 1966-1987 period. The difference was passed through the reservoir during operation of the spillway. The deposition is very close to what was observed during this period. Therefore, this sediment supply rating curve was used as the upper limit in this study.

Since the bed profile for 1995 is also available, it was thus used for model verification. However, when the sediment routing was performed for the 1987-1995 period using the above derived sediment inflow rating curve, it was found that the computed average sediment deposition rate is about 55,800 yd^3/yr, rather than about 37,000 yd^3/yr, as measured from the field data. The computed bed profile at the end of 1995 is depicted in Figure 10, which shows that the computed sediment deposition is much more than observed in the field. This is not a surprise, since about 39% of the total deposition during this eight-year period was dredged and removed. The exclusion of this dredged material in the computer model is due to the limitations of the HEC-6 model to simulate dredging at various locations that occur only during certain specified short periods, and the uncertainty in the timing and exact location of the dredging.

It was, therefore, decided to perform the simulation using a lower sediment supply rating curve. Qualitatively, this approach indirectly simulates the dredging as a decrease in the sediment supply. An average of 45,000 yd^3/yr was thus selected for a sensitivity analysis. Using this lower sediment supply curve gave the results shown in Figure 11 for the period from 1987 to 1995. As expected, this lower sediment supply resulted in a better agreement in the deposition pattern in the middle and upper reaches of the reservoir. Although the removed sediment was therefore not directly included in the

HEC-6 simulation, we believe that this approximation generally verifies the model and provides assurance that the calibrated gradation and supply curves can be used in the simulation of SPT operations. The agreement between the measured and computed profiles is surprisingly good, and provides confidence in the capability of the model to simulate sediment transport and deposition in Ralston Afterbay Reservoir.

The results of the calibrated sediment supply also indicated that although about 30% of the deposited sediment is material coarse than fine gravel, about 90% of the total sediment supply is material finer than coarse sand. This finding is important for the evaluation of the impact on the downstream environment during SPT operations because we need to know the size of the material that must be transported downstream from the dam to avoid adverse environmental impacts.

3.6. RESERVOIR DRAWDOWN AND SEDIMENT TRANSPORT CAPACITY

3.6.1 Drawdown Initialization Discharge for Drawdown Operation

The preliminary analyses using HEC-2 showed that:

1. Without reservoir drawdown, sediment accumulation would continue to occur in the lower and middle reaches of the reservoir,

2. During major floods with peak discharges of 10,000 cfs or more, the sediment already deposited in the lower reach of the reservoir could be transported further downstream toward the existing 72-inch low-level outlet, if the reservoir is drawn down to its maximum allowable limits.

Based on the above assessment, it was clear that reservoir drawdown can move sediment already deposited in the reservoir from the upstream reaches to the mid reaches of the reservoir. Now, the question was how to schedule the drawdown in order to minimize the sediment deposition in the reservoir that will affect power generation at Ralston Powerhouse. To answer this question, a series of HEC-RAS (formally HEC-2) runs with various combinations of assumed reservoir drawdown and flow rates were performed to estimate the available shear stress at various locations within the reservoir. A summary of the results is shown in Appendix B. It was found that during a maximum drawdown condition, even with a moderate discharge of 2,000 cfs at the dam site, sufficient sediment transport capacity could be attained to move the fine sediment toward the lower portion of the reservoir. An analysis of the daily flow data for the period from 1970 to 1995 shows that the number of days in which the daily inflow exceed specific discharges are as shown in Table 3-3.

Table 3-3 Number of Days the Mean Daily Flow Exceeds the Specified Discharge for the 25-Year Period from 1970 to 1995

Specified Mean Daily Discharge cfs	Number of Days Flow is Exceeded in 25-year period
2,000	628
3,500	140
5,000	47
8,000	23

A discharge of 2,000 cfs was first chosen as the discharge required to initiate reservoir drawdown. Discharges of 3,500 cfs, 5,000 cfs and 8,000 cfs were also used to investigate the efficacy of the SPT concept as a function of the discharge required to initiate drawdown.

3.6.2 RATING CURVE FOR SPILLWAY AND LOW-LEVEL OUTLET

Since the proposed SPT operation includes the operation of the existing low-level outlet, a flow rating curve and the minimum possible reservoir elevation (maximum reservoir drawdown) for various outflows flows was computed and is shown in Table 3-4.

3.7 HEC-6 SEDIMENT ROUTING FOR THE PROPOSED SPT OPERATION

The Sediment-Pass-Through (SPT) concept was investigated as a means to alleviate the sediment problem in Ralston Afterbay Reservoir using the calibrated HEC-6 model. The following sets of hydrologic and sediment data were used to simulate the sediment deposition in the reservoir:

Hydrologic Data: Two sets of 25-year daily flow hydrographs were considered, first from 1966 to 1990, and second, from 1970 to 1995. As shown in Figure 8, both sets of data cover the 7-year wet period which occurred from 1979 to 1986.

Table 3-4 Rating Curve for Ralston Afterbay Spillway And Low-Level Outlet

W. S. Elev. (ft)	Low-Level Outlet (cfs)	Spillway Q	Total Outflow (cfs)
1149.0	886	0	886
1150.3	900	1100	2000
1151.3	910	2500	3410
1152.6	924	5000	5924
1153.8	936	7500	8436
1154.8	946	10000	10946
1155.7	955	12500	13455
1156.6	964	15000	15964
1157.4	972	17500	19472
1158.2	979	20000	20979
1158.9	987	22500	23487
1159.6	994	25000	25994
1160.3	1000	27500	28500
1161.0	1007	30000	31007
1161.7	1013	32500	33513
1162.3	1019	35000	36019
1162.9	1025	37500	38525
1163.5	1031	40000	41031
1164.1	1036	42500	43536
1164.7	1042	45000	46042
1165.3	1047	47500	48547
1165.9	1052	50000	51052
1166.4	1057	52500	53557
1167.0	1062	55000	56062
1167.5	1067	57500	58567
1168.0	1072	60000	61072
1168.6	1076	62500	63576
1169.1	1081	65000	66081
1169.6	1085	67500	68585
1170.1	1090	70000	71090
1170.6	1094	72500	73594
1171.1	1099	75000	76099
1171.6	1103	77500	78603
1172.1	1107	80000	81107
1172.5	1111	82500	83611
1175.0	1132	100000	101132

Sediment Inflow Data: Two sets of sediment rating curves were used, first a high rating curve with an annual deposition rate of 58,000 yd^3/yr and second, a low rating curve with an average annual deposition rates of 45,000 yd^3/yr.

The analyses included the following three conditions for reservoir operation:

1. Baseline condition (without reservoir drawdown): This is the "do-nothing" condition.

2. Reservoir drawdown condition with the existing low-level outlet and spillway condition

3. Reservoir drawdown condition with an increased low-level outlet capacity

The HEC-6 runs and the results of the investigations for these three condition are presented below.

3.7.1 Baseline Condition

The baseline condition was used to predict the future sediment deposition pattern in the reservoir if no sediment management measures were implemented. This condition was simulated using the calibrated HEC-6 model with the high sediment rating curve and the two different sets of 25-year daily inflow hydrographs.

Table 3-5 Summary of Sediment Study Results for Ralston Afterbay Without SPT

Case	Sediment Supply Curve	Hydrograph Period	Sediment Supply/Deposit yd^3/yr	Trap Efficiency (%)
A-1	High	1966-1991	61,600/47,800	77.6
A-2	High	1970-1995	63,000/55,750	88.1
A-3	Low	1970-1995	50,500/42,000	84

The results presented in Table 3-5 show that the 25-year hydrograph for the 1970-1995 period (Case A-2) results in more sediment inflow and deposition than for the inflow hydrograph for the period from 1966 to 1991 (Case A-1). Plotting the results on Figure 12 shows that the middle reach of the reservoir could be totally silted up in about 15 to 20 years, if the "do-nothing" option is adopted. Even if the low sediment supply curve is used, the middle reach of the reservoir would be choked with sediment in about 25 years if "do-nothing" option is adopted (Case A-3). The trap efficiency is the ratio of the sediment deposited in the reservoir to the sediment supplied. This ratio will be used in comparing results with the SPT operation.

Based on the above findings, the 25-year daily flow hydrograph for the 1970-1995 period was adopted as the inflow hydrograph for the remaining HEC-6 runs. To be conservative, the high sediment supply rating curve was also selected for the remaining HEC-6 runs.

3.7.2 Reservoir Drawdown with Existing 72-inch Low-Level Outlet

Three important parameters were considered in the reservoir drawdown operations:

1. The discharge at which the reservoir drawdown should be initiated,
2. The amount of drawdown, and
3. The duration and frequency of drawdown.

The effective tractive force necessary to move the sediment is governed by the flow rate and corresponding drawdown level while the duration and frequency of drawdown determines the success of sediment pass-through operation. Four reservoir drawdown initiation or trigger discharges of 2,000 cfs, 3,500 cfs, 5,000 cfs and 8,000 cfs were selected to examine the effectiveness of the reservoir drawdown operation on the sediment deposition. For each trigger discharge, the maximum allowable drawdown was used to simulate the SPT operation. Maximum allowable drawdown means that the reservoir is drawn down as far as possible with the spillway and low-level outlet as given by the rating curve in Table 3-4. During the HEC-6 simulations, it was assumed that the sediment discharge coefficient (sediment concentration in the low-level outlet) for the low-level outlet is about 200% of the ambient sediment concentration (Cases D-1a, B-1a, E-1a and C-1a. in Table 3-6). The computed sediment inflow, deposition, outflow through the low-level outlet, and drawdown operations and trap efficiency for these cases are shown in Table 3-6. The corresponding bed profiles after 5-,10-, 15-, 20-, and 25-year operations for each trigger discharge are depicted in Figures 13 to 16.

Table 3-6 Summary of Sediment Study results with Drawdown, High Sediment Supply Curve, Period: 1970-1995

Case	Trigger Discharge (Cfs)	Low-Level Outlet Diameter (inches)	Diversion Ratio	Sediment in yd^3/yr Supply/Deposition	Sediment in yd^3/yr Outlet/Drawdown	Total Number of Drawdown Days (days)	Trap Efficiency (%)
D-1a	8,000	72	2.0	63,300/27,000	4,100/32,200	23	42.7
B-1a	5,000	72	2.0	63,300/18,500	7,300/37,400	47.25	34.8
B-1b	5,000	closed	-	63,300/23,900	0/39,400	47.25	38.8
B-1c	3,500	108	3.0	63,300/20000	20,100/20,200	47.25	31.6
E-1a	3,500	72	2.0	63,300/36,700	9,300/36,700	140.25	27.3
E-1b	3,500	108	2.0	63,300/17,300	19,000/26,600	140.25	28
E-1c	2,000	108	3.0	63,300/17,800	28,400/17,000	140.25	28.1
C-1a	2,000	72	2.0	63,300/11,200	16,200/35,900	628.25	17.7
C-1b	2,000	72	3.0	63,300/11,100	23,200/29,000	628.25	17.5
C-1c	2,000	72	1.5	63,300/11,500	17,200/34,600	628.25	18.1
F-1a	2,000	108	2.0	63,300/9,300	37,900/14,300	628.25	14.7

Note: The diversion ratio is the ratio of the concentration of sediment in the low-level outlet discharge to the ambient flow

The results shown in Table 3-6 and Figures 13 to 16 indicate that after 25 years of operation, the sediment trap efficiency with the drawdown initialization at discharges of 8,000 cfs, 5,000 cfs, 3,500 cfs and 2,000 cfs are about 43%, 35%, 27% and 18%, respectively. Since about 33% of the existing reservoir storage of 4,500,000 yd^3 has already being filled up by deposited sediment, the computed results appear to indicate that for drawdown initialization discharges greater than 5,000 cfs, excessive deposition in the reservoir may occur in 15 to 20 years and this will significantly hinder the future operations at Ralston and Oxbow powerhouses. Therefore, the trigger discharge should be between 2000 and 3500 cfs for the SPT concept to be effective.

Several HEC-6 runs, Cases C-1b and C-1c, were also performed to investigate the sensitivity of the low-level concentration ratio on the deposition pattern. Cases C-1b and C-1c used concentration ratios of 3.0 and 1.5, respectively, to examine these effects on the deposition. The results, shown in Table 3-6, indicate that the low-level outlet capacity is not particularly sensitive to the assumed concentration ratio and the assumed concentration ratio of 2.0 appears to be reasonable.

3.7.3 Reservoir Drawdown with Enlarged Low-Level Outlet Capacity

The computed sediment deposition pattern depicted in Figures 15 and 16 indicated that if the drawdown operations were initiated at a flow rate of 3,500 cfs or 2,000 cfs, the sediment transport capacity could move almost all of the sediment inflow toward the lower reaches of the reservoir. However, due to the limitations of the HEC-6 model, the sediment bypass operations at the local area near the spillway and low-level outlet could not be simulated. As a result, the computed deposition in the lower reservoir areas appears to be more than is physically possible or reasonable.

We therefore investigated the effects of increasing the capacity of the low-level outlet on the local accumulation of sediment near the existing 72-inch low-level outlet. Additional HEC-6 runs were performed with drawdown initialization discharges of 3,500 cfs and 2,000 cfs (Cases B-1c, E-1b, E-1c and F-1a in Table 3-6) using a 108-inch diameter level outlet. The computed bed profiles for Cases E-1b and F-1a were also plotted in Figures 17 and 18, respectively. The results show that increasing the capacity by about 200% (Case E-1b) to 245% (Case F-1a), resulted in an insignificant improvement in the trap efficiency. This result was caused by the simultaneous reduction of sediment outflow through the spillways when more flow was drawn through the low-level outlets. We therefore conclude that increasing the size of the existing sluice is not warranted if the SPT operation is implemented.

These results also showed that it would be necessary to greatly increase the capacity of the low-level outlet works in order to actually sluice material from the reservoir. By sluicing, we mean an operation that removes more sediment than comes in. As our results for an increase in low-level outlet capacity by a factor of about 2 show, (Cases E-1b and F-1a), more material is, in fact, retained in the reservoir than comes in during the proposed SPT operation. What the SPT operation has done is to significantly increase the quantity of material that passes through the reservoir, and decrease the quantity of material that is deposited in the reservoir during flood events. It has not resulted in a net outflow of sediment, and therefore is definitely not a sluicing operation.

3.8 DOWNSTREAM ENVIRONMENTAL CONSIDERATIONS

3.8.1 Bed Material Variation During 25-year of SPT Operation

During SPT operations, the sediments will be moved toward the lower portion of the reservoir material and will be bypassed through the low-level outlet. After 25 years of reservoir operations, the computed median sizes of the sediment in the lower reach (Sta. 5+10 to 22+90), the middle reach (Sta. 47+80 to 61+30), and the upper reach (Sta. 82+10) of the reservoir for various conditions are summarized in Table 3-7. The results show that without reservoir drawdown (Case A-2), the whole reservoir would be filled up with fine and coarse material while the fine material could be moved to the lower reaches, with a majority of these fine material being bypassed, if the SPT operation is implemented (Cases E-1a & C-1a).

Table 3-7 Bed Material, d_{50}, for Various Drawdown Initialization Discharges at the End of the 25-year Simulation

Station (ft)	d_{50} for Various Drawdown Initialization Discharges				
	No Drawdown Case A-2	8000 cfs Case D-1a	5000 cfs Case B-1a	3500 cfs Case E-1a	2000 cfs Case C-1a
5+10	VFS	VFS	VFS	VFS	VFS
22+90	VFS	MS	VCG	CG	CG
47+80	VFS	CG	VCG	VCG	SC
61+30	VFS	VFS	VFS	VCG-SC	VCG-SC
82+10	FG	FG	VFS	VCS	FG

Notation

SC = small cobbles
FG = fine gravel
VFG = very fine gravels
VCS = very coarse sand

CS = coarse sand
MS = medium sand
FS = fine sand
VFS = very fine sand

The results presented in Table 3-6 indicate that about 70% to 80% of the total sediment supply would be discharged to the downstream channel. The results of HEC-6 calibration runs also reveal that about 85% to 90% of the total sediment inflow would be fine material that would be finer than coarse sand. Therefore, it is reasonable to conclude that the median size of the bypassed sediment during SPT operations would be fine sand, which corresponds to $d_{50} = 0.18$ mm. This was further confirmed by the bed material gradation shown in the HEC-6 output (Table 3-7, Case E-1a), which shows that the median sediment size of the bed material near the dam area at Sta. 5+10 is very fine sand (VFS) or fine sand (FS).

3.8.2 Downstream Channel Hydraulics

The HEC-2 model of the downstream channel provided by the PCWA was originally developed by Sierra Hydrotech (1988) to estimate the 100-year flood level in the 1.6 mile stretch of channel downstream from Ralston Afterbay Dam. Figure 19 shows that the channel profile downstream of Ralston Afterbay Dam. It was found that the Sierra Hydrotech's(1988) HEC-2 model did not adequately simulate river bottom invert elevation, bends, and channel length, and therefore, would not provide us with sufficient hydraulic information for the assessment of the sediment transport in this reach of the Middle Fork of the American River. The model was therefore modified and new HEC-2 runs were subsequently, performed to determine the sediment transport capacity for flow rates varying from 2,000 cfs to 10,000 cfs. The computed shear stress along the 1.6-mile downstream channel was found to vary from 0.25 lb/ft^2 to 9.0 lb/ft^2 (Appendix C). The median size of the bypassed material was estimated to be about 0.18 mm (fine sand), which has a corresponding critical shear stress of about 0.02 lb/ft^2. Therefore, we expect that during the SPT operations (Cases C-1a or E-1a), the bypassed sediment would be transported further downstream from Ralston Afterbay Dam toward Folsom Dam and Reservoir, just as it would have prior to the construction of Ralston Afterbay Dam. Therefore, this bypassed material will not be an environmental concern to the areas immediately below the Ralston Afterbay Dam.

3.9 EFFECT OF SPT OPERATION ON POWER OPERATION

The purpose of the power operation study is to determine the percentage of time that the power production at Ralston and Oxbow powerhouses would be curtailed due to encroachment on storage caused by effects of excessive sediment deposition. The evaluation was conducted in accordance with three assumed reservoir operation conditions:

1. the "do-noting" option,
2. drawdown with existing 72-inch low-level outlet operation, and

3. drawdown with enlarged low-level outlet capacity.

As indicated in Section 3.7.1, if the "do-nothing" option is adopted, the reservoir near Stà. 60+00 in the middle reach of the reservoir could be totally silted up after about 15 to 20 years of operations. Due to sediment deposition in the reservoir, the water level at the tailrace of Ralston Powerhouse could easily exceed the allowable limit of El. 1178.

With the proposed SPT operations, the encroachment on reservoir storage caused by sediment deposition would be greatly reduced. The extent of improvement depends on the minimum flow rate used to initiate the reservoir drawdown operations. Table 3-9 compares the number of required shutdown days during a 25-year simulation period for the assumed minimum drawdown initialization discharges of 2,000 cfs, 3,500 cfs, 5,000 cfs and 8,000 cfs. The required shutdown condition is defined as when the computed tailwater level at Ralston Powerhouse exceeds El. 1178.0. At the end of the 25-year simulation, the resulting sediment deposition pattern would also result in encroachment on the tailrace of Ralston Powerhouse; this would result in a corresponding maximum allowable inflow which would not require a shutdown of the powerhouse. This maximum allowable inflow without shutdown of the powerhouse is also shown in Table 3-8. The 25-year time histories of the Rubicon River inflow, and the computed water surface elevations at Ralston Powerhouse for drawdown initialization discharges of 2,000 cfs, 3,500 cfs, 5,000 cfs and 8,000 cfs are shown in Figures 20 to 22, respectively.

Table 3-8 Summary of Ralston Afterbay Power Curtailment Study

Case	Drawdown Initialization discharge (cfs)	Ralston Powerhouse	
		Number of Days Shutdown (days)	Allowable Maximum Flow (cfs)
C-1a	2000	12	10,000
E-1a	3500	16	9,00
B-1a	5000	18	8,000
D-1a	8000	39.5	4,000

The results shown in Table 3-8 and in Figures 20-22 show that if the daily flow history of the next 25 years repeats the flow history for the 1970-1995 period, the proposed SPT would result in only about 12 days, 16 days, 18 days and 40 days of shutdown for the drawdown initialization discharge of 2,000 cfs, 3,500 cfs, 5,000 cfs, and 8,000 cfs, respectively. It was noted that the required shutdown occurred during high flow conditions at the times near the end of the 25-year simulation period. The loss of power generation due to these total number days of power plant shutdown is very small. However, it should be emphasized that the number of required shutdown depends on the hydrologic data used in the simulation. For example, for a wet period, Ralston Powerhouse might have to be shutdown more frequently whenever the inflow exceeds the respective maximum allowable discharge indicated in the Table 3-9. The maximum allowable Rubicon flows for the drawdown initialization discharges of 2,000 cfs, 3,500 cfs, 5,000 cfs, and 8,000 cfs were estimated to be about 10,000 cfs, 9,000 cfs, 8,000 cfs and 4,000 cfs, respectively. This represents the flow conditions in which the resulting water level at the Ralston Powerhouse tailrace exceeds El. 1178.0.

In comparing the number of required shutdown days, it would appear that the benefit of using a trigger discharge of 2,000 cfs (Case C-1a) or 3,500 cfs (Case E-1a) over that of 8,000 cfs (Case D-1a) is insignificant as far as power production is concerned. Power production is not, however, the governing criterion. The principal benefit of using a 2,000 cfs or 3,500 cfs trigger discharge is the ability to prolong the reservoir life well beyond the 25 years of operation which we simulated. Indeed, the real benefit is that without frequent drawdown as will occur with a trigger level at 3,500 cfs, the powerhouse will essentially be out of service much sooner than if a higher trigger discharge is selected for the SPT concept.

The effects on the total generation at Oxbow Powerhouse are also small. As Tables 3-3 and 3-6 show, there are 140 days that the reservoir is drawn down over the 25-year period of simulation, or about 1.5 % of the time. Oxbow will not be out of service for all of the 140 days, because it takes time to draw down far enough to require shut-down of the generator. In addition, sediment concentrations for conditions requiring drawdown may cause shut-down of the units due to high concentrations of sediment the cooling water. Thus, we anticipate that the overall effect of the SPT operations on power generation at Oxbow Powerhouse is insignificant in the long term, and is certainly balanced by benefits to Ralston Powerhouse operations.

3.10 OTHER STUDY CONSIDERATIONS

3.10.1 Transient Condition during Drawdown Operation

The reservoir is normally maintained at a water level of El. 1175.0. The proposed SPT drawdown operations in the HEC-6 model only considers the sediment transport capacity for steady state conditions when the reservoir was drawn down to the maximum allowable elevations indicated in Table 3-4. In reality, it could take 1 to 2 hours before the reservoir water level can be lowered to the maximum allowable elevation. During this transition period, the outflow discharge through the spillway and low-level outlet would be much higher than the inflow rate used in the HEC-6 routing. As a result, it is anticipated that the actual sediment outflow through the low-level outlet and/or spillway could be greater than computed in the HEC-6 model. However, since this duration would represent only about 4%-8% of the total time the low-level outlet is open, we believe that the overall results predicted by HEC-6 model are sufficient to assess the efficacy of the proposed SPT concept.

3. 10.2 Tailwater Depression System and Training Wall

Our preliminary analysis showed that deposition of sediment at the Ralston Powerhouse tailrace area is inevitable, because of the channel excavation from the original El. 1170 to El. 1162 and local reduction in channel slope that was made during construction in 1966. The rise in the tailwater level is further aggravated by backwater effects due to sediment deposition in the downstream reservoir. The predicted bed profile computed by the HEC-6 model further confirmed the preliminary hydraulic assessment that sediment deposition indeed would continue to occur at the powerhouse area, although at a much reduced rate if the SPT concept is implemented. As shown in Table 3-8, with the trigger discharge set to 2,000 cfs or 3,500 cfs, the maximum flows allowable in the Rubicon without shutting down the powerhouse would be about 8,000 cfs to 10,000 cfs, and the number of days of shutdown is rather small. Therefore, it appears that if the proposed SPT concept is implemented, it is not economical or necessary to install a tailwater depression system. We therefore recommend that the tailwater depression system not be installed.

However, since coarse material, such as gravel and cobbles, would continue to deposit at the tailrace area, keeping the tailrace clean may continue to be an operation problem to the PCWA. Therefore, a debris training wall may warrant further consideration to alleviate this problem. However, as discussed in Section 4.5, the economics of this training wall, the complexities in installation, and the powerhouse tailrace gates make the training wall unattractive at present. We therefore recommend that operating experience with the SPT concept be used to determine if a training wall should be investigated further.

3.10.3 Reservoir Dredging

Since about 10%-15% of the total sediment inflow would be coarse material with size larger than very coarse sand, we expect that the proposed SPT operation will not be capable of transporting this coarse material completely through the reservoir. This is also evidenced by the fact that the computed trap efficiency for drawdown initialization discharges of 3,500 cfs and 2,000 cfs is still about 28% and 18%, respectively as shown in Table 3-6). Consequently, we anticipate that future reservoir dredging of coarse material will still be required. The benefit of SPT operations is that it delays the required dredging for about 20 to 25 years in comparison with the "do nothing" option.

3.11 IMPLEMENTATION OF THE SEDIMENT PASS-THROUGH CONCEPT

3.11.1 General

The preceding analytical studies shown that the SPT concept is a viable means of managing the sediment problems with Ralston Afterbay and the effects on power generation at Ralston and Oxbow Powerhouses. In this section, we provide recommendations for the sequence of operations required to implement the SPT concept. Particular attention is given to the operation of the low-level outlet because we want to emphasize that operation of this outlet will not result in an extended release of highly turbid flows through the outlet. We have also developed procedures to ensure against the possibility of such releases. We first review the SPT concept, set the stage with the initial conditions prior to drawdown, describe the initiation of drawdown, operation of the spillway gates, operation of both Ralston and Oxbow Powerhouses during the SPT operation, refilling of the reservoir, and return to normal operating conditions

3.11.2 The Concept

The Sediment Pass-Through concept as developed for application at Ralston Afterbay is a change in operation procedures for the spillway and low-level outlet that will permit more of the material conveyed into the reservoir during a flood event to pass through the reservoir and less of this material to be deposited in the reservoir. Existing operating procedures were directed toward maximizing power production during high flow conditions. This meant that the reservoir water level was kept at the normal operating pool as long as practicable in order the keep a high head on the Oxbow power plant and maximize power generation. These procedures promote a low velocity in the reservoir by keeping the reservoir water level high, which, in turn, promotes deposition of sediment in the reservoir.

The Sediment Pass-Through concept involves drawing down the reservoir during flood events by opening the spillway gates and low-level outlet at the beginning of a flood. This procedure increases the flow velocity through the reservoir and promotes passage of sediment through the reservoir during high flow conditions, hence the term "Sediment Pass-Through". The concept is basically very simple, let more material pass through the reservoir, and keep less of the material from depositing in the reservoir.

The Sediment Pass-Through concept is not a flushing or sluicing of the reservoir. Sluicing or flushing implies that more material is removed than comes in. Our analytical studies show that we are able to significantly decrease the trap efficiency of the reservoir, which means that we are able to significantly reduce the quantity of material deposited in the reservoir, but we cannot remove more than comes in. Implementing the SPT concept requires some consideration of the operation sequence for the spillway gates, low-level outlet and discharge through Oxbow Powerhouse.

3.11.3 Initial Conditions.

For purposes of discussion, we shall assume that the reservoir is at the normal operating level, El. 1175. Both Ralston and Oxbow powerhouses are in operation, and the flow at Ralston Afterbay Dam, including the withdrawal through the Oxbow powerhouse intake is below the trigger discharge of 3500 cfs. As the flow increases, the spillway gates will be opened to pass the excess flow, but maintain the reservoir at the normal operating level of El. 1175 When the trigger discharge of 3500 cfs is reached, the low-level outlet is opened to begin the drawdown process.

3.11.4 Initiation of Drawdown, Opening the Low-Level Outlet

Opening the low-level outlet will not result in a large slug of sediment being discharged into the river downstream from the dam. It is a common misconception that opening the low-level outlet is somehow going to sluice large quantities of material out of the reservoir. This will not happen. There may be a discharge of highly turbid water for a minute or so when the sluice is first opened, but the high concentration will not persist. Past operating experience with the low-level outlet at Ralston Afterbay shows this to be true. For example, the PCWA opened the low-level outlet gate on March 3,1995 to satisfy California Division of Safety of Dams (DSOD) requirements for dam safety. This was the first time that the outlet had been opened in 9 years. There was only a few seconds during which turbid water appeared at the outlet, and most of the turbidity appeared to be caused by material that had been deposited in the outlet pipe downstream from the control gate. The valve has since been exercised on January 25, 1996 and December 30, 1996. In January, there was again only a few seconds of turbid water when the valve was initially opened, while in December, there was none. The procedures developed for implementing the SPT concept have taken the possibility of sediment accumulation both upstream and downstream from the gate into account, and are directed at minimizing the chances of material accumulating near the outlet that could result in discharge of high concentrations of turbid water through the low-level outlet.

Flow velocities in the outlet pipe are about 40 ft/s when the reservoir is at the normal operating pool elevation, but these velocities drop off very rapidly with distance from the inlet on the upstream side of the dam. Consequently, there is only a relatively small, cone-shaped depression in the sediment around the inlet in the reservoir which defines the limited area over which the low-level outlet can withdraw sediment. Operating the low-level outlet fairly often, will ensure that material does not deposit in this cone, and that only a small quantity of sediment can be released when the low-level outlet is opened.

The low-level outlet will be opened very slowly because the gate operator requires 9 minutes to fully open the gate. Therefore, for the first 2 to 3 minutes of operation, the discharge through the low-level outlet will be only a fraction of the fully-open discharge. This means that if there is any turbidity in the initial flow, it will be highly diluted by the flows over the spillway and through Oxbow Powerhouse. When the low-level outlet is fully open with the reservoir at El. 1175, about 1/3 of the total outflow of 3500 cfs will pass through the outlet. Therefore, any turbidity in the flow from the low-level outlet will be highly diluted at first, and will gradually reduce to a dilution of about 3: 1 when the gate is fully open. Since the PCWA's operating experience shows that even if the low-level outlet is not operated very frequently, there is very little material that is discharged through the outlet when it is first opened; this opening procedure is therefore conservative and will ensure against any possibility of highly turbid discharges causing adverse environmental effects in the river reach downstream from the dam during SPT operations.

3.11.5 Spillway Gates

We want to get the low-level outlet in service as soon as practicable to promote sediment passage through the reservoir rather than deposition in it. Once the low-level outlet is open, the spillway gates should be operated to draw down the reservoir as low as possible as rapidly as possible. The drawdown will have to be accomplished without exceeding the maximum permissible rate of change of stage of 3 feet per hour as measured at the gauging station located just above Horseshoe Bar. This will mean that eventually all five of the radial gates will be fully opened. Drawing down the reservoir increases the flow velocity through the reservoir. This has two effects. First, it increases the bottom shear so that more of the incoming material gets further into the reservoir. This reduces the potential for deposition of material at the bend in the Rubicon River downstream from Ralston Powerhouse thereby reducing the tailwater levels at Ralston Powerhouse and keeping the powerhouse in service for a longer period of time. Second, the drawdown also decreases the detention time in the reservoir, so that less material settles out, and more passes through. The spillway gates and the low-level outlet should remain fully open until the combined discharge through the spillway, low level outlet, and Oxbow Powerhouse again returns to 3,500 cfs.

3.11.6 Operation of Oxbow Powerhouse

Oxbow Powerhouse should remain in operation as long as possible during the drawdown of the reservoir. If there is a major flood under way, it may become necessary to shut down the generator because the cooling water strainers have become inoperable due to high concentrations of suspended sediment. For many floods, it will become necessary to shut the generator down because the reservoir level has become too low. In either case, once the generator has been shut down, the bypass valve should be opened so that there is flow through Oxbow Powerhouse throughout the SPT operation. The reason for maintaining flow through Oxbow Powerhouse is to preclude any deposition of sediment in front of the Oxbow Intake that might interfere with operation of the powerhouse once the SPT operations have been completed. Operating the Oxbow Intake will ensure that the cone of influence around the Oxbow Intake remains clear of deposited material in the unlikely event that there is a tendency for sediment to deposit at the intake area during SPT operations.

3.11.7 Refilling the Reservoir

Once the combined discharge through the spillway, low-level outlet, and Oxbow Powerhouse again drops to the trigger discharge of 3500 cfs, the spillway gates should be closed and the reservoir refilled to return to normal operating conditions as soon as possible. Again the refilling must be accomplished so that the rate of change of stage of 3 feet per hour as measured at the gauging station located at Horseshoe Bar is not exceeded. The low level outlet should remain open for an additional hour after the spillway gates have been closed. The reason for keeping the low-level outlet open a short time longer is to preclude any deposition of material in the cone around the low-level intake that might be released when the low-level outlet is opened for the next inspection or SPT operation. This precaution with regard to the deposition of material around the low-level intake may appear overly cautious, in view of the past operating experience with this outlet. However, we believe that these operating procedures are a prudent, common sense approach to making sure that the changes in operating procedures required by implementation of the Sediment Pass-Through concept do not result in adverse environmental effects downstream from the dam.

Once the low-level outlet has been closed, the reservoir will refill. Oxbow Powerhouse should be returned to service once the reservoir rises above the minimum operating level of El. 1155. This then completes the SPT operation; once the reservoir has reached El. 1175, the system is then back to normal operating conditions.

3.11.8 Operation of Ralston Powerhouse during SPT Conditions.

Drawing the reservoir down will lower the tailwater at Ralston Powerhouse and permit operation for higher flows in the Rubicon River than would be possible without reservoir drawdown. Ralston Powerhouse should remain in operation throughout most SPT operations, unless there is an exceptionally high flood on the Rubicon. If it becomes necessary to shut down Ralston Powerhouse for any reason whatsoever during an SPT operation, it is essential that the tailrace gates be closed to prevent the deposition of sediment in the turbine wheel pit. If Ralston Powerhouse is shut down during an SPT operation, the tailrace should be inspected prior to returning the unit to service to make sure that excessive deposition has not occurred in front of the tailrace gates.

3.12 SUMMARY OF ANALYTICAL RESULTS AND RECOMMENDATIONS

A summary of our analytical results, conclusions obtained from these results, and recommendations are as follows:

(1) If the "do-nothing" option is adopted, the middle reach of the reservoir near the confluence of the Middle Fork and Rubicon River would become silted up with sediment in about 15 to 20 years. The backwater effects on the tailwater level at Ralston Powerhouse would probably render the powerhouse inoperable in 10 to 15 years.

(2) The Sediment-Pass-Through (SPT) method is a viable approach to mitigate the sediment deposition problem in the Ralston Afterbay reservoir and its consequences on the operation of Oxbow and Ralston Powerhouses. The proposed SPT operation is a combination of maximum reservoir drawdown and operation of the existing 72-inch low-level outlet. This proposed SPT operations could keep the bed profile in the reservoir similar to the profile that was measured in 1995, thus significantly reducing the need for periodic dredging of the reservoir.

Clearly, the more frequent the SPT drawdown operation occurs, the more effective the SPT is in the long term, as shown by a comparison of the results for several trigger discharges in Table 3-6. There is, however, a significant difference in the number of required drawdowns between a trigger discharge of 2000 cfs (628) and 3500 cfs (140) as shown in Table 3-3. We also understand that the environmental regulatory agency may desire the PCWA to bypass the sediment using a minimum flow ratio between the spillway overflow and the low-level sluice flow of 2:1 and preferably 3:1. This potential operational constraint suggests that a trigger discharge of 3,500 cfs (Case E-1a) be used for the initial implementation of the SPT concept It should be noted that a 3:1 flow ratio between the flows through the spillway and the low-level outlet is also achievable, if so desired, using a partial opening of the low-level outlet.

Although the bed profiles for the cases of trigger discharges of 3,500 cfs (Figure 15) and 2,000 cfs (Figure 16) did not reveal significant differences, the fact is that the trap efficiency for the latter would be about 10% more than that of the former. This difference is primarily due to a much more frequent drawdown operation in the latter (Case C-1a), as shown in Table 3-6. Consequently, using a trigger discharge of 3,500 cfs will require somewhat more frequent dredging than using 2000 cfs. Our recommendation is to start with the 3500 cfs trigger discharge, monitor the results, and adjust the trigger discharge accordingly.

(3) The addition of moderate increases in the capacity of the low-level outlet does not significantly improve the sediment bypass operation, or decrease the trap efficiency in the reservoir, unless the existing spillway configuration and capacity is also modified, or unless the capacity of the low-level outlet is greatly increased Therefore, there is no need to enlarge the capacity of the existing sluice.

(4) The proposed SPT operations do not seem to result in a significant reduction in loss of power up to the point at which the unit at Ralston Powerhouse becomes inoperable. However, if the SPT method is not implemented, Ralston Powerhouse could be inoperable in about 15 years due to sediment deposition in the reservoir, whereas implementation of the SPT concept indicates that the powerhouse can remain in for a period longer than the 25 years of simulated operation that was used in the computer model.

(5) If the SPT operation is initiated, it does not appear that a tailwater depression system will be required at Ralston Powerhouse. The SPT option results in only relatively few days of shut down and makes a tailwater depression system an uneconomical approach to increasing power production at Ralston Powerhouse.

(6) Coarse material deposition, such as gravel and cobbles, will continue to occur at the tailrace area of Ralston Powerhouse. This may continue to be an operation and maintenance problem to the PCWA, and is discussed in detail in Section 4.6.2, where we recommend that operational experience with the SPT concept should be gained before a tailrace training wall is constructed.

(7) The proposed SPT operations would not have significant environmental impacts to downstream habitats.

4. CONCEPTUAL LAYOUTS, AND ECONOMIC EVALUATION OF THE SPT CONCEPT

4.1 INTRODUCTION

An extensive analysis of the Ralston Afterbay Reservoir using the one-dimensional HEC-6 computer model, "Scour and Deposition in Rivers and Reservoirs" showed that drawing down the Ralston Afterbay reservoir and using the existing spillway gates in combination with opening the low-level outlet would significantly prolong the life of the reservoir and greatly reduce the need for dredging. This procedure is called the Sediment Pass-Through (SPT) operation, and is basically a change in reservoir operating procedures that results in more sediment passing through the reservoir and less deposition in the reservoir than would occur if existing operating procedures continue to be used. If the SPT operation is not implemented and the reservoir is not dredged, (the "do nothing option"), then the analysis indicates that Ralston Afterbay reservoir would silt up in 10 to 15 years, and the backwater effects would render Ralston Power house inoperable. The analysis also showed that the existing 72-inch diameter low-level outlet located at El. 1108 could be used to supplement an SPT operation, and that it was not necessary to enlarge this low-level outlet.

Conceptual layouts for the modifications required to implement the SPT concept are developed in the section. The three principal areas considered are:

1. The addition of a new gate for the low-level sluice.

2. A training wall for the tailrace at Ralston Powerhouse.

3. The effects of the SPT option on sedimentation at the Oxbow Powerhouse Intake.

4.2. LOW-LEVEL SLUICE

4.2.1 General

The existing low-level outlet consists of a 72-inch circular conduit located at El. 1108 which is controlled by a sluice gate located on the upstream face of the dam and operated from the deck of Ralston Afterbay dam. The low-level opening is protected by a grizzly, which prevents large logs and trash from entering the outlet pipe. In the 1986 flood, large water-logged trees damaged the original grizzly and jammed the low-level outlet in a partially open position. There is nothing to prevent such an incident from reoccurring. Furthermore, the probability of the reoccurrence of such an incident will increase if the

SPT operation is implemented. Consequently, we conclude that it is essential that an additional gate be installed on the low level outlet to permit the outlet to function safely during an SPT operation.

The work in this part of this study therefore included:

1. Selection of a new gate and development of conceptual level sketches for facilities required for the installation and operation of this gate at Ralston Afterbay Dam.

2. Preparation of conceptual level sketches, consistent with the format for FERC Exhibit drawings.

3. Preparation of a conceptual level cost estimate with a 30% accuracy for the civil works. Budget level costs for the mechanical equipment obtained from gate manufacturers are also included.

It is our understanding that stability analyses for Ralston Afterbay Dam are being conducted by others, and that stability analyses are not part of the scope of work for this study.

4.2.2 Criteria for Selection of the Gate

In selecting a gate for the low level sluice, we established the following criteria:

1. The gate or valve must be upstream sealing and capable of withstanding 90 feet of unseating head.

2. The design must interface with the existing 6-foot diameter pipe.

For a gate installation, a frame could be mounted externally on the sloping downstream face of the dam to which the gate guides and sealing surfaces would be anchored. The frame could be vertical or follow the slope of the dam. For attachment, a thimble welded to the inside of the existing pipe could make the transition from the pipe to the frame, or where the gate follows the slope of the dam, the frame could be fixed to the dam face with suitable concrete anchors.

For a valve application, a spool piece could be welded to the inside of the existing pipe with a flanged end onto which the valve could be mounted.

For both cases, if support work were required under the gate frame or valve to take the vertical load, the support work could be attached to the dam with suitable concrete anchors.

3. The gate or valve must present unobstructed flow when fully open. A butterfly valve would not be acceptable.

4. The sluice pipe, with centerline at El. 1108, is submerged by the tailwater for most flow conditions. The 100 year flood tailwater elevation is El. 1132.4. The 500 year tailwater elevation is El. 1143. (It should be noted that these elevations differ from those shown on the project drawings because we have revised them on the basis of our studies of the channel downstream from the dam presented in Section 3.) The gate or valve must therefore be designed to operate submerged, and the drive for the actuator cannot be locally mounted on the gate frame or valve body. The drive may be mounted at the same elevation as the ring jet valve actuator at El. 1144.

There is an existing access ladder to the ring jet valve actuator at El. 1144. The platform for this valve actuator can be extended for access to the new gate or valve actuator.

5. The valve or gate actuator should be electrically driven, 480 volt, 3 phase, 60 Hz. It may be screw type (Limitorque) or hydraulic, but if hydraulic, the hydraulic power pack must be self-contained.

6. A platform or bracket for the actuator capable of supporting the raising and lowering forces will be required. For a hydraulic actuator, the power pack may be placed on the El. 1144 platform and the hoses to the hydraulic cylinder secured to the dam, or the power pack and hydraulic cylinder may be self-contained if mounted above flood level. All of the equipment must be suitable for outdoor service.

7. The existing slide gate has a closure time of 9 minutes. We consider this too slow and would prefer a closure time for the new gate or valve to be no longer than 10 minutes.

Inquiries were sent to several manufacturers of both gates and valves requesting a technical proposal and budgetary cost estimate for their preferred solution.

The following responses were received:

Company	Solution	Cost
Rodney Hunt	Sluice gate with self-contained hydraulic actuator. Gate frame affixed to dam.	$ 74,200

Noell	Sluice Gate with Limitorque actuator. Gate frame affixed to thimble welded to sluice pipe.	$122,000
Fabrivalve	Knife gate valve with electric motor operator. Requires spool piece to connect to sluice pipe.	$ 94,880
Grove Valve	Through-conduit gate valve, hydraulic motor operator.	$300,000
Kurimoto	Slide gate valve	$500,000

4.2.3 Selection of Gate

Based on the responses listed above, it is our conclusion that a sluice gate affixed to the downstream face of the dam is the most suitable solution for this application. It will perform the desired function and is, by far, the most economically attractive option. It should be noted that one of the valve manufacturers also indicated that a sluice gate would be the best solution even though they proposed a valve for the application.

All of the proposals received are attached for reference in Appendix D. We find the Rodney Hunt proposal to be a reasonable approach. The self-contained hydraulic actuator offered by Rodney Hunt has advantageous features not available in a Limitorque operator and, in our opinion, would be the preferred solution. However, Noell illustrated an arrangement using a Limitorque actuator, and a Limitorque actuator solution would also be acceptable if the PCWA would prefer a Limitorque actuator. We should also note that although Noell (Germany) responded to the inquiry, they indicated that they could not be competitive for this order and recommended the gate be obtained through a U. S. firm.

We have prepared a general arrangement drawing for the sluice gate arrangement as shown on Plate 1 (located after Figure 23). This drawing is formatted according to FERC requirements so it can be revised with minimal effort for submittal to FERC. The sluice gate is a 72-inch wide by 90-inch high gate that is anchored to the sloping face of the dam over the outlet for the existing 72-inch low-level conduit. The gate operator would be mounted on a new platform that would be an extension of the existing platform for the fish release valve at El. 1144 as shown on Plate 1. We have assumed that all drilling for the anchors can be done from a skip using an air-track drill that will be maneuvered with a crawler crane from the top deck of the dam. The crawler crane will also be used to install the sluice gate, operating shaft, brackets, and formwork for the extension of the deck at El. 1144.

4.2.4 Cost Estimate

The estimated contractor's cost for the installation is $199,000. A summary of the cost estimate for the installation of the gate is shown in Appendix E. The total estimated cost of the mechanical equipment and installation of the sluice gate for Ralston Afterbay Dam is therefore $273,200.

4.3 RALSTON POWERHOUSE

4.3.1 Sediment Deposition at Ralston Powerhouse

The 1986 flood caused two problems at Ralston Powerhouse. First, a deposit of cobbles and boulders in the channel for the Rubicon River past the powerhouse filled the river channel and raised the tailwater enough to prevent operation of the units. A clamshell operation lasting about two weeks was required to remove material from in front of the exit from the turbine wheel pit. The second problem was a deposit of sand and silt in the turbine wheel pit that made it impossible to operate the unit itself. Much of the muck from the wheel pit had to be removed by a combination of hand work and bucket brigade. There was essentially no large material in the turbine wheel pit.

The reason for the sand and silt in the turbine pit is readily apparent. Since there was no flow from the unit, the pit became a silt trap where material swept into the pit by the exchange of flow between the pit and the main stream simply settled out. The PCWA has installed gates which can be operated from the powerhouse deck that will close off the turbine pit once a flood renders the powerhouse inoperable.

The powerhouse may be shut down because of high tailwater levels in the Rubicon, or because the sediment in the intake for the cooling water system overloads the cooling water strainers. In either case, the gates would be closed to prevent accumulation of sediment in the turbine pit. Thus, the problem becomes one of trying to prevent accumulation of material in front of the gates, and to try and pass the larger material past the powerhouse and further downstream into the reservoir. This approach would then reduce the potential down time following a major flood, or in the best case, would permit the powerhouse to remain in service while any remedial measures are being undertaken in the Rubicon River channel.

4.3.2 Alternatives Considered.

The principal difficulty in developing alternatives for managing sediment deposition at Ralston Powerhouse is the highly three-dimensional nature of the flow past the tailrace exit and the fact that the Rubicon River transports both cobbles and boulders as well as a high concentration of suspended loads during major floods. The use of the tailrace gates will prevent sands and gravels from depositing in the turbine wheel pit. The concern is that there may be deposits of material in front of the tailrace gates that prevents the hoists from lifting the gates after the flood has receded. Our assumption is that sands and gravels could be easily removed with a clamshell operated from the powerhouse deck. However, if there is a deposit of cobbles and boulders along with the sands and gravels, it may not be an easy task to clear enough of the deposit to permit raising the tailrace gates.

We have therefore taken the approach that it is necessary to consider some means of bypassing the large size material, so that if there are any deposits, they consist of sands and gravels that can be readily excavated and flushed out of in front of the powerhouse by discharge from the turbine. It is also necessary to insert a word of caution. No matter what we do to try and manage the sediment deposition at Ralston Powerhouse, there may be conditions generated by extreme flood events that will still result in sediment problems. We have therefore decided to develop a system that is simple, and provides assurance that the powerhouse will not be significantly impacted by an event comparable to the 1986 flood. It is uneconomical to develop a system that will work for extreme events.

The alternatives that we considered were:

1. Use the Existing Tailrace Retaining Wall.

2. Install a Deflector Wall.

3. Install Iowa vanes

4.3.2.1 Existing Tailrace Training Wall

There is a distinct possibility that the existing tailrace training wall will do an adequate job of deflecting the large bed load away from the front of the tailrace gates. This wall is also low, so that the eddy in the wake of the retaining wall is not very large and is probably fairly intense, due to the high velocity of the flood flows in the Rubicon River at this point. Consequently, there may not be a very large deposit of fines in front of the tailrace gates following an SPT operation. Small deposits from low to moderate events may not even require excavation to open the gates, and the discharge from the unit would then wash out the sand and gravel deposits in front of the powerhouse.

The principal concern is high flows with very high suspended loads. The analytical studies using HEC-RAS for the analysis of flow profiles in the Ralston Afterbay Reservoir show that drawing down the reservoir for the SPT operation significantly increases the shear stress, and thus the sediment transport capacity, in the bend in the Rubicon River downstream from Ralston Powerhouse. The analysis also shows that the flow in the Rubicon River past Ralston Powerhouse is essentially the same as it would have been prior to construction of Ralston Afterbay Dam. What this means is that the aggradation of the river channel in front of the powerhouse appears to be caused by material depositing in the bend area, raising the water level, and causing the deposition to progress upstream. Hence, the Rubicon River between the powerhouse and river bend becomes filled with large material during major floods. According to our analysis, the SPT operation will draw the reservoir down far enough that the material will no longer deposit to the degree that it would have in the bend, but be carried further down into the reservoir. This would imply that the deposit of larger size material between the powerhouse and the river bend similar to that which occurred in the 1986 flood would not occur as frequently as when the SPT operation is implemented because the larger material would tend to be deposited further downstream. Thus the channel in front of the powerhouse should not aggrade as severely as in the 1986 flood, which is, of course, one of the objectives in recommending the SPT operation in the first place.

As long as the river channel between the powerhouse and the bend located downstream does not aggrade to a level that causes enough backwater to preclude operation of the turbine, then it is possible that the existing configuration will deflect large material from depositing in front of the tailrace gates. Assuming that the existing tailrace training wall does keep large material from depositing in front of the tailrace gates, then the deposit should only contain sands and gravel. This deposit may prevent the hoists from raising the tailrace gates. However, a relatively minimal effort with a clam shell would undoubtedly remove enough material to raise the gates and permit operation of the units to flush out the area in front of the powerhouse. It would thus be likely that powerhouse operation could be restored in a day or two, depending on availability of equipment and access to the powerhouse. Exactly what sort of sediment deposition would occur cannot be determined without a hydraulic model study. The approach here would be to evaluate the performance of the existing training wall with operation of the SPT and tailrace gates and then determine if additional measures need to be taken.

Thus, one approach to managing the sediment at Ralston Powerhouse is to implement the SPT operation, and to shut down the powerhouse and close the tailrace gates when tailwater levels exceed El. 1180. The consequences of any deposition in front of the tailrace gates can then be evaluated, and a determination made whether or not to proceed with a hydraulic model study and development of the deflector wall concept.

4.3.2.2 Deflector Wall

Our preliminary layout for a deflector wall is shown on Plate 2, and consists of a single deflector wall located about 75 ft upstream from the south wall of the powerhouse. The wall is approximately 50 feet long, is founded on rock, with the top of the wall at El. 1172. The purpose of this wall is to deflect large bed load material toward the opposite bank of the Rubicon River so that it will move past the powerhouse tailrace and not deposit in front of the tailrace gates or in the channel directly in front of the powerhouse.

The deflector wall cannot be too high, or it will obstruct the river flow and possibly aggravate flooding upstream as well as encourage deposition in the wake of the wall. It cannot be too low, or it will not deflect the bed load. We have chosen El. 1172 as the initial estimate of the top of the wall because this provides about 4 ft above the existing bed. This height appears sufficient to deflect the bed load. An analysis using HEC-RAS shows that the shear stress in front of the powerhouse tailrace is increased 15 to 20 % above that computed with the existing tailrace training wall. These estimates are approximate, but indicate that the deflector wall will promote sediment transport past the powerhouse tailrace.

At high flows, the wall is overtopped and suspended material will be conveyed into the area in front of the tailrace gates. The average velocities in front of the powerhouse are rather high. Results from calculations using HEC-RAS, as shown in Table 4-1 for cross sections in the vicinity of the powerhouse, indicate velocities as high as 14 ft/s for a discharge of 30,000 cfs. A discharge of 30,000 cfs is comparable to the 1986 flood.

Table 4-1. Average Velocities in the Rubicon River at Ralston Powerhouse

River Discharge cfs	Velocity, Upstream from Powerhouse ft/s	Velocity, at Tailrace Outlet ft/s	Velocity, Downstream from Powerhouse ft/s
1,000	1.7	2.1	1.4
5,000	6.2	8.0	5.9
10,000	8.9	11.1	9.0
30,000	13.8	15.5	14.6

The flow in front of the tailrace gates is highly three-dimensional because of the existing tailrace retaining wall and the turbulence generated by flow over the proposed deflector wall. Consequently, it is impossible to predict analytically how much, or even if there is any, significant deposition of materials in front of the tailrace gates.

It is clear that a physical hydraulic model test will be required to finalize the design of the deflector wall. While the location height, length, and angle to the river channel represent our best engineering judgment, it is essential that a model test be conducted to ensure that the wall does indeed perform as intended. The model study should also investigate variations in elevation of the top of wall, different lengths, and angles to the stream channel to make sure that the results are not overly sensitive to small changes.

Any design of sediment control structures that are sensitive to small changes is not satisfactory. Thus, the model test would certainly have to include a study of the performance of the existing tailrace training wall and the proposed deflector wall to determine how cost effective the proposed deflector wall would be. The model study may even show that there is a solution that keeps suspended load from depositing in front of the gates. We have contacted Mr. Tom Demlow of ENSR Consulting and Engineering, Redmond, WA, and have obtained a budget price of $120,000 for a hydraulic model study of the potential sediment problems at Ralston Powerhouse.

We have performed a feasibility level cost estimate for the installation of the deflector wall which would require construction of a cofferdam in the river. This would have to be done during the summer months so that there would be minimal interference with flows in the Rubicon River. The deflector wall can be constructed without shutting down Ralston Powerhouse. The estimated contractor's cost is $387,000. This does not include management costs for the PCWA. The combined cost of the model study and installation of the deflector wall is therefore $507,000. A breakdown of the costs and an outline of the construction methodology is contained in Appendix E.

4.3.2.3 Iowa Vanes

Iowa Vanes are a set of concrete vanes that would have to be installed in the tailrace area, possibly extending upstream from the tailrace training wall. These vanes have been used at pump intakes to prevent deposition of material in the pump intake structure. We believe that they could be used at Ralston Powerhouse because the flow from the turbine pit can pass through the vanes during normal operation without incurring significant increases in tailwater elevation in the turbine pit. When the tailrace gates are closed, the vanes would provide enough circulation to keep deposits from forming in front of the intake gates, assuming, of course, that the vanes upstream and the tailrace training wall can keep large material from depositing among the vanes located at the outlet of the turbine pit.

While the concept has some merit, we have concluded that it not a feasible alternative for this project. First, the vanes must be installed directly in front of the exit from the turbine pit, which would mean a shut-down of the powerhouse while installation takes place. Second, we do not know if the vanes would be buried with coarse material, since we do not know how effective the tailrace training wall would be in deflecting large material. Third, if large material does deposit among the vanes, it would be very difficult to clamshell the material out. Finally, the concept requires a very thorough and extensive hydraulic model study. On the basis of these considerations, we have eliminated the Iowa Vanes as a viable approach to the management of sediment at Ralston Powerhouse.

4.3.3 Summary of Costs for Alternatives

Costs for the three alternatives are summarized as follows:

1. Use the existing training wall.

    a) There are no capital costs, because there is no additional work that needs to be done.

    b) There are some unknown maintenance costs associated with removal of deposits in front of the tailrace gates, if they occur.

2. Deflector Wall

    a) The cost of the hydraulic model study is $120,000.

    b) The cost of constructing the deflector wall is estimated at $387,000

    c) The total cost of the deflector wall is estimated as $507,000

These costs do not include management by the PCWA. In addition, there are also unknown maintenance costs associated with possible deposition of sands and gravels in front of the tailrace gates.

3. Iowa Vanes

    a) We did no obtain a cost of a model study for the Iowa Vanes, but would expect it to be in the order of $150,000, since it would be more complicated than the study for the deflector wall.

    b) Construction costs would be of the same order of magnitude as the deflector wall. A reasonable estimate for purposes of this study is $500,000.

    c) There would be costs for loss of generation while the vanes were being installed.

    d) The total direct cost for Iowa Vanes is of the order of $650,000 plus the cost of lost generation.

There are also unknown maintenance costs associated with possible deposition of large material among the vanes which would have to be installed in front of the powerhouse tailrace.

4.3.4 Recommended Alternative

We recommend that the PCWA implement the SPT operation and use the tailrace gates in combination with the existing tailrace training wall as the approach to managing the sediment problem at Ralston Powerhouse. It is our opinion that the existing training wall may very well deflect large material from in front of the tailrace gates. Furthermore, it is likely that the clamshell operation to remove deposits may not be significantly impeded even if there is larger material deposited in front of the tailrace gates. Therefore, the most logical and cost effective approach is to use the existing tailrace configuration and experience obtained from operation of the SPT and tailrace gates to determine if additional measures such as the deflector wall need to be considered.

4.4. EFFECTS OF SPT OPTION ON OXBOW POWERHOUSE INTAKE AREA

The discussion of the results of the HEC-6 analysis noted that the flow pattern and sediment deposition in front of the Oxbow intake was very difficult to predict using a one-dimensional model such as the HEC-6 model used in this investigation. This is because the flow near the Oxbow intake is really two or three-dimensional and is complicated by the presence of a sharp bend about 800 to 1000 feet upstream from the dam. We therefore evaluated the need for further analysis of this area, either with a 2-D computational model, or a physical model study.

Based on our evaluation, we do not believe that an analysis of the sediment deposition in the area of the Oxbow intake using a 2-D computer model or a physical hydraulic model is warranted at this time. We have reviewed the results of our HEC-6 analysis, and have looked at the general flow pattern in the intake area. Our conclusion is that the bend in the river promotes scour on the outside of the bend, right where the Oxbow Intake is located. Increasing the flow velocities through use of the SPT operation can only lead to more potential scour on the outside of the bend. Unless there is an overall aggradation of the sediment at the downstream end of the reservoir, this increase in scour potential implies that the intake should remain clear of sediment deposits. If there is a general aggradation of the sediment near the intake, the scour induced by the bend will tend to counteract it.

We do not believe that a general aggradation this close to the spillway and low-level sluice is likely if the SPT options is implemented. As a further precaution, we strongly recommend that the bypass for Oxbow Power house be operated during any SPT event where the Oxbow unit is shut down. For major floods, we believe that it will be necessary to shut the Oxbow turbine down because the concentration of suspended sediment will overwhelm the capacity of the cooling water strainers. It is our opinion that the operation of both the low-level sluice and the turbine by-pass valve for Oxbow will be sufficient to maintain operation of the Oxbow intake. Consequently, the SPT option, combined with operation of the Oxbow bypass valve, and the mechanics of the flow around the bend will keep the Oxbow Intake in service.

Should a general aggradation of the sediment in the lower reservoir occur, operating the Oxbow turbine and bypass during all SPT events should maintain a drawdown cone of sediment around the Oxbow Intake structure so that the powerhouse can remain in service once the reservoir is refilled after an SPT event. On the basis of this reasoning, we do not foresee that there will be adverse effects of operation with the SPT option that would result in putting Oxbow Powerhouse out of service. Since there are no adverse effects that can permanently interfere with the operation of the Oxbow Powerhouse, we conclude that a computational model or a physical model is not warranted at this time.

4.5 CONCLUSIONS

4.5.1 Guard Gate for the Low-Level Outlet Works

1. Installation of a guard gate for the low-level sluice is essential to implementation of the SPT operation using the existing 72-inch low-level outlet works. It is almost certain that there will be some debris problems with the existing upstream gate and grizzly during a major flood. Consequently, the installation of a gate on the downstream face of the dam to permit closure of the low-level outlet is mandatory for successful SPT operation.

2. A review of submittals from several gate and valve manufacturers shows that installation of a sluice gate on the downstream face of the dam is the most economical solution.

3. Valves are considerably more expensive than the sluice gate.

4.5.2 Management of Sediment at Ralston Powerhouse

The Placer County Water Agency has installed tailrace gates that will be used to close off the turbine pit at Ralston Powerhouse once the tailwater from floods on the Rubicon River exceed about El. 1180 and/or suspended sediment overloads the cooling water strainers and makes it impossible to operate the unit. The installation of these gates has led to consideration of several alternatives for managing the sediment problem at Ralston Powerhouse. Our conclusions are:

1. It is impossible to predict analytically whether flood flows will deposit material against the tailrace gates once they are closed.

2. The existing tailrace retaining wall may be sufficient to deflect large material during floods and prevent it from depositing against the tailrace gates.

3. If the existing tailrace retaining wall is not effective in keeping large material from deposition against the gates, a deflector wall located upstream from the powerhouse may be necessary.

4. The use of Iowa vanes as a means of controlling sediment deposition at Ralston Powerhouse does not appear to be a viable approach.

4.5.3 Effects of the SPT Operation on Oxbow Powerhouse Intake

The one-dimensional computer model used in this analysis is not capable of determining the effects of the two and three-dimensional flow along the outside of the bend at the Oxbow Powerhouse Intake. Consequently, consideration was given to what effect the SPT operation would have, and whether additional computational physical modeling would be required. Our conclusions are:

1. The use of a 2-D computational model or a physical hydraulic model is not warranted at this time.

2. The bypass valve at Oxbow Powerhouse must be operated if Oxbow Powerhouse is out of service during any SPT operation.

4.6 RECOMMENDATIONS

4.6.1 Sluice Gate for Low Level Outlet

The installation of the sluice gate for the low-level outlet is essential to implementation of the SPT operation. We therefore recommend that the PCWA proceed immediately with the final design, procurement and installation of this gate.

4.6.2 Sediment Management at Ralston Powerhouse.

There is an excellent chance that the existing tailrace training wall will be effective in keeping large material from depositing against the tailrace gates. We therefore recommend that no changes to the existing configuration of the tailrace and tailrace retaining wall be implemented until experience has been obtained with the SPT operation. The SPT operation should be implemented and the tailrace gates be closed whenever the tailwater exceeds El. 1180, and/or the sediment concentration overloads the cooling water strainers. Therefore, we do not recommend that the deflector wall, which was discussed in Section 4.3.2.2, be installed unless observations of sediment deposition in front of the tailrace gates indicates that it is necessary. The SPT operation should be implemented, and the deposition in front of the tailrace gates be observed with the existing tailrace retaining wall. If there are significant quantities of large material deposited in front of the gates that do cause difficulties in removal, then consideration should be given to installation of the deflector wall. If removal of material does not present undue difficulties, then we see no need for the deflector wall, and the existing configuration of the tailrace will be satisfactory.

4.6.3 Effects of SPT Operation on Oxbow Intake

It is not possible to predict quantitatively the pattern of sediment aggradation or degradation near the Oxbow Powerhouse Intake with the HEC-6 computer model used in our analysis because flow is complicated by the bend in the Rubicon River upstream from Ralston Afterbay Dam. However, we do not recommend that either two-dimensional computational model or a physical hydraulic model be conducted to investigate the effects of the SPT operation a the Oxbow Powerhouse Intake at this time because we believe that experience gained through the SPT operation is the best approach to determining what the effects are. Furthermore, we do not foresee adverse effects that will require shut-down of Oxbow Powerhouse because of SPT operations. A review of the possibilities indicates that operation of the powerhouse or the turbine bypass (if the unit has to be shut down) during an SPT event will be sufficient to maintain operation of the Oxbow Powerhouse Intake once the SPT operation has been completed and the reservoir has been refilled. We therefore recommend that Oxbow Powerhouse and bypass be operated during SPT operation to ensure that the intake can remain in service once the SPT operation has been completed.

5.0 References

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12. Yang, C. T., (1973) "Incipient Motion and Sediment Transport: J. of Hyd. Div., ASCE, Vol. 99, No. HY10, Oct., 1973, pp. 1679-1704.

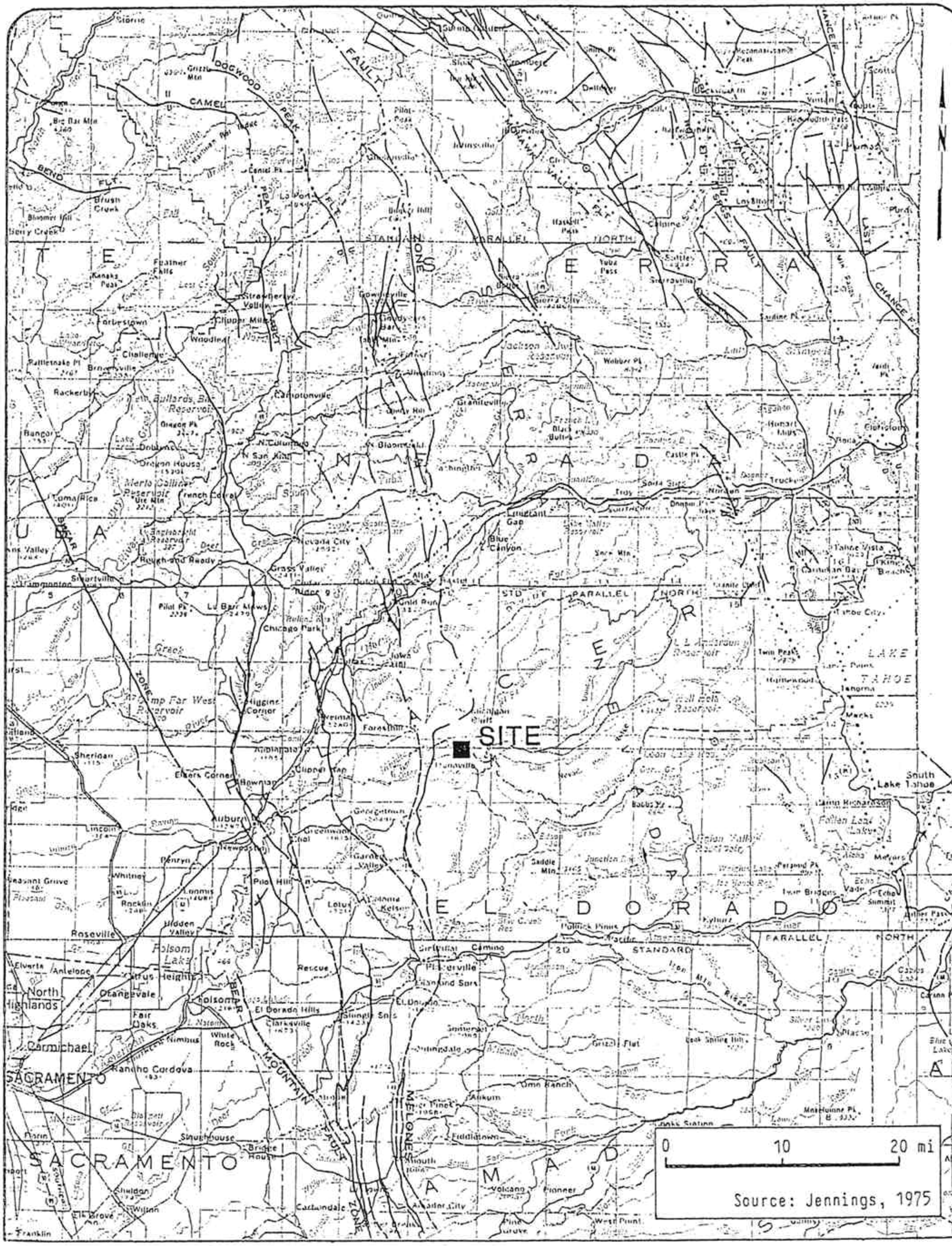
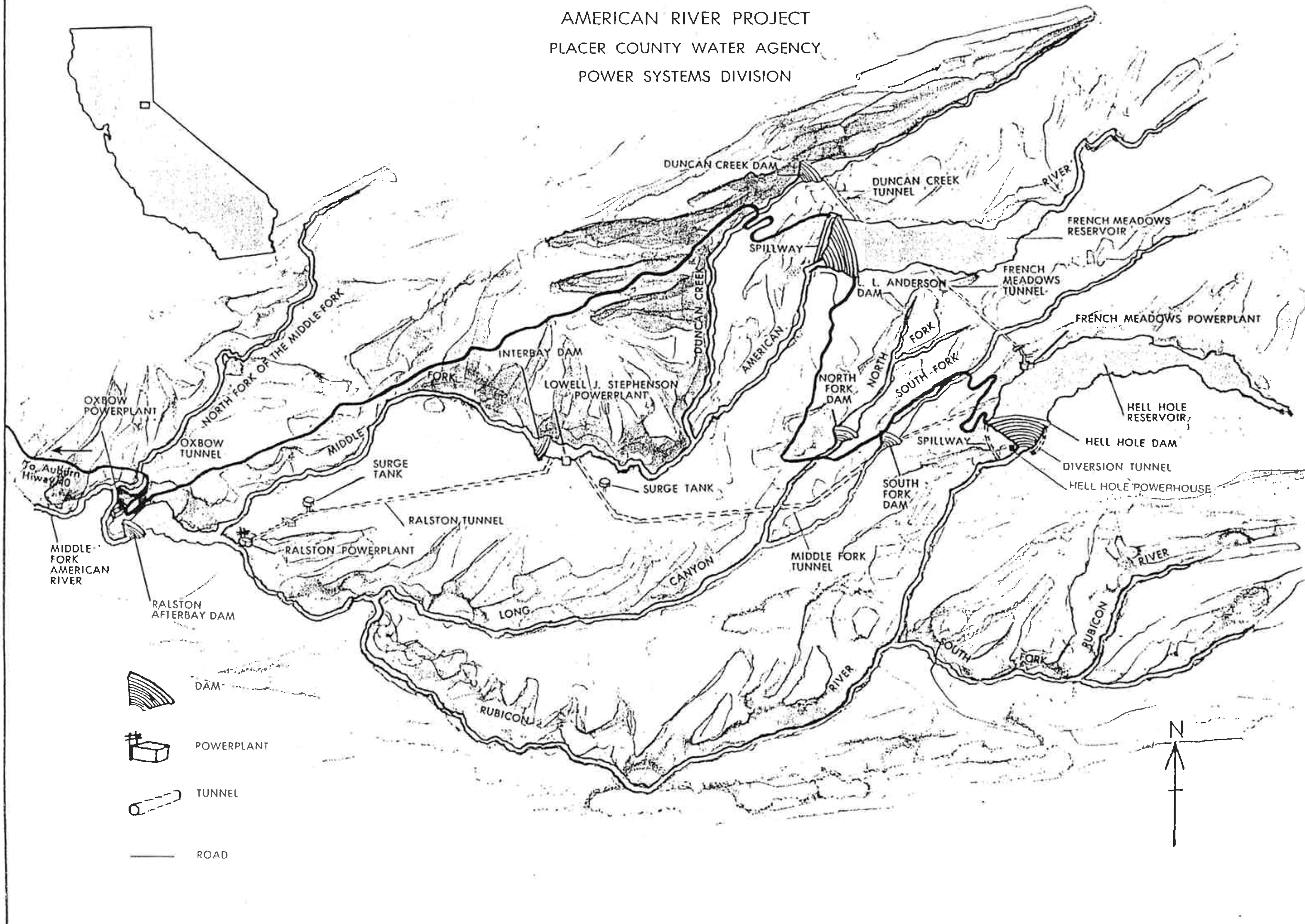


Figure 1: Site Location Map

Figure 2:

AMERICAN RIVER PROJECT
PLACER COUNTY WATER AGENCY
POWER SYSTEMS DIVISION



LEGEND

MANHOLE	○	PAVED ROAD		WATER		SMALL SIGN	
DRAIN INLET		CURB		MEDIAN BARRIER		MEDIUM SIGN	
FIRE HYDRANT		CONCRETE		MASONRY WALL		MARSH	
VALVE		DIRT ROAD		RETAINING WALL		PHOTO CENTER	
VAULT		LEVEE / DIKE		FENCE		HORIZ. VERT. CONTROL	△
POWER POLE		TREES		GUARDRAIL		HORIZONTAL CONTROL	△
GUY WIRE		GROUND COVER		ROCKS		VERTICAL CONTROL	○
ELECTROLIER						BENCHMARK	■

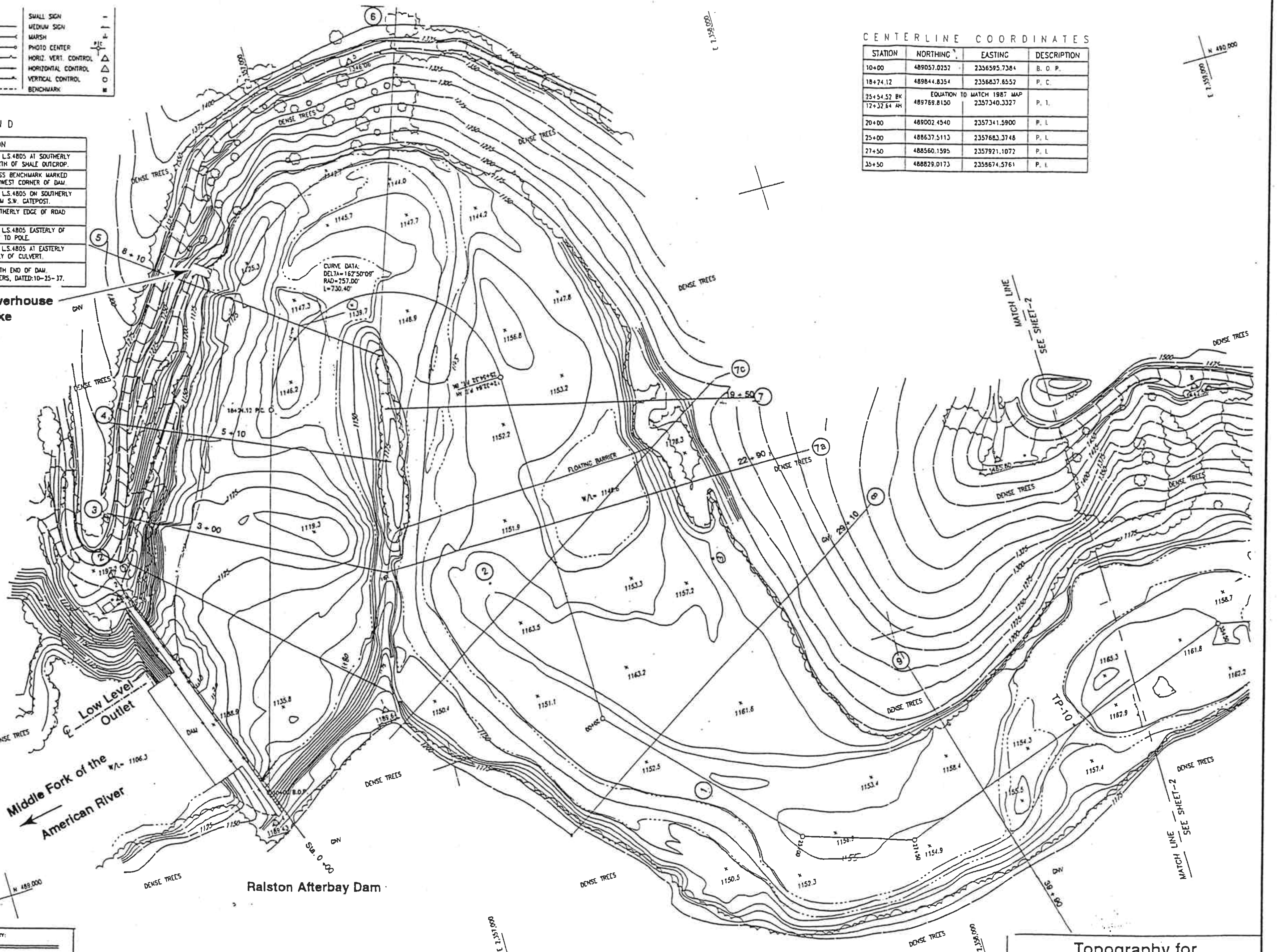
SURVEY CONTROL LEGEND

POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	489153.60	2356886.69	1189.64	3/8" REBAR WITH PLASTIC CAP L.S.4805 AT SOUTHERLY END OF HARD RIDGE, 20' NORTH OF SHALE OUTCROP.
2	489547.83	2356410.13	1189.38	BUREAU OF RECLAMATION BRASS BENCHMARK MARKED "OXBOW" TOP CURB AT NORTHWEST CORNER OF DAM.
4	488990.07	2356592.11	1189.43	3/8" REBAR WITH PLASTIC CAP L.S.4805 ON SOUTHERLY END OF DAM S40°W ±13' FROM S.W. GATEPOST.
5	490516.01	2357215.33	1346.06	P.K. NAIL AND SHINER IN SOUTHERLY EDGE OF ROAD S70°W ±60' FROM POLE.
6	489293.53	2358327.12	1485.80	3/8" REBAR WITH PLASTIC CAP L.S.4805 EASTERLY OF ROAD JUNCTION & S80°E ±56' TO POLE.
8	489326.36	2356772.51	1442.56	3/8" REBAR WITH PLASTIC CAP L.S.4805 AT EASTERLY EDGE OF TURNOUT & WESTERLY OF CULVERT.

ELEVATIONS BASED UPON USCGS DATUM TAKEN FROM BRASS CAP STAMPED "OXBOW" ON NORTH END OF DAM. COORDINATES ARE CALIFORNIA STATE PLANE, ZONE-2, FROM P.C.W.A. MAP BY HERMAN & PETERS, DATED:10-25-37.

CENTERLINE COORDINATES

STATION	NORTHING	EASTING	DESCRIPTION
10+00	489057.0252	2356595.7384	B. O. P.
18+74.12	489844.8354	2356837.6557	P. C.
25+54.52 BK / 12+32.64 AH	EQUATION TO MATCH 1987 MAP 489769.8150	2357340.3327	P. I.
20+00	489002.4540	2357341.5900	P. I.
25+00	488637.5113	2357683.3748	P. I.
27+50	488560.1595	2357921.1072	P. I.
35+50	488829.0173	2358674.5761	P. I.



1" = 100' scale 100 0 100 200 feet

REVISION NOTES:

△ *TOPOGRAPHY SHOWN BELOW THE 10/3/95 WATER LEVEL WAS OBTAINED BY TAKING RANDOM DEPTH MEASUREMENTS FROM A BOAT WHILE BEING TIED TO THE HORIZONTAL CONTROL USING A SOKKIA (SET-3B) TOTAL STATION ON SHORE.*

AERIAL PHOTOGRAPHY & CONTOURS BY: GEONEX, 3979 FREEPORT BLVD. SACRAMENTO, CA 95822, TEL (916) 421-3465 FAX (916) 427-9631

JOB NO. 73560	PHOTO NO. 95189
SCALE 1" = 100' 5' C.I.	PHOTO DATE 10/3/95

GROUND CONTROL, CALCULATIONS, & DRAWINGS BY:

S. & E. ENGINEERING CO.

P. O. BOX 126, NEVADA CITY, CALIFORNIA 95959
PHONE: (916) 272-7886 FAX: (916) 272-7888

Ralston Afterbay Reservoir
Middle Fork American River

Topography for Sediment Studies

Job Number	Drawing No.	Rev.
20282	FIGURE 3 (Sheet 1)	0

LEGEND

MANHOLE	○					SMALL SIGN	
DRAIN INLET		PAVED ROAD		WATER		MEDIUM SIGN	
FIRE HYDRANT		CURB		MEDIAN BARRIER		MARSH	
VALVE		CONCRETE		MASONRY WALL		PHOTO CENTER	
VAULT		DIRT ROAD		RETAINING WALL		HORIZ. VERT. CONTROL	
POWER POLE		LEVEE / DIKE		FENCE		HORIZONTAL CONTROL	△
GUY WIRE		TREES		GUARDRAIL		VERTICAL CONTROL	○
ELECTROLIER		GROUND COVER		ROCKS		BENCHMARK	

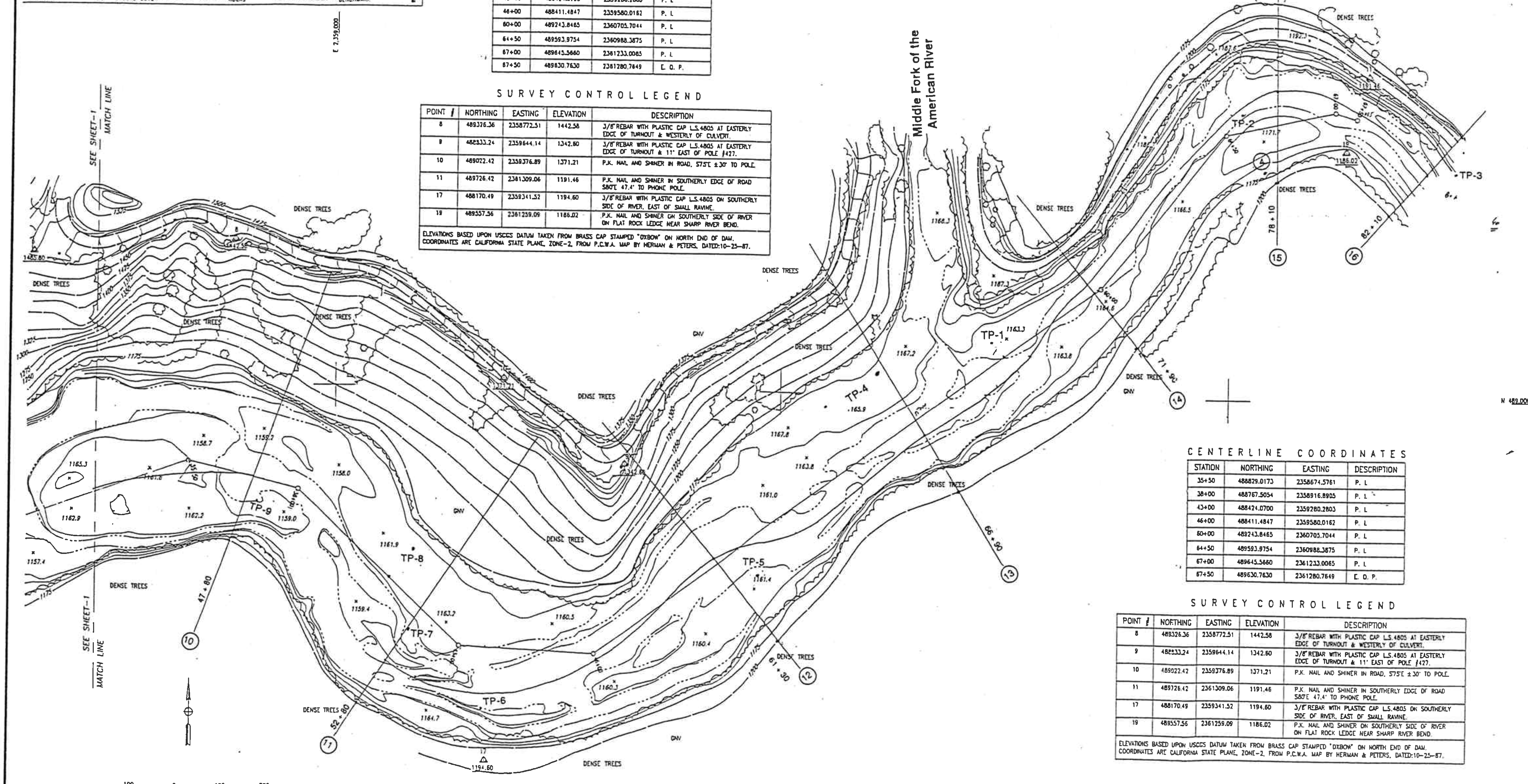
CENTERLINE COORDINATES

STATION	NORTHING	EASTING	DESCRIPTION
35+50	488829.0173	2358674.5761	P. L
38+00	488767.5054	2358916.8905	P. L
43+00	488424.0700	2359280.2803	P. L
46+00	488411.4847	2359580.0162	P. L
60+00	489243.8465	2360705.7044	P. L
64+50	489593.9754	2360988.3875	P. L
67+00	489645.5660	2361233.0065	P. L
67+50	489630.7630	2361280.7649	E. O. P.

SURVEY CONTROL LEGEND

POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
8	489376.36	2358772.51	1442.58	3/8" REBAR WITH PLASTIC CAP L.S.4805 AT EASTERLY EDGE OF TURNOUT & WESTERLY OF CULVERT.
9	488333.24	2359644.14	1342.60	3/8" REBAR WITH PLASTIC CAP L.S.4805 AT EASTERLY EDGE OF TURNOUT & 11' EAST OF POLE #427.
10	489022.42	2359376.89	1371.21	P.K. NAIL AND SHINER IN ROAD, S75E ±30' TO POLE
11	489726.42	2361309.06	1191.46	P.K. NAIL AND SHINER IN SOUTHERLY EDGE OF ROAD S80E 47.4' TO PHONE POLE
17	488170.49	2359341.52	1194.60	3/8" REBAR WITH PLASTIC CAP L.S.4805 ON SOUTHERLY SIDE OF RIVER, EAST OF SMALL RAVINE.
19	489557.56	2361259.09	1186.02	P.K. NAIL AND SHINER ON SOUTHERLY SIDE OF RIVER ON FLAT ROCK LEDGE NEAR SHARP RIVER BEND.

ELEVATIONS BASED UPON USCGS DATUM TAKEN FROM BRASS CAP STAMPED "OXBOW" ON NORTH END OF DAM.
COORDINATES ARE CALIFORNIA STATE PLANE, ZONE-2, FROM P.C.W.A. MAP BY HERMAN & PETERS, DATED:10-25-87.



CENTERLINE COORDINATES

STATION	NORTHING	EASTING	DESCRIPTION
35+50	488829.0173	2358674.5761	P. L
38+00	488767.5054	2358916.8905	P. L
43+00	488424.0700	2359280.2803	P. L
46+00	488411.4847	2359580.0162	P. L
60+00	489243.8465	2360705.7044	P. L
64+50	489593.9754	2360988.3875	P. L
67+00	489645.5660	2361233.0065	P. L
67+50	489630.7630	2361280.7649	E. O. P.

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10	489022.42	2359376.89	1371.21	P.K. NAIL AND SHINER IN ROAD, S75E ±30' TO POLE
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COORDINATES ARE CALIFORNIA STATE PLANE, ZONE-2, FROM P.C.W.A. MAP BY HERMAN & PETERS, DATED:10-25-87.

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JOB NO.	73560	PHOTO NO.	95189
SCALE	1"=100' 5' C.I.	PHOTO DATE	10/3/95

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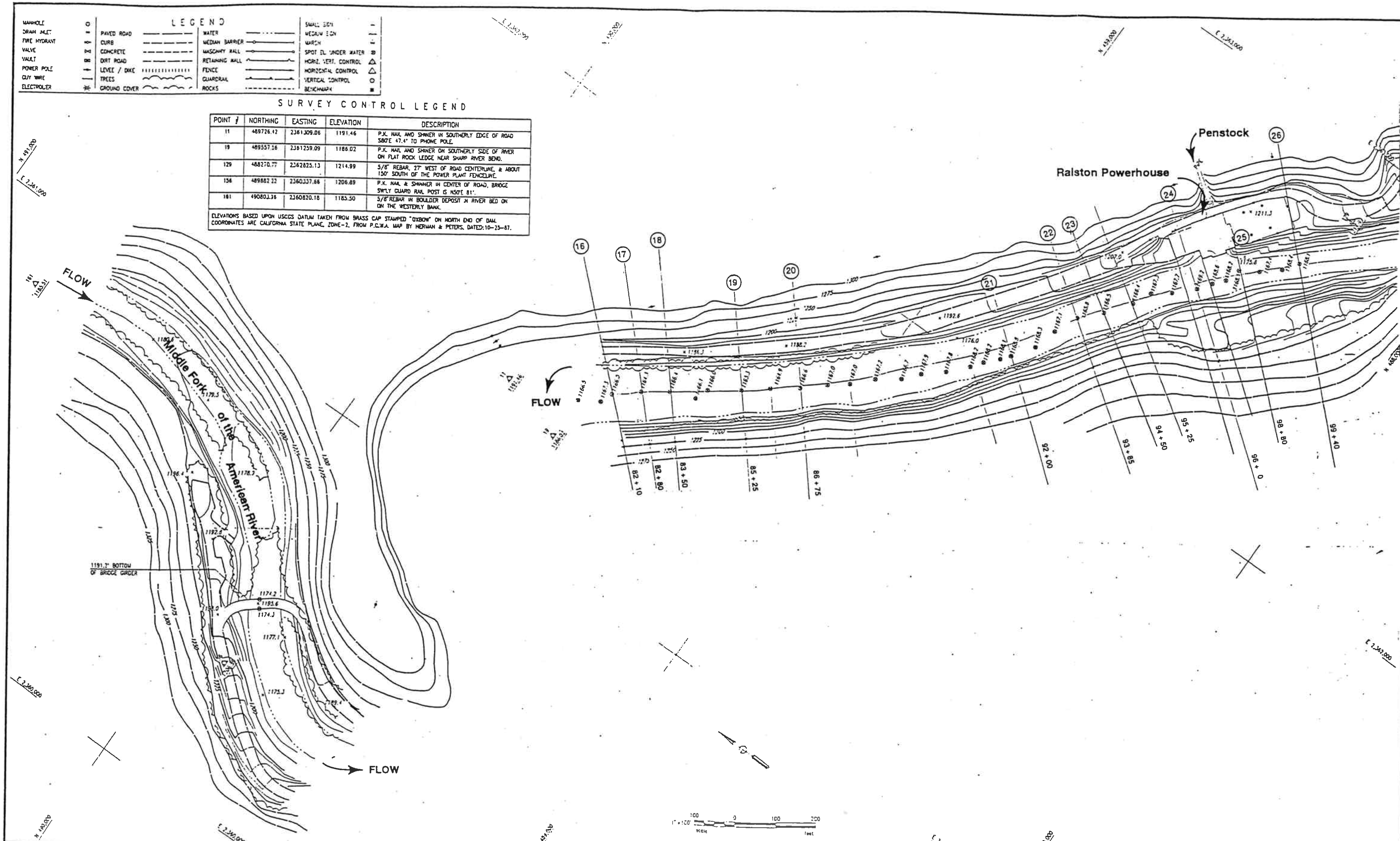
Ralston Afterbay Reservoir
Middle Fork American River

Topography for Sediment Studies

Job Number	Drawing No.	Rev.
20282	FIGURE 3 (Sheet 2)	0



SURVEY CONTROL LEGEND

POINT #	NORTHING	EASTING	ELEVATION	DESCRIPTION
11	489726.12	2361309.06	1191.46	P.K. NAIL AND SHINER IN SOUTHERLY EDGE OF ROAD S80°E 47.4' TO PHONE POLE.
19	489557.56	2361259.09	1186.02	P.K. NAIL AND SHINER ON SOUTHERLY SIDE OF RIVER ON FLAT ROCK LEDGE NEAR SHARP RIVER BEND.
129	488270.77	2362825.13	1214.99	5/8" REBAR, 27' WEST OF ROAD CENTERLINE, & ABOUT 150' SOUTH OF THE POWER PLANT FENCELINE.
156	489882.22	2360337.66	1206.89	P.K. NAIL & SHINNER IN CENTER OF ROAD, BRIDGE SW'LY GUARD RAIL POST IS N50°E 81'.
181	490803.36	2360820.18	1185.50	5/8" REBAR IN BOULDER DEPOSIT IN RIVER BED ON ON THE WESTERLY BANK.

ELEVATIONS BASED UPON USCGS DATUM TAKEN FROM BRASS CAP STAMPED "OXBOW" ON NORTH END OF DAM. COORDINATES ARE CALIFORNIA STATE PLANE, ZONE-2, FROM P.C.W.A. MAP BY HERMAN & PETERS, DATED: 10-23-87.

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JOB NO. 73560	PHOTO NO. 95189
SCALE 1"=100' 5' C.I.	PHOTO DATE 10/3/95

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Ralston Afterbay Reservoir
Middle Fork American River

Topography for Sediment Studies

Job Number	Drawing No.	Rev.
20282	FIGURE 3 (Sheet 3)	0

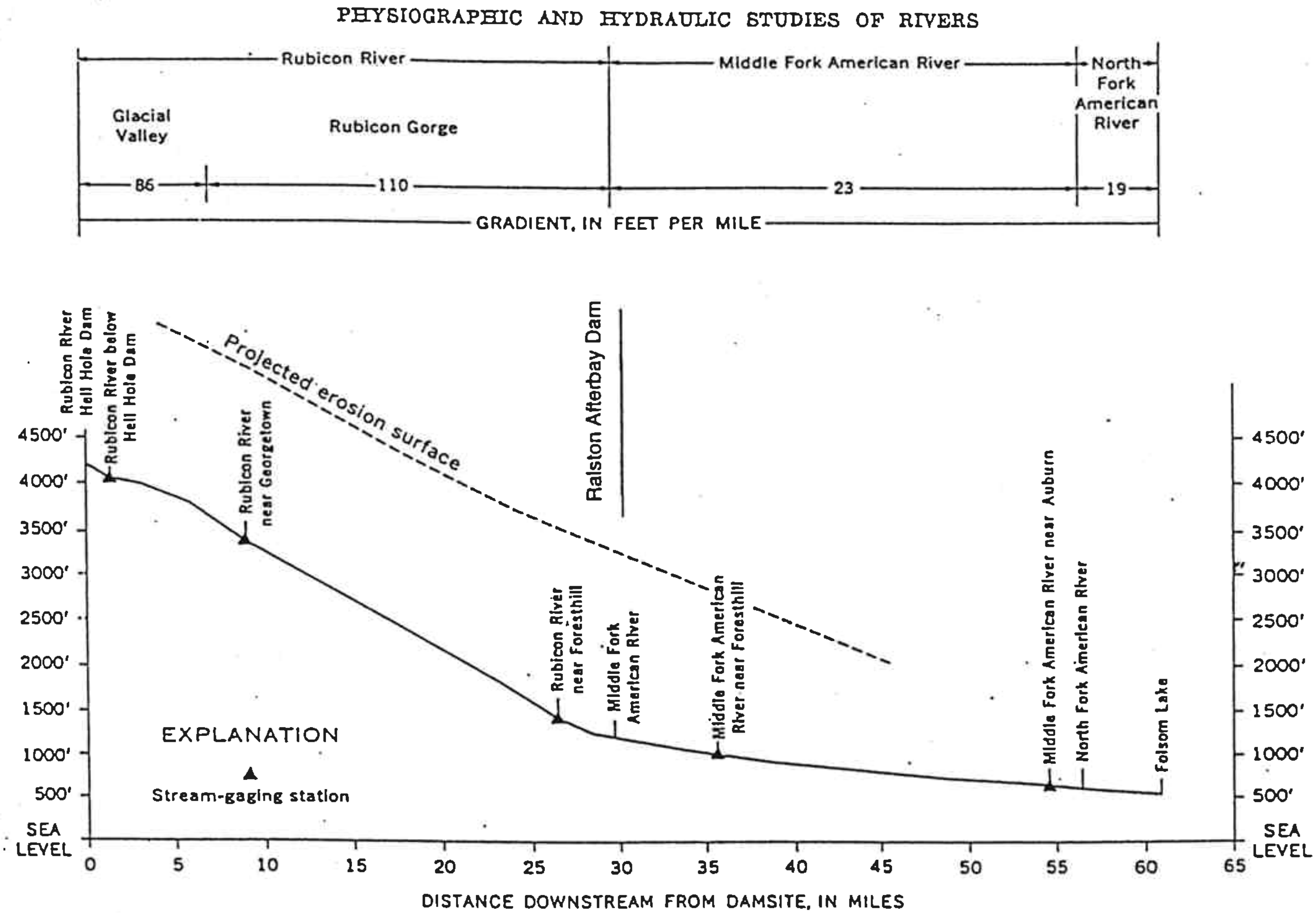


Figure 4a Longitudinal Profile of the Flood Route , from Scott and Gravlee (1968)

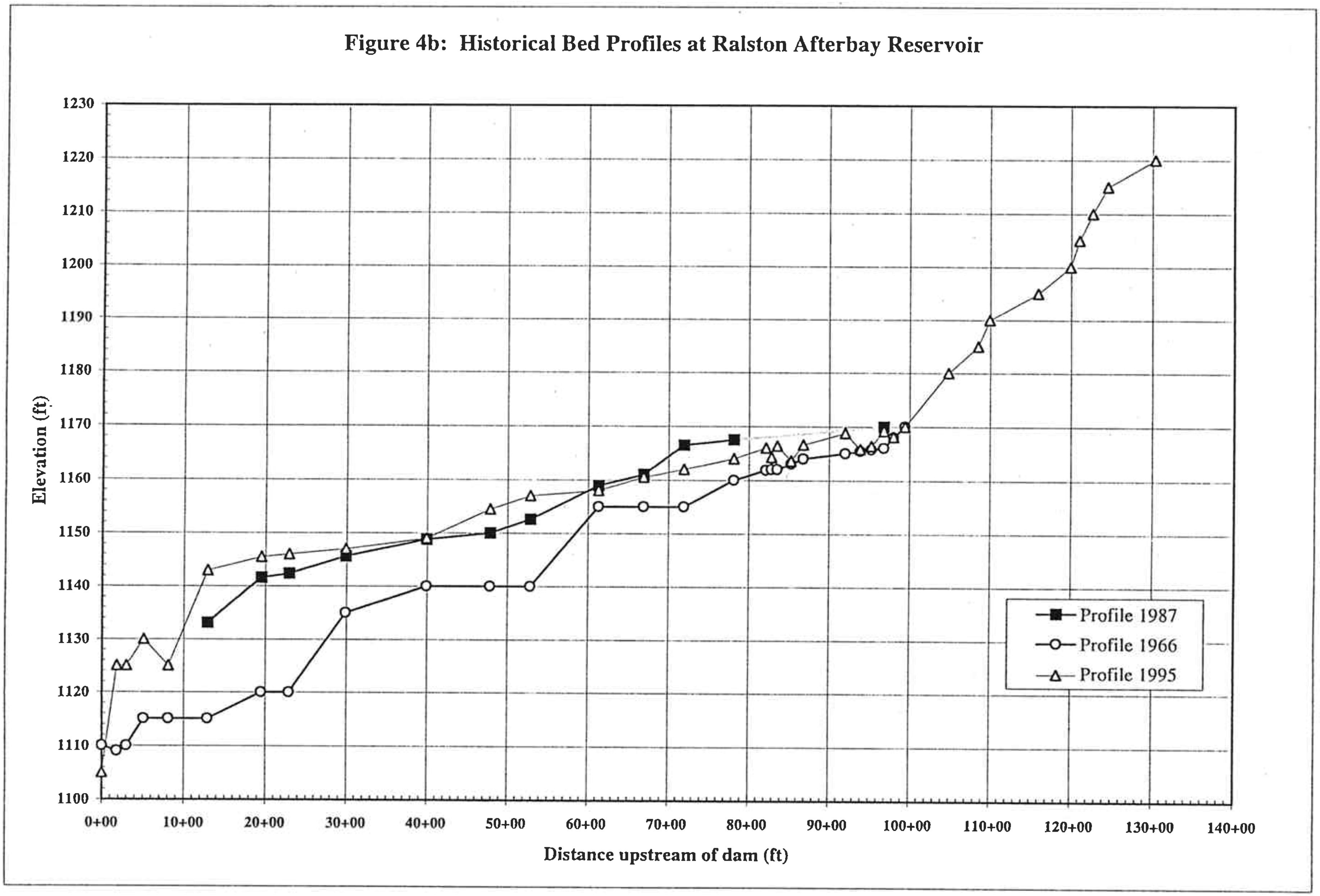
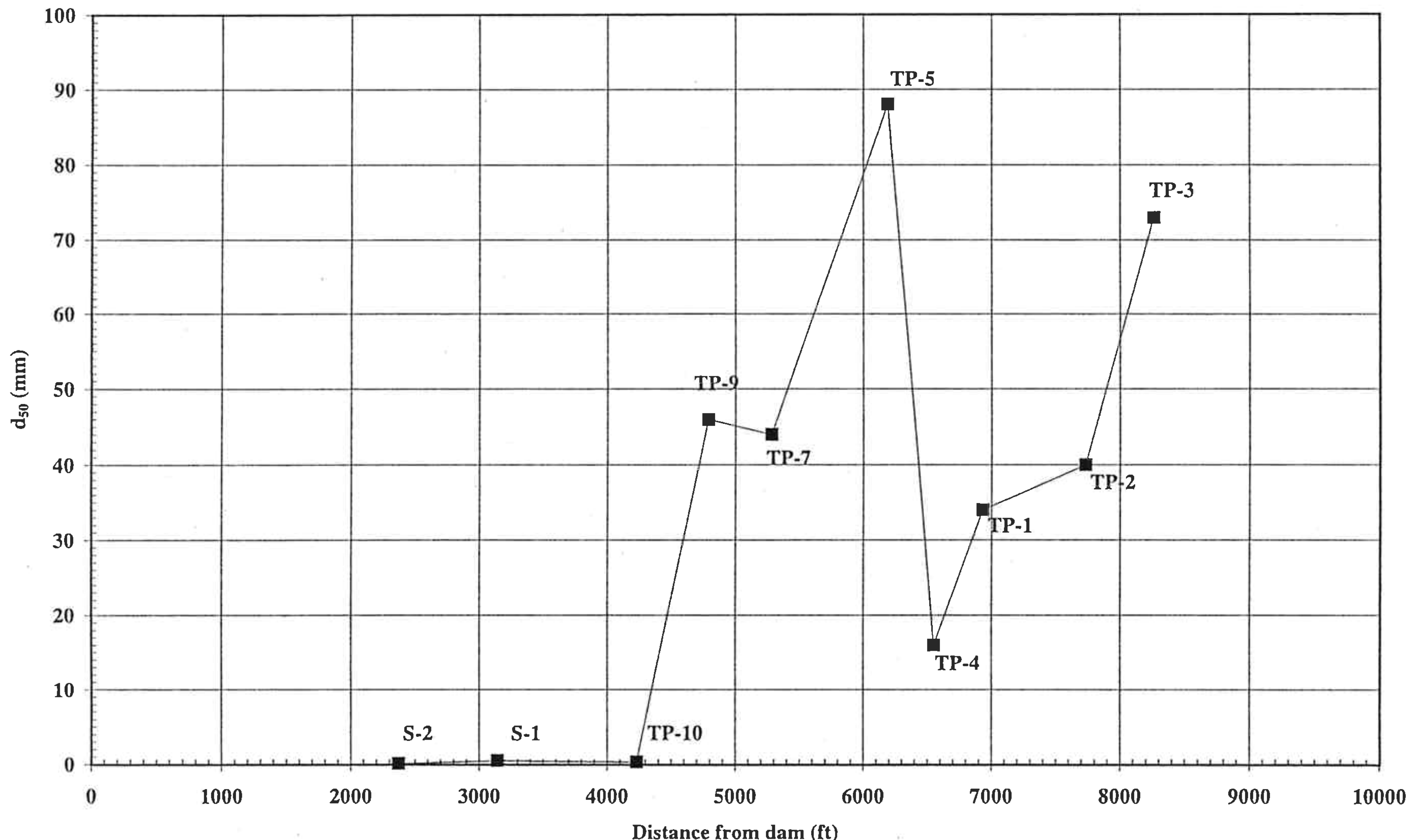


Figure 4b: Historical Bed Profiles at Ralston Afterbay Reservoir
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
Elevation (ft)
0+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00
Distance upstream of dam (ft)
Profile 1987
Profile 1966
Profile 1995

Figure 5: Distribution of Bed Material (d_{50})



Note: Data obtained from Alpha Geotechnical Consultants, Inc. (1988).

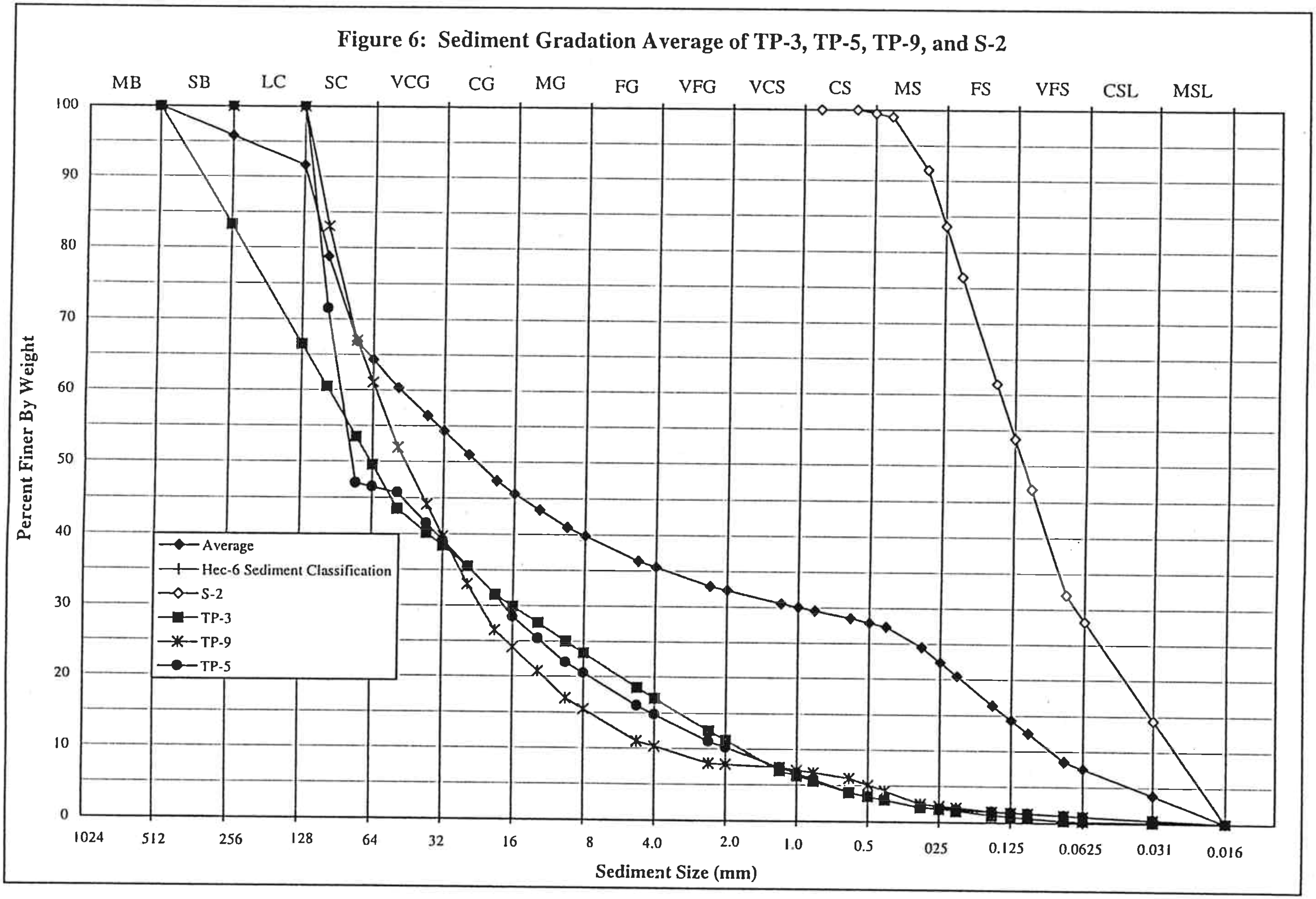


Figure 6: Sediment Gradation Average of TP-3, TP-5, TP-9, and S-2
MB
SB
LC
SC
VCG
CG
MG
FG
VFG
VCS
CS
MS
FS
VFS
CSL
MSL
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
Average
Hec-6 Sediment Classification
S-2
TP-3
TP-9
TP-5
1024
512
256
128
64
32
16
8
4.0
2.0
1.0
0.5
025
0.125
0.0625
0.031
0.016
Sediment Size (mm)

Figure 7: Placer County Sediment Study - Bechtel's Data

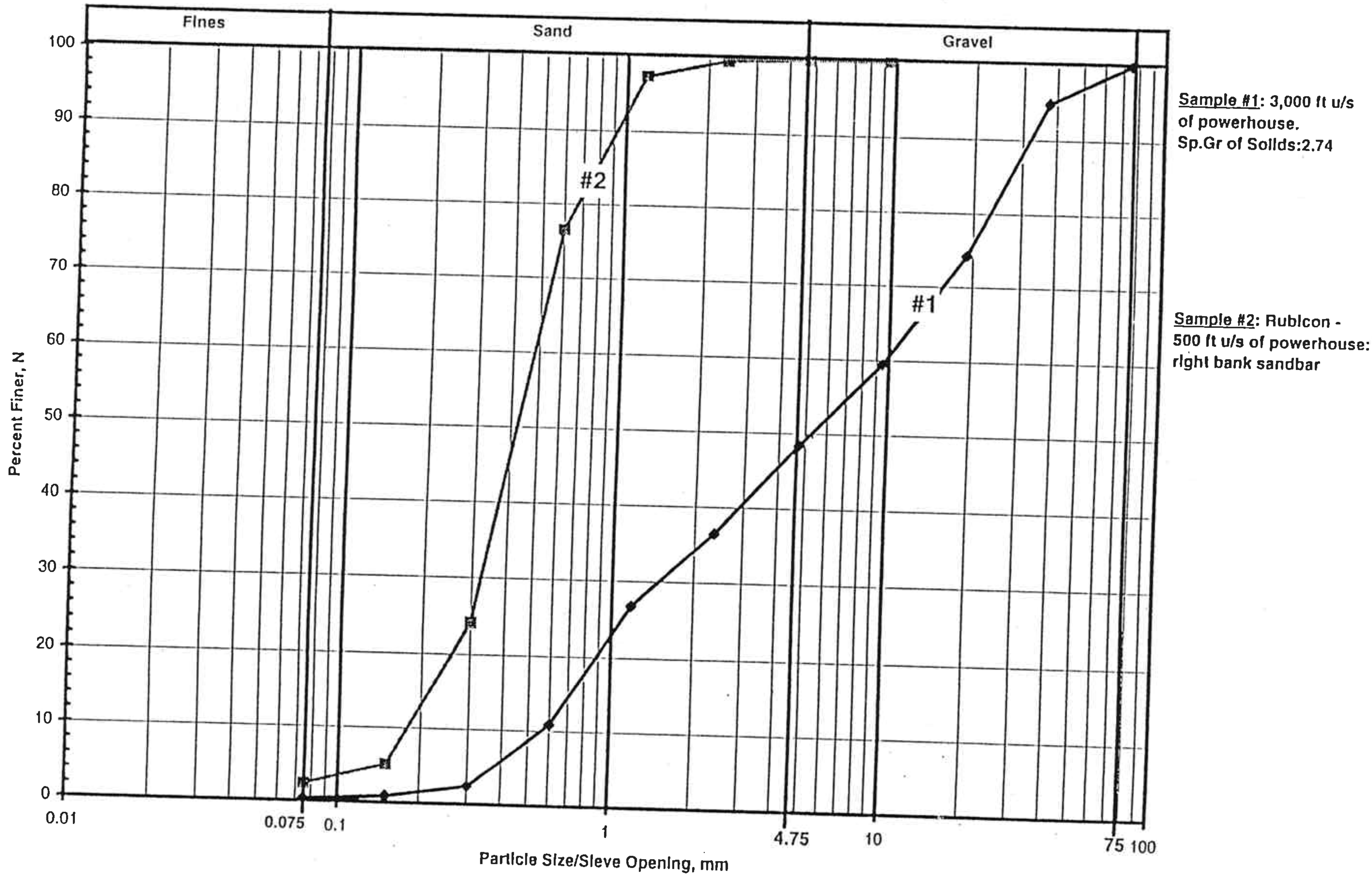


Figure 8: Daily Inflow Histogram and Reservoir Operation for Ralston Afterbay Reservoir

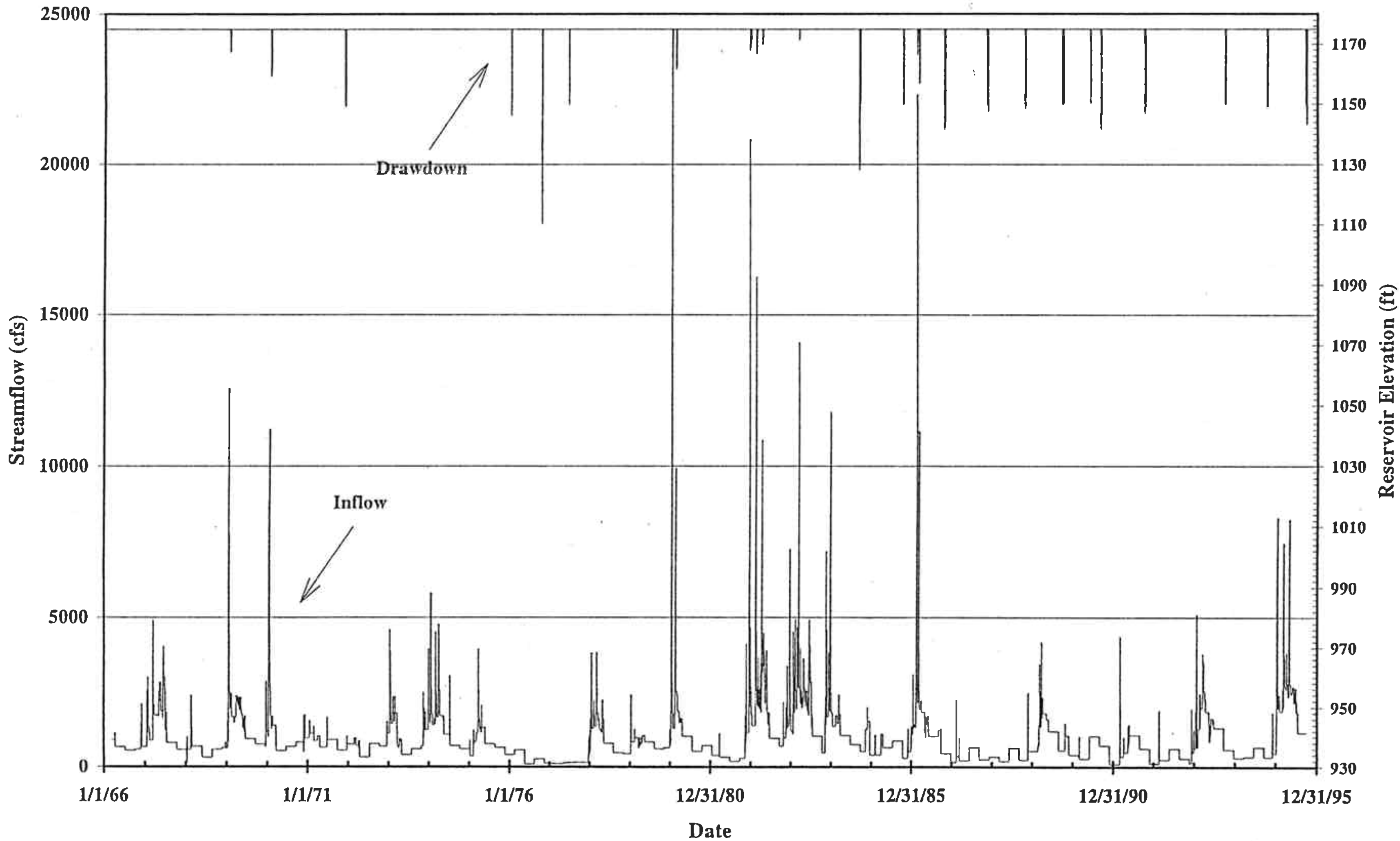


Figure 9: Ralston Afterbay Reservoir

1966-1987 Calibration Run - Total Sediment Deposition = 58,000 yd³/yr

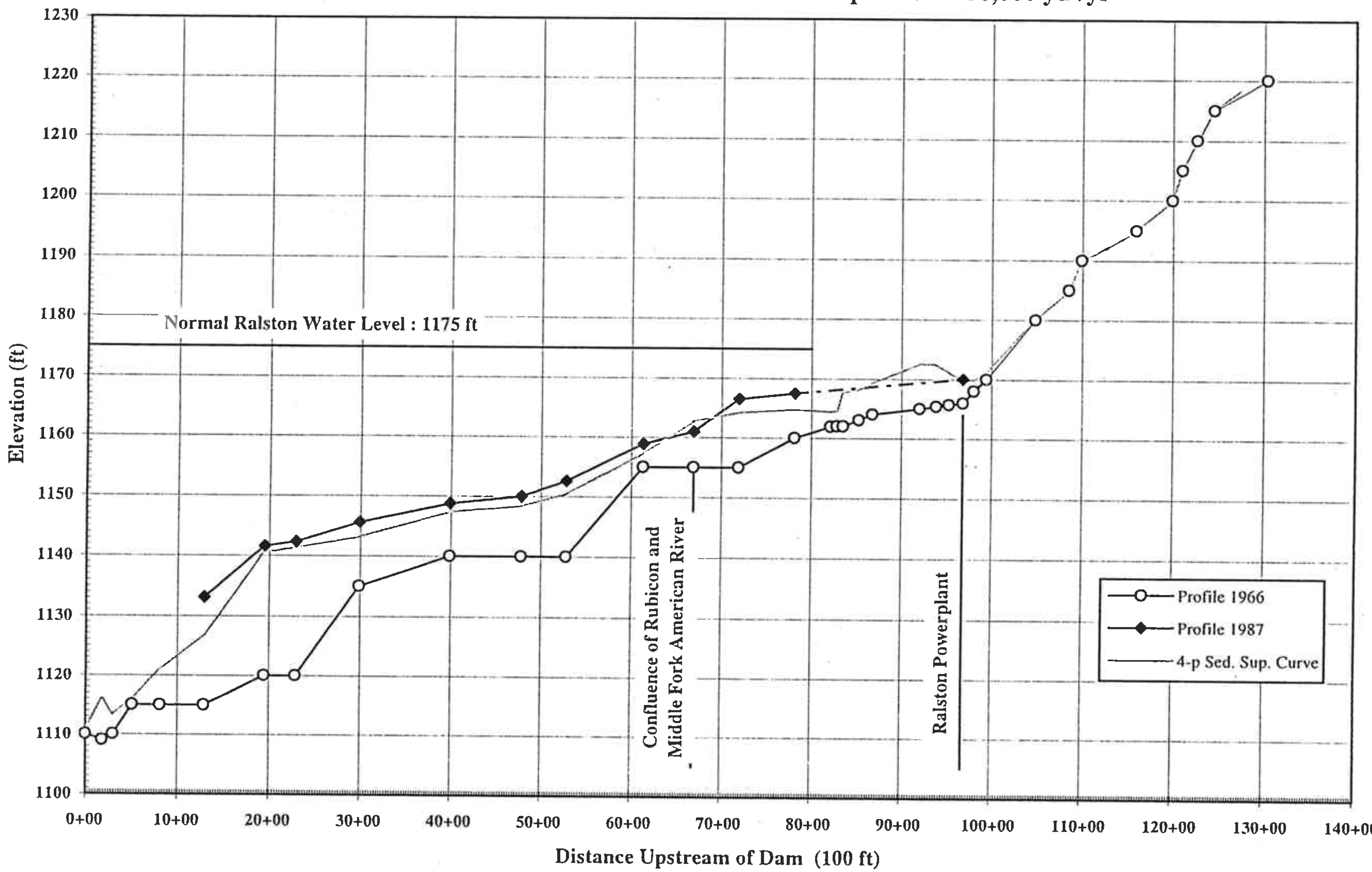


Figure 10: Ralston Afterbay Reservoir

1987-1995 Verification Run - Total Sediment Deposition = 55,800 yd^3/yr

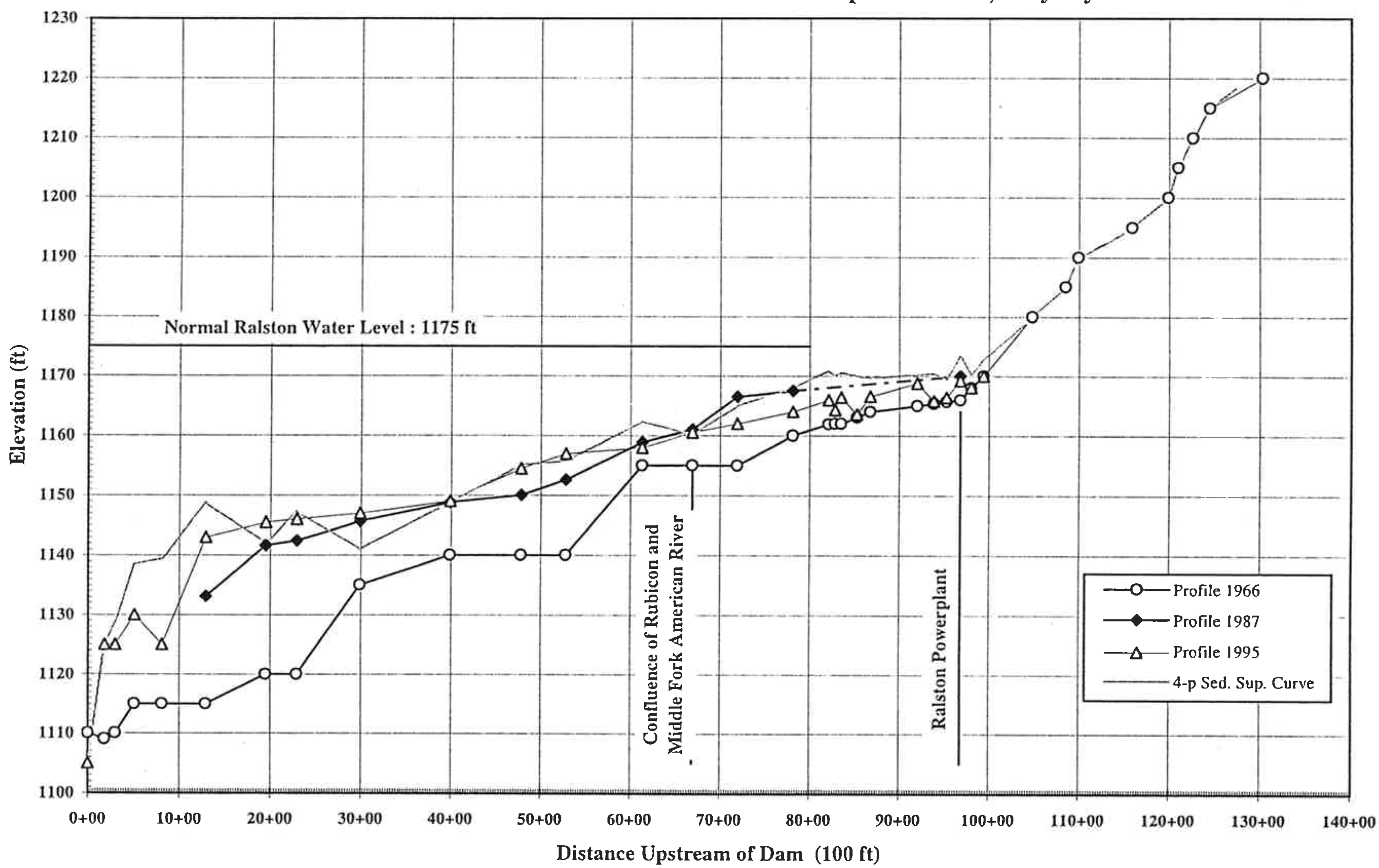
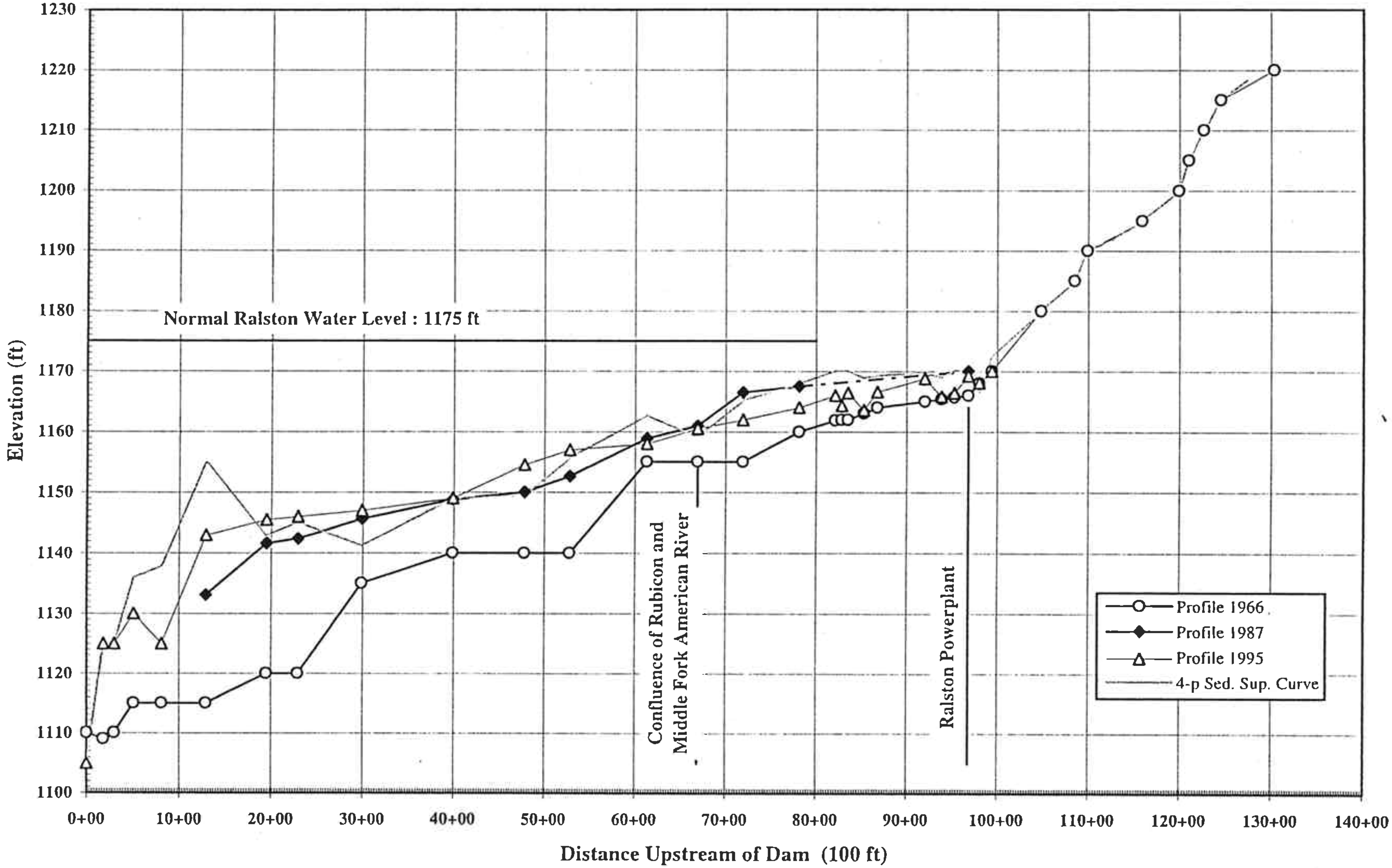


Figure 11: Ralston Afterbay Reservoir

1987-1995 Verification Run - Total Sediment Deposition = 45,000 yd^3/yr



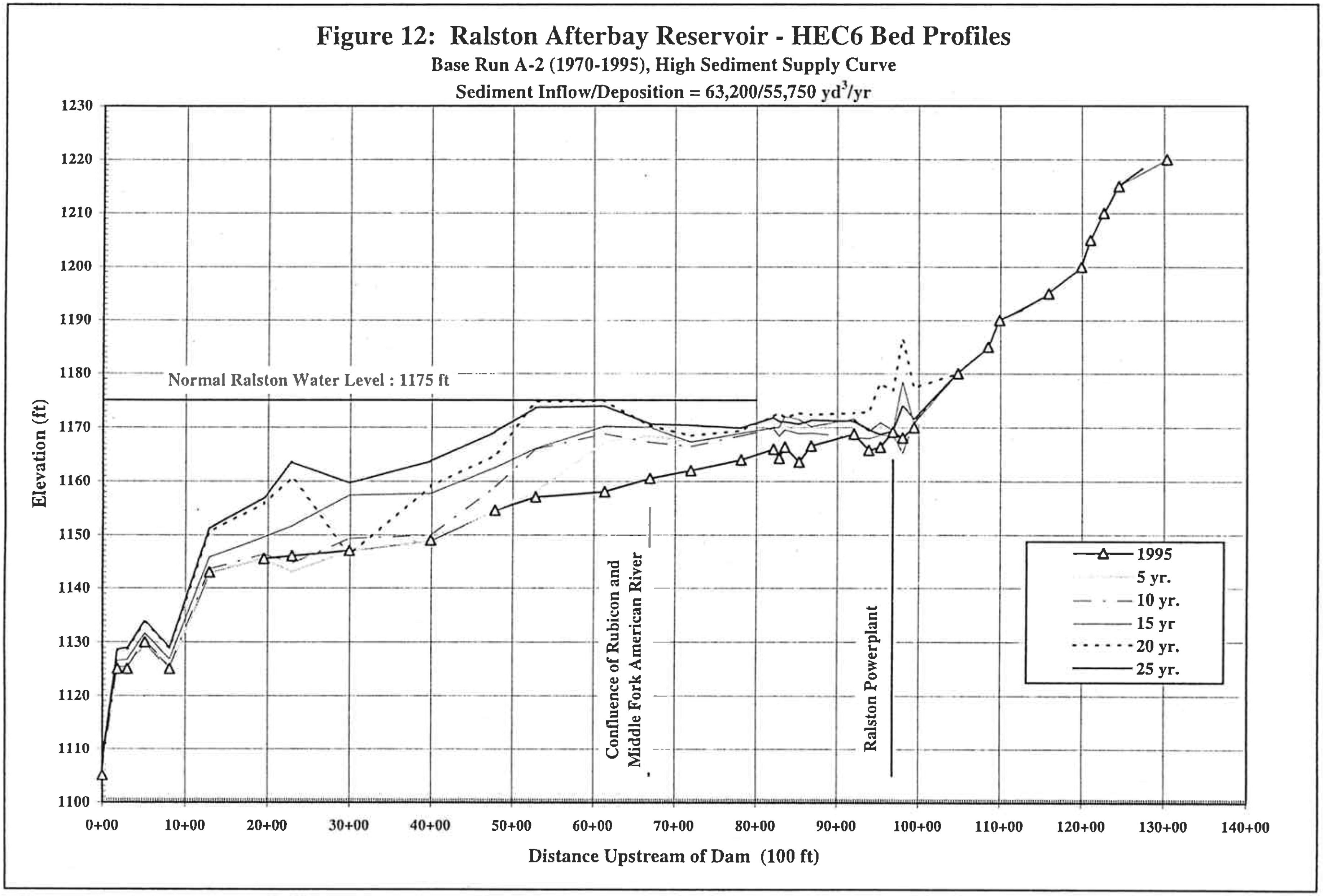


Figure 12: Ralston Afterbay Reservoir - HEC6 Bed Profiles
Base Run A-2 (1970-1995), High Sediment Supply Curve
Sediment Inflow/Deposition = 63,200/55,750 yd³/yr
Normal Ralston Water Level : 1175 ft
Confluence of Rubicon and Middle Fork American River
Ralston Powerplant
1995
5 yr.
10 yr.
15 yr
20 yr.
25 yr.
Elevation (ft)
Distance Upstream of Dam (100 ft)
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
0+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00

Figure 13: Ralston Afterbay Reservoir - HEC6 Bed Profiles

Run D-1a (1970-1995), High Sediment Supply, Drawdown Initialization Discharge = 8000cfs, With Sluice

Sediment Inflow / Deposition = 63,300 / 27,000 yd^3/yr

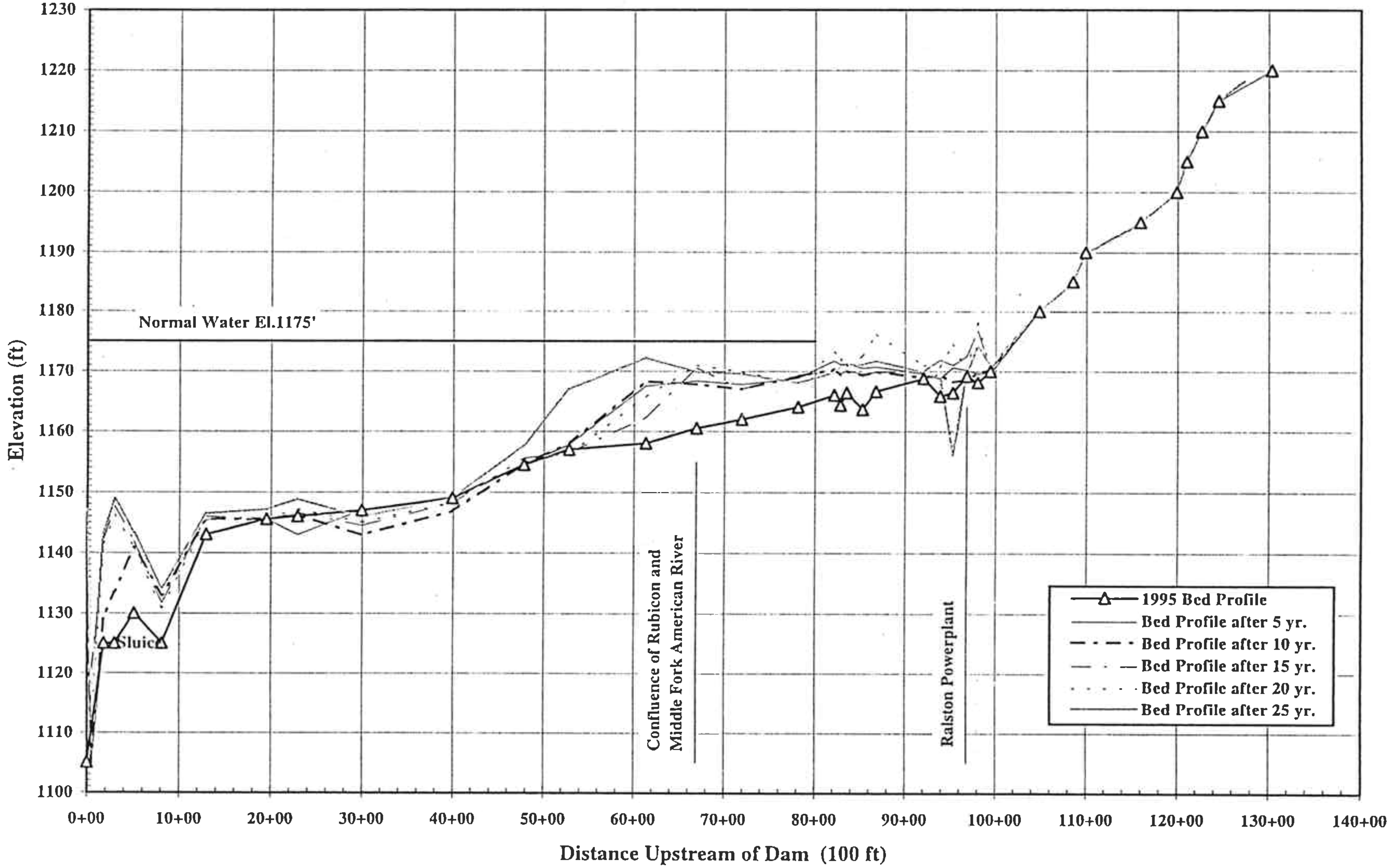


Figure 15: Ralston Afterbay Reservoir - Sediment Study - HEC6 Bed Profiles

Run E-1a (1970-1995), High Sediment Supply, Drawdown Initialization Discharge = 3500cfs, With D=6' Sluice

Sediment Inflow / Deposition = 63,300 / 17,300 yd^3/yr

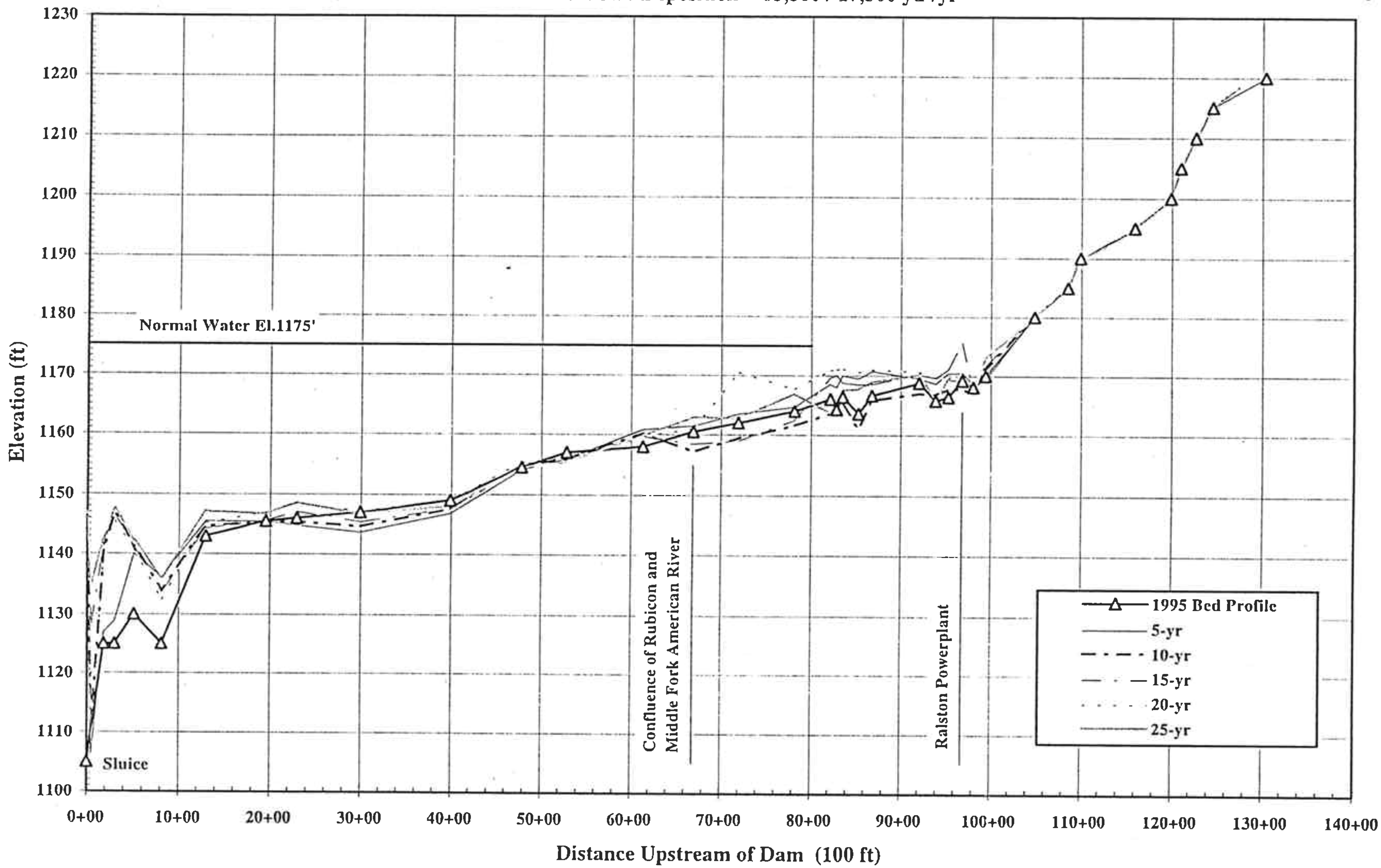


Figure 16: Ralston Afterbay Reservoir - Sediment Study - HEC6 Bed Profiles

Run C-1a (1970-1995), High Sediment Supply, Drawdown Initialization Discharge = 2000cfs, With D=6' Sluice

Sediment Inflow/Deposition = 63,300/11,200 yd³/yr

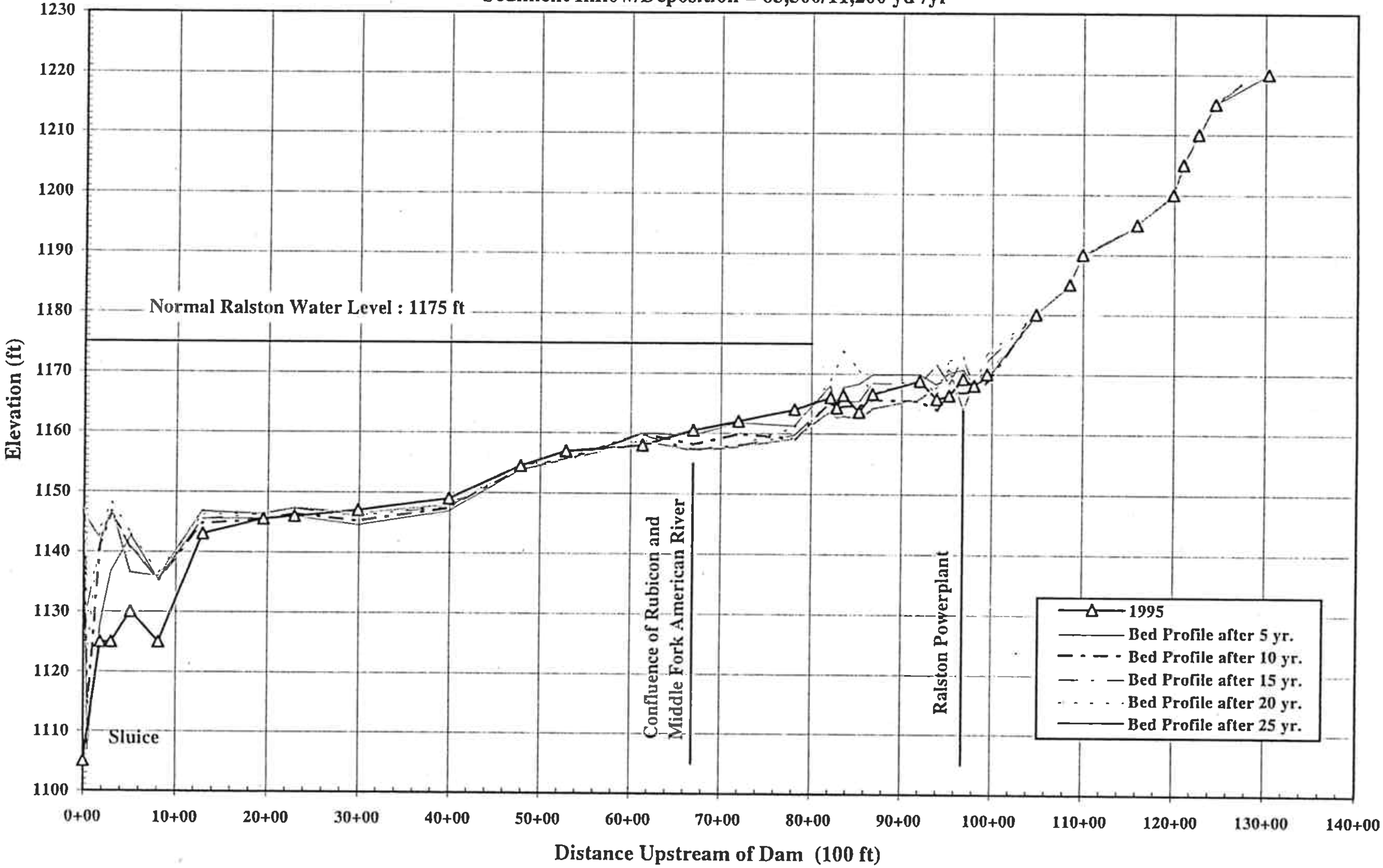


Figure 17: Ralston Afterbay Reservoir - Sediment Study - HEC6 Bed Profiles

Run E-1b (1970-1995), High Sediment Supply, Drawdown Initialization Discharge = 3500cfs, With D=9' Sluice

Sediment Inflow / Deposition = 63,300 / 17,700 yd^3/yr

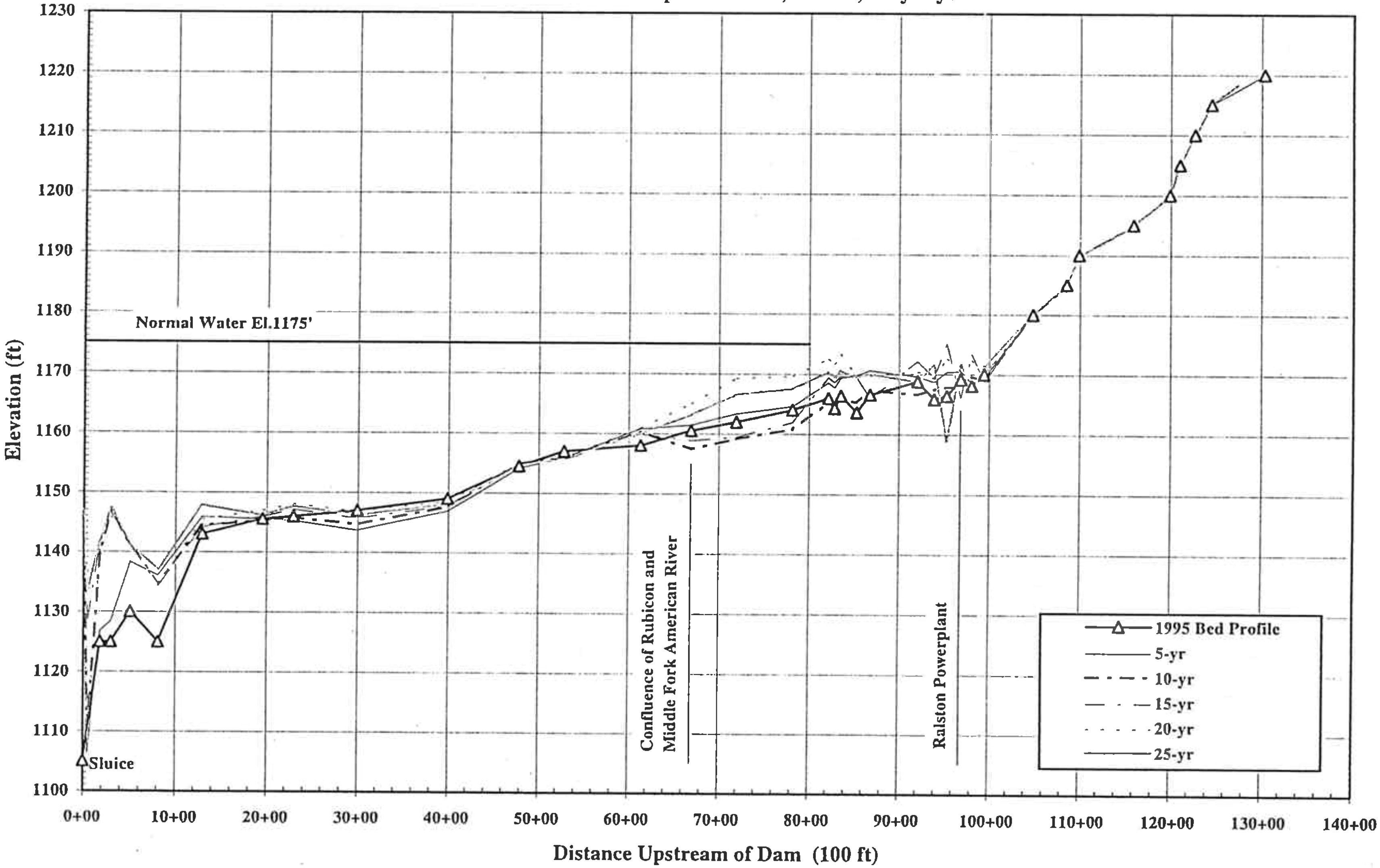


Figure 14: Ralston Afterbay Reservoir - Sediment Study - HEC6 Bed Profile

Run B-1a (1970-1995), High Sediment Supply, Drawdown Initialization Discharge = 5000cfs, With D=6' Sluice

Sediment Inflow/Deposition = 63,300/18,500 yd^3/yr

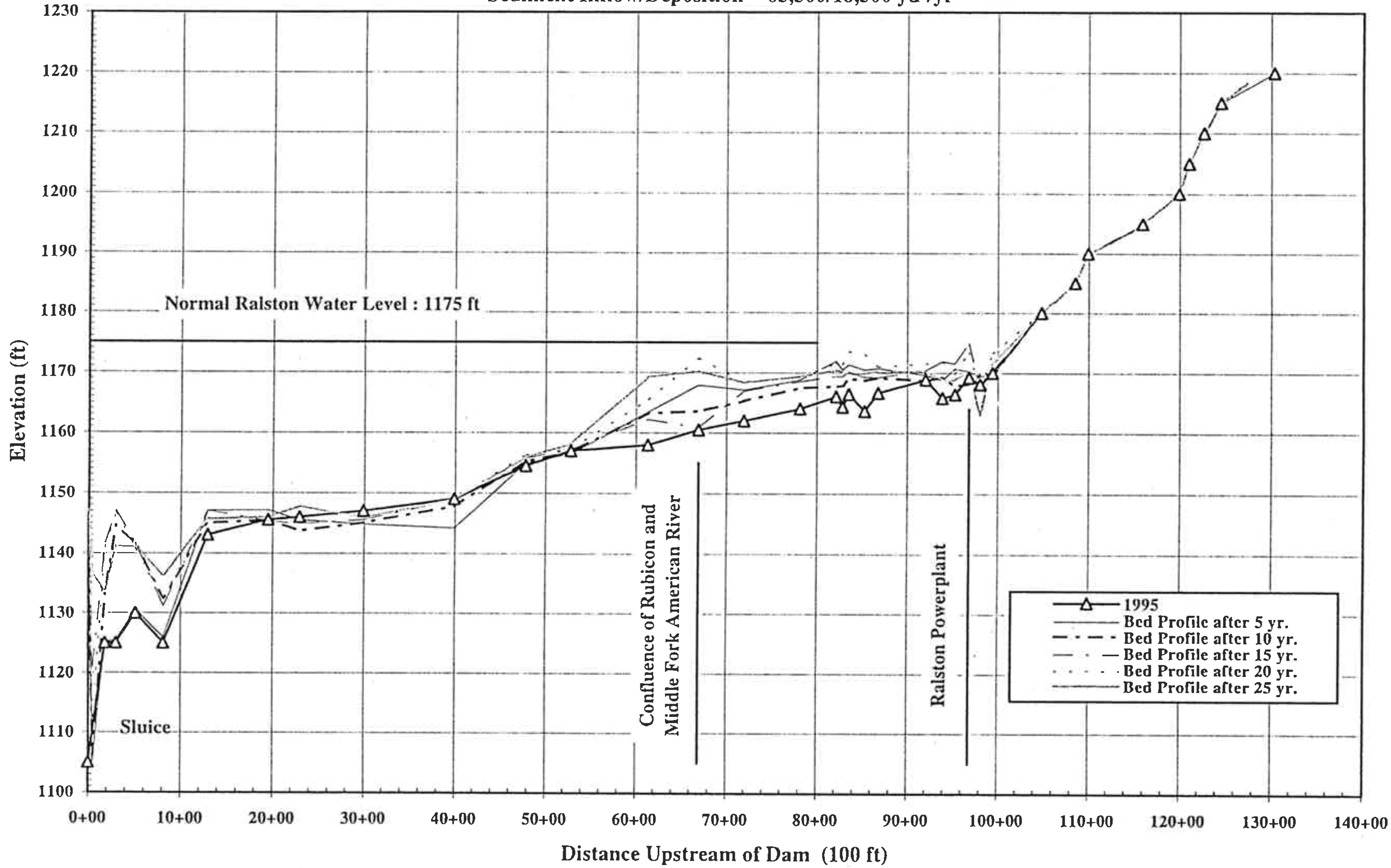
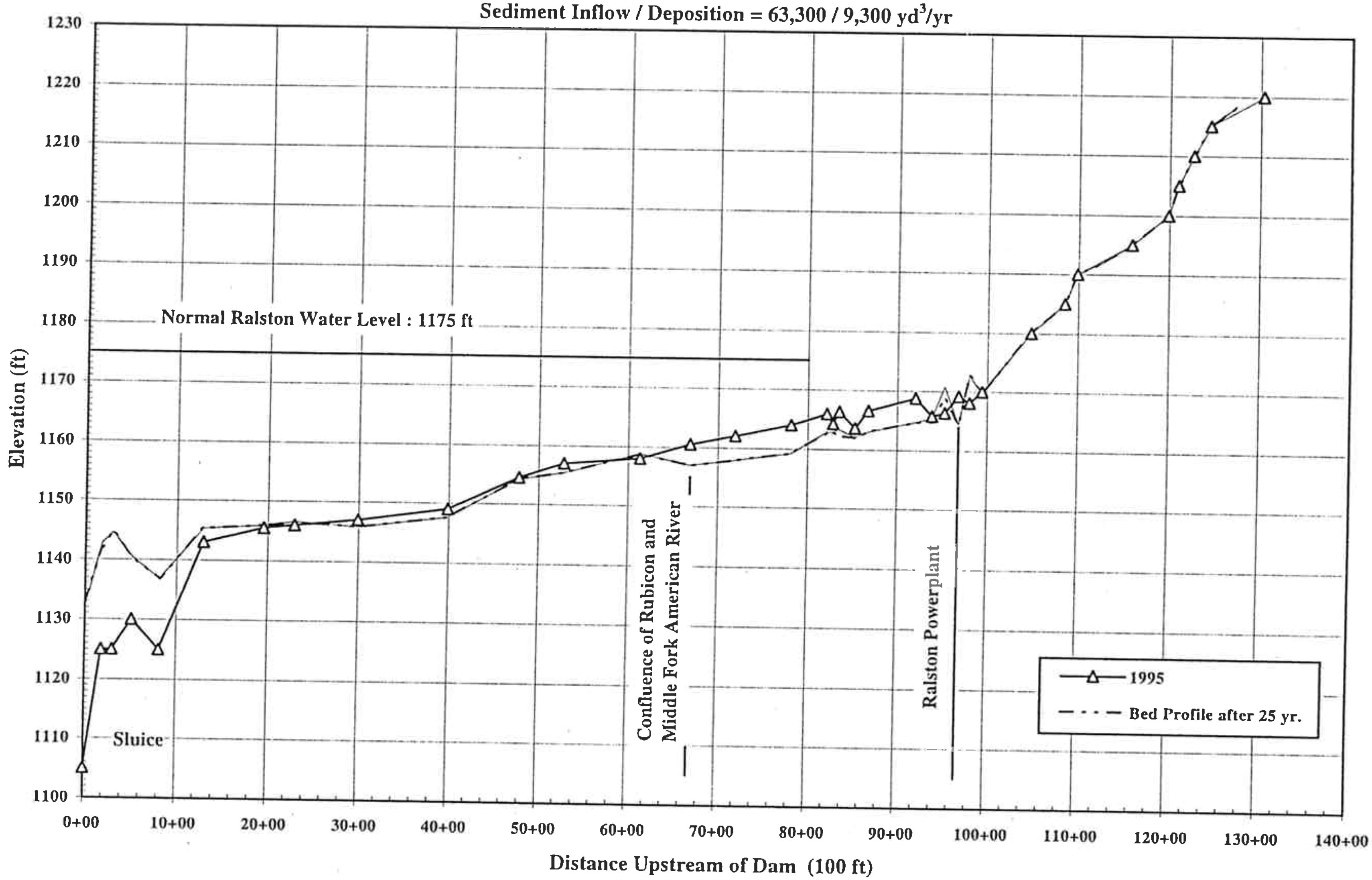


Figure 18: Ralston Afterbay Reservoir - Sediment Study - HEC6 Bed Profile

Run F-1a (1970-1995), High Sediment Supply, Drawdown Initialization Discharge = 2000cfs, With D=9' Sluice

Sediment Inflow / Deposition = 63,300 / 9,300 yd^3/yr



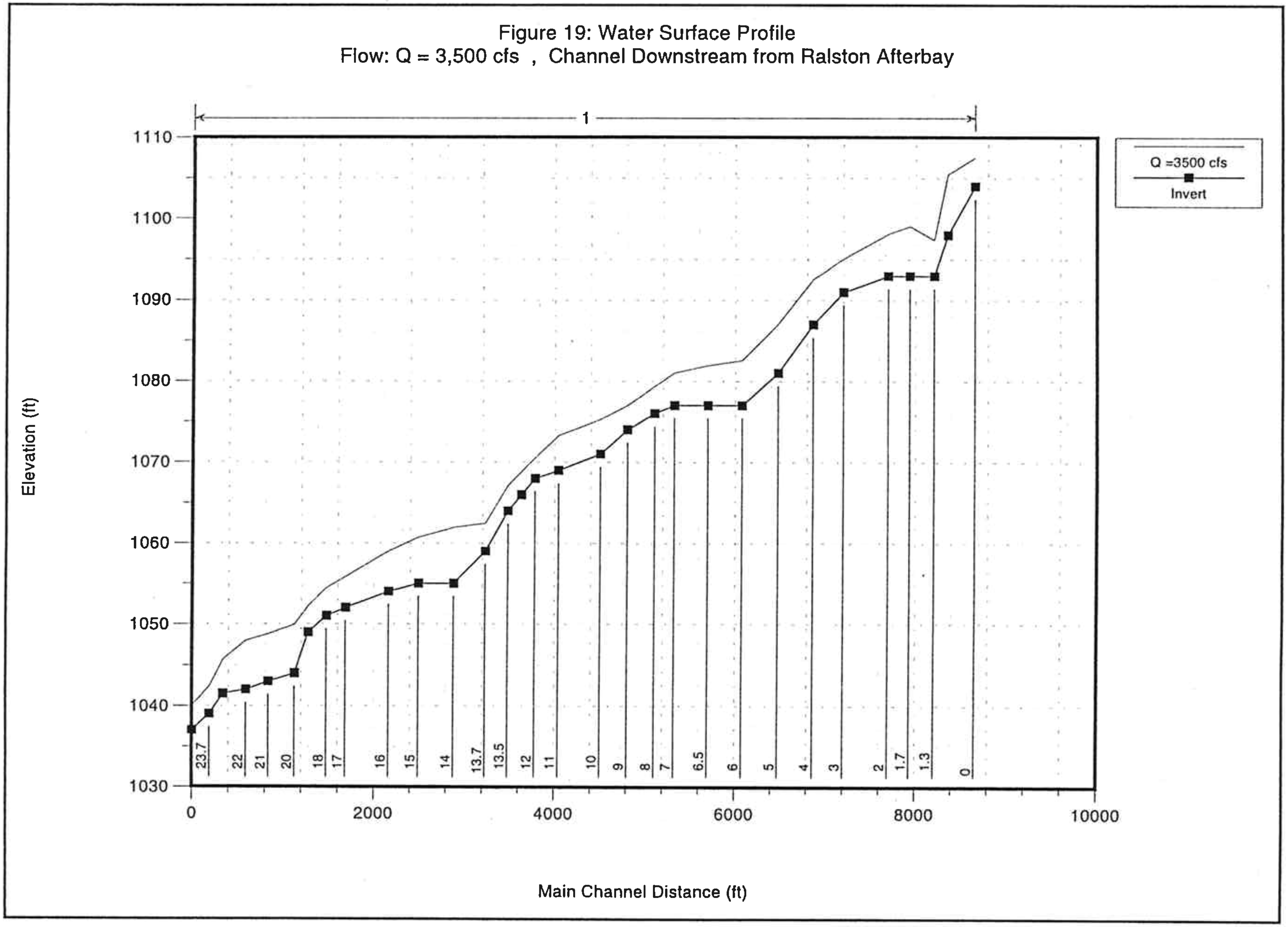
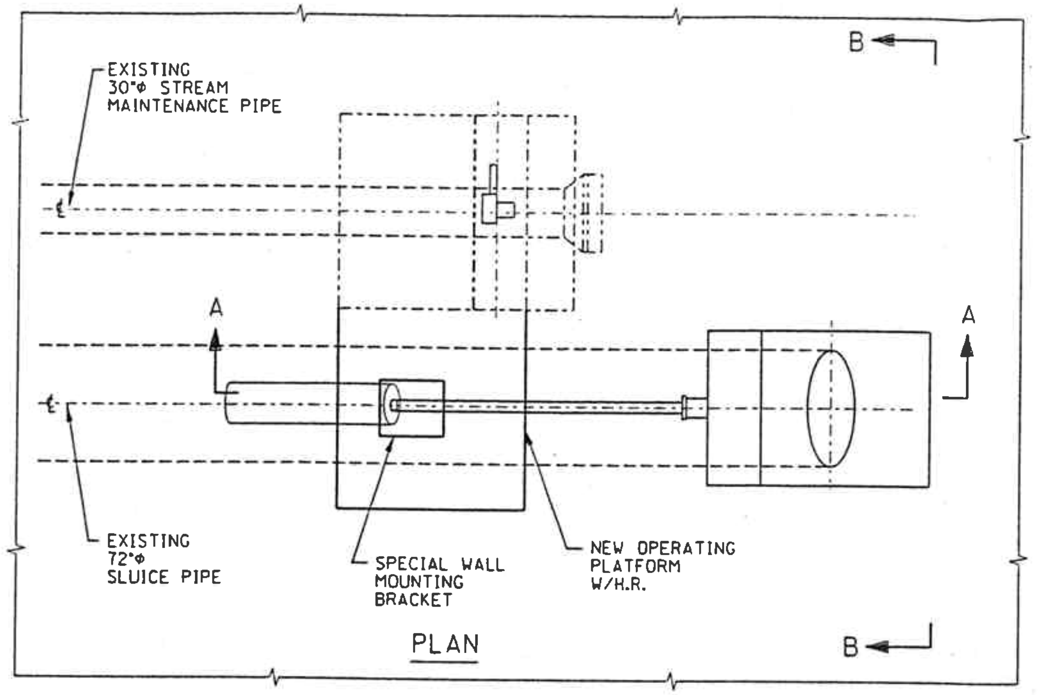
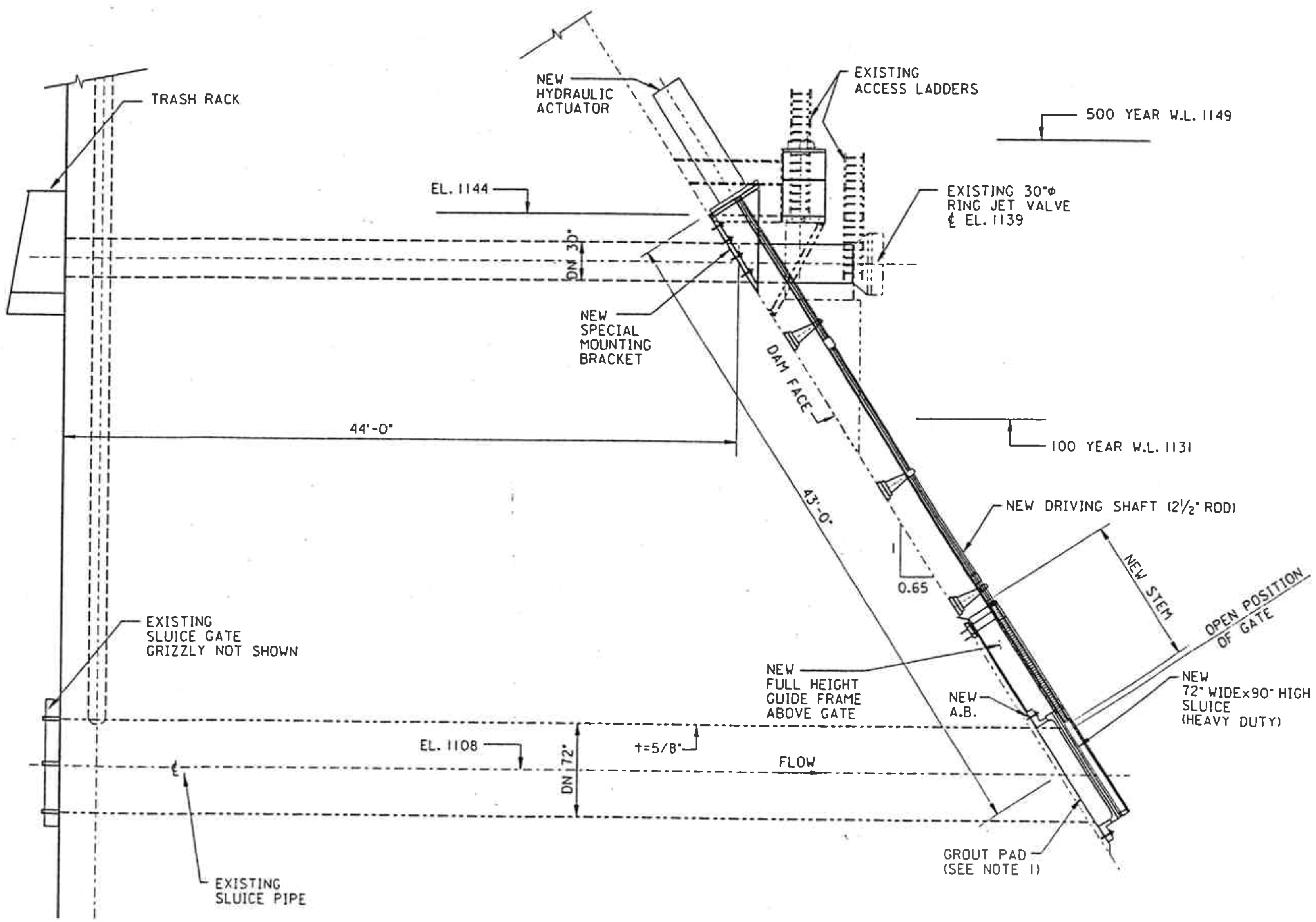


Figure 19: Water Surface Profile
Flow: Q = 3,500 cfs , Channel Downstream from Ralston Afterbay
Q =3500 cfs
Invert
Elevation (ft)
Main Channel Distance (ft)

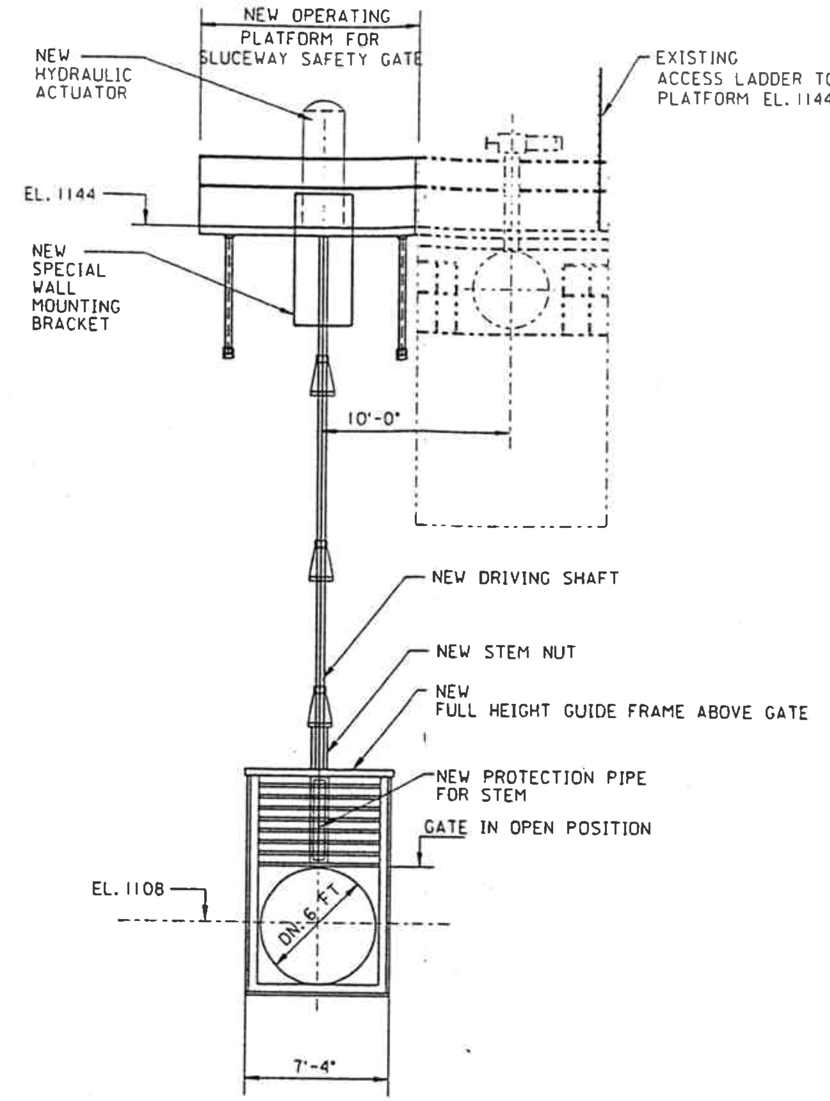


PLAN



SECTION A-A

PIPE



SECTION B-B

NOTE

1. SUITABLE ANCHORAGE OF THE NEW SLUICE GATE FRAME INTO EXISTING DAM AND INTO THE EXISTING STEEL PIPE MODIFIED FOR ATTACHMENT OF GATE, AS REQUIRED.

SCALE 1" = 5'
5' 0 5' 10 FT

PLACER COUNTY WATER AGENCY
MIDDLE FORK AMERICAN RIVER PROJECT

RALSTON AFTERBAY DAM
STREAM MAINTENANCE, SLUICE VALVES AND PIPING

EXHIBIT
GENERAL ARRANGEMENT

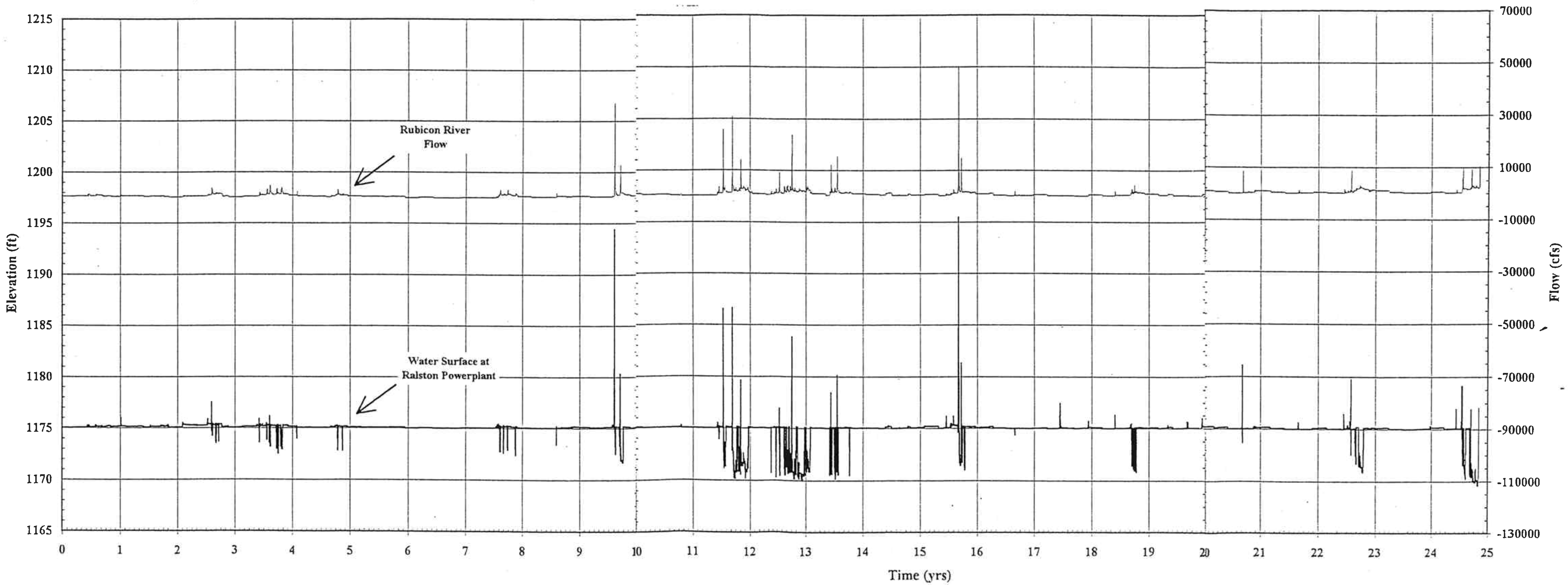
SAFETY GATE FOR LOW-LEVEL SLUICE

SEDIMENT STUDY
OF
RALSTON AFTERBAY RESERVOIR
FINAL REPORT

JOB NO. 23218-003

PLATE 1

Figure 20: Ralston Afterbay Reservoir - Ralston Powerhouse
Run C-1a, Trigger Discharge = 2000 cfs, Outlet D=6 ft



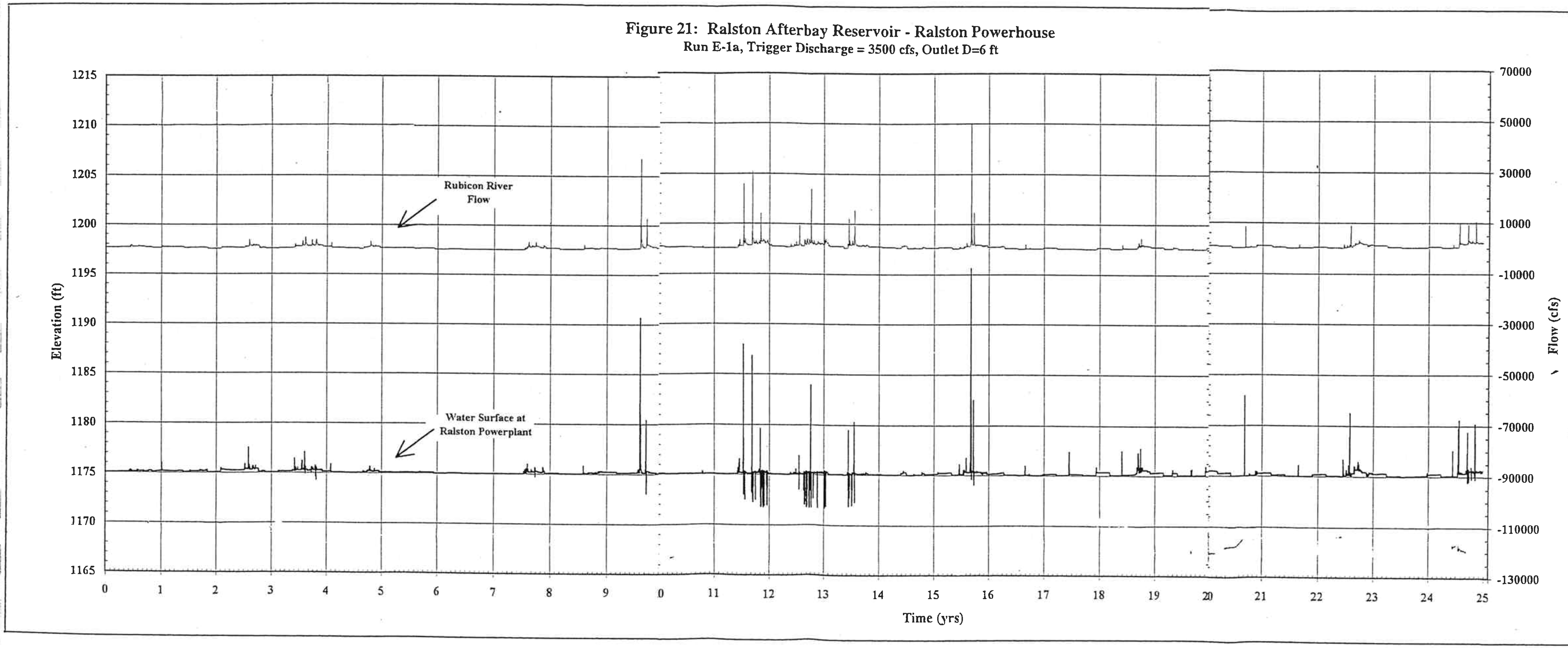


Figure 21: Ralston Afterbay Reservoir - Ralston Powerhouse
Run E-1a, Trigger Discharge = 3500 cfs, Outlet D=6 ft
Rubicon River Flow
Water Surface at Ralston Powerplant
Elevation (ft)
Flow (cfs)
Time (yrs)
1215
1210
1205
1200
1195
1190
1185
1180
1175
1170
1165
70000
50000
30000
10000
-10000
-30000
-50000
-70000
-90000
-110000
-130000
0
1
2
3
4
5
6
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11
12
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14
15
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21
22
23
24
25

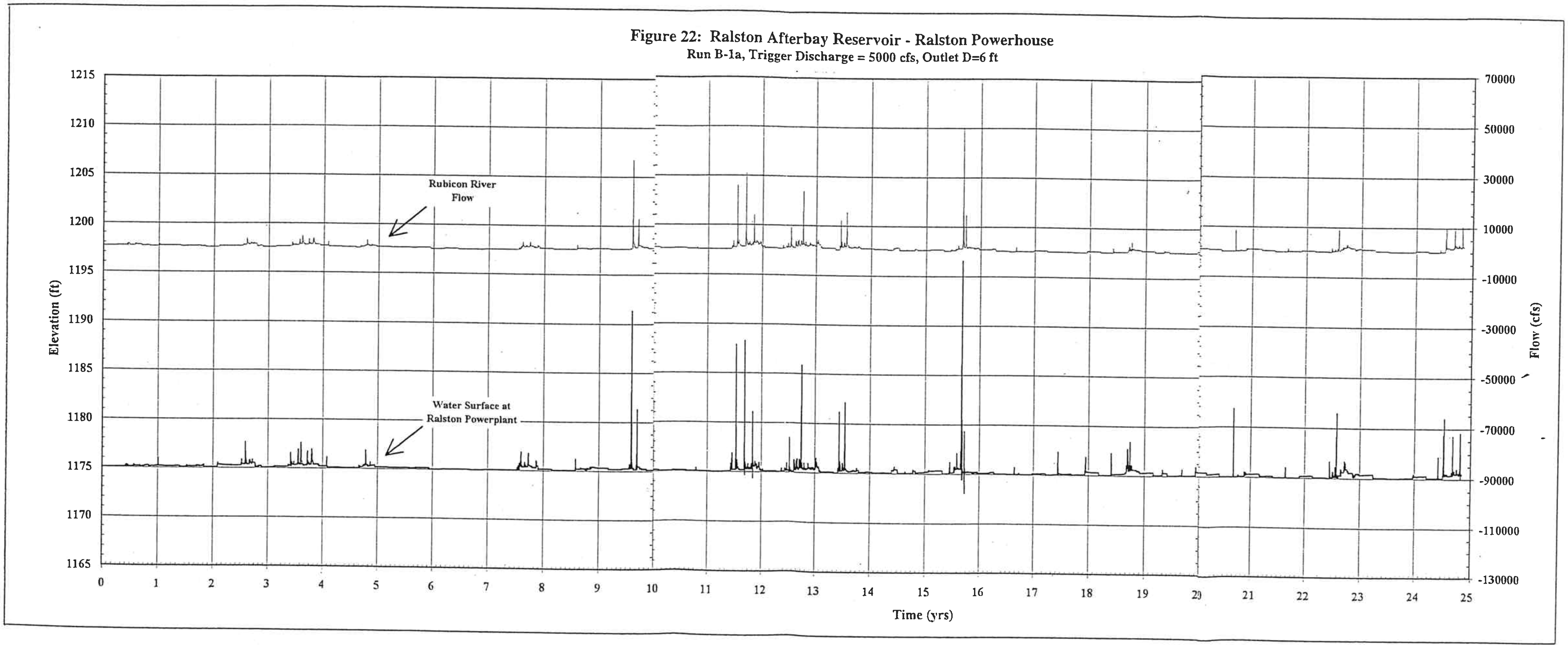


Figure 22: Ralston Afterbay Reservoir - Ralston Powerhouse
Run B-1a, Trigger Discharge = 5000 cfs, Outlet D=6 ft
Rubicon River Flow
Water Surface at Ralston Powerplant
Elevation (ft)
Flow (cfs)
Time (yrs)
1215
1210
1205
1200
1195
1190
1185
1180
1175
1170
1165
70000
50000
30000
10000
-10000
-30000
-50000
-70000
-90000
-110000
-130000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

PLAN

SEDIMENT DEFLECTOR WALL

SCALE 1" - 50'

50' 0 50' 100 FT

LEGEND

MANHOLE		PAVED ROAD	
DRAIN INLET		CURB	
FIRE HYDRANT		CONCRETE	
VALVE		DIRT ROAD	
VAULT		LEVEE/DIKE	
POWER POLE		TREES	
GUY WIRE		GROUND COVER	
ELECTROLIER			

WATER		SMALL SIGN	
MEDIAN BARRIER		MEDIUM SIGN	
MASONRY WALL		MARSH	
RETAINING WALL		SPOT EL. UNDER WTR	
FENCE		HORIZ. VERT. CONTROL	
GUARDRAIL		HORIZONTAL CONTROL	
ROCKS		VERTICAL CONTROL	
		BENCHMARK	

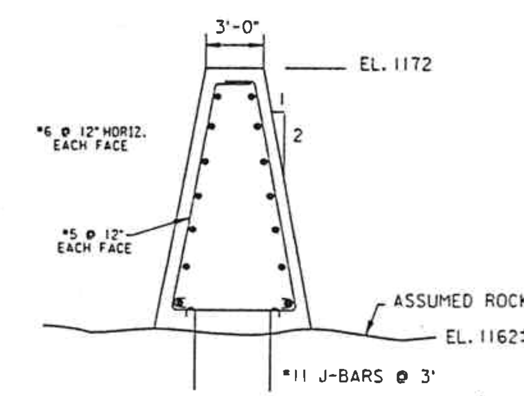
SURVEY CONTROL LEGEND

POINT *	NORTHING	EASTING	ELEVATION	DESCRPITION
129	488270.77	2362825.13	1214.99	5/8" REBAR, 27' WEST OF ROAD CENTERLINE, & ABOUT SOUTH OF THE POWER PLANT FENCELINE.

ELEVATIONS BASED UPON USCGS DATUM TAKEN FROM BRASS CAP STAMPED "OXBOW" ON NORTH END OF DAM. COORDINATES ARE CALIFORNIA STATE PLANE, ZONE-2. FROM P.C.W.A. MAP BY HERMAN & PETERS, DATED: 10-25-87.

NOTE:

TOPOGRAPHY ENLARGED FROM SHEET 1A, TOPOGRAPHY FOR SEDIMENT STUDIES, S & E ENGINEERING CO. P.O. BOX 126, NEVADA CITY, CA
AERIAL PHOTOGRAPHY & CONTRACTS BY GEONEX, 5979 FREEPORT BLVD, SACRAMENTO, CA



SEDIMENT DEFLECTOR WALL

TYPICAL SECTION

N.T.S.

PLACER COUNTY WATER AGENCY
MIDDLE FORK AMERICAN RIVER PROJECT

RALSTON AFTERBAY DAM
GUIDE WALL FOR SEDIMENT BY PASS

EXHIBIT
GENERAL ARRANGEMENT

RALSTON AFTERBAY POWERHOUSE
SEDIMENT MANAGEMENT SYSTEM
DEFLECTOR WALL

SEDIMENT STUDY
OF
RALSTON AFTERBAY RESERVOIR
FINAL REPORT

JOB NO. 23218-003

PLATE 2

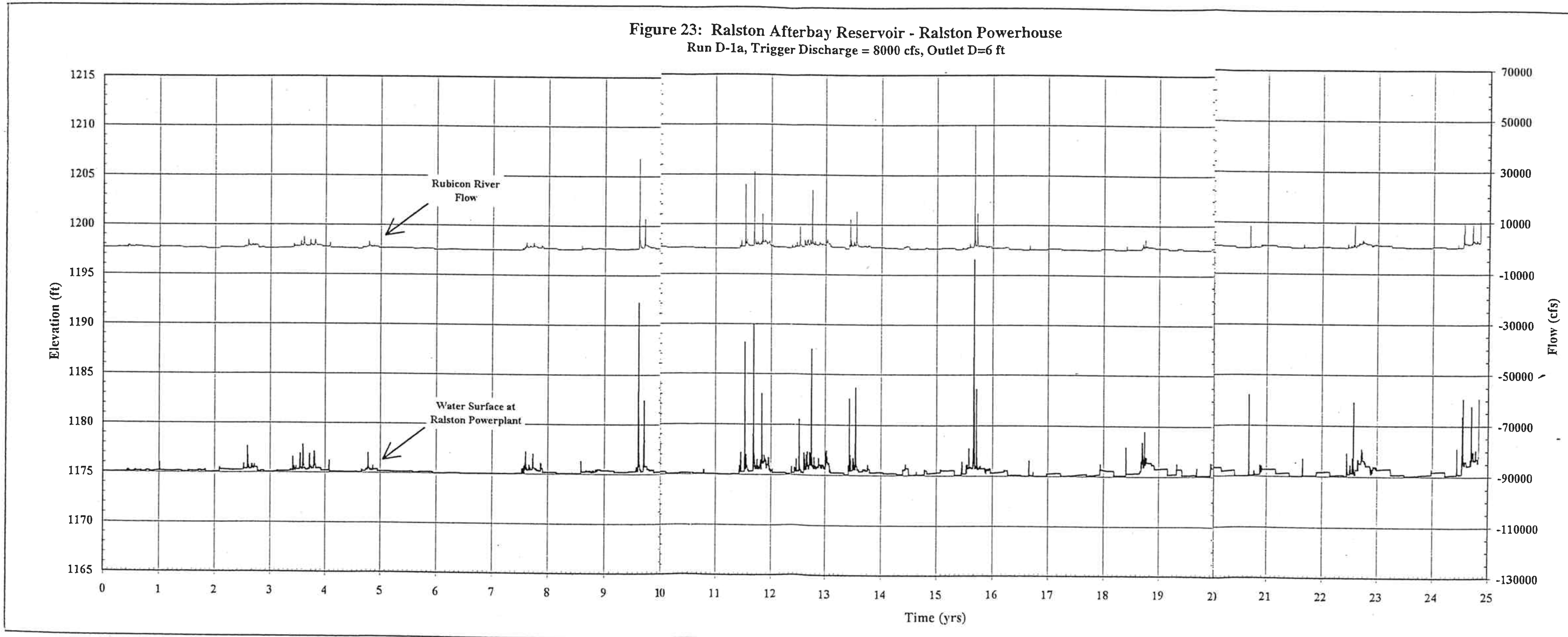
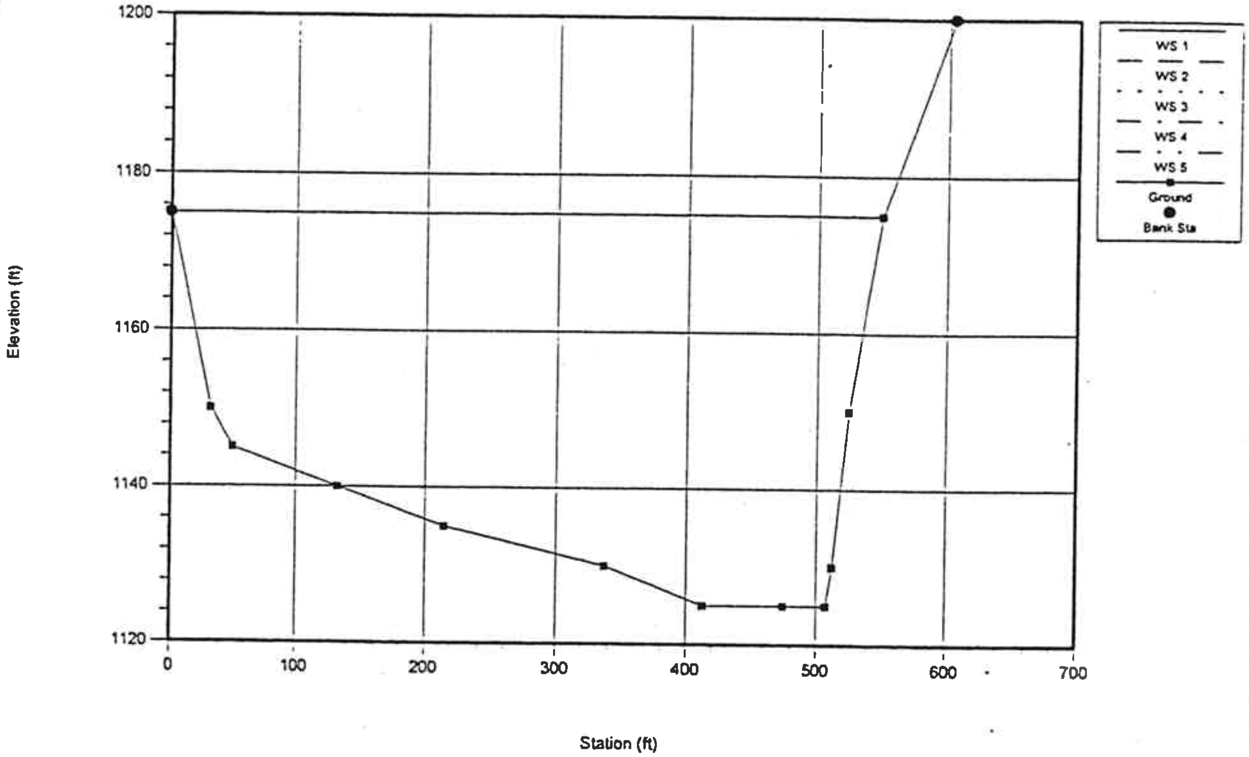


Figure 23: Ralston Afterbay Reservoir - Ralston Powerhouse
Run D-1a, Trigger Discharge = 8000 cfs, Outlet D=6 ft
Rubicon River Flow
Water Surface at Ralston Powerplant
Elevation (ft)
1215
1210
1205
1200
1195
1190
1185
1180
1175
1170
1165
Flow (cfs)
70000
50000
30000
10000
-10000
-30000
-50000
-70000
-90000
-110000
-130000
Time (yrs)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

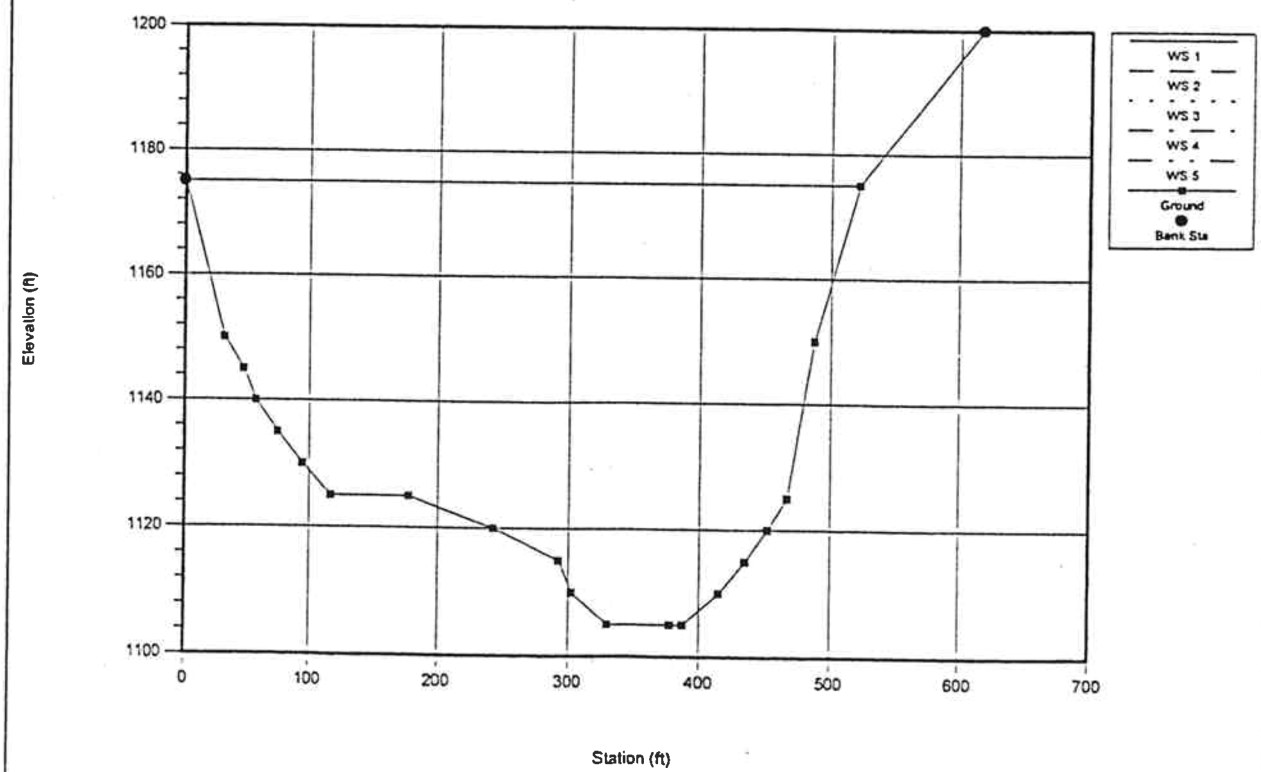
APPENDIX A

CHANNEL CROSS-SECTIONS
FOR
RUBICON AND MIDDLE FORK OF THE AMERICAN RIVERS

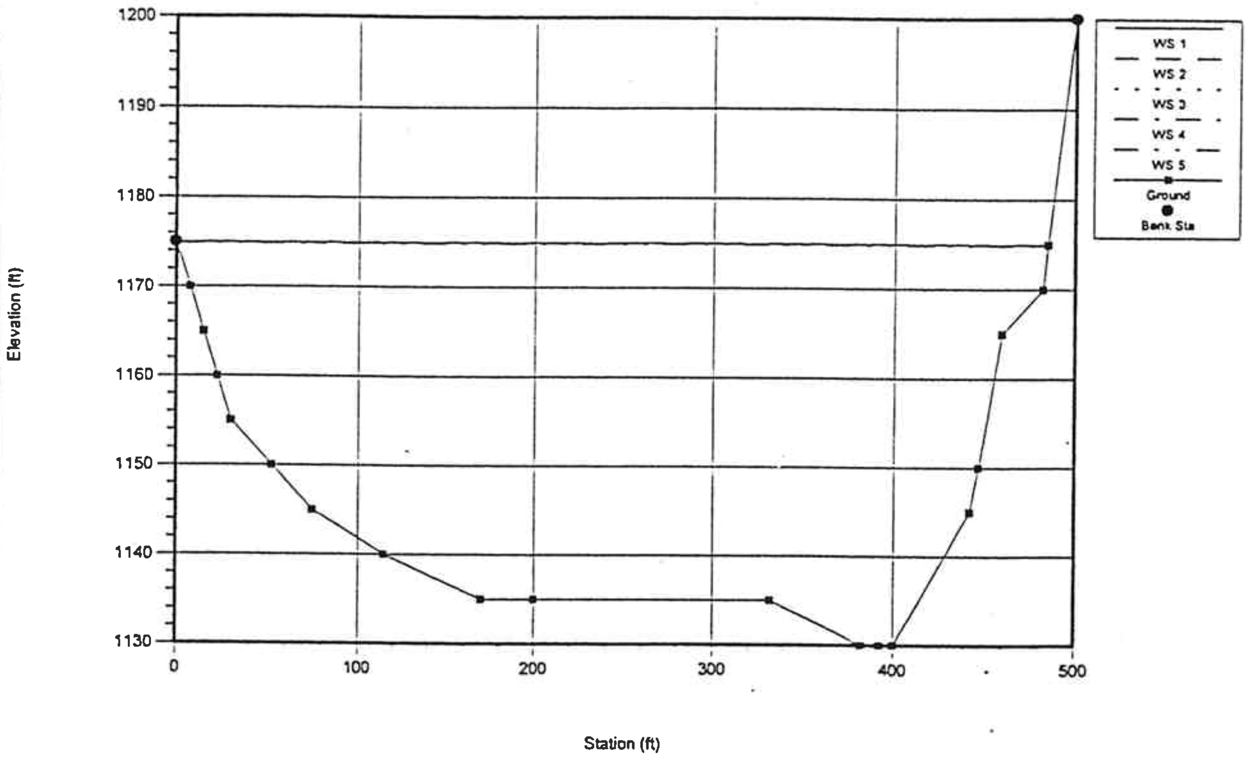
Ralston Afterbay Reservoir - Extended1
01+80 Riv Sta = 180



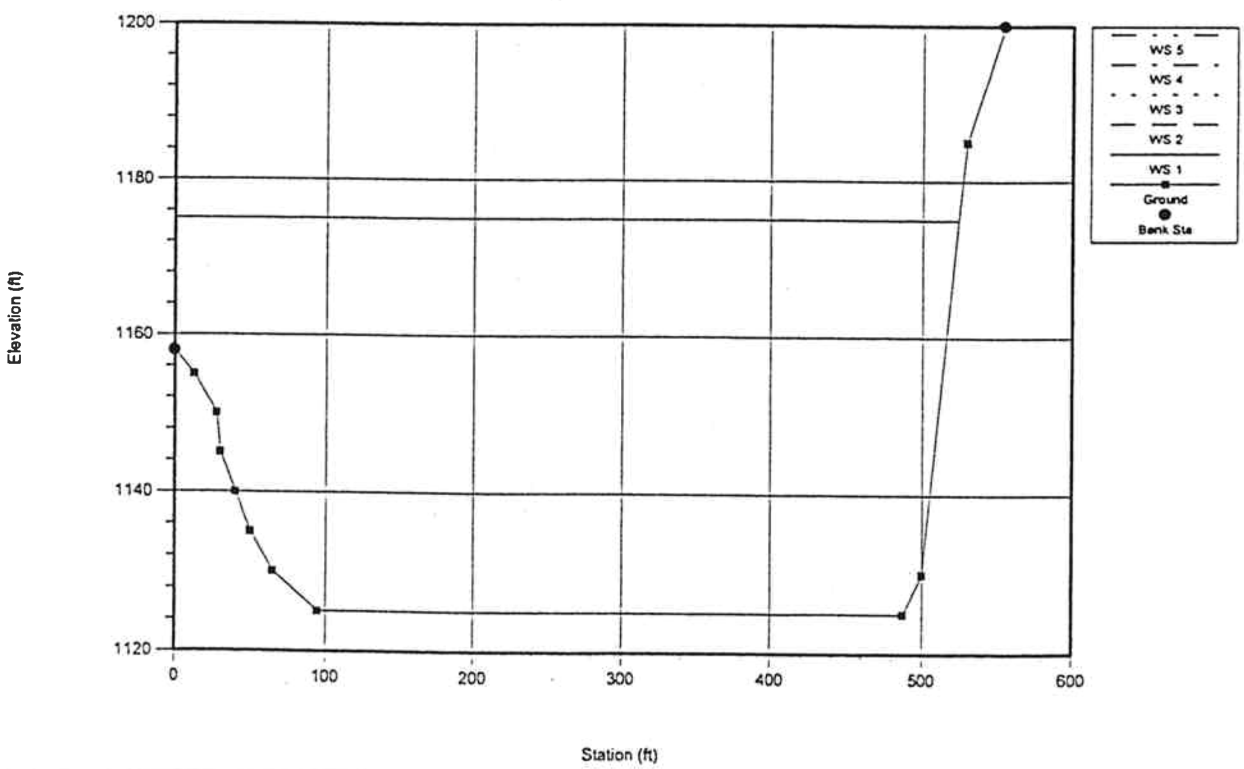
Ralston Afterbay Reservoir - Extended1
00+00 Riv Sta = 0



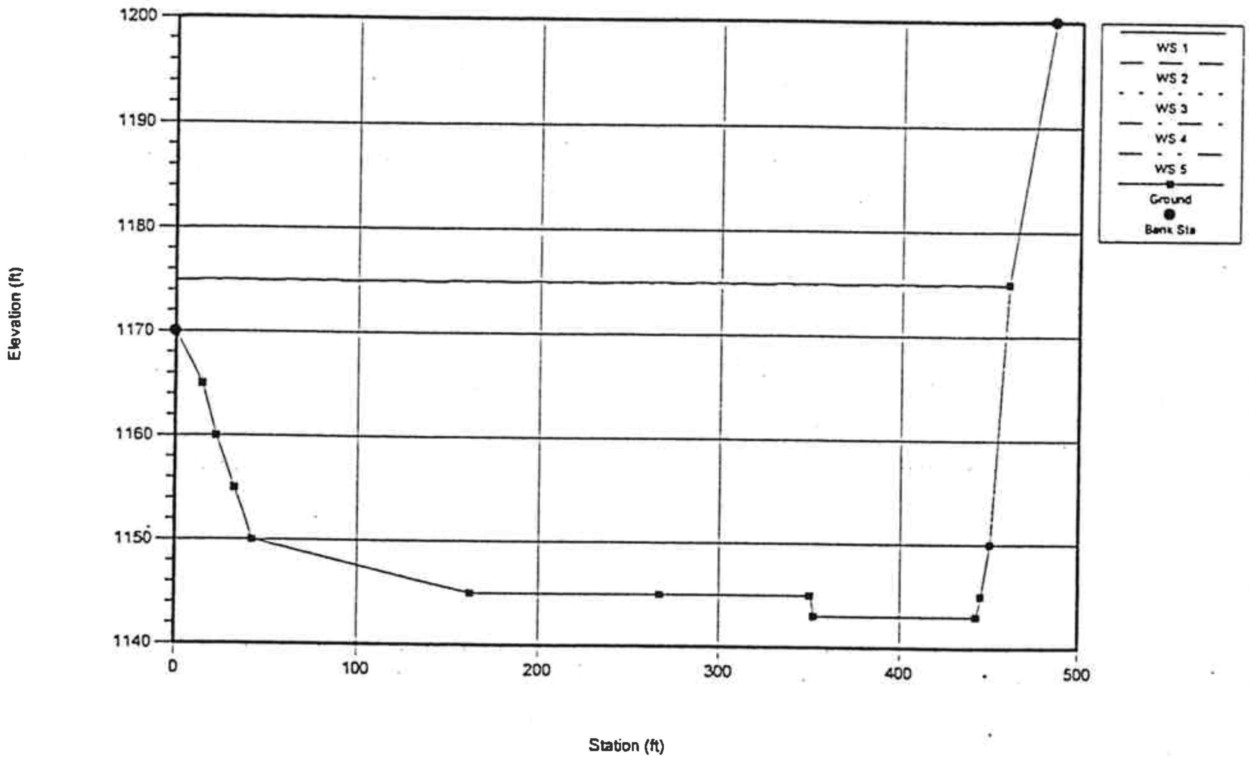
Ralston Afterbay Reservoir - Extended1
05+10 Riv Sta = 510



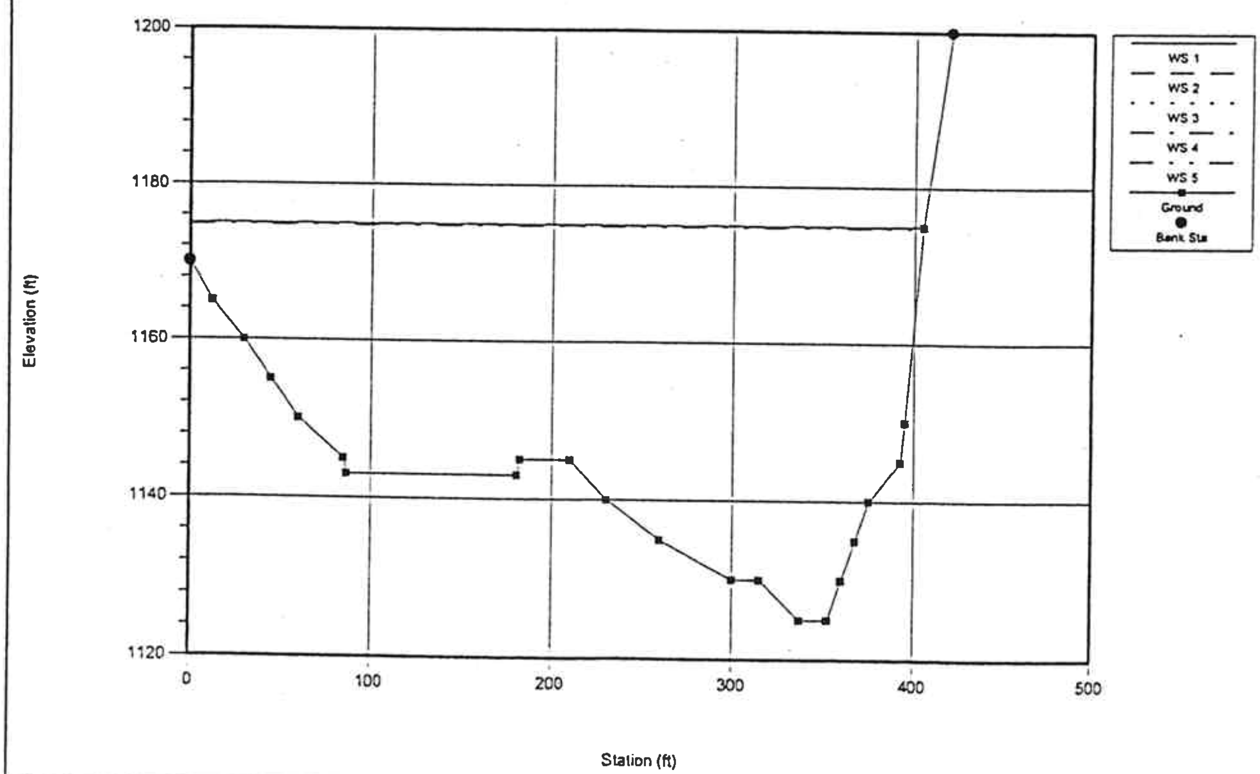
Ralston Afterbay Reservoir - Extended1
03+00 Riv Sta = 300



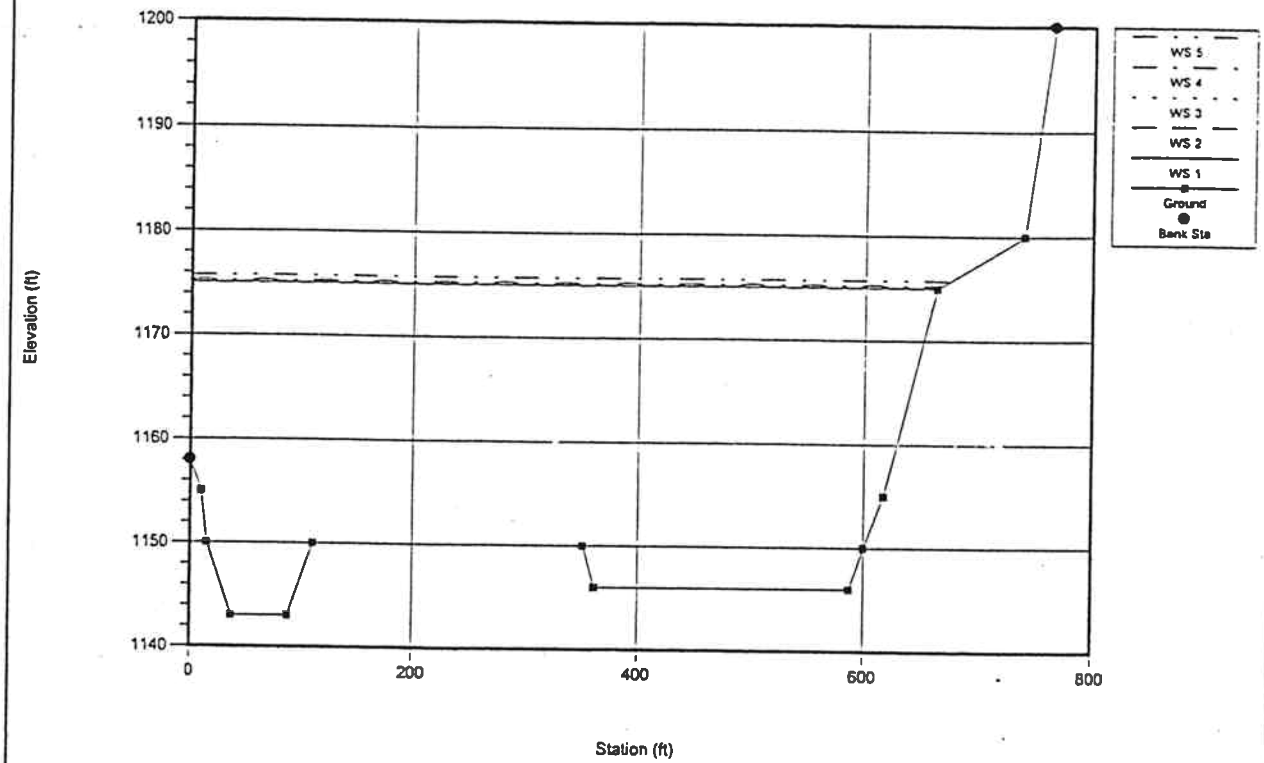
Ralston Afterbay Reservoir - Extended1
12+90 Riv Sta = 1290



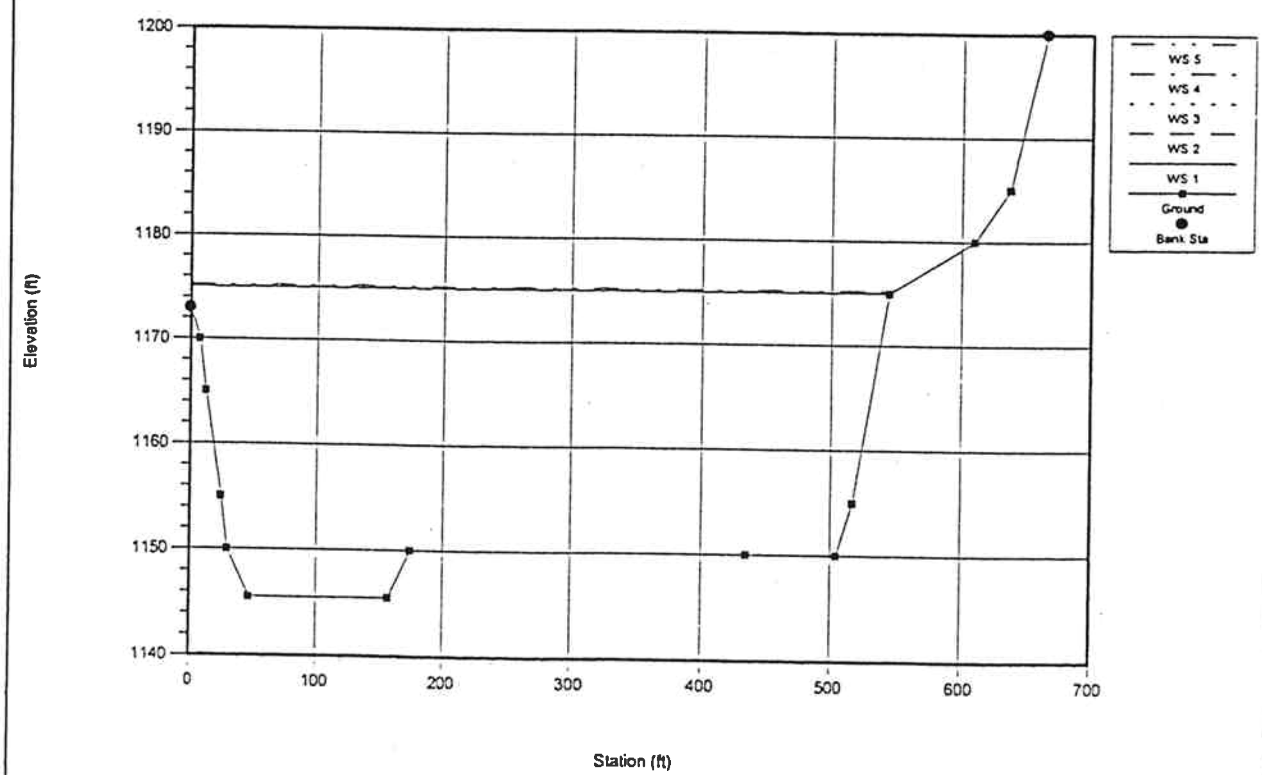
Ralston Afterbay Reservoir - Extended1
08+10 Riv Sta = 810



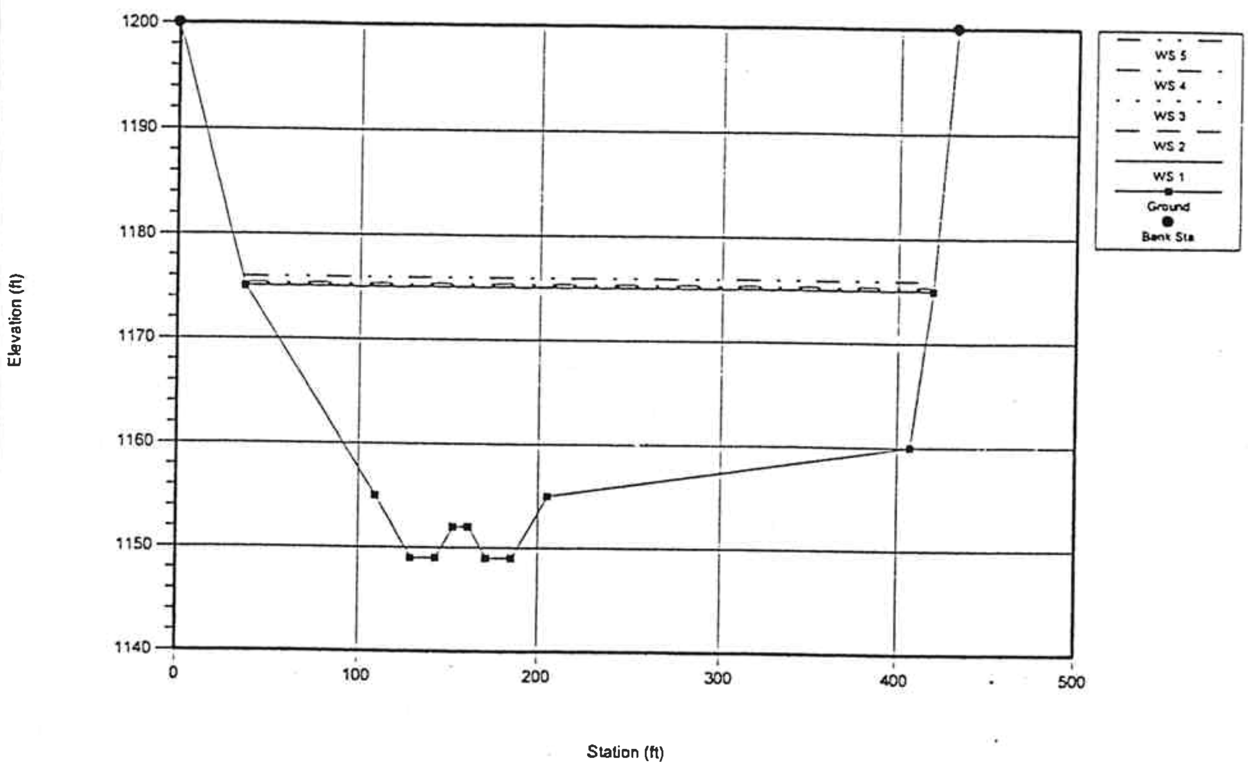
Ralston Afterbay Reservoir - Extended1
22+90 Riv Sta = 2290



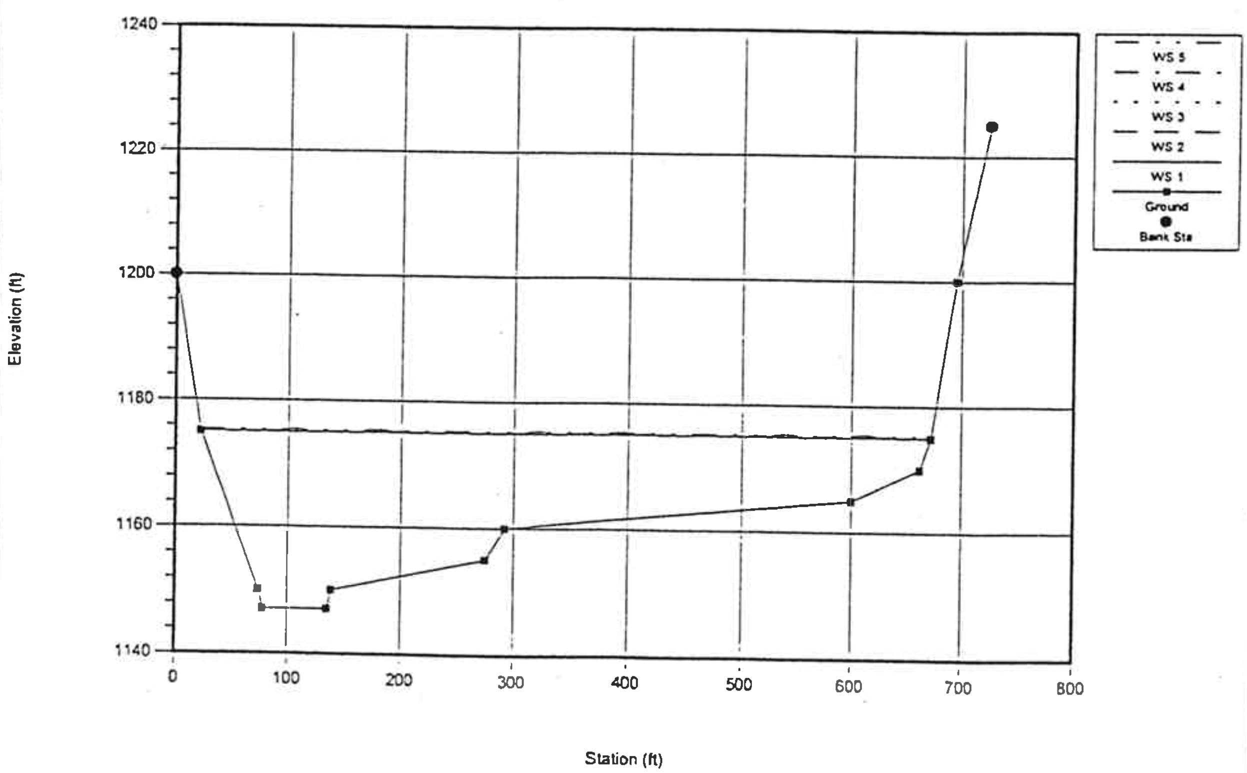
Ralston Afterbay Reservoir - Extended1
19+50 Riv Sta = 1950



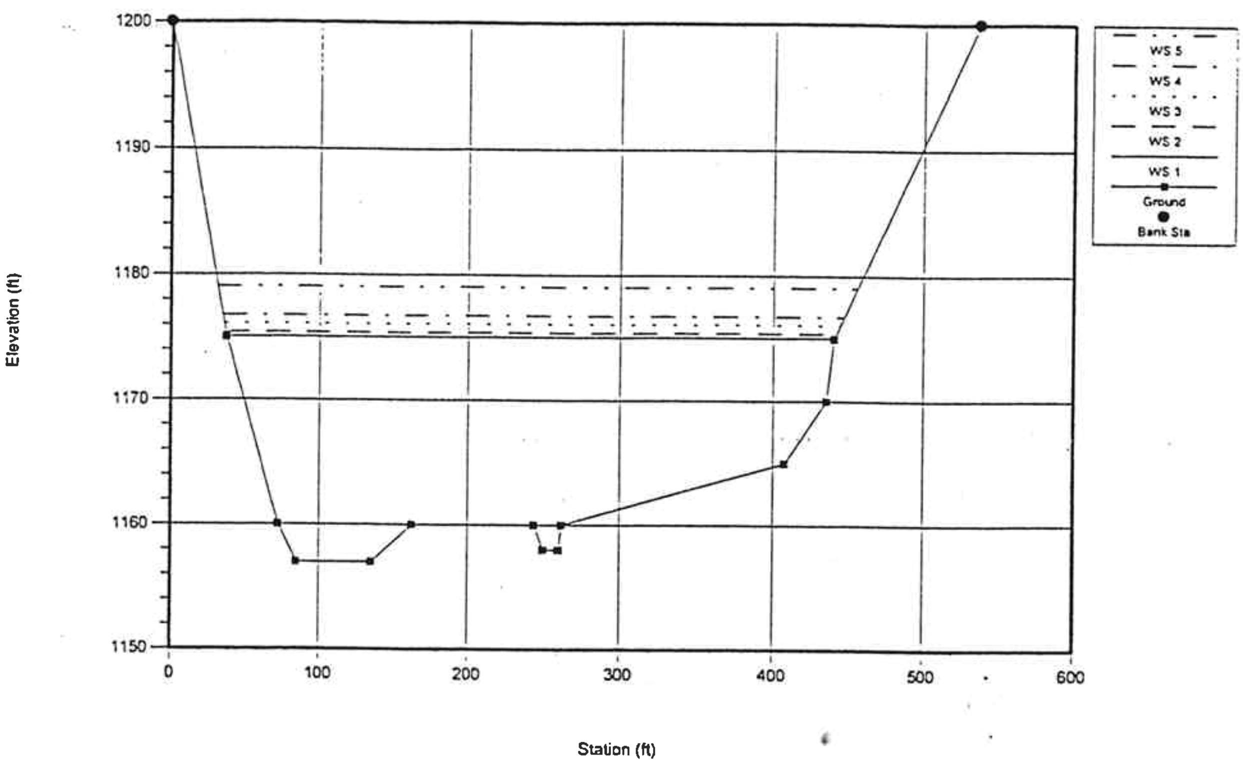
Ralston Afterbay Reservoir - Extended1
39+90 Riv Sta = 3990



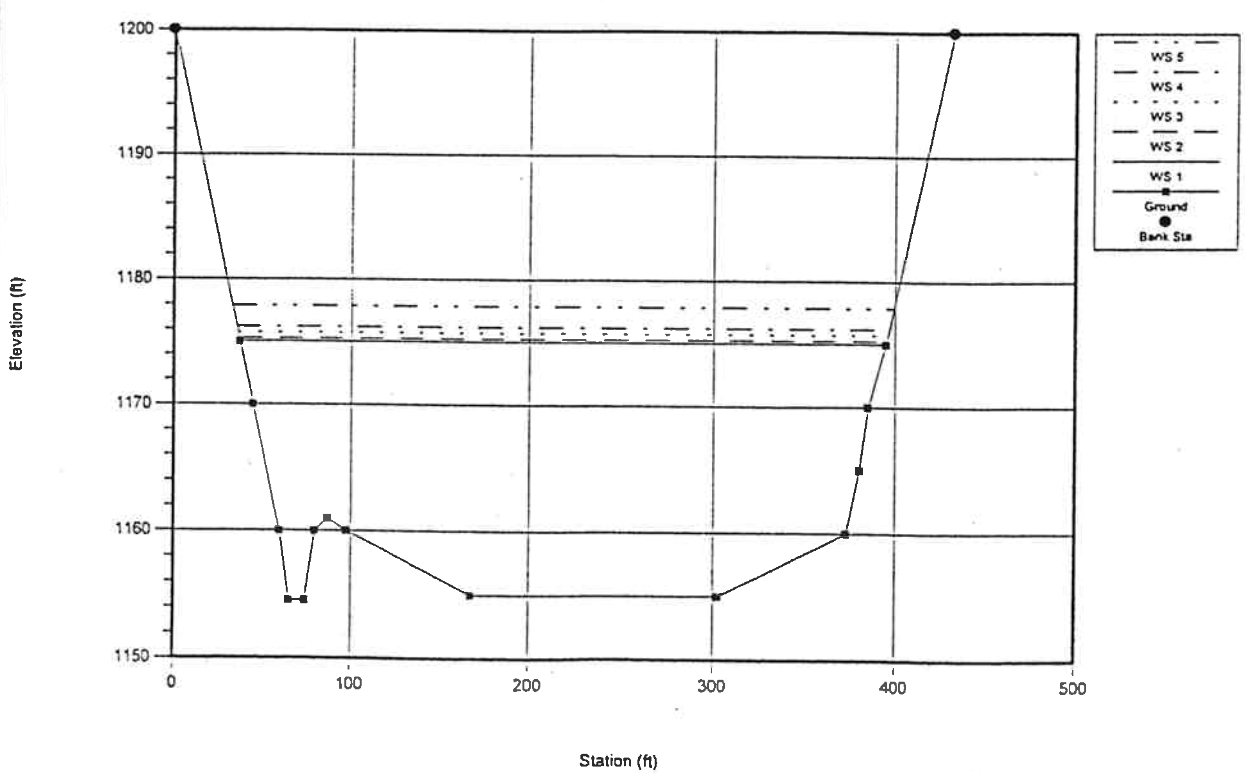
Ralston Afterbay Reservoir - Extended1
29+90 Riv Sta = 2990



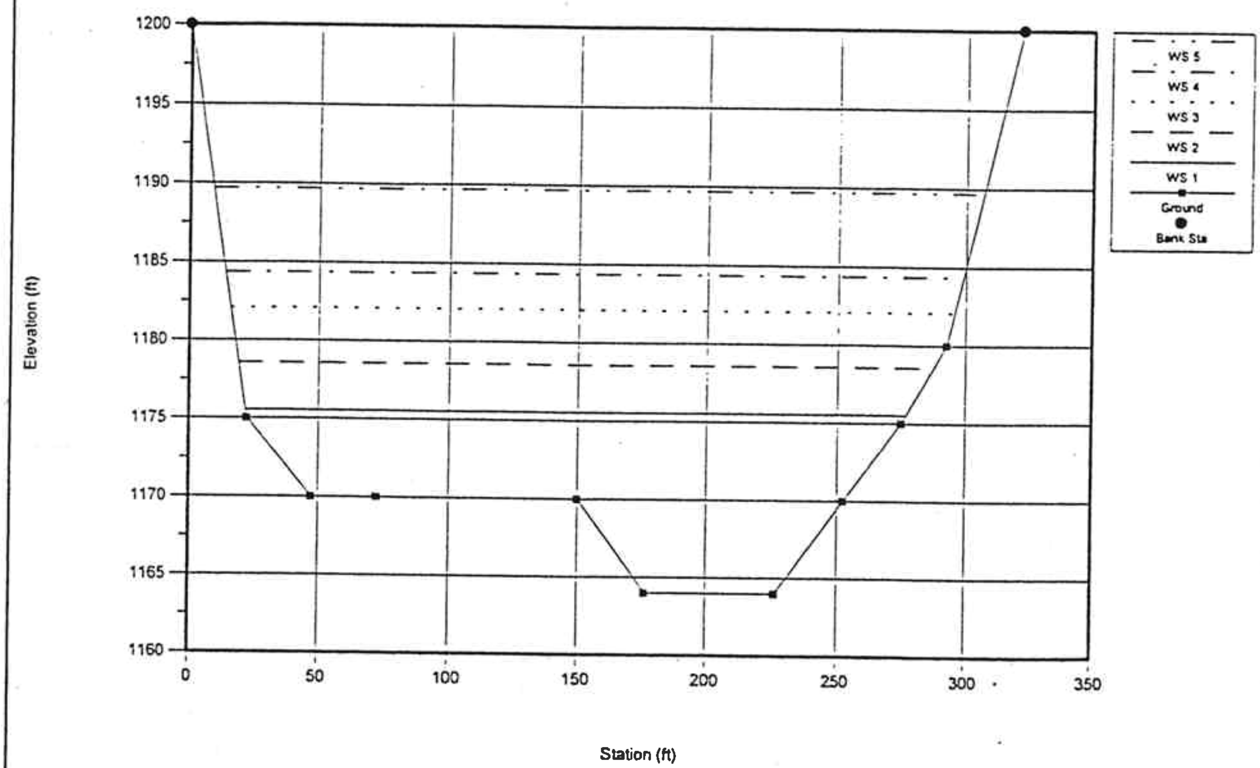
Ralston Afterbay Reservoir - Extended1
52+80 Riv Sta = 5280



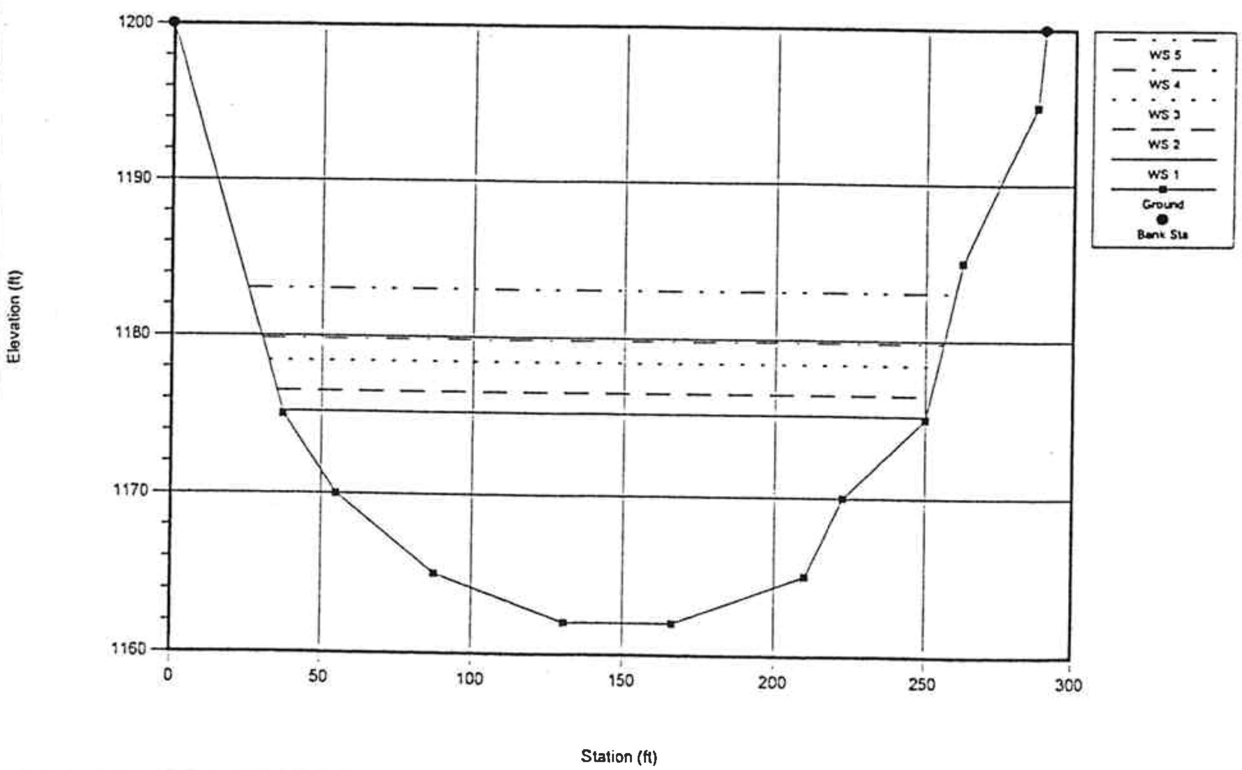
Ralston Afterbay Reservoir - Extended1
47+80 Riv Sta = 4780



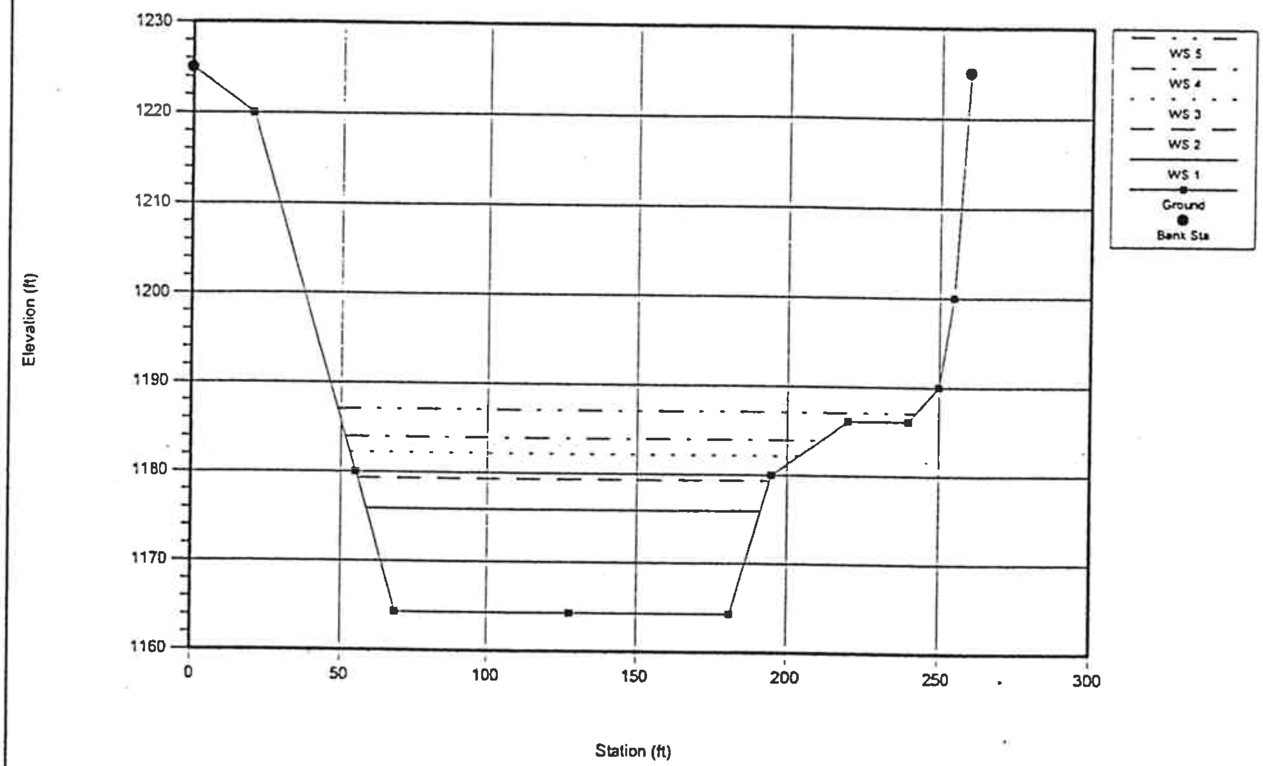
Ralston Afterbay Reservoir - Extended1
78+10 Riv Sta = 7810



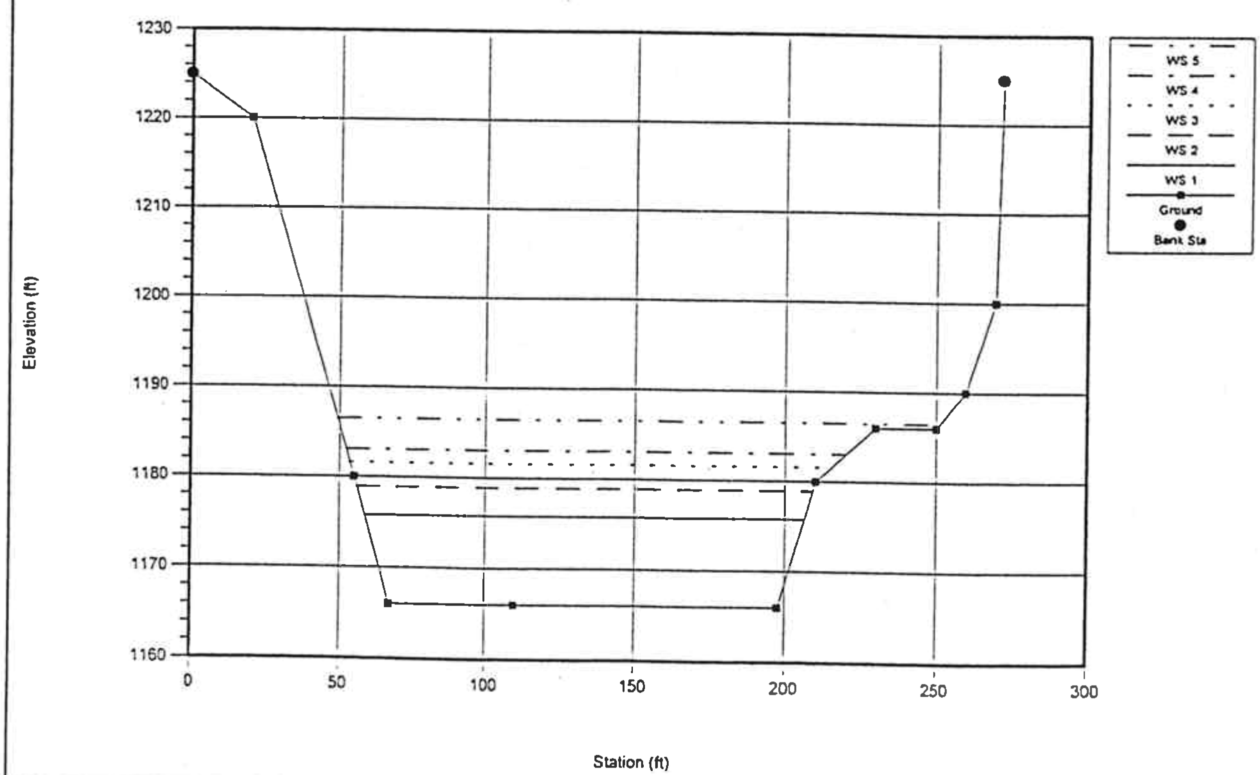
Ralston Afterbay Reservoir - Extended1
71+90 Riv Sta = 7190



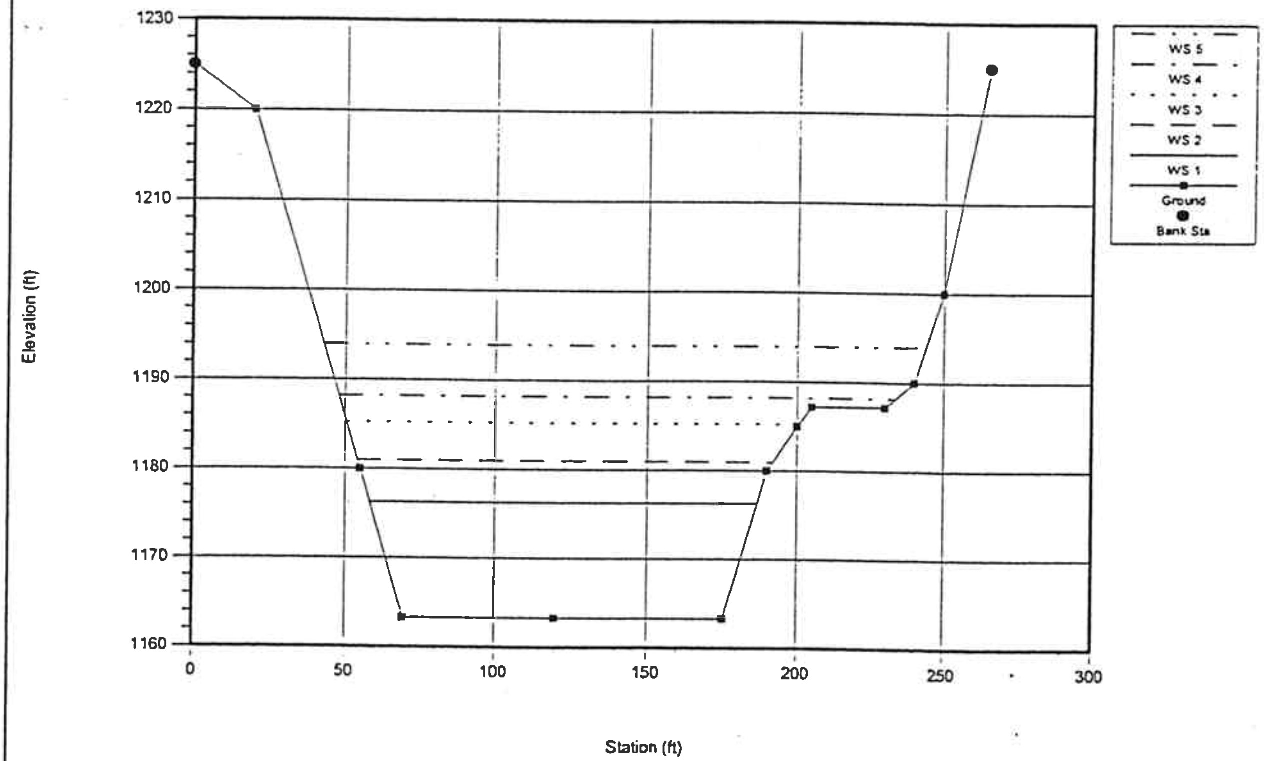
Ralston Afterbay Reservoir - Extended1
82+80 Riv Sta = 8280



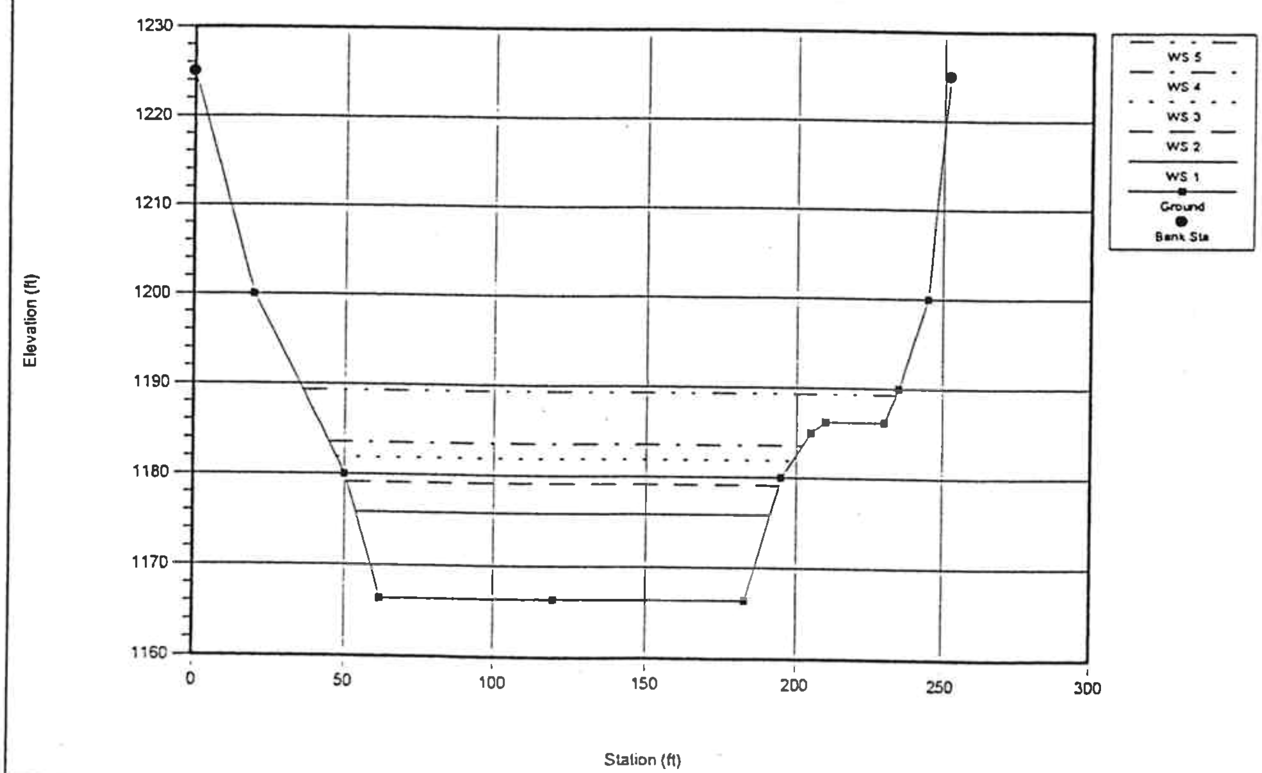
Ralston Afterbay Reservoir - Extended1
82+10 Riv Sta = 8210

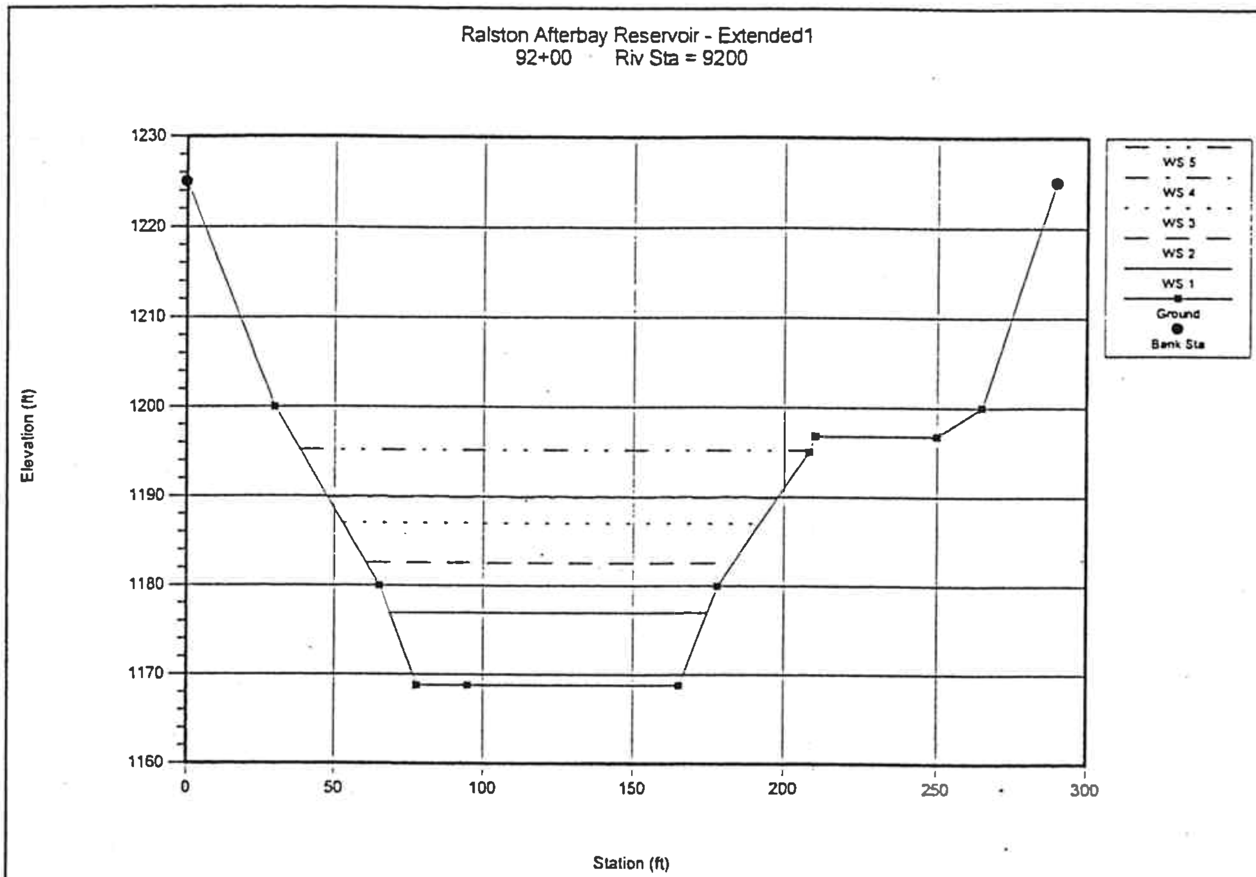


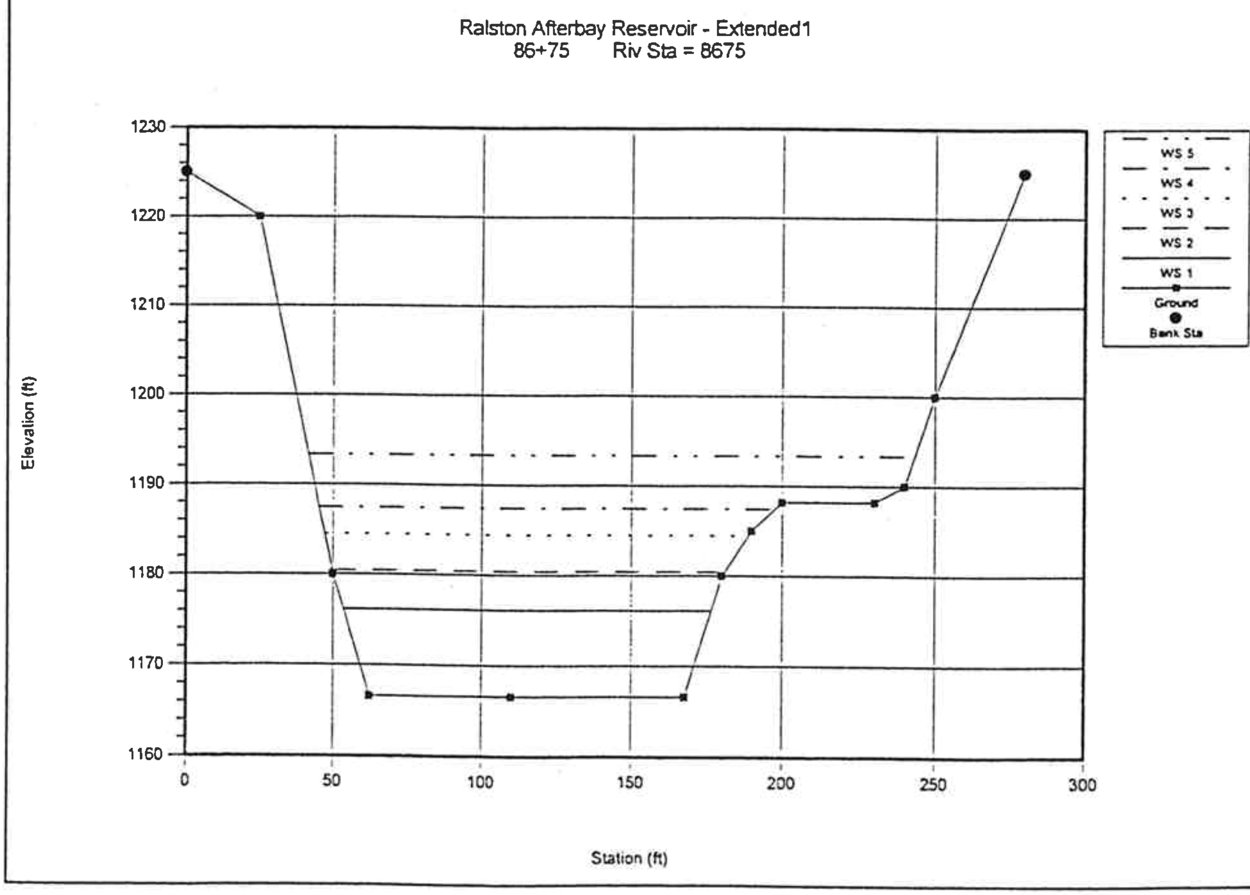
Ralston Afterbay Reservoir - Extended1
85+25 Riv Sta = 8525

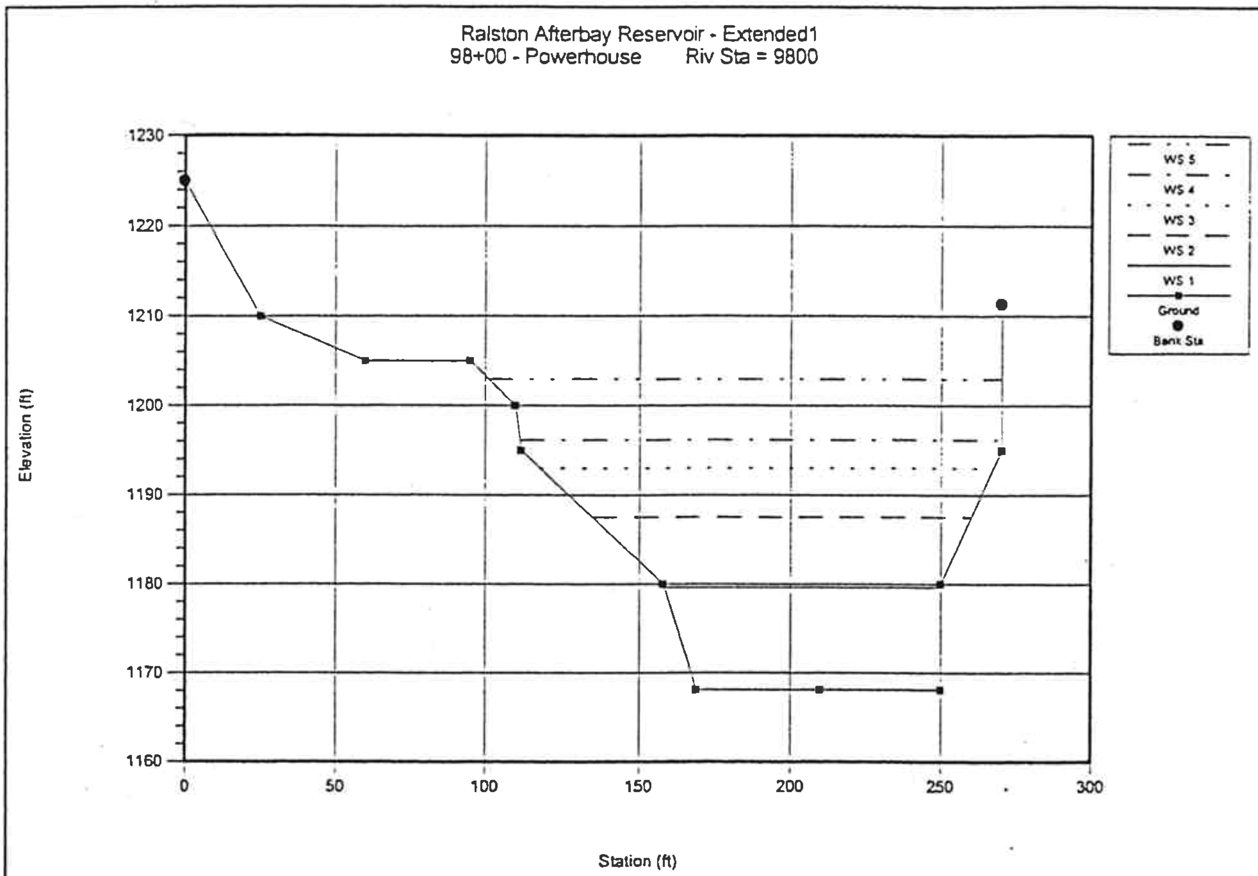


Ralston Afterbay Reservoir - Extended1
83+50 Riv Sta = 8350

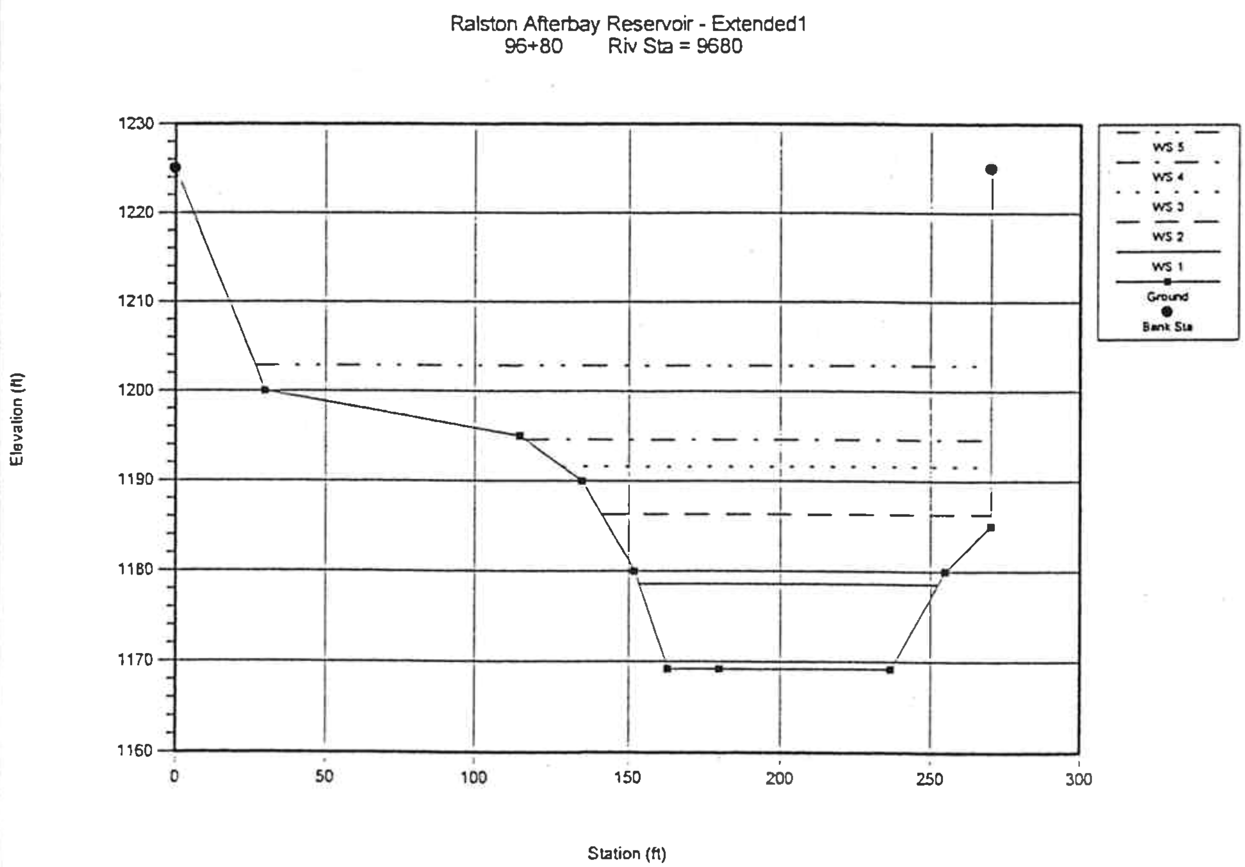



Ralston Afterbay Reservoir - Extended1
92+00 Riv Sta = 9200
Elevation (ft)
Station (ft)
WS 5
WS 4
WS 3
WS 2
WS 1
Ground
Bank Sta


Ralston Afterbay Reservoir - Extended1
86+75 Riv Sta = 8675
Elevation (ft)
Station (ft)
WS 5
WS 4
WS 3
WS 2
WS 1
Ground
Bank Sta

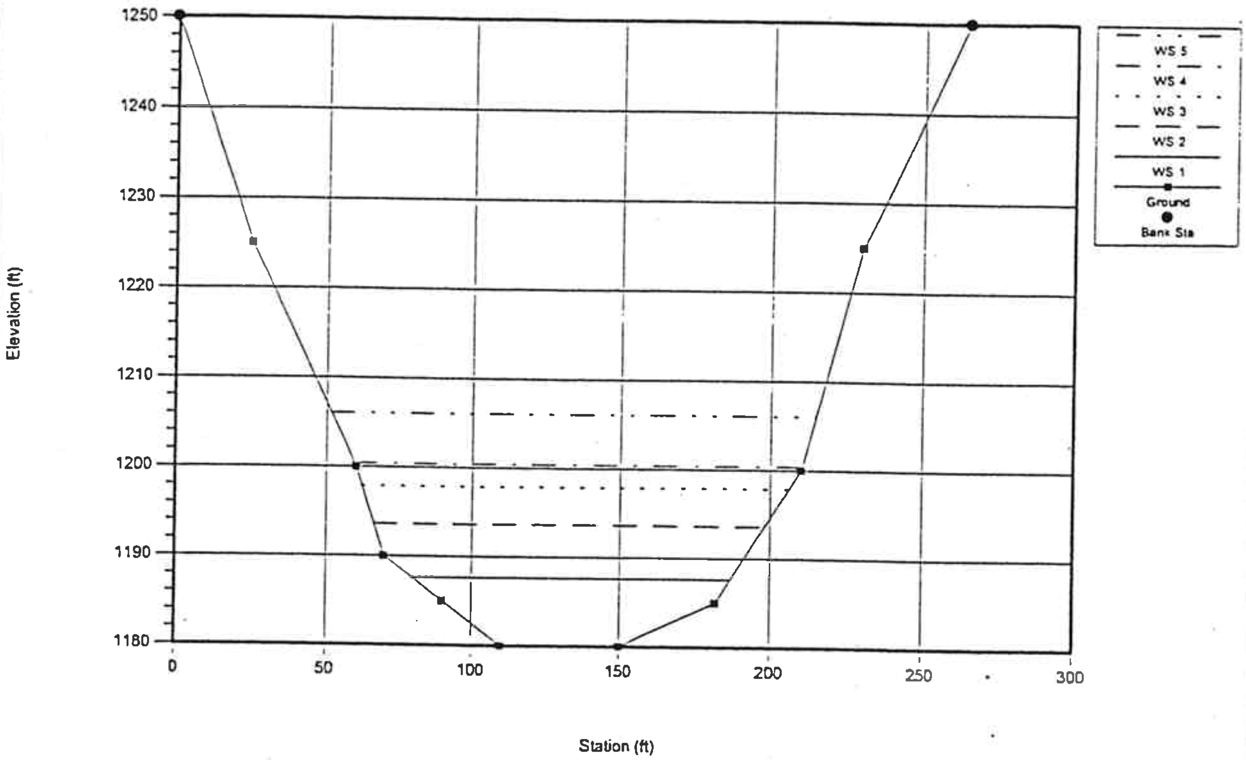


Ralston Afterbay Reservoir - Extended1
98+00 - Powerhouse Riv Sta = 9800
Elevation (ft)
Station (ft)
1230
1220
1210
1200
1190
1180
1170
1160
0
50
100
150
200
250
300
WS 5
WS 4
WS 3
WS 2
WS 1
Ground
Bank Sta

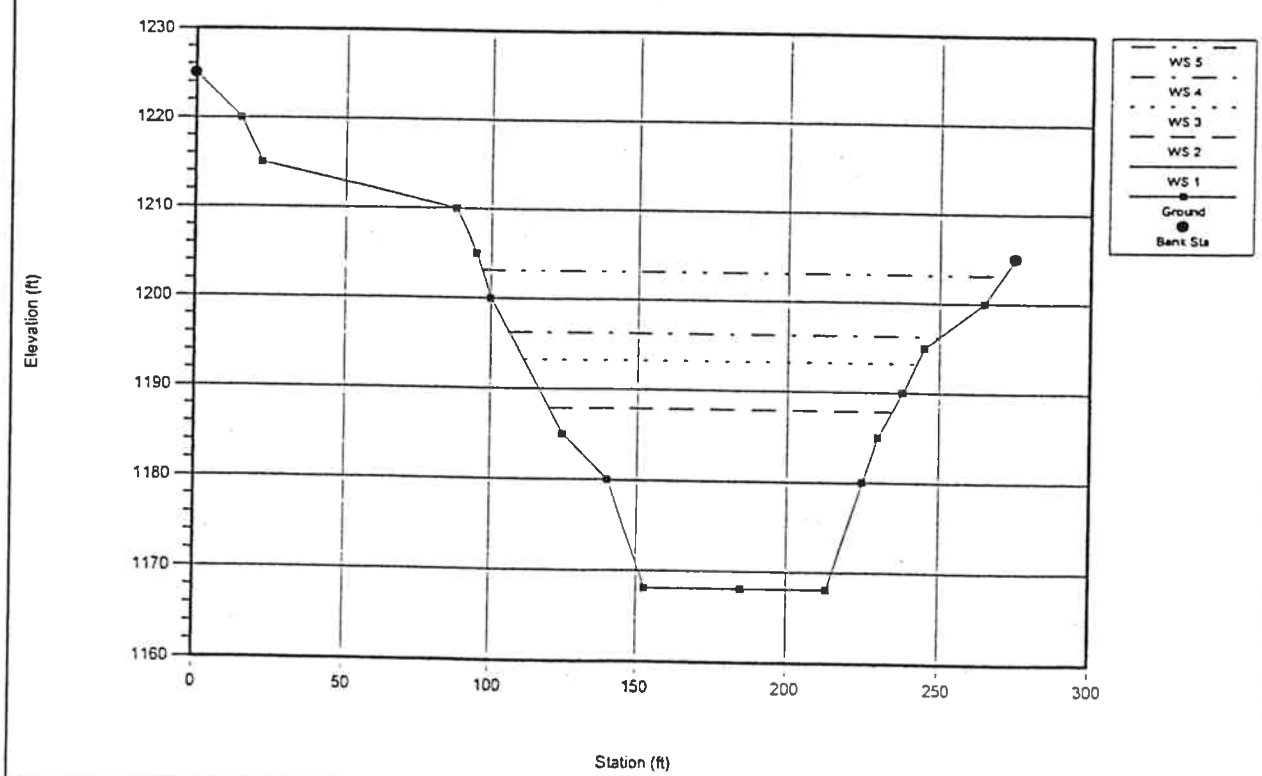


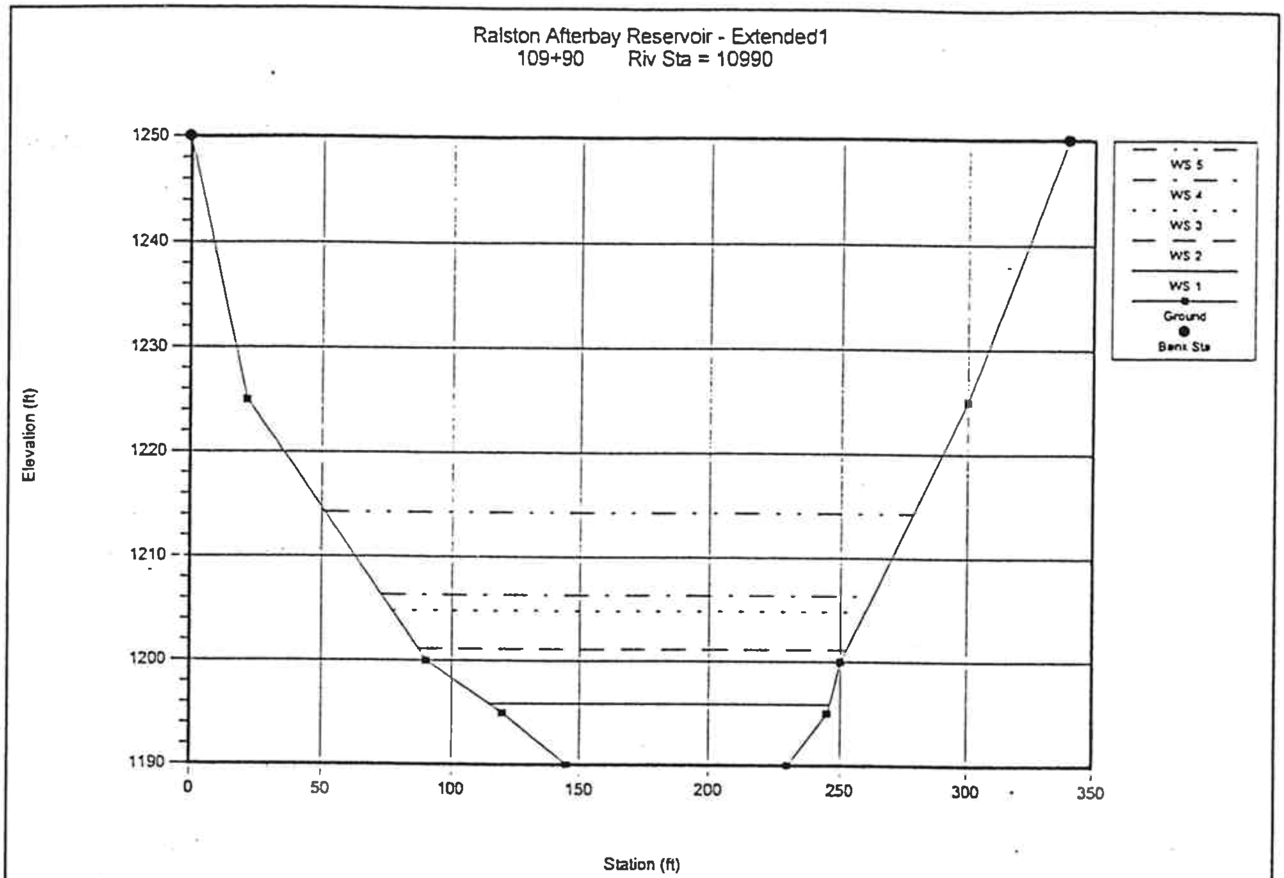
Ralston Afterbay Reservoir - Extended1
96+80 Riv Sta = 9680
Elevation (ft)
Station (ft)
1230
1220
1210
1200
1190
1180
1170
1160
0
50
100
150
200
250
300
WS 5
WS 4
WS 3
WS 2
WS 1
Ground
Bank Sta

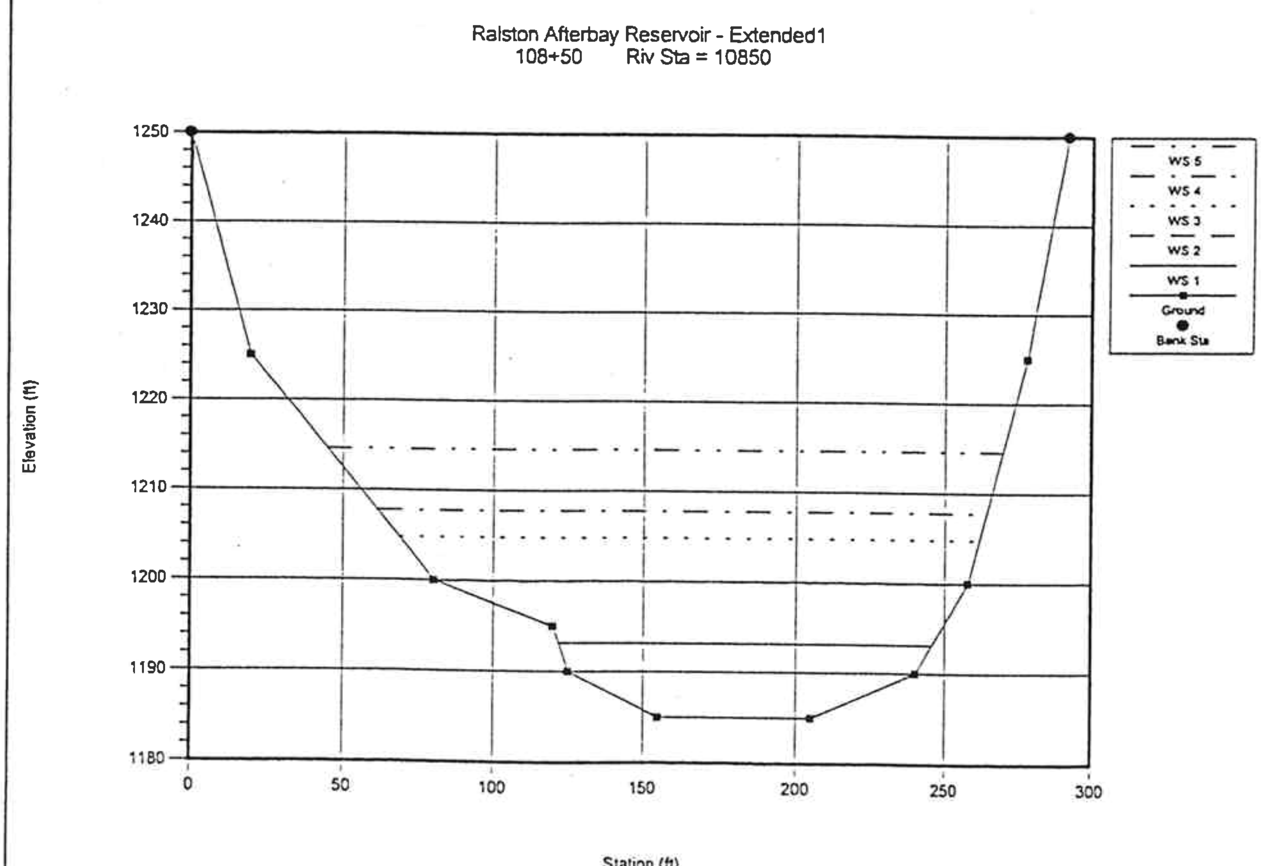
Ralston Afterbay Reservoir - Extended1
104+80 Riv Sta = 10480



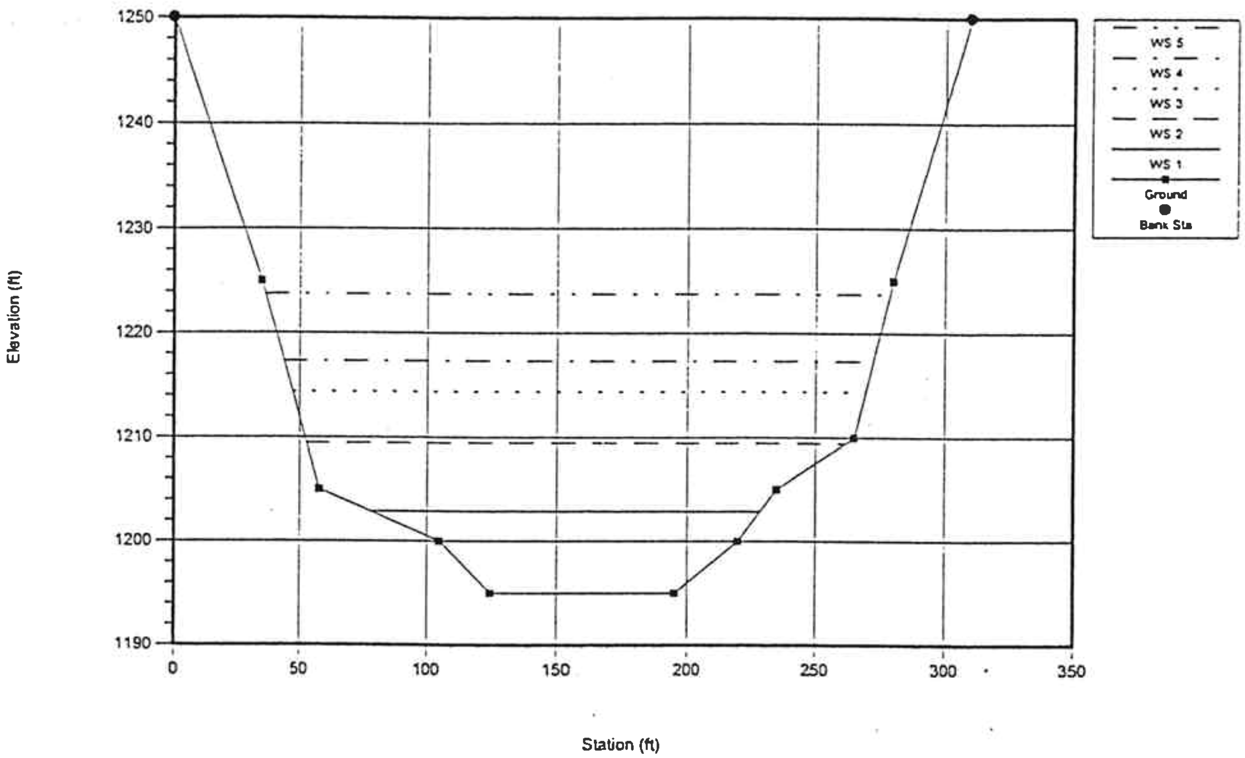
Ralston Afterbay Reservoir - Extended1
99+40 Riv Sta = 9940



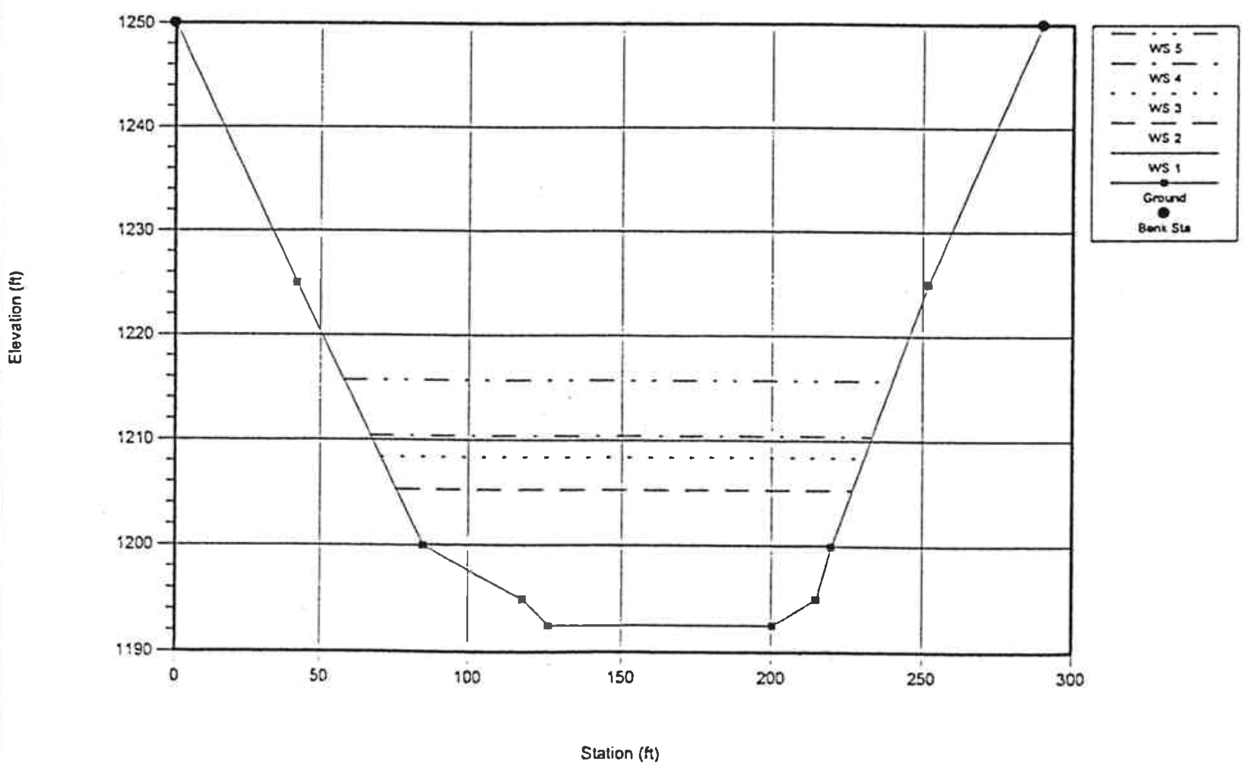

Ralston Afterbay Reservoir - Extended1
109+90 Riv Sta = 10990
1250
1240
1230
1220
1210
1200
1190
Elevation (ft)
0
50
100
150
200
250
300
350
Station (ft)
WS 5
WS 4
WS 3
WS 2
WS 1
Ground
Bank Sta


Ralston Afterbay Reservoir - Extended1
108+50 Riv Sta = 10850
1250
1240
1230
1220
1210
1200
1190
1180
Elevation (ft)
0
50
100
150
200
250
300
Station (ft)
WS 5
WS 4
WS 3
WS 2
WS 1
Ground
Bank Sta

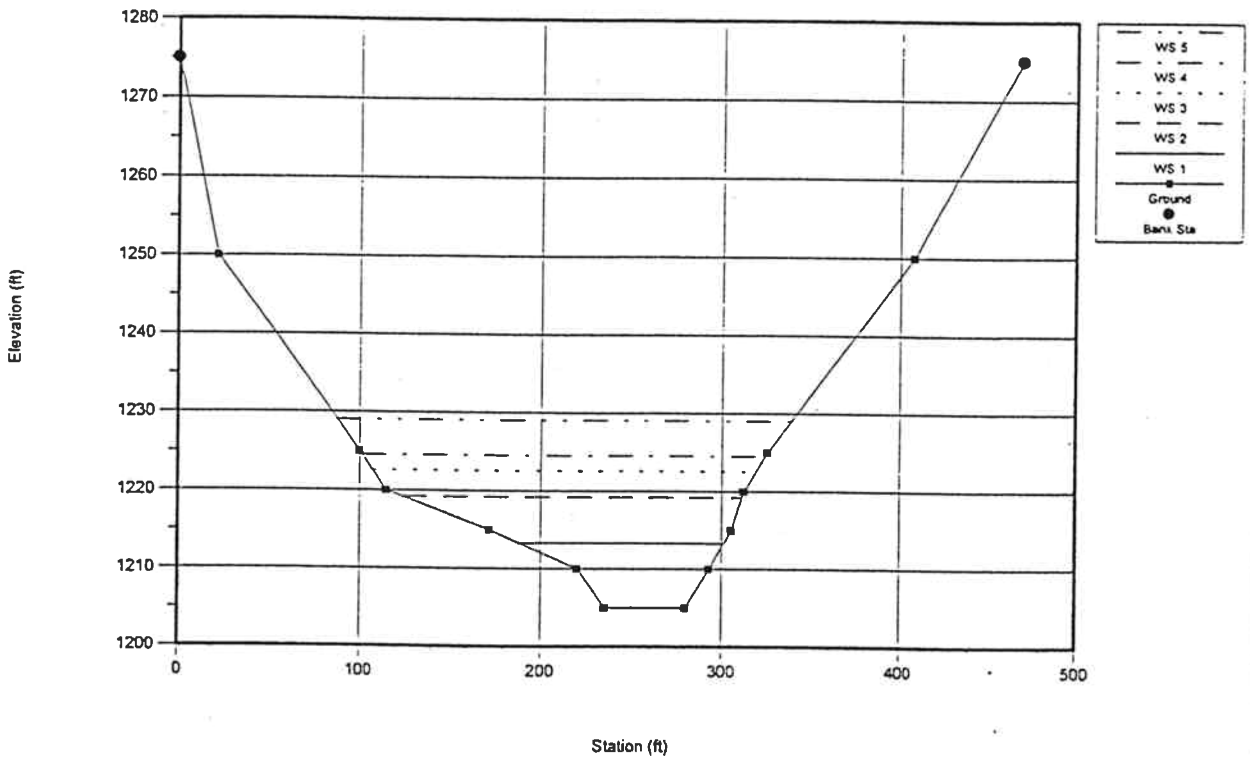
Ralston Afterbay Reservoir - Extended1
115+90 Riv Sta = 11590



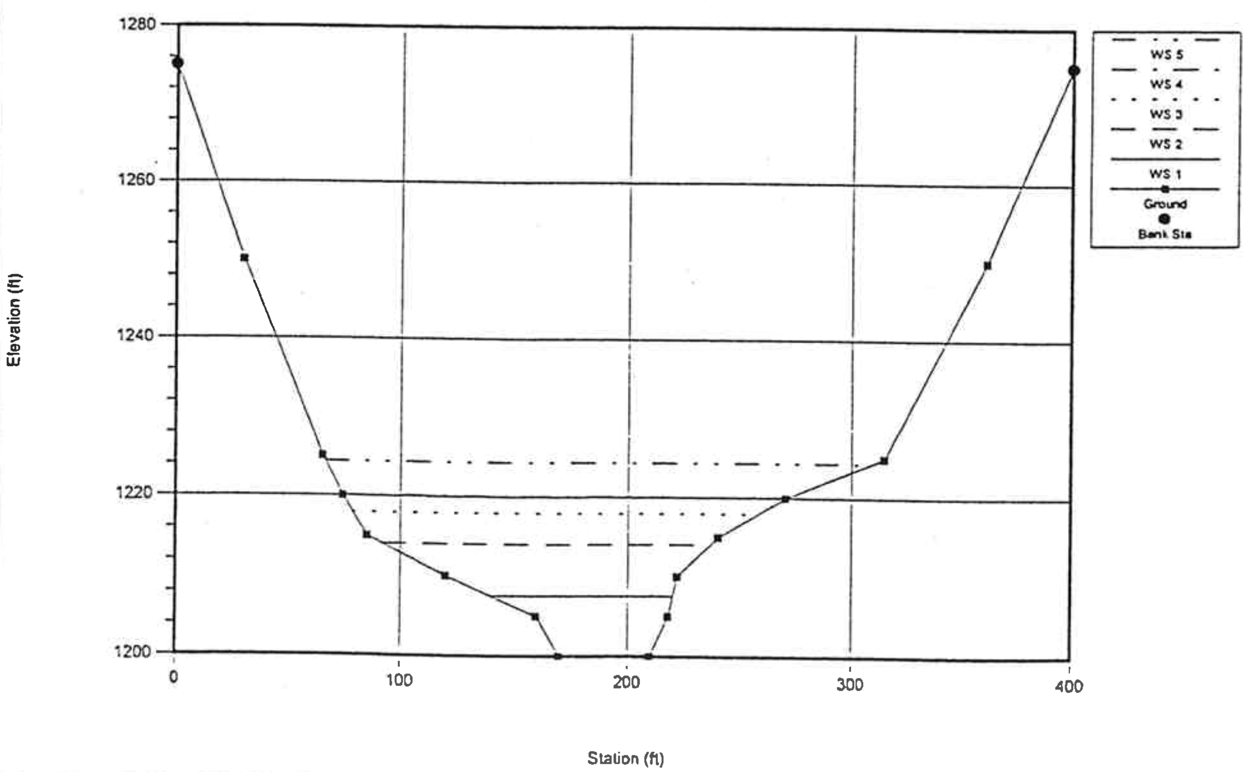
Ralston Afterbay Reservoir - Extended1
112+70 Riv Sta = 11270



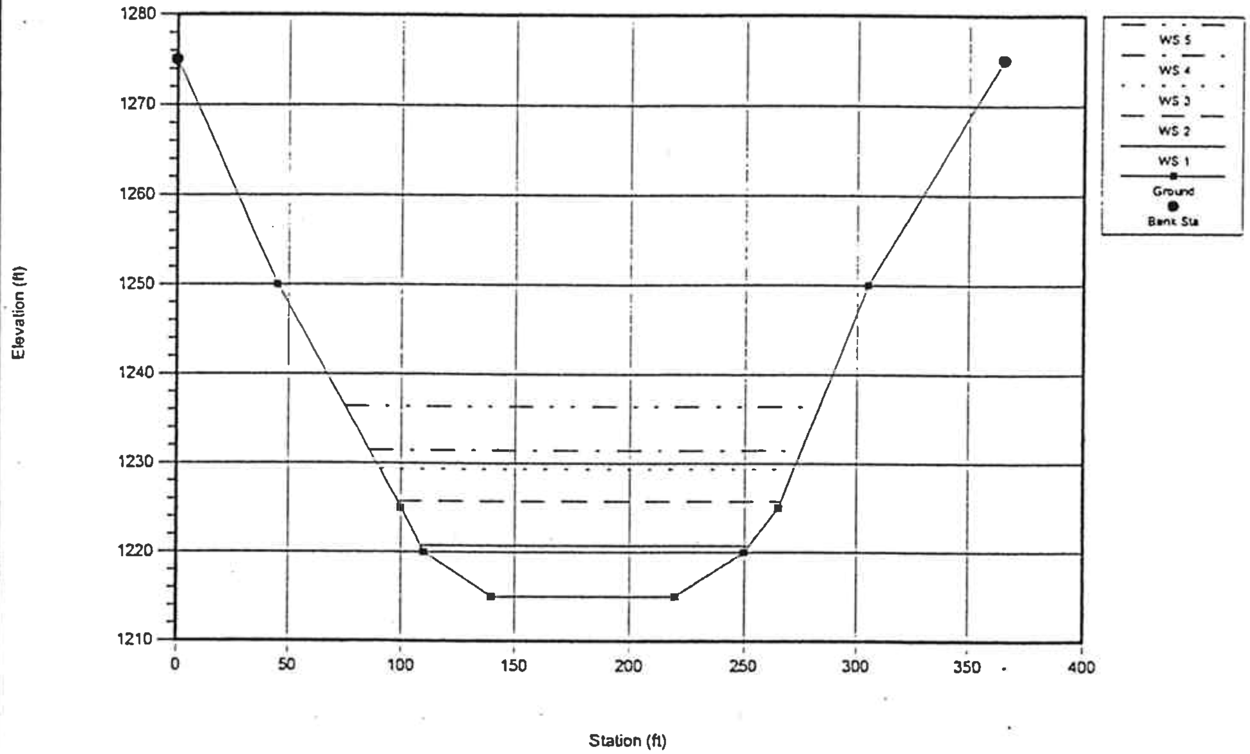
Ralston Afterbay Reservoir - Extended1
121+00   Riv Sta = 12100



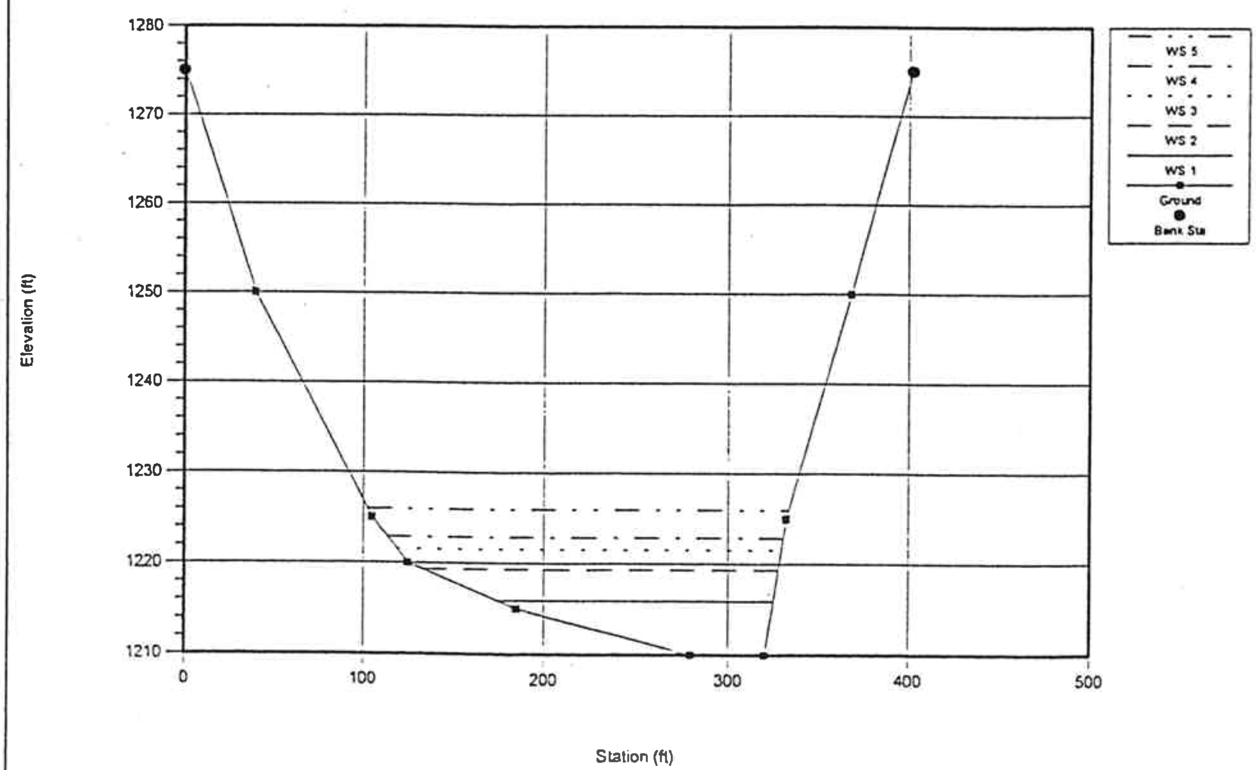
Ralston Afterbay Reservoir - Extended1
119+90   Riv Sta = 11990



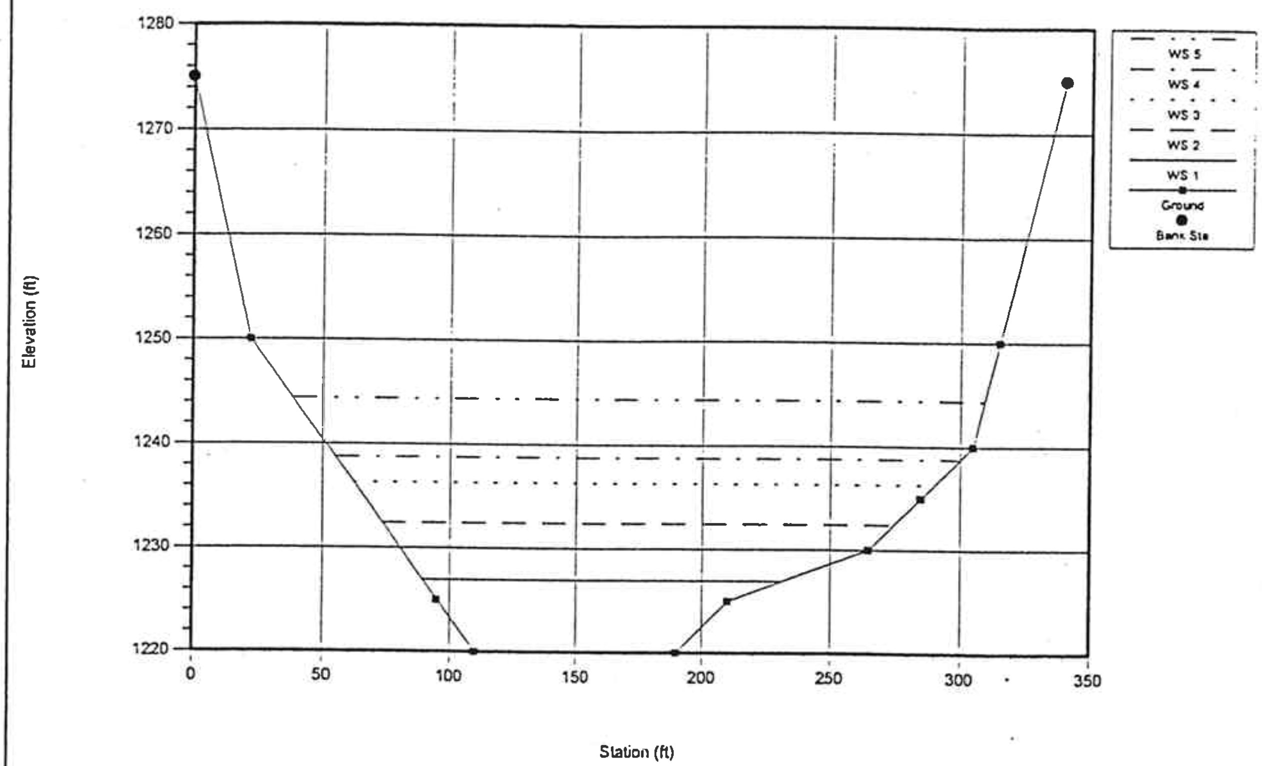
Ralston Afterbay Reservoir - Extended1
124+50 Riv Sta = 12450



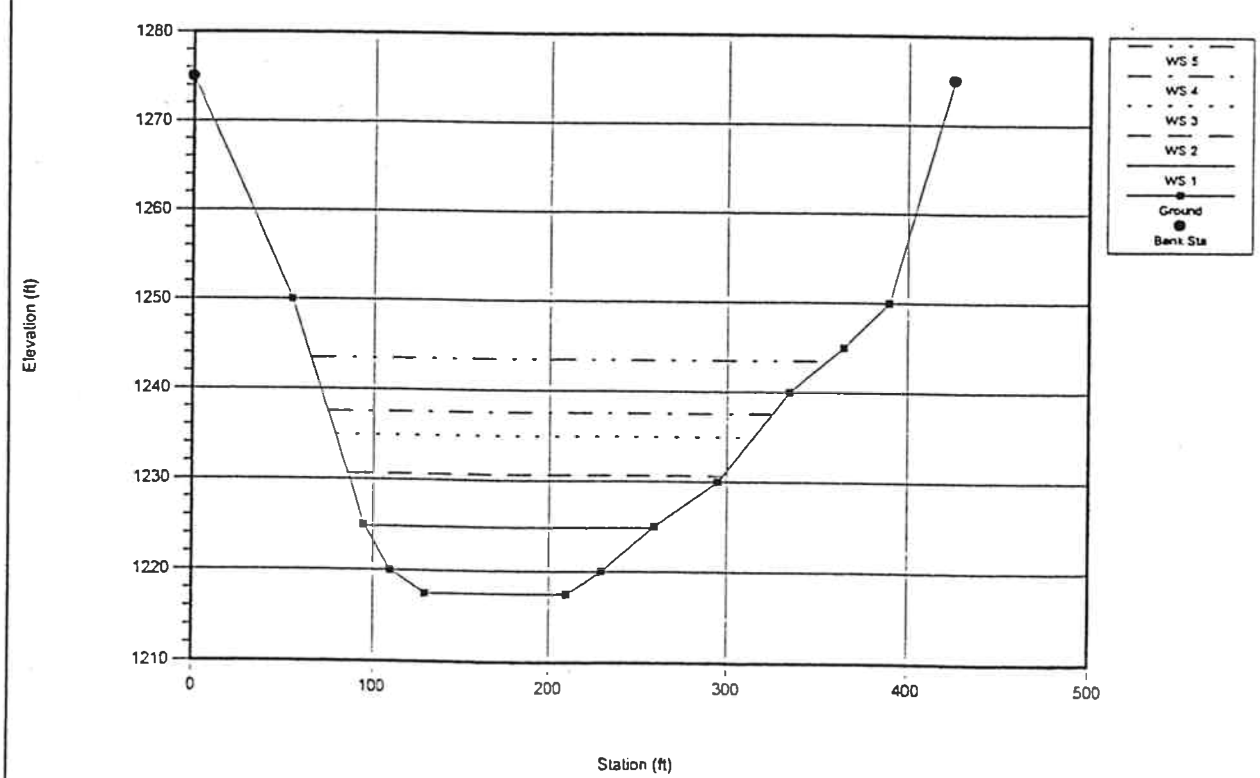
Ralston Afterbay Reservoir - Extended1
122+65 Riv Sta = 12265



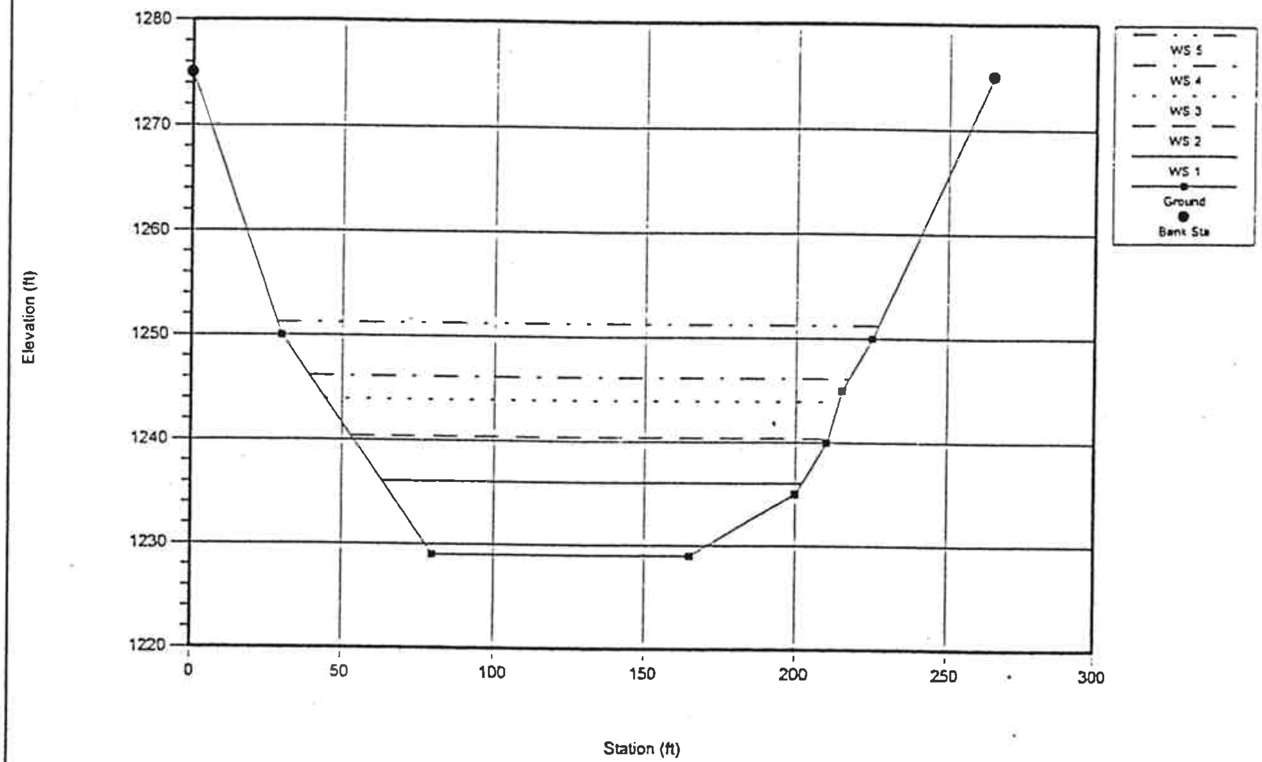
Ralston Afterbay Reservoir - Extended1
130+30 Riv Sta = 13030



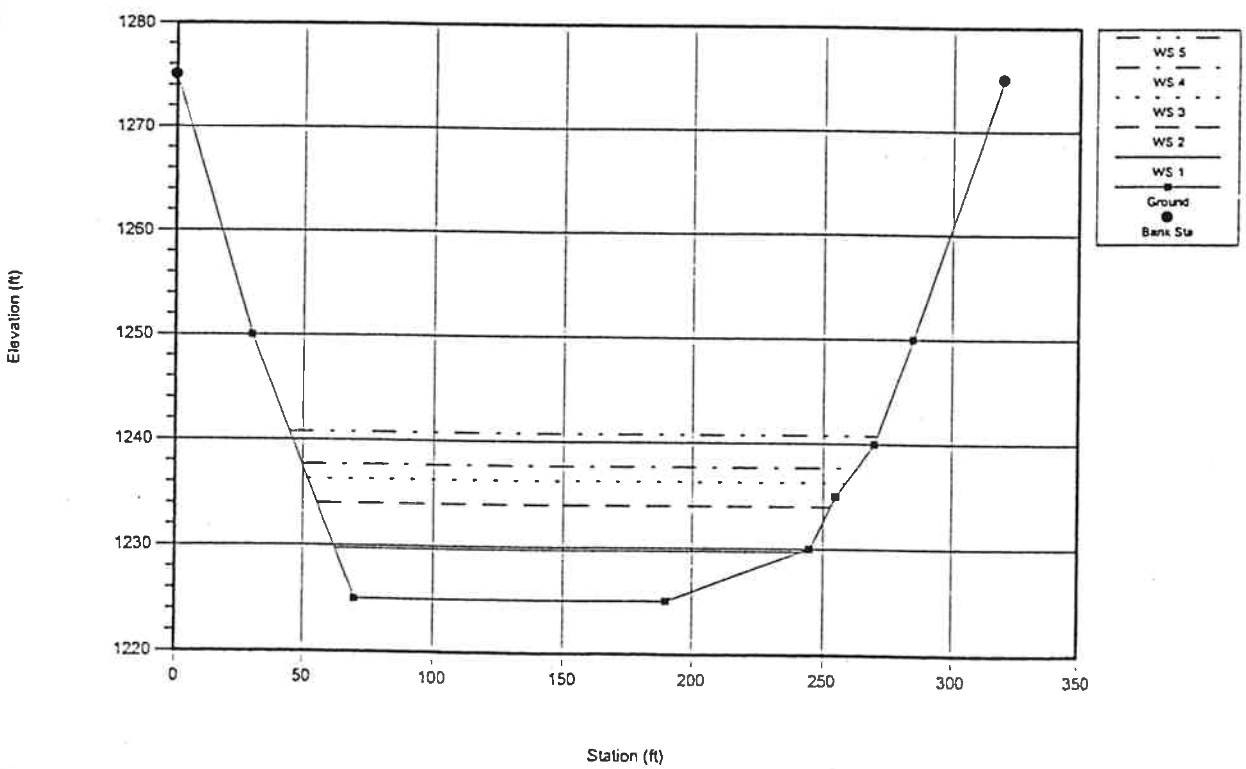
Ralston Afterbay Reservoir - Extended1
127+30 Riv Sta = 12730



Ralston Afterbay Reservoir - Extended1
136+70 Riv Sta = 13670



Ralston Afterbay Reservoir - Extended1
132+00 Riv Sta = 13200



APPENDIX B

SUMMARY OF HEC-RAS OUTPUTS FOR RUBICON AND MIDDLE FORK OF THE AMERICAN RIVER SIMULATION

Reservoir W.L. At El. 1150.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
3990	2000.00	1149.00	1155.51	1152.93	1155.81	0.001814	4.38	456.74	118.46	0.43
3990	3000.00	1149.00	1156.91	1153.80	1157.23	0.002010	4.50	666.28	180.20	0.46
3990	5000.00	1149.00	1158.53	1155.42	1158.91	0.002124	4.92	1015.89	251.47	0.53
3990	8000.00	1149.00	1160.11	1157.25	1160.58	0.002160	5.45	1468.25	316.51	0.62
3990	10000.00	1149.00	1160.82	1158.03	1161.36	0.002128	5.90	1693.53	319.65	0.70
2990	2000.00	1147.00	1150.46	1150.46	1151.83	0.013288	9.42	212.41	77.48	2.21
2990	3000.00	1147.00	1151.52	1151.52	1152.96	0.013045	9.64	311.29	108.73	2.28
2990	5000.00	1147.00	1152.87	1152.87	1154.52	0.012506	10.32	484.32	148.33	2.50
2990	8000.00	1147.00	1154.25	1154.25	1156.18	0.011904	11.15	717.38	188.98	2.78
2990	10000.00	1147.00	1155.00	1155.00	1157.06	0.011395	11.52	868.32	211.11	2.88
2290	2000.00	1143.00	1150.40	1146.53	1150.42	0.000193	1.19	1685.59	586.79	0.03
2290	3000.00	1143.00	1150.75	1146.87	1150.79	0.000295	1.58	1894.96	588.39	0.06
2290	5000.00	1143.00	1151.47	1147.47	1151.54	0.000422	2.16	2317.51	591.62	0.10
2290	8000.00	1143.00	1152.40	1148.20	1152.52	0.000536	2.79	2868.89	595.80	0.16
2290	10000.00	1143.00	1152.96	1148.67	1153.11	0.000585	3.12	3201.01	598.30	0.19
1950	2000.00	1145.50	1150.05	1147.62	1150.22	0.004593	3.35	597.59	475.18	0.36
1950	3000.00	1145.50	1150.14	1148.25	1150.48	0.008224	4.69	640.18	475.49	0.69
1950	5000.00	1145.50	1150.53	1149.33	1151.10	0.009757	6.04	827.40	476.87	1.05
1950	8000.00	1145.50	1151.35	1150.84	1152.02	0.006988	6.58	1215.89	479.71	1.10
1950	10000.00	1145.50	1151.87	1151.19	1152.59	0.005862	6.81	1467.94	481.54	1.11
1290	2000.00	1143.00	1150.00	1145.51	1150.01	0.000079	1.05	1908.81	407.43	0.02
1290	3000.00	1143.00	1149.99	1145.86	1150.03	0.000177	1.57	1907.31	407.34	0.05
1290	5000.00	1143.00	1149.98	1146.47	1150.09	0.000496	2.63	1902.69	407.05	0.14
1290	8000.00	1143.00	1149.95	1147.23	1150.23	0.001294	4.23	1890.63	406.31	0.37
1290	10000.00	1143.00	1149.92	1147.66	1150.36	0.002059	5.32	1878.98	405.59	0.59
810	2000.00	1125.00	1150.00	1130.83	1150.00	0.000006	0.52	3815.59	334.99	0.00
810	3000.00	1125.00	1150.00	1131.85	1150.01	0.000014	0.79	3815.06	334.98	0.01
810	5000.00	1125.00	1149.99	1133.49	1150.02	0.000039	1.31	3813.55	334.96	0.03
810	8000.00	1125.00	1149.98	1135.31	1150.05	0.000100	2.10	3809.66	334.90	0.07
810	10000.00	1125.00	1149.97	1136.28	1150.08	0.000157	2.63	3806.15	334.84	0.11
510	2000.00	1130.00	1150.00	1134.51	1150.00	0.000003	0.38	5249.61	394.99	0.00
510	3000.00	1130.00	1150.00	1135.63	1150.00	0.000006	0.57	5249.13	394.99	0.00
510	5000.00	1130.00	1149.99	1136.34	1150.01	0.000016	0.95	5247.73	394.97	0.01
510	8000.00	1130.00	1149.99	1137.20	1150.02	0.000042	1.53	5244.17	394.92	0.03
510	10000.00	1130.00	1149.98	1137.69	1150.03	0.000066	1.91	5240.94	394.87	0.05
300	2000.00	1125.00	1150.00	1125.93	1150.00	0.000000	0.18	11346.71	483.41	0.00
300	3000.00	1125.00	1150.00	1126.22	1150.00	0.000001	0.26	11346.77	483.41	0.00
300	5000.00	1125.00	1150.00	1126.71	1150.00	0.000002	0.44	11347.18	483.41	0.00
300	8000.00	1125.00	1150.00	1127.33	1150.01	0.000004	0.70	11348.07	483.42	0.01
300	10000.00	1125.00	1150.00	1127.69	1150.02	0.000007	0.88	11348.95	483.43	0.01
180	2000.00	1125.00	1150.00	1127.25	1150.00	0.000001	0.25	8137.32	492.50	0.00
180	3000.00	1125.00	1150.00	1127.88	1150.00	0.000002	0.37	8137.08	492.50	0.00
180	5000.00	1125.00	1150.00	1128.90	1150.00	0.000005	0.61	8136.42	492.49	0.01
180	8000.00	1125.00	1149.99	1130.20	1150.01	0.000013	0.98	8134.61	492.48	0.01
180	10000.00	1125.00	1149.99	1130.94	1150.01	0.000021	1.23	8133.05	492.46	0.02

Reservoir W.L. At El. 1150.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
8350	1613.00	1166.40	1169.65	1168.17	1169.90	0.001977	4.02	401.40	126.36	0.38
8350	2419.00	1166.40	1170.50	1168.72	1170.85	0.002055	4.75	509.58	127.89	0.50
8350	4032.00	1166.40	1171.75	1169.63	1172.31	0.002367	6.01	670.37	130.14	0.73
8350	6452.00	1166.40	1173.11	1170.83	1174.01	0.002854	7.60	849.32	132.59	1.09
8350	8065.00	1166.40	1173.88	1171.52	1174.99	0.003112	8.47	951.73	133.97	1.31
8280	1613.00	1164.30	1169.70	1166.16	1169.80	0.000422	2.55	633.34	121.97	0.13
8280	2419.00	1164.30	1170.56	1166.72	1170.73	0.000581	3.27	738.91	123.48	0.21
8280	4032.00	1164.30	1171.83	1167.68	1172.14	0.000877	4.50	896.63	125.70	0.37
8280	6452.00	1164.30	1173.22	1168.92	1173.78	0.001280	6.01	1072.93	128.13	0.63
8280	8065.00	1164.30	1174.00	1169.66	1174.73	0.001513	6.87	1173.80	129.50	0.80
8210	1613.00	1166.00	1169.57	1167.68	1169.75	0.001237	3.38	477.08	136.75	0.26
8210	2419.00	1166.00	1170.40	1168.20	1170.66	0.001392	4.09	590.91	138.20	0.36
8210	4032.00	1166.00	1171.61	1169.08	1172.05	0.001727	5.31	759.30	140.31	0.56
8210	6452.00	1166.00	1172.92	1170.20	1173.65	0.002196	6.82	945.63	142.62	0.87
8210	8065.00	1166.00	1173.67	1170.88	1174.58	0.002444	7.66	1052.54	143.92	1.06
7810	1613.00	1164.00	1168.33	1167.65	1168.79	0.005907	5.44	296.33	137.00	0.79
7810	2419.00	1164.00	1169.13	1168.29	1169.66	0.005338	5.80	417.14	162.54	0.85
7810	4032.00	1164.00	1170.34	1169.27	1170.96	0.004604	6.36	634.14	192.55	0.94
7810	6452.00	1164.00	1171.72	1170.31	1172.50	0.003843	7.11	907.37	203.05	1.07
7810	8065.00	1164.00	1172.53	1170.85	1173.40	0.003563	7.51	1074.34	209.20	1.13
7190	1613.00	1162.00	1166.00	1164.77	1166.30	0.002808	4.43	364.32	131.47	0.48
7190	2419.00	1162.00	1166.67	1165.37	1167.11	0.003206	5.32	454.78	137.52	0.66
7190	4032.00	1162.00	1167.83	1166.32	1168.49	0.003487	6.49	620.96	148.00	0.91
7190	6452.00	1162.00	1169.28	1167.49	1170.19	0.003598	7.64	844.15	161.00	1.17
7190	8065.00	1162.00	1170.07	1168.17	1171.13	0.003696	8.28	974.45	168.13	1.32
6690	2000.00	1160.50	1162.90	1162.68	1163.66	0.010449	6.99	285.98	138.62	1.33
6690	3000.00	1160.50	1163.81	1163.31	1164.60	0.007565	7.17	418.69	153.27	1.28
6690	5000.00	1160.50	1165.12	1164.30	1166.08	0.006330	7.89	633.47	175.08	1.41
6690	8000.00	1160.50	1166.47	1165.58	1167.73	0.006403	8.97	891.49	204.95	1.72
6690	10000.00	1160.50	1167.20	1166.29	1168.62	0.006508	9.57	1044.96	220.81	1.90
6130	2000.00	1158.00	1162.43	1159.83	1162.53	0.000648	2.45	814.80	237.65	0.14
6130	3000.00	1158.00	1163.30	1160.36	1163.44	0.000745	2.91	1031.31	258.83	0.18
6130	5000.00	1158.00	1164.58	1161.22	1164.78	0.000909	3.62	1381.31	289.81	0.27
6130	8000.00	1158.00	1165.93	1162.27	1166.24	0.001065	4.48	1786.30	306.49	0.39
6130	10000.00	1158.00	1166.64	1162.86	1167.02	0.001157	4.99	2005.89	311.47	0.46
5280	2000.00	1157.00	1160.41	1160.28	1161.02	0.012085	6.27	318.86	202.90	1.18
5280	3000.00	1157.00	1160.75	1160.75	1161.67	0.014852	7.69	390.25	213.64	1.68
5280	5000.00	1157.00	1161.56	1161.56	1162.74	0.013333	8.73	572.66	238.90	1.98
5280	8000.00	1157.00	1162.62	1162.49	1164.02	0.011181	9.49	843.04	272.06	2.15
5280	10000.00	1157.00	1163.31	1163.02	1164.75	0.009643	9.63	1038.96	293.76	2.11
4780	2000.00	1154.50	1157.53	1156.68	1157.81	0.003795	4.28	467.59	220.90	0.50
4780	3000.00	1154.50	1158.66	1157.16	1158.92	0.002274	4.07	737.14	254.89	0.40
4780	5000.00	1154.50	1160.15	1157.97	1160.45	0.001772	4.35	1150.07	298.13	0.42
4780	8000.00	1154.50	1161.66	1158.94	1162.04	0.001586	4.94	1617.85	317.47	0.50
4780	10000.00	1154.50	1162.37	1159.47	1162.83	0.001613	5.42	1846.22	319.62	0.57

Reservoir W.L. At El. 1150.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
10480	1613.00	1180.00	1183.21	1183.21	1184.43	0.021835	8.88	181.64	73.34	3.35
10480	2419.00	1180.00	1184.01	1184.01	1185.54	0.021275	9.92	243.84	81.68	3.93
10480	4032.00	1180.00	1185.35	1185.35	1187.27	0.019082	11.12	362.48	94.05	4.54
10480	6452.00	1180.00	1186.81	1186.81	1189.33	0.018107	12.74	506.45	102.64	5.49
10480	8065.00	1180.00	1187.72	1187.72	1190.51	0.017029	13.39	602.43	107.98	5.82
9940	1613.00	1168.10	1173.45	1170.88	1173.78	0.002479	4.58	352.05	71.35	0.72
9940	2419.00	1168.10	1174.59	1171.70	1175.07	0.002925	5.57	434.54	73.72	1.00
9940	4032.00	1168.10	1176.40	1173.12	1177.17	0.003556	7.06	571.25	77.49	1.51
9940	6452.00	1168.10	1178.51	1174.90	1179.69	0.004231	8.73	739.29	81.89	2.16
9940	8065.00	1168.10	1179.68	1175.93	1181.12	0.004590	9.63	837.13	84.34	2.56
9800	1613.00	1168.10	1173.25	1170.40	1173.46	0.001669	3.73	432.51	87.06	0.48
9800	2419.00	1168.10	1174.37	1171.11	1174.69	0.001974	4.56	530.75	88.37	0.67
9800	4032.00	1168.10	1176.16	1172.32	1176.69	0.002417	5.83	691.30	90.49	1.03
9800	6452.00	1168.10	1178.27	1173.85	1179.09	0.002916	7.30	884.42	92.96	1.51
9800	8065.00	1168.10	1179.45	1174.74	1180.47	0.003194	8.11	994.76	94.35	1.81
9680	1613.00	1169.20	1172.35	1171.63	1173.02	0.009560	6.58	245.23	82.20	1.74
9680	2419.00	1169.20	1173.39	1172.36	1174.21	0.008232	7.27	332.53	85.03	1.94
9680	4032.00	1169.20	1175.06	1173.61	1176.16	0.007411	8.43	478.08	89.57	2.36
9680	6452.00	1169.20	1177.02	1175.18	1178.51	0.007145	9.79	658.76	94.89	2.93
9680	8065.00	1169.20	1178.12	1176.06	1179.85	0.007116	10.54	765.22	97.89	3.27
9525	1613.00	1166.40	1172.42	1168.85	1172.60	0.000695	3.40	474.89	84.85	0.23
9525	2419.00	1166.40	1173.44	1169.60	1173.73	0.000929	4.30	562.14	86.88	0.35
9525	4032.00	1166.40	1175.08	1170.89	1175.59	0.001281	5.70	707.34	90.16	0.58
9525	6452.00	1166.40	1177.01	1172.49	1177.84	0.001671	7.29	885.07	94.02	0.90
9525	8065.00	1166.40	1178.10	1173.40	1179.13	0.001880	8.16	988.28	96.19	1.10
9385	1613.00	1165.80	1172.36	1168.27	1172.51	0.000527	3.11	519.36	86.02	0.19
9385	2419.00	1165.80	1173.35	1169.02	1173.60	0.000739	3.99	605.75	88.10	0.30
9385	4032.00	1165.80	1174.96	1170.29	1175.40	0.001077	5.38	749.60	91.45	0.51
9385	6452.00	1165.80	1176.84	1171.91	1177.60	0.001465	6.97	925.82	95.39	0.81
9385	8065.00	1165.80	1177.90	1172.83	1178.86	0.001678	7.84	1028.21	97.61	1.00
9200	1613.00	1168.80	1171.62	1170.96	1172.23	0.005957	6.29	256.30	94.14	0.99
9200	2419.00	1168.80	1172.43	1171.64	1173.25	0.005752	7.25	333.63	95.97	1.21
9200	4032.00	1168.80	1173.79	1172.77	1174.95	0.005551	8.66	465.64	99.02	1.57
9200	6452.00	1168.80	1175.39	1174.20	1177.03	0.005583	10.28	627.77	102.63	2.03
9200	8065.00	1168.80	1176.30	1175.02	1178.24	0.005660	11.17	721.97	104.68	2.31
8675	1613.00	1166.60	1169.86	1168.54	1170.18	0.002567	4.56	353.39	111.46	0.50
8675	2419.00	1166.60	1170.77	1169.12	1171.21	0.002537	5.30	456.18	113.13	0.62
8675	4032.00	1166.60	1172.14	1170.13	1172.81	0.002757	6.59	612.09	115.62	0.87
8675	6452.00	1166.60	1173.66	1171.41	1174.70	0.003148	8.16	790.48	118.41	1.25
8675	8065.00	1166.60	1174.52	1172.17	1175.79	0.003355	9.03	893.29	119.99	1.47
8525	1613.00	1163.30	1169.95	1165.23	1170.02	0.000240	2.17	741.94	117.42	0.09
8525	2419.00	1163.30	1170.88	1165.82	1171.00	0.000349	2.84	852.04	119.05	0.15
8525	4032.00	1163.30	1172.28	1166.81	1172.52	0.000553	3.95	1020.43	121.50	0.27
8525	6452.00	1163.30	1173.86	1168.11	1174.30	0.000827	5.31	1214.73	124.26	0.47
8525	8065.00	1163.30	1174.76	1168.88	1175.33	0.000985	6.08	1326.96	125.83	0.60

Reservoir W.L. At El. 1150.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
12730	1613.00	1218.40	1221.21	1220.46	1221.63	0.007715	5.17	312.23	130.92	1.14
12730	2419.00	1218.40	1221.94	1221.01	1222.48	0.007534	5.91	409.05	137.42	1.39
12730	4032.00	1218.40	1223.06	1221.94	1223.84	0.007670	7.08	569.09	147.53	1.84
12730	6452.00	1218.40	1224.41	1223.12	1225.48	0.007780	8.32	775.92	159.65	2.34
12730	8065.00	1218.40	1225.14	1223.80	1226.40	0.007952	9.00	895.93	166.22	2.65
12450	1613.00	1215.00	1217.25	1217.21	1218.16	0.022112	7.68	210.00	106.96	2.70
12450	2419.00	1215.00	1217.82	1217.82	1219.04	0.022372	8.84	273.71	113.88	3.34
12450	4032.00	1215.00	1218.87	1218.87	1220.45	0.020336	10.10	399.17	126.41	3.99
12450	6452.00	1215.00	1220.09	1220.09	1222.13	0.019138	11.47	562.39	140.44	4.76
12450	8065.00	1215.00	1220.80	1220.80	1223.09	0.017864	12.16	663.47	144.00	5.10
12265	1613.00	1210.00	1212.90	1212.90	1213.92	0.023720	8.11	198.94	97.36	2.98
12265	2419.00	1210.00	1213.57	1213.62	1214.83	0.023139	8.98	269.24	110.73	3.46
12265	4032.00	1210.00	1214.48	1214.70	1216.25	0.025370	10.66	378.16	128.74	4.57
12265	6452.00	1210.00	1215.47	1215.91	1217.91	0.027274	12.53	514.95	145.08	5.93
12265	8065.00	1210.00	1215.96	1216.60	1218.89	0.029194	13.74	586.78	151.28	6.93
12100	1613.00	1205.00	1207.95	1208.20	1209.59	0.028382	10.28	156.98	61.51	4.45
12100	2419.00	1205.00	1208.86	1209.09	1210.82	0.024732	11.21	215.73	66.64	4.90
12100	4032.00	1205.00	1210.51	1210.64	1212.78	0.020254	12.08	333.77	79.12	5.21
12100	6452.00	1205.00	1212.46	1212.46	1214.94	0.017709	12.63	510.95	102.53	5.39
12100	8065.00	1205.00	1213.39	1213.39	1216.09	0.017454	13.19	611.38	113.68	5.73
11990	1613.00	1200.00	1202.72	1203.51	1205.42	0.049942	13.18	122.35	49.81	7.45
11990	2419.00	1200.00	1203.49	1204.51	1206.98	0.048344	14.99	161.35	52.55	8.96
11990	4032.00	1200.00	1204.83	1206.30	1209.39	0.043506	17.14	235.23	57.39	10.66
11990	6452.00	1200.00	1206.64	1208.25	1211.86	0.039846	18.32	352.09	72.45	11.53
11990	8065.00	1200.00	1207.65	1209.32	1213.12	0.037416	18.76	429.91	81.35	11.76
11590	1613.00	1195.00	1198.04	1197.42	1198.66	0.010345	6.34	254.36	97.36	1.68
11590	2419.00	1195.00	1198.88	1198.11	1199.67	0.009806	7.12	339.86	104.96	1.97
11590	4032.00	1195.00	1200.25	1199.26	1201.30	0.009309	8.19	492.08	118.15	2.40
11590	6452.00	1195.00	1201.89	1200.68	1203.20	0.009013	9.19	702.27	138.46	2.62
11590	8065.00	1195.00	1202.80	1201.47	1204.25	0.008867	9.69	832.53	149.67	3.04
11270	1613.00	1192.00	1195.71	1194.59	1196.14	0.005971	5.26	306.41	102.38	1.10
11270	2419.00	1192.00	1196.53	1195.27	1197.12	0.006372	6.16	392.84	108.60	1.42
11270	4032.00	1192.00	1197.83	1196.40	1198.69	0.006906	7.46	540.41	118.48	1.93
11270	6452.00	1192.00	1199.33	1197.79	1200.55	0.007481	8.88	726.90	129.89	2.56
11270	8065.00	1192.00	1200.16	1198.59	1201.60	0.007749	9.64	837.01	135.47	2.92
10990	1613.00	1190.00	1192.17	1192.17	1193.15	0.023305	7.93	203.28	102.36	2.67
10990	2419.00	1190.00	1192.81	1192.81	1194.05	0.021630	8.94	270.47	107.48	3.37
10990	4032.00	1190.00	1193.86	1193.86	1195.54	0.020003	10.39	388.02	115.90	4.14
10990	6452.00	1190.00	1195.17	1195.17	1197.34	0.018390	11.81	546.37	126.19	4.92
10990	8065.00	1190.00	1195.93	1195.93	1198.36	0.017600	12.52	644.06	131.50	5.31
10850	1613.00	1185.00	1188.67	1187.80	1189.22	0.008375	5.95	271.30	97.74	1.44
10850	2419.00	1185.00	1189.57	1188.55	1190.25	0.008237	6.65	363.77	109.35	1.70
10850	4032.00	1185.00	1190.84	1189.75	1191.81	0.008228	7.91	509.55	117.34	2.21
10850	6452.00	1185.00	1192.38	1191.05	1193.72	0.007989	9.30	693.76	121.66	2.79
10850	8065.00	1185.00	1193.23	1191.80	1194.81	0.008064	10.10	798.40	124.04	3.17

Reservoir W.L. At El. 1155.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
3990	2000.00	1149.00	1155.64	1152.93	1155.92	0.001721	4.23	472.83	124.29	0
3990	3000.00	1149.00	1156.39	1153.80	1156.81	0.002698	5.19	577.87	157.14	1
3990	5000.00	1149.00	1157.97	1155.42	1158.47	0.002970	5.67	881.95	226.83	1
3990	8000.00	1149.00	1160.11	1157.25	1160.58	0.002160	5.45	1468.25	316.51	1
3990	10000.00	1149.00	1160.82	1158.03	1161.36	0.002128	5.90	1693.53	319.65	1
2990	2000.00	1147.00	1154.97	1150.46	1155.06	0.000464	2.32	862.48	210.36	0
2990	3000.00	1147.00	1154.94	1151.52	1155.13	0.001066	3.51	855.43	209.38	0
2990	5000.00	1147.00	1154.81	1152.87	1155.38	0.003214	6.03	828.69	205.58	1
2990	8000.00	1147.00	1154.25	1154.25	1156.18	0.011904	11.15	717.38	188.98	3
2990	10000.00	1147.00	1155.00	1155.00	1157.06	0.011395	11.52	868.32	211.11	3
2290	2000.00	1143.00	1155.01	1146.53	1155.02	0.000008	0.45	4442.06	607.58	0
2290	3000.00	1143.00	1155.03	1146.87	1155.04	0.000018	0.67	4452.44	607.67	0
2290	5000.00	1143.00	1155.09	1147.47	1155.10	0.000049	1.11	4485.46	607.98	0
2290	8000.00	1143.00	1155.21	1148.20	1155.26	0.000118	1.75	4564.47	608.70	0
2290	10000.00	1143.00	1155.33	1148.67	1155.40	0.000175	2.16	4635.84	609.35	0
1950	2000.00	1145.50	1155.01	1147.62	1155.01	0.000023	0.67	2995.09	492.51	0
1950	3000.00	1145.50	1155.01	1148.25	1155.03	0.000051	1.00	2998.33	492.53	0
1950	5000.00	1145.50	1155.03	1149.33	1155.08	0.000139	1.66	3008.79	492.59	0
1950	8000.00	1145.50	1155.08	1150.84	1155.19	0.000346	2.64	3034.29	492.72	0
1950	10000.00	1145.50	1155.13	1151.19	1155.30	0.000526	3.27	3058.17	492.85	0
1290	2000.00	1143.00	1155.00	1145.51	1155.00	0.000007	0.50	3977.35	419.50	0
1290	3000.00	1143.00	1155.00	1145.86	1155.01	0.000016	0.75	3977.14	419.50	0
1290	5000.00	1143.00	1155.00	1146.47	1155.02	0.000045	1.26	3976.58	419.49	0
1290	8000.00	1143.00	1154.99	1147.23	1155.06	0.000115	2.01	3975.09	419.49	0
1290	10000.00	1143.00	1154.99	1147.66	1155.09	0.000180	2.52	3973.97	419.48	0
810	2000.00	1125.00	1155.00	1130.83	1155.00	0.000002	0.36	5533.29	352.00	0
810	3000.00	1125.00	1155.00	1131.85	1155.00	0.000004	0.54	5532.98	352.00	0
810	5000.00	1125.00	1155.00	1133.49	1155.01	0.000012	0.90	5532.08	351.99	0
810	8000.00	1125.00	1154.99	1135.31	1155.02	0.000031	1.45	5529.85	351.96	0
810	10000.00	1125.00	1154.98	1136.28	1155.03	0.000049	1.81	5527.91	351.95	0
510	2000.00	1130.00	1155.00	1134.51	1155.00	0.000001	0.27	7291.51	421.66	0
510	3000.00	1130.00	1155.00	1135.63	1155.00	0.000002	0.41	7291.25	421.66	0
510	5000.00	1130.00	1155.00	1136.34	1155.00	0.000006	0.69	7290.48	421.65	0
510	8000.00	1130.00	1154.99	1137.20	1155.01	0.000015	1.10	7288.68	421.63	0
510	10000.00	1130.00	1154.99	1137.69	1155.02	0.000024	1.37	7287.09	421.61	0
300	2000.00	1125.00	1155.00	1125.93	1155.00	0.000000	0.14	13808.02	501.14	0
300	3000.00	1125.00	1155.00	1126.22	1155.00	0.000000	0.22	13808.08	501.14	0
300	5000.00	1125.00	1155.00	1126.71	1155.00	0.000001	0.36	13808.20	501.14	0
300	8000.00	1125.00	1155.00	1127.33	1155.01	0.000002	0.58	13808.63	501.14	0
300	10000.00	1125.00	1155.00	1127.69	1155.01	0.000004	0.72	13809.12	501.15	0
180	2000.00	1125.00	1155.00	1127.25	1155.00	0.000000	0.19	10628.69	504.00	0
180	3000.00	1125.00	1155.00	1127.88	1155.00	0.000001	0.28	10628.57	504.00	0
180	5000.00	1125.00	1155.00	1128.90	1155.00	0.000002	0.47	10628.20	504.00	0
180	8000.00	1125.00	1155.00	1130.20	1155.01	0.000006	0.75	10627.27	503.99	0
180	10000.00	1125.00	1155.00	1130.94	1155.01	0.000009	0.94	10626.47	503.99	0

Reservoir W.L. At El. 1155.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
8350	1613.00	1166.40	1169.65	1168.17	1169.90	0.001977	4.02	401.40	126.36	0
8350	2419.00	1166.40	1170.50	1168.72	1170.85	0.002055	4.75	509.58	127.89	0
8350	4032.00	1166.40	1171.75	1169.63	1172.31	0.002367	6.01	670.37	130.14	1
8350	6452.00	1166.40	1173.11	1170.83	1174.01	0.002854	7.60	849.32	132.59	1
8350	8065.00	1166.40	1173.88	1171.52	1174.99	0.003112	8.47	951.73	133.97	1
8280	1613.00	1164.30	1169.70	1166.16	1169.80	0.000422	2.55	633.34	121.97	0
8280	2419.00	1164.30	1170.56	1166.72	1170.73	0.000581	3.27	738.91	123.48	0
8280	4032.00	1164.30	1171.83	1167.68	1172.14	0.000877	4.50	896.63	125.70	0
8280	6452.00	1164.30	1173.22	1168.92	1173.78	0.001280	6.01	1072.93	128.13	1
8280	8065.00	1164.30	1174.00	1169.66	1174.73	0.001513	6.87	1173.80	129.50	1
8210	1613.00	1166.00	1169.57	1167.68	1169.75	0.001237	3.38	477.08	136.75	0
8210	2419.00	1166.00	1170.40	1168.20	1170.66	0.001392	4.09	590.91	138.20	0
8210	4032.00	1166.00	1171.61	1169.08	1172.05	0.001727	5.31	759.30	140.31	1
8210	6452.00	1166.00	1172.92	1170.20	1173.65	0.002196	6.82	945.63	142.62	1
8210	8065.00	1166.00	1173.67	1170.88	1174.58	0.002444	7.66	1052.54	143.92	1
7810	1613.00	1164.00	1168.33	1167.65	1168.79	0.005904	5.44	296.38	137.01	1
7810	2419.00	1164.00	1169.13	1168.29	1169.66	0.005338	5.80	417.14	162.54	1
7810	4032.00	1164.00	1170.34	1169.27	1170.96	0.004604	6.36	634.14	192.55	1
7810	6452.00	1164.00	1171.72	1170.31	1172.50	0.003843	7.11	907.37	203.05	1
7810	8065.00	1164.00	1172.53	1170.85	1173.40	0.003563	7.51	1074.34	209.20	1
7190	1613.00	1162.00	1166.00	1164.77	1166.30	0.002810	4.43	364.20	131.46	0
7190	2419.00	1162.00	1166.67	1165.37	1167.11	0.003206	5.32	454.78	137.52	1
7190	4032.00	1162.00	1167.83	1166.32	1168.49	0.003487	6.49	620.96	148.00	1
7190	6452.00	1162.00	1169.28	1167.49	1170.19	0.003598	7.64	844.15	161.00	1
7190	8065.00	1162.00	1170.07	1168.17	1171.13	0.003695	8.28	974.45	168.13	1
6690	2000.00	1160.50	1162.90	1162.68	1163.66	0.010422	6.99	286.23	138.65	1
6690	3000.00	1160.50	1163.81	1163.31	1164.60	0.007565	7.17	418.69	153.27	1
6690	5000.00	1160.50	1165.12	1164.30	1166.08	0.006330	7.89	633.47	175.08	1
6690	8000.00	1160.50	1166.47	1165.58	1167.73	0.006403	8.97	891.49	204.95	2
6690	10000.00	1160.50	1167.20	1166.29	1168.62	0.006508	9.57	1044.96	220.81	2
6130	2000.00	1158.00	1162.44	1159.83	1162.53	0.000646	2.45	815.75	237.74	0
6130	3000.00	1158.00	1163.30	1160.36	1163.44	0.000745	2.91	1031.31	258.83	0
6130	5000.00	1158.00	1164.58	1161.22	1164.78	0.000909	3.62	1381.31	289.81	0
6130	8000.00	1158.00	1165.93	1162.27	1166.24	0.001065	4.48	1786.30	306.49	0
6130	10000.00	1158.00	1166.64	1162.86	1167.02	0.001157	4.99	2005.89	311.47	0
5280	2000.00	1157.00	1160.39	1160.28	1161.02	0.012581	6.36	314.63	202.24	1
5280	3000.00	1157.00	1160.75	1160.75	1161.67	0.014852	7.69	390.25	213.64	2
5280	5000.00	1157.00	1161.56	1161.56	1162.74	0.013333	8.73	572.66	238.90	2
5280	8000.00	1157.00	1162.62	1162.49	1164.02	0.011181	9.49	843.04	272.06	2
5280	10000.00	1157.00	1163.31	1163.02	1164.75	0.009643	9.63	1038.96	293.76	2
4780	2000.00	1154.50	1157.56	1156.68	1157.84	0.003648	4.22	473.94	221.76	0
4780	3000.00	1154.50	1158.58	1157.16	1158.85	0.002469	4.19	716.30	252.42	0
4780	5000.00	1154.50	1160.05	1157.97	1160.36	0.001925	4.47	1118.64	295.96	0
4780	8000.00	1154.50	1161.66	1158.94	1162.04	0.001586	4.94	1617.85	317.47	0
4780	10000.00	1154.50	1162.37	1159.47	1162.83	0.001613	5.42	1846.22	319.62	1

Reservoir W.L. At El. 1155.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
10480	1613.00	1180.00	1183.21	1183.21	1184.43	0.021835	8.88	181.64	73.34	3.35
10480	2419.00	1180.00	1184.01	1184.01	1185.54	0.021275	9.92	243.84	81.68	3.93
10480	4032.00	1180.00	1185.35	1185.35	1187.27	0.019082	11.12	362.48	94.05	4.54
10480	6452.00	1180.00	1186.81	1186.81	1189.33	0.018107	12.74	506.45	102.64	5.49
10480	8065.00	1180.00	1187.72	1187.72	1190.51	0.017029	13.39	602.43	107.98	5.82
9940	1613.00	1168.10	1173.45	1170.88	1173.78	0.002479	4.58	352.05	71.35	0.72
9940	2419.00	1168.10	1174.59	1171.70	1175.07	0.002925	5.57	434.54	73.72	1.00
9940	4032.00	1168.10	1176.40	1173.12	1177.17	0.003556	7.06	571.25	77.49	1.51
9940	6452.00	1168.10	1178.51	1174.90	1179.69	0.004231	8.73	739.29	81.89	2.16
9940	8065.00	1168.10	1179.68	1175.93	1181.12	0.004590	9.63	837.13	84.34	2.56
9800	1613.00	1168.10	1173.25	1170.40	1173.46	0.001669	3.73	432.51	87.06	0.48
9800	2419.00	1168.10	1174.37	1171.11	1174.69	0.001974	4.56	530.75	88.37	0.67
9800	4032.00	1168.10	1176.16	1172.32	1176.69	0.002417	5.83	691.30	90.49	1.03
9800	6452.00	1168.10	1178.27	1173.85	1179.09	0.002916	7.30	884.42	92.96	1.51
9800	8065.00	1168.10	1179.45	1174.74	1180.47	0.003194	8.11	994.76	94.35	1.81
9680	1613.00	1169.20	1172.35	1171.63	1173.02	0.009560	6.58	245.23	82.20	1.74
9680	2419.00	1169.20	1173.39	1172.36	1174.21	0.008232	7.27	332.53	85.03	1.94
9680	4032.00	1169.20	1175.06	1173.61	1176.16	0.007411	8.43	478.08	89.57	2.36
9680	6452.00	1169.20	1177.02	1175.18	1178.51	0.007145	9.79	658.76	94.89	2.93
9680	8065.00	1169.20	1178.12	1176.06	1179.85	0.007116	10.54	765.22	97.89	3.27
9525	1613.00	1166.40	1172.42	1168.85	1172.60	0.000695	3.40	474.89	84.85	0.23
9525	2419.00	1166.40	1173.44	1169.60	1173.73	0.000929	4.30	562.14	86.88	0.35
9525	4032.00	1166.40	1175.08	1170.89	1175.59	0.001281	5.70	707.34	90.16	0.58
9525	6452.00	1166.40	1177.01	1172.49	1177.84	0.001671	7.29	885.07	94.02	0.90
9525	8065.00	1166.40	1178.10	1173.40	1179.13	0.001880	8.16	988.28	96.19	1.10
9385	1613.00	1165.80	1172.36	1168.27	1172.51	0.000527	3.11	519.36	86.02	0.19
9385	2419.00	1165.80	1173.35	1169.02	1173.60	0.000739	3.99	605.75	88.10	0.30
9385	4032.00	1165.80	1174.96	1170.29	1175.40	0.001077	5.38	749.60	91.45	0.51
9385	6452.00	1165.80	1176.84	1171.91	1177.60	0.001465	6.97	925.82	95.39	0.81
9385	8065.00	1165.80	1177.90	1172.83	1178.86	0.001678	7.84	1028.21	97.61	1.00
9200	1613.00	1168.80	1171.62	1170.96	1172.23	0.005957	6.29	256.30	94.14	0.99
9200	2419.00	1168.80	1172.43	1171.64	1173.25	0.005752	7.25	333.63	95.97	1.21
9200	4032.00	1168.80	1173.79	1172.77	1174.95	0.005551	8.66	465.64	99.02	1.57
9200	6452.00	1168.80	1175.39	1174.20	1177.03	0.005583	10.28	627.77	102.63	2.03
9200	8065.00	1168.80	1176.30	1175.02	1178.24	0.005660	11.17	721.97	104.68	2.31
8675	1613.00	1166.60	1169.86	1168.54	1170.18	0.002567	4.56	353.39	111.46	0.50
8675	2419.00	1166.60	1170.77	1169.12	1171.21	0.002537	5.30	456.18	113.13	0.62
8675	4032.00	1166.60	1172.14	1170.13	1172.81	0.002757	6.59	612.09	115.62	0.87
8675	6452.00	1166.60	1173.66	1171.41	1174.70	0.003148	8.16	790.48	118.41	1.25
8675	8065.00	1166.60	1174.52	1172.17	1175.79	0.003355	9.03	893.29	119.99	1.47
8525	1613.00	1163.30	1169.95	1165.23	1170.02	0.000240	2.17	741.94	117.42	0.09
8525	2419.00	1163.30	1170.88	1165.82	1171.00	0.000349	2.84	852.04	119.05	0.15
8525	4032.00	1163.30	1172.28	1166.81	1172.52	0.000553	3.95	1020.43	121.50	0.27
8525	6452.00	1163.30	1173.86	1168.11	1174.30	0.000827	5.31	1214.73	124.26	0.47
8525	8065.00	1163.30	1174.76	1168.88	1175.33	0.000985	6.08	1326.96	125.83	0.60

Reservoir W.L. At El. 1155.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
12730	1613.00	1218.40	1221.21	1220.46	1221.63	0.007715	5.17	312.23	130.92	1.14
12730	2419.00	1218.40	1221.94	1221.01	1222.48	0.007534	5.91	409.05	137.42	1.39
12730	4032.00	1218.40	1223.06	1221.94	1223.84	0.007670	7.08	569.09	147.53	1.84
12730	6452.00	1218.40	1224.41	1223.12	1225.48	0.007780	8.32	775.92	159.65	2.34
12730	8065.00	1218.40	1225.14	1223.80	1226.40	0.007952	9.00	895.93	166.22	2.65
12450	1613.00	1215.00	1217.25	1217.21	1218.16	0.022112	7.68	210.00	106.96	2.70
12450	2419.00	1215.00	1217.82	1217.82	1219.04	0.022372	8.84	273.71	113.88	3.34
12450	4032.00	1215.00	1218.87	1218.87	1220.45	0.020336	10.10	399.17	126.41	3.99
12450	6452.00	1215.00	1220.09	1220.09	1222.13	0.019138	11.47	562.39	140.44	4.76
12450	8065.00	1215.00	1220.80	1220.80	1223.09	0.017864	12.16	663.47	144.00	5.10
12265	1613.00	1210.00	1212.90	1212.90	1213.92	0.023720	8.11	198.94	97.36	2.98
12265	2419.00	1210.00	1213.57	1213.62	1214.83	0.023139	8.98	269.24	110.73	3.46
12265	4032.00	1210.00	1214.48	1214.70	1216.25	0.025370	10.66	378.16	128.74	4.57
12265	6452.00	1210.00	1215.47	1215.91	1217.91	0.027274	12.53	514.95	145.08	5.93
12265	8065.00	1210.00	1215.96	1216.60	1218.89	0.029194	13.74	586.78	151.28	6.93
12100	1613.00	1205.00	1207.95	1208.20	1209.59	0.028382	10.28	156.98	61.51	4.45
12100	2419.00	1205.00	1208.86	1209.09	1210.82	0.024732	11.21	215.73	66.64	4.90
12100	4032.00	1205.00	1210.51	1210.64	1212.78	0.020254	12.08	333.77	79.12	5.21
12100	6452.00	1205.00	1212.46	1212.46	1214.94	0.017709	12.63	510.95	102.53	5.39
12100	8065.00	1205.00	1213.39	1213.39	1216.09	0.017454	13.19	611.38	113.68	5.73
11990	1613.00	1200.00	1202.72	1203.51	1205.42	0.049942	13.18	122.35	49.81	7.45
11990	2419.00	1200.00	1203.49	1204.51	1206.98	0.048344	14.99	161.35	52.55	8.96
11990	4032.00	1200.00	1204.83	1206.30	1209.39	0.043506	17.14	235.23	57.39	10.66
11990	6452.00	1200.00	1206.64	1208.25	1211.86	0.039846	18.32	352.09	72.45	11.53
11990	8065.00	1200.00	1207.65	1209.32	1213.12	0.037416	18.76	429.91	81.35	11.76
11590	1613.00	1195.00	1198.04	1197.42	1198.66	0.010345	6.34	254.36	97.36	1.68
11590	2419.00	1195.00	1198.88	1198.11	1199.67	0.009806	7.12	339.86	104.96	1.97
11590	4032.00	1195.00	1200.25	1199.26	1201.30	0.009309	8.19	492.08	118.15	2.40
11590	6452.00	1195.00	1201.89	1200.68	1203.20	0.009013	9.19	702.27	138.46	2.82
11590	8065.00	1195.00	1202.80	1201.47	1204.25	0.008867	9.69	832.53	149.67	3.04
11270	1613.00	1192.00	1195.71	1194.59	1196.14	0.005971	5.26	306.41	102.38	1.10
11270	2419.00	1192.00	1196.53	1195.27	1197.12	0.006372	6.16	392.84	108.60	1.42
11270	4032.00	1192.00	1197.83	1196.40	1198.69	0.006906	7.46	540.41	118.48	1.93
11270	6452.00	1192.00	1199.33	1197.79	1200.55	0.007481	8.88	726.90	129.89	2.56
11270	8065.00	1192.00	1200.16	1198.59	1201.60	0.007749	9.64	837.01	135.47	2.92
10990	1613.00	1190.00	1192.17	1192.17	1193.15	0.023305	7.93	203.28	102.36	2.87
10990	2419.00	1190.00	1192.81	1192.81	1194.05	0.021630	8.94	270.47	107.48	3.37
10990	4032.00	1190.00	1193.86	1193.86	1195.54	0.020003	10.39	388.02	115.90	4.14
10990	6452.00	1190.00	1195.17	1195.17	1197.34	0.018390	11.81	546.37	126.19	4.92
10990	8065.00	1190.00	1195.93	1195.93	1198.36	0.017600	12.52	644.06	131.50	5.31
10850	1613.00	1185.00	1188.67	1187.80	1189.22	0.008375	5.95	271.30	97.74	1.44
10850	2419.00	1185.00	1189.57	1188.55	1190.25	0.008237	6.65	363.77	109.35	1.70
10850	4032.00	1185.00	1190.84	1189.75	1191.81	0.008228	7.91	509.55	117.34	2.21
10850	6452.00	1185.00	1192.38	1191.05	1193.72	0.007989	9.30	693.76	121.66	2.79
10850	8065.00	1185.00	1193.23	1191.80	1194.81	0.008064	10.10	798.40	124.04	3.17

Reservoir W.L. At El. 1160.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
3990	2000.00	1149.00	1160.05	1152.93	1160.08	0.000142	1.38	1446.89	316.21	0.04
3990	3000.00	1149.00	1160.11	1153.80	1160.17	0.000306	2.05	1465.28	316.47	0.09
3990	5000.00	1149.00	1160.29	1155.42	1160.45	0.000750	3.28	1522.99	317.27	0.22
3990	8000.00	1149.00	1160.70	1157.25	1161.07	0.001466	4.83	1655.44	319.12	0.47
3990	10000.00	1149.00	1161.05	1158.03	1161.55	0.001855	5.66	1767.39	320.67	0.63
2990	2000.00	1147.00	1160.00	1150.46	1160.01	0.000034	1.00	1991.85	238.93	0.02
2990	3000.00	1147.00	1159.99	1151.52	1160.03	0.000077	1.51	1990.45	238.89	0.04
2990	5000.00	1147.00	1159.97	1152.87	1160.07	0.000215	2.52	1986.02	238.79	0.11
2990	8000.00	1147.00	1159.92	1154.25	1160.18	0.000559	4.05	1974.72	238.53	0.28
2990	10000.00	1147.00	1159.88	1155.00	1160.28	0.000889	5.09	1963.69	238.27	0.45
2290	2000.00	1143.00	1160.00	1146.53	1160.00	0.000001	0.27	7536.29	628.76	0.00
2290	3000.00	1143.00	1160.01	1146.87	1160.01	0.000003	0.40	7538.52	628.76	0.00
2290	5000.00	1143.00	1160.02	1147.47	1160.02	0.000009	0.66	7545.58	628.79	0.01
2290	8000.00	1143.00	1160.05	1148.20	1160.06	0.000023	1.06	7563.08	628.85	0.02
2290	10000.00	1143.00	1160.07	1148.67	1160.10	0.000036	1.32	7579.20	628.91	0.03
1950	2000.00	1145.50	1160.00	1147.62	1160.00	0.000003	0.36	5488.43	505.63	0.00
1950	3000.00	1145.50	1160.00	1148.25	1160.01	0.000007	0.55	5489.11	505.63	0.00
1950	5000.00	1145.50	1160.01	1149.33	1160.02	0.000020	0.91	5491.21	505.64	0.01
1950	8000.00	1145.50	1160.02	1150.84	1160.05	0.000050	1.46	5496.64	505.67	0.03
1950	10000.00	1145.50	1160.03	1151.19	1160.08	0.000078	1.82	5501.64	505.70	0.05
1290	2000.00	1143.00	1160.00	1145.51	1160.00	0.000002	0.33	6104.95	431.50	0.00
1290	3000.00	1143.00	1160.00	1145.86	1160.00	0.000004	0.49	6104.84	431.50	0.00
1290	5000.00	1143.00	1160.00	1146.47	1160.01	0.000011	0.82	6104.47	431.50	0.01
1290	8000.00	1143.00	1160.00	1147.23	1160.02	0.000029	1.31	6103.79	431.49	0.02
1290	10000.00	1143.00	1160.00	1147.66	1160.04	0.000045	1.64	6103.16	431.49	0.04
810	2000.00	1125.00	1160.00	1130.83	1160.00	0.000001	0.27	7335.86	369.00	0.00
810	3000.00	1125.00	1160.00	1131.85	1160.00	0.000002	0.41	7335.69	369.00	0.00
810	5000.00	1125.00	1160.00	1133.49	1160.00	0.000005	0.68	7335.05	368.99	0.01
810	8000.00	1125.00	1159.99	1135.31	1160.01	0.000013	1.09	7333.75	368.98	0.02
810	10000.00	1125.00	1159.99	1136.28	1160.02	0.000021	1.36	7332.53	368.97	0.02
510	2000.00	1130.00	1160.00	1134.51	1160.00	0.000000	0.21	9429.06	433.33	0.00
510	3000.00	1130.00	1160.00	1135.63	1160.00	0.000001	0.32	9428.90	433.33	0.00
510	5000.00	1130.00	1160.00	1136.34	1160.00	0.000003	0.53	9428.43	433.33	0.00
510	8000.00	1130.00	1160.00	1137.20	1160.01	0.000007	0.85	9427.53	433.32	0.01
510	10000.00	1130.00	1159.99	1137.69	1160.01	0.000011	1.06	9426.63	433.32	0.01
300	2000.00	1125.00	1160.00	1125.93	1160.00	0.000000	0.12	16364.27	516.36	0.00
300	3000.00	1125.00	1160.00	1126.22	1160.00	0.000000	0.18	16364.27	516.36	0.00
300	5000.00	1125.00	1160.00	1126.71	1160.00	0.000001	0.31	16364.27	516.36	0.00
300	8000.00	1125.00	1160.00	1127.33	1160.00	0.000001	0.49	16364.65	516.36	0.00
300	10000.00	1125.00	1160.00	1127.69	1160.01	0.000002	0.61	16364.96	516.36	0.00
180	2000.00	1125.00	1160.00	1127.25	1160.00	0.000000	0.15	13177.50	515.50	0.00
180	3000.00	1125.00	1160.00	1127.88	1160.00	0.000000	0.23	13177.38	515.50	0.00
180	5000.00	1125.00	1160.00	1128.90	1160.00	0.000001	0.38	13177.12	515.50	0.00
180	8000.00	1125.00	1160.00	1130.20	1160.00	0.000003	0.61	13176.68	515.50	0.00
180	10000.00	1125.00	1160.00	1130.94	1160.01	0.000004	0.76	13176.24	515.49	0.01

Reservoir W.L. At El. 1160.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
8350	1613.00	1166.40	1169.65	1168.17	1169.90	0.001977	4.02	401.43	126.36	0.38
8350	2419.00	1166.40	1170.50	1168.72	1170.85	0.002055	4.75	509.58	127.89	0.50
8350	4032.00	1166.40	1171.75	1169.63	1172.31	0.002367	6.01	670.37	130.14	0.73
8350	6452.00	1166.40	1173.11	1170.83	1174.01	0.002854	7.60	849.32	132.59	1.09
8350	8065.00	1166.40	1173.88	1171.52	1174.99	0.003112	8.47	951.73	133.97	1.31
8280	1613.00	1164.30	1169.70	1166.16	1169.80	0.000422	2.55	633.37	121.98	0.13
8280	2419.00	1164.30	1170.56	1166.72	1170.73	0.000581	3.27	738.91	123.48	0.21
8280	4032.00	1164.30	1171.83	1167.68	1172.14	0.000877	4.50	896.63	125.70	0.37
8280	6452.00	1164.30	1173.22	1168.92	1173.78	0.001280	6.01	1072.93	128.13	0.63
8280	8065.00	1164.30	1174.00	1169.66	1174.73	0.001513	6.87	1173.80	129.50	0.80
8210	1613.00	1166.00	1169.57	1167.68	1169.75	0.001236	3.38	477.11	136.75	0.26
8210	2419.00	1166.00	1170.40	1168.20	1170.66	0.001392	4.09	590.91	138.20	0.36
8210	4032.00	1166.00	1171.61	1169.08	1172.05	0.001727	5.31	759.30	140.31	0.56
8210	6452.00	1166.00	1172.92	1170.20	1173.65	0.002196	6.82	945.63	142.62	0.87
8210	8065.00	1166.00	1173.67	1170.88	1174.58	0.002444	7.66	1052.54	143.92	1.06
7810	1613.00	1164.00	1168.33	1167.65	1168.79	0.005887	5.44	296.70	137.08	0.79
7810	2419.00	1164.00	1169.13	1168.29	1169.66	0.005338	5.80	417.14	162.54	0.85
7810	4032.00	1164.00	1170.34	1169.27	1170.96	0.004604	6.36	634.14	192.55	0.94
7810	6452.00	1164.00	1171.72	1170.31	1172.50	0.003843	7.11	907.37	203.05	1.07
7810	8065.00	1164.00	1172.53	1170.85	1173.40	0.003563	7.51	1074.34	209.20	1.13
7190	1613.00	1162.00	1165.99	1164.77	1166.30	0.002628	4.44	363.45	131.41	0.49
7190	2419.00	1162.00	1166.67	1165.37	1167.11	0.003206	5.32	454.78	137.52	0.66
7190	4032.00	1162.00	1167.83	1166.32	1168.49	0.003487	6.49	620.96	148.00	0.91
7190	6452.00	1162.00	1169.28	1167.49	1170.19	0.003595	7.64	844.41	161.02	1.17
7190	8065.00	1162.00	1170.07	1168.17	1171.13	0.003695	8.28	974.57	168.13	1.32
6690	2000.00	1160.50	1162.91	1162.68	1163.66	0.010238	6.95	287.93	138.84	1.31
6690	3000.00	1160.50	1163.81	1163.31	1164.60	0.007565	7.17	418.69	153.27	1.28
6690	5000.00	1160.50	1165.12	1164.30	1166.08	0.006330	7.89	633.47	175.08	1.41
6690	8000.00	1160.50	1166.47	1165.58	1167.72	0.006426	8.99	890.29	204.82	1.72
6690	10000.00	1160.50	1167.19	1166.29	1168.62	0.006519	9.58	1044.32	220.75	1.90
6130	2000.00	1158.00	1162.46	1159.83	1162.55	0.000632	2.43	822.03	238.38	0.14
6130	3000.00	1158.00	1163.30	1160.36	1163.44	0.000745	2.91	1031.31	258.83	0.18
6130	5000.00	1158.00	1164.58	1161.22	1164.78	0.000909	3.62	1381.31	289.81	0.27
6130	8000.00	1158.00	1165.92	1162.27	1166.23	0.001071	4.49	1783.12	306.42	0.39
6130	10000.00	1158.00	1166.63	1162.86	1167.02	0.001159	4.99	2004.40	311.43	0.46
5280	2000.00	1157.00	1160.28	1160.28	1161.01	0.015674	6.84	292.53	198.79	1.43
5280	3000.00	1157.00	1160.75	1160.75	1161.67	0.014852	7.69	390.25	213.64	1.68
5280	5000.00	1157.00	1161.56	1161.56	1162.74	0.013333	8.73	572.66	238.90	1.98
5280	8000.00	1157.00	1162.66	1162.49	1164.02	0.010749	9.36	854.76	273.41	2.08
5280	10000.00	1157.00	1163.34	1163.02	1164.75	0.009461	9.56	1045.96	294.50	2.08
4780	2000.00	1154.50	1160.19	1156.68	1160.23	0.000276	1.72	1160.42	298.84	0.07
4780	3000.00	1154.50	1160.40	1157.16	1160.49	0.000531	2.45	1223.69	303.15	0.13
4780	5000.00	1154.50	1160.95	1157.97	1161.15	0.001005	3.59	1393.08	314.40	0.27
4780	8000.00	1154.50	1161.85	1158.94	1162.20	0.001406	4.77	1678.79	318.05	0.45
4780	10000.00	1154.50	1162.45	1159.47	1162.89	0.001548	5.35	1869.83	319.84	0.55

Reservoir W.L. At El. 1160.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
10480	1613.00	1180.00	1183.21	1183.21	1184.43	0.021835	8.88	181.64	73.34	3.35
10480	2419.00	1180.00	1184.01	1184.01	1185.54	0.021275	9.92	243.84	81.68	3.93
10480	4032.00	1180.00	1185.35	1185.35	1187.27	0.019082	11.12	362.48	94.05	4.54
10480	6452.00	1180.00	1186.81	1186.81	1189.33	0.018107	12.74	506.45	102.64	5.49
10480	8065.00	1180.00	1187.72	1187.72	1190.51	0.017029	13.39	602.43	107.98	5.82
9940	1613.00	1168.10	1173.45	1170.88	1173.78	0.002479	4.58	352.05	71.35	0.72
9940	2419.00	1168.10	1174.59	1171.70	1175.07	0.002925	5.57	434.54	73.72	1.00
9940	4032.00	1168.10	1176.40	1173.12	1177.17	0.003556	7.06	571.25	77.49	1.51
9940	6452.00	1168.10	1178.51	1174.90	1179.69	0.004231	8.73	739.29	81.89	2.16
9940	8065.00	1168.10	1179.68	1175.93	1181.12	0.004590	9.63	837.13	84.34	2.56
9800	1613.00	1168.10	1173.25	1170.40	1173.46	0.001669	3.73	432.51	87.06	0.48
9800	2419.00	1168.10	1174.37	1171.11	1174.69	0.001974	4.56	530.75	88.37	0.67
9800	4032.00	1168.10	1176.16	1172.32	1176.69	0.002417	5.83	691.30	90.49	1.03
9800	6452.00	1168.10	1178.27	1173.85	1179.09	0.002916	7.30	884.42	92.96	1.51
9800	8065.00	1168.10	1179.45	1174.74	1180.47	0.003194	8.11	994.76	94.35	1.81
9680	1613.00	1169.20	1172.35	1171.63	1173.02	0.009560	6.58	245.23	82.20	1.74
9680	2419.00	1169.20	1173.39	1172.36	1174.21	0.008232	7.27	332.53	85.03	1.94
9680	4032.00	1169.20	1175.06	1173.61	1176.16	0.007411	8.43	478.08	89.57	2.36
9680	6452.00	1169.20	1177.02	1175.18	1178.51	0.007145	9.79	658.76	94.89	2.93
9680	8065.00	1169.20	1178.12	1176.06	1179.85	0.007116	10.54	765.22	97.89	3.27
9525	1613.00	1166.40	1172.42	1168.85	1172.60	0.000695	3.40	474.89	84.85	0.23
9525	2419.00	1166.40	1173.44	1169.60	1173.73	0.000929	4.30	562.14	86.88	0.35
9525	4032.00	1166.40	1175.08	1170.89	1175.59	0.001281	5.70	707.34	90.16	0.58
9525	6452.00	1166.40	1177.01	1172.49	1177.84	0.001671	7.29	885.07	94.02	0.90
9525	8065.00	1166.40	1178.10	1173.40	1179.13	0.001880	8.16	988.28	96.19	1.10
9385	1613.00	1165.80	1172.36	1168.27	1172.51	0.000527	3.11	519.36	86.02	0.19
9385	2419.00	1165.80	1173.35	1169.02	1173.60	0.000739	3.99	605.75	88.10	0.30
9385	4032.00	1165.80	1174.96	1170.29	1175.40	0.001077	5.38	749.60	91.45	0.51
9385	6452.00	1165.80	1176.84	1171.91	1177.60	0.001465	6.97	925.82	95.39	0.81
9385	8065.00	1165.80	1177.90	1172.83	1178.86	0.001678	7.84	1028.21	97.61	1.00
9200	1613.00	1168.80	1171.62	1170.96	1172.23	0.005957	6.29	256.30	94.14	0.99
9200	2419.00	1168.80	1172.43	1171.64	1173.25	0.005752	7.25	333.63	95.97	1.21
9200	4032.00	1168.80	1173.79	1172.77	1174.95	0.005551	8.66	465.64	99.02	1.57
9200	6452.00	1168.80	1175.39	1174.20	1177.03	0.005583	10.28	627.77	102.63	2.03
9200	8065.00	1168.80	1176.30	1175.02	1178.24	0.005660	11.17	721.97	104.68	2.31
8675	1613.00	1166.60	1169.86	1168.54	1170.18	0.002567	4.56	353.39	111.46	0.50
8675	2419.00	1166.60	1170.77	1169.12	1171.21	0.002537	5.30	456.18	113.13	0.62
8675	4032.00	1166.60	1172.14	1170.13	1172.81	0.002757	6.59	612.09	115.62	0.87
8675	6452.00	1166.60	1173.66	1171.41	1174.70	0.003148	8.16	790.48	118.41	1.25
8675	8065.00	1166.60	1174.52	1172.17	1175.79	0.003355	9.03	893.29	119.99	1.47
8525	1613.00	1163.30	1169.95	1165.23	1170.02	0.000240	2.17	741.94	117.42	0.09
8525	2419.00	1163.30	1170.88	1165.82	1171.00	0.000349	2.84	852.04	119.05	0.15
8525	4032.00	1163.30	1172.28	1166.81	1172.52	0.000553	3.95	1020.43	121.50	0.27
8525	6452.00	1163.30	1173.86	1168.11	1174.30	0.000827	5.31	1214.73	124.26	0.47
8525	8065.00	1163.30	1174.76	1168.88	1175.33	0.000985	6.08	1326.96	125.83	0.60

Reservoir W.L. At El. 1160.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
12730	1613.00	1218.40	1221.21	1220.46	1221.63	0.007715	5.17	312.23	130.92	1.14
12730	2419.00	1218.40	1221.94	1221.01	1222.48	0.007534	5.91	409.05	137.42	1.39
12730	4032.00	1218.40	1223.06	1221.94	1223.84	0.007670	7.08	569.09	147.53	1.84
12730	6452.00	1218.40	1224.41	1223.12	1225.48	0.007780	8.32	775.92	159.65	2.34
12730	8065.00	1218.40	1225.14	1223.80	1226.40	0.007952	9.00	895.93	166.22	2.65
12450	1613.00	1215.00	1217.25	1217.21	1218.16	0.022112	7.68	210.00	106.96	2.70
12450	2419.00	1215.00	1217.82	1217.82	1219.04	0.022372	8.84	273.71	113.88	3.34
12450	4032.00	1215.00	1218.87	1218.87	1220.45	0.020336	10.10	399.17	126.41	3.99
12450	6452.00	1215.00	1220.09	1220.09	1222.13	0.019138	11.47	562.39	140.44	4.76
12450	8065.00	1215.00	1220.80	1220.80	1223.09	0.017864	12.16	663.47	144.00	5.10
12265	1613.00	1210.00	1212.90	1212.90	1213.92	0.023720	8.11	198.94	97.36	2.98
12265	2419.00	1210.00	1213.57	1213.62	1214.83	0.023139	8.98	269.24	110.73	3.46
12265	4032.00	1210.00	1214.48	1214.70	1216.25	0.025370	10.66	378.16	128.74	4.57
12265	6452.00	1210.00	1215.47	1215.91	1217.91	0.027274	12.53	514.95	145.08	5.93
12265	8065.00	1210.00	1215.96	1216.60	1218.89	0.029194	13.74	586.78	151.28	6.93
12100	1613.00	1205.00	1207.95	1208.20	1209.59	0.028382	10.28	156.98	61.51	4.45
12100	2419.00	1205.00	1208.86	1209.09	1210.82	0.024732	11.21	215.73	66.64	4.90
12100	4032.00	1205.00	1210.51	1210.64	1212.78	0.020254	12.08	333.77	79.12	5.21
12100	6452.00	1205.00	1212.46	1212.46	1214.94	0.017709	12.63	510.95	102.53	5.39
12100	8065.00	1205.00	1213.39	1213.39	1216.09	0.017454	13.19	611.38	113.68	5.73
11990	1613.00	1200.00	1202.72	1203.51	1205.42	0.049942	13.18	122.35	49.81	7.45
11990	2419.00	1200.00	1203.49	1204.51	1206.98	0.048344	14.99	161.35	52.55	8.96
11990	4032.00	1200.00	1204.83	1206.30	1209.39	0.043506	17.14	235.23	57.39	10.66
11990	6452.00	1200.00	1206.64	1208.25	1211.86	0.039846	18.32	352.09	72.45	11.53
11990	8065.00	1200.00	1207.65	1209.32	1213.12	0.037416	18.76	429.91	81.35	11.76
11590	1613.00	1195.00	1198.04	1197.42	1198.66	0.010345	6.34	254.35	97.36	1.68
11590	2419.00	1195.00	1198.88	1198.11	1199.67	0.009805	7.12	339.86	104.96	1.97
11590	4032.00	1195.00	1200.25	1199.26	1201.30	0.009309	8.19	492.08	118.15	2.40
11590	6452.00	1195.00	1201.89	1200.68	1203.20	0.009013	9.19	702.27	138.46	2.82
11590	8065.00	1195.00	1202.80	1201.47	1204.25	0.008667	9.69	832.53	149.67	3.04
11270	1613.00	1192.00	1195.71	1194.59	1196.14	0.005971	5.26	306.41	102.38	1.10
11270	2419.00	1192.00	1196.53	1195.27	1197.12	0.006372	6.16	392.84	108.60	1.42
11270	4032.00	1192.00	1197.83	1196.40	1198.69	0.006906	7.46	540.41	118.48	1.93
11270	6452.00	1192.00	1199.33	1197.79	1200.55	0.007481	8.88	726.90	129.89	2.56
11270	8065.00	1192.00	1200.16	1198.59	1201.60	0.007749	9.64	837.01	135.47	2.92
10990	1613.00	1190.00	1192.17	1192.17	1193.15	0.023305	7.93	203.28	102.36	2.87
10990	2419.00	1190.00	1192.81	1192.81	1194.05	0.021630	8.94	270.47	107.48	3.37
10990	4032.00	1190.00	1193.86	1193.86	1195.54	0.020003	10.39	388.02	115.90	4.14
10990	6452.00	1190.00	1195.17	1195.17	1197.34	0.018390	11.81	546.37	126.19	4.92
10990	8065.00	1190.00	1195.93	1195.93	1198.36	0.017600	12.52	644.06	131.50	5.31
10850	1613.00	1185.00	1188.67	1187.80	1189.22	0.008375	5.95	271.30	97.74	1.44
10850	2419.00	1185.00	1189.57	1188.55	1190.25	0.008237	6.65	363.77	109.35	1.70
10850	4032.00	1185.00	1190.84	1189.75	1191.81	0.008228	7.91	509.55	117.34	2.21
10850	6452.00	1185.00	1192.38	1191.05	1193.72	0.007989	9.30	693.76	121.66	2.79
10850	8065.00	1185.00	1193.23	1191.80	1194.81	0.008064	10.10	798.40	124.04	3.17

Reservoir W.L. At El. 1165.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
3990	2000.00	1149.00	1165.01	1152.93	1165.02	0.000013	0.65	3070.47	338.21	0.01
3990	3000.00	1149.00	1165.02	1153.80	1165.04	0.000029	0.98	3074.39	338.26	0.02
3990	5000.00	1149.00	1165.06	1155.42	1165.10	0.000078	1.62	3086.58	338.42	0.04
3990	8000.00	1149.00	1165.14	1157.25	1165.25	0.000195	2.57	3116.26	338.81	0.11
3990	10000.00	1149.00	1165.22	1158.03	1165.38	0.000296	3.18	3143.28	339.16	0.17
2990	2000.00	1147.00	1165.00	1150.46	1165.00	0.000010	0.50	3981.98	556.77	0.00
2990	3000.00	1147.00	1165.00	1151.52	1165.01	0.000023	0.75	3981.77	556.75	0.01
2990	5000.00	1147.00	1165.00	1152.87	1165.02	0.000064	1.26	3980.62	556.61	0.03
2990	8000.00	1147.00	1164.99	1154.25	1165.06	0.000165	2.01	3978.31	556.35	0.07
2990	10000.00	1147.00	1164.99	1155.00	1165.09	0.000259	2.52	3976.07	556.09	0.11
2290	2000.00	1143.00	1165.00	1146.53	1165.00	0.000000	0.19	10706.88	640.00	0.00
2290	3000.00	1143.00	1165.00	1146.87	1165.00	0.000001	0.28	10707.81	640.01	0.00
2290	5000.00	1143.00	1165.01	1147.47	1165.01	0.000003	0.47	10710.31	640.01	0.00
2290	8000.00	1143.00	1165.02	1148.20	1165.03	0.000007	0.75	10716.88	640.04	0.01
2290	10000.00	1143.00	1165.03	1148.67	1165.04	0.000012	0.93	10722.81	640.06	0.01
1950	2000.00	1145.50	1165.00	1147.62	1165.00	0.000001	0.25	8048.94	518.75	0.00
1950	3000.00	1145.50	1165.00	1148.25	1165.00	0.000002	0.37	8049.19	518.75	0.00
1950	5000.00	1145.50	1165.00	1149.33	1165.01	0.000006	0.62	8049.89	518.76	0.01
1950	8000.00	1145.50	1165.01	1150.84	1165.02	0.000015	0.99	8051.73	518.76	0.01
1950	10000.00	1145.50	1165.01	1151.19	1165.03	0.000023	1.24	8053.37	518.77	0.02
1290	2000.00	1143.00	1165.00	1145.51	1165.00	0.000001	0.24	8286.20	441.00	0.00
1290	3000.00	1143.00	1165.00	1145.86	1165.00	0.000002	0.36	8286.14	441.00	0.00
1290	5000.00	1143.00	1165.00	1146.47	1165.00	0.000004	0.60	8285.93	441.00	0.00
1290	8000.00	1143.00	1165.00	1147.23	1165.01	0.000011	0.97	8285.39	441.00	0.01
1290	10000.00	1143.00	1165.00	1147.66	1165.02	0.000017	1.21	8284.90	440.99	0.02
810	2000.00	1125.00	1165.00	1130.83	1165.00	0.000000	0.22	9229.66	388.50	0.00
810	3000.00	1125.00	1165.00	1131.85	1165.00	0.000001	0.33	9229.51	388.50	0.00
810	5000.00	1125.00	1165.00	1133.49	1165.00	0.000003	0.54	9229.13	388.49	0.00
810	8000.00	1125.00	1165.00	1135.31	1165.01	0.000007	0.87	9228.18	388.48	0.01
810	10000.00	1125.00	1164.99	1136.28	1165.01	0.000010	1.08	9227.33	388.48	0.01
510	2000.00	1130.00	1165.00	1134.51	1165.00	0.000000	0.17	11624.95	445.00	0.00
510	3000.00	1130.00	1165.00	1135.63	1165.00	0.000001	0.26	11624.84	445.00	0.00
510	5000.00	1130.00	1165.00	1136.34	1165.00	0.000001	0.43	11624.56	445.00	0.00
510	8000.00	1130.00	1165.00	1137.20	1165.00	0.000004	0.69	11623.91	444.99	0.01
510	10000.00	1130.00	1165.00	1137.69	1165.01	0.000006	0.86	11623.32	444.99	0.01
300	2000.00	1125.00	1165.00	1125.93	1165.00	0.000000	0.11	18952.84	519.09	0.00
300	3000.00	1125.00	1165.00	1126.22	1165.00	0.000000	0.16	18952.84	519.09	0.00
300	5000.00	1125.00	1165.00	1126.71	1165.00	0.000000	0.26	18952.97	519.09	0.00
300	8000.00	1125.00	1165.00	1127.33	1165.00	0.000001	0.42	18953.09	519.09	0.00
300	10000.00	1125.00	1165.00	1127.69	1165.01	0.000001	0.53	18953.22	519.09	0.00
180	2000.00	1125.00	1165.00	1127.25	1165.00	0.000000	0.13	15783.68	527.00	0.00
180	3000.00	1125.00	1165.00	1127.88	1165.00	0.000000	0.19	15783.68	527.00	0.00
180	5000.00	1125.00	1165.00	1128.90	1165.00	0.000001	0.32	15783.56	527.00	0.00
180	8000.00	1125.00	1165.00	1130.20	1165.00	0.000002	0.51	15783.24	527.00	0.00
180	10000.00	1125.00	1165.00	1130.94	1165.00	0.000003	0.63	15782.91	527.00	0.00

Reservoir W.L. At El. 1165.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
8350	1613.00	1166.40	1169.66	1168.17	1169.91	0.001957	4.01	402.71	126.38	0.38
8350	2419.00	1166.40	1170.51	1168.72	1170.86	0.002041	4.74	510.64	127.91	0.49
8350	4032.00	1166.40	1171.75	1169.63	1172.31	0.002362	6.01	670.83	130.14	0.73
8350	6452.00	1166.40	1173.11	1170.83	1174.01	0.002854	7.60	849.36	132.59	1.09
8350	8065.00	1166.40	1173.88	1171.52	1174.99	0.003113	8.47	951.65	133.97	1.32
8280	1613.00	1164.30	1169.71	1166.16	1169.81	0.000419	2.54	634.55	121.99	0.13
8280	2419.00	1164.30	1170.57	1166.72	1170.74	0.000579	3.27	739.91	123.49	0.21
8280	4032.00	1164.30	1171.83	1167.68	1172.14	0.000876	4.49	897.04	125.70	0.37
8280	6452.00	1164.30	1173.22	1168.92	1173.78	0.001280	6.01	1072.99	128.13	0.63
8280	8065.00	1164.30	1174.00	1169.66	1174.73	0.001513	6.87	1173.73	129.50	0.80
8210	1613.00	1166.00	1169.58	1167.68	1169.76	0.001224	3.37	478.58	136.77	0.26
8210	2419.00	1166.00	1170.41	1168.20	1170.67	0.001382	4.08	592.17	138.21	0.36
8210	4032.00	1166.00	1171.61	1169.08	1172.05	0.001723	5.31	759.81	140.32	0.56
8210	6452.00	1166.00	1172.93	1170.20	1173.65	0.002196	6.82	945.72	142.62	0.87
8210	8065.00	1166.00	1173.67	1170.88	1174.58	0.002444	7.66	1052.47	143.92	1.06
7810	1613.00	1164.00	1168.40	1167.65	1168.83	0.005374	5.25	307.03	139.45	0.74
7810	2419.00	1164.00	1169.19	1168.29	1169.69	0.005049	5.68	425.92	164.24	0.81
7810	4032.00	1164.00	1170.36	1169.27	1170.98	0.004510	6.32	638.33	192.71	0.93
7810	6452.00	1164.00	1171.72	1170.31	1172.50	0.003836	7.11	907.84	203.06	1.06
7810	8065.00	1164.00	1172.53	1170.85	1173.40	0.003565	7.51	1074.11	209.19	1.13
7190	1613.00	1162.00	1165.81	1164.77	1166.16	0.003478	4.75	339.84	129.78	0.57
7190	2419.00	1162.00	1166.49	1165.37	1166.98	0.003799	5.62	430.13	135.90	0.75
7190	4032.00	1162.00	1167.71	1166.32	1168.41	0.003799	6.68	603.41	146.93	0.97
7190	6452.00	1162.00	1169.21	1167.49	1170.14	0.003742	7.75	832.93	160.37	1.20
7190	8065.00	1162.00	1170.02	1168.17	1171.10	0.003790	8.35	966.11	167.68	1.35
6690	2000.00	1160.50	1165.17	1162.68	1165.32	0.000975	3.11	642.45	176.20	0.22
6690	3000.00	1160.50	1165.36	1163.31	1165.67	0.001902	4.43	676.96	180.46	0.44
6690	5000.00	1160.50	1165.88	1164.30	1166.53	0.003671	6.46	773.87	191.91	0.91
6690	8000.00	1160.50	1166.79	1165.58	1167.87	0.005290	8.36	956.64	211.83	1.47
6690	10000.00	1160.50	1167.39	1166.29	1168.70	0.005834	9.19	1088.15	225.07	1.74
6130	2000.00	1158.00	1165.12	1159.83	1165.15	0.000106	1.30	1541.34	300.85	0.03
6130	3000.00	1158.00	1165.26	1160.36	1165.32	0.000219	1.89	1584.05	301.84	0.07
6130	5000.00	1158.00	1165.66	1161.22	1165.79	0.000462	2.93	1704.57	304.62	0.17
6130	8000.00	1158.00	1166.41	1162.27	1166.67	0.000830	4.14	1934.21	309.85	0.32
6130	10000.00	1158.00	1166.94	1162.86	1167.29	0.001003	4.76	2099.50	313.57	0.42
5280	2000.00	1157.00	1165.03	1160.28	1165.05	0.000117	1.26	1589.23	346.88	0.03
5280	3000.00	1157.00	1165.06	1160.75	1165.12	0.000256	1.87	1601.31	347.16	0.07
5280	5000.00	1157.00	1165.17	1161.56	1165.32	0.000661	3.05	1639.11	348.01	0.19
5280	8000.00	1157.00	1165.43	1162.49	1165.76	0.001431	4.63	1727.72	350.00	0.44
5280	10000.00	1157.00	1165.65	1163.02	1166.12	0.001944	5.54	1805.33	351.73	0.62
4780	2000.00	1154.50	1165.02	1156.68	1165.03	0.000019	0.74	2702.48	327.55	0.01
4780	3000.00	1154.50	1165.04	1157.16	1165.06	0.000042	1.11	2710.63	327.61	0.02
4780	5000.00	1154.50	1165.12	1157.97	1165.17	0.000113	1.83	2736.20	327.81	0.06
4780	8000.00	1154.50	1165.31	1158.94	1165.43	0.000270	2.86	2796.62	328.27	0.14
4780	10000.00	1154.50	1165.47	1159.47	1165.66	0.000397	3.51	2850.03	328.67	0.21

Reservoir W.L. At El. 1165.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
10480	1613.00	1180.00	1183.21	1183.21	1184.43	0.021835	8.88	181.64	73.34	3.35
10480	2419.00	1180.00	1184.01	1184.01	1185.54	0.021275	9.92	243.84	81.68	3.93
10480	4032.00	1180.00	1185.35	1185.35	1187.27	0.019082	11.12	362.48	94.05	4.54
10480	6452.00	1180.00	1186.81	1186.81	1189.33	0.018107	12.74	506.45	102.64	5.49
10480	8065.00	1180.00	1187.72	1187.72	1190.51	0.017029	13.39	602.43	107.98	5.82
9940	1613.00	1168.10	1173.45	1170.88	1173.78	0.002479	4.58	352.05	71.35	0.72
9940	2419.00	1168.10	1174.59	1171.70	1175.07	0.002925	5.57	434.54	73.72	1.00
9940	4032.00	1168.10	1176.40	1173.12	1177.17	0.003556	7.06	571.25	77.49	1.51
9940	6452.00	1168.10	1178.51	1174.90	1179.69	0.004231	8.73	739.29	81.89	2.16
9940	8065.00	1168.10	1179.68	1175.93	1181.12	0.004590	9.63	837.13	84.34	2.56
9800	1613.00	1168.10	1173.25	1170.40	1173.46	0.001669	3.73	432.51	87.06	0.48
9800	2419.00	1168.10	1174.37	1171.11	1174.69	0.001974	4.56	530.75	88.37	0.67
9800	4032.00	1168.10	1176.16	1172.32	1176.69	0.002417	5.83	691.30	90.49	1.03
9800	6452.00	1168.10	1178.27	1173.85	1179.09	0.002916	7.30	884.42	92.96	1.51
9800	8065.00	1168.10	1179.45	1174.74	1180.47	0.003194	8.11	994.76	94.35	1.81
9680	1613.00	1169.20	1172.35	1171.63	1173.02	0.009560	6.58	245.23	82.20	1.74
9680	2419.00	1169.20	1173.39	1172.36	1174.21	0.008232	7.27	332.53	85.03	1.94
9680	4032.00	1169.20	1175.06	1173.61	1176.16	0.007411	8.43	478.08	89.57	2.36
9680	6452.00	1169.20	1177.02	1175.18	1178.51	0.007145	9.79	658.76	94.89	2.93
9680	8065.00	1169.20	1178.12	1176.06	1179.85	0.007116	10.54	765.22	97.89	3.27
9525	1613.00	1166.40	1172.42	1168.85	1172.60	0.000695	3.40	474.89	84.85	0.23
9525	2419.00	1166.40	1173.44	1169.60	1173.73	0.000929	4.30	562.14	86.88	0.35
9525	4032.00	1166.40	1175.08	1170.89	1175.59	0.001281	5.70	707.34	90.16	0.58
9525	6452.00	1166.40	1177.01	1172.49	1177.84	0.001671	7.29	885.07	94.02	0.90
9525	8065.00	1166.40	1178.10	1173.40	1179.13	0.001880	8.16	988.28	96.19	1.10
9385	1613.00	1165.80	1172.36	1168.27	1172.51	0.000527	3.11	519.36	86.02	0.19
9385	2419.00	1165.80	1173.35	1169.02	1173.60	0.000739	3.99	605.75	88.10	0.30
9385	4032.00	1165.80	1174.96	1170.29	1175.40	0.001077	5.38	749.60	91.45	0.51
9385	6452.00	1165.80	1176.84	1171.91	1177.60	0.001465	6.97	925.82	95.39	0.81
9385	8065.00	1165.80	1177.90	1172.83	1178.86	0.001678	7.84	1028.21	97.61	1.00
9200	1613.00	1168.80	1171.62	1170.96	1172.23	0.005957	6.29	256.30	94.14	0.99
9200	2419.00	1168.80	1172.43	1171.64	1173.25	0.005752	7.25	333.63	95.97	1.21
9200	4032.00	1168.80	1173.79	1172.77	1174.95	0.005551	8.66	465.64	99.02	1.57
9200	6452.00	1168.80	1175.39	1174.20	1177.03	0.005583	10.28	627.77	102.63	2.03
9200	8065.00	1168.80	1176.30	1175.02	1178.24	0.005660	11.17	721.97	104.68	2.31
8675	1613.00	1166.60	1169.86	1168.54	1170.18	0.002567	4.56	353.39	111.46	0.50
8675	2419.00	1166.60	1170.77	1169.12	1171.21	0.002537	5.30	456.18	113.13	0.62
8675	4032.00	1166.60	1172.14	1170.13	1172.81	0.002757	6.59	612.09	115.62	0.87
8675	6452.00	1166.60	1173.66	1171.41	1174.70	0.003148	8.16	790.48	118.41	1.25
8675	8065.00	1166.60	1174.52	1172.17	1175.79	0.003355	9.03	893.29	119.99	1.47
8525	1613.00	1163.30	1169.95	1165.23	1170.02	0.000240	2.17	741.94	117.42	0.09
8525	2419.00	1163.30	1170.88	1165.82	1171.00	0.000349	2.84	852.04	119.05	0.15
8525	4032.00	1163.30	1172.28	1166.81	1172.52	0.000553	3.95	1020.43	121.50	0.27
8525	6452.00	1163.30	1173.86	1168.11	1174.30	0.000827	5.31	1214.73	124.26	0.47
8525	8065.00	1163.30	1174.76	1168.88	1175.33	0.000985	6.08	1326.96	125.83	0.60

Reservoir W.L. At El. 1165.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
12730	1613.00	1218.40	1221.21	1220.46	1221.63	0.007715	5.17	312.23	130.92	1.14
12730	2419.00	1218.40	1221.94	1221.01	1222.48	0.007534	5.91	409.05	137.42	1.39
12730	4032.00	1218.40	1223.06	1221.94	1223.84	0.007670	7.08	569.09	147.53	1.84
12730	6452.00	1218.40	1224.41	1223.12	1225.48	0.007780	8.32	775.92	159.65	2.34
12730	8065.00	1218.40	1225.14	1223.80	1226.40	0.007952	9.00	895.93	166.22	2.65
12450	1613.00	1215.00	1217.25	1217.21	1218.16	0.022112	7.68	210.00	106.96	2.70
12450	2419.00	1215.00	1217.82	1217.82	1219.04	0.022372	8.84	273.71	113.88	3.34
12450	4032.00	1215.00	1218.87	1218.87	1220.45	0.020336	10.10	399.17	126.41	3.99
12450	6452.00	1215.00	1220.09	1220.09	1222.13	0.019138	11.47	562.39	140.44	4.76
12450	8065.00	1215.00	1220.80	1220.80	1223.09	0.017864	12.16	663.47	144.00	5.10
12265	1613.00	1210.00	1212.90	1212.90	1213.92	0.023720	8.11	198.94	97.36	2.98
12265	2419.00	1210.00	1213.57	1213.62	1214.83	0.023139	8.98	269.24	110.73	3.46
12265	4032.00	1210.00	1214.48	1214.70	1216.25	0.025370	10.66	378.16	128.74	4.57
12265	6452.00	1210.00	1215.47	1215.91	1217.91	0.027274	12.53	514.95	145.08	5.93
12265	8065.00	1210.00	1215.96	1216.60	1218.89	0.029194	13.74	586.78	151.28	6.93
12100	1613.00	1205.00	1207.95	1208.20	1209.59	0.028362	10.28	156.98	61.51	4.45
12100	2419.00	1205.00	1208.86	1209.09	1210.82	0.024732	11.21	215.73	66.64	4.90
12100	4032.00	1205.00	1210.51	1210.64	1212.78	0.020254	12.08	333.77	79.12	5.21
12100	6452.00	1205.00	1212.46	1212.46	1214.94	0.017709	12.63	510.95	102.53	5.39
12100	8065.00	1205.00	1213.39	1213.39	1216.09	0.017454	13.19	611.38	113.68	5.73
11990	1613.00	1200.00	1202.72	1203.51	1205.42	0.049942	13.18	122.35	49.81	7.45
11990	2419.00	1200.00	1203.49	1204.51	1206.98	0.048344	14.99	161.35	52.55	8.96
11990	4032.00	1200.00	1204.83	1206.30	1209.39	0.043506	17.14	235.23	57.39	10.66
11990	6452.00	1200.00	1206.64	1208.25	1211.86	0.039846	18.32	352.09	72.45	11.53
11990	8065.00	1200.00	1207.65	1209.32	1213.12	0.037416	18.76	429.91	81.35	11.76
11590	1613.00	1195.00	1198.04	1197.42	1198.66	0.010345	6.34	254.36	97.36	1.68
11590	2419.00	1195.00	1198.88	1198.11	1199.67	0.009806	7.12	339.86	104.95	1.97
11590	4032.00	1195.00	1200.25	1199.26	1201.30	0.009309	8.19	492.08	118.15	2.40
11590	6452.00	1195.00	1201.89	1200.68	1203.20	0.009013	9.19	702.27	138.46	2.82
11590	8065.00	1195.00	1202.80	1201.47	1204.25	0.008867	9.69	832.53	149.67	3.04
11270	1613.00	1192.00	1195.71	1194.59	1196.14	0.005971	5.26	306.41	102.38	1.10
11270	2419.00	1192.00	1196.53	1195.27	1197.12	0.006372	6.16	392.84	108.60	1.42
11270	4032.00	1192.00	1197.83	1196.40	1198.69	0.006906	7.46	540.41	118.48	1.93
11270	6452.00	1192.00	1199.33	1197.79	1200.55	0.007481	8.88	726.90	129.89	2.56
11270	8065.00	1192.00	1200.16	1198.59	1201.60	0.007749	9.64	837.01	135.47	2.92
10990	1613.00	1190.00	1192.17	1192.17	1193.15	0.023305	7.93	203.28	102.36	2.87
10990	2419.00	1190.00	1192.81	1192.81	1194.05	0.021630	8.94	270.47	107.48	3.37
10990	4032.00	1190.00	1193.86	1193.86	1195.54	0.020003	10.39	388.02	115.90	4.14
10990	6452.00	1190.00	1195.17	1195.17	1197.34	0.018390	11.81	546.37	126.19	4.92
10990	8065.00	1190.00	1195.93	1195.93	1198.36	0.017600	12.52	644.06	131.50	5.31
10850	1613.00	1185.00	1188.67	1187.80	1189.22	0.008375	5.95	271.30	97.74	1.44
10850	2419.00	1185.00	1189.57	1188.55	1190.25	0.008237	6.65	363.77	109.35	1.70
10850	4032.00	1185.00	1190.84	1189.75	1191.81	0.008228	7.91	509.55	117.34	2.21
10850	6452.00	1185.00	1192.38	1191.05	1193.72	0.007989	9.30	693.76	121.66	2.79
10850	8065.00	1185.00	1193.23	1191.80	1194.81	0.008064	10.10	798.40	124.04	3.17

Reservoir W.L. At El. 1170.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
3990	2000.00	1149.00	1170.00	1152.93	1170.00	0.000003	0.42	4814.19	360.34	0.00
3990	3000.00	1149.00	1170.00	1153.80	1170.01	0.000007	0.62	4814.90	360.35	0.01
3990	5000.00	1149.00	1170.01	1155.42	1170.03	0.000020	1.04	4817.32	360.38	0.02
3990	8000.00	1149.00	1170.03	1157.25	1170.07	0.000050	1.66	4822.73	360.44	0.04
3990	10000.00	1149.00	1170.04	1158.03	1170.11	0.000077	2.07	4827.83	360.51	0.06
2990	2000.00	1147.00	1170.00	1150.46	1170.00	0.000002	0.29	6948.38	629.65	0.00
2990	3000.00	1147.00	1170.00	1151.52	1170.00	0.000004	0.43	6948.53	629.65	0.00
2990	5000.00	1147.00	1170.00	1152.87	1170.01	0.000012	0.72	6949.14	629.65	0.01
2990	8000.00	1147.00	1170.00	1154.25	1170.02	0.000030	1.15	6949.84	629.66	0.02
2990	10000.00	1147.00	1170.00	1155.00	1170.04	0.000047	1.44	6950.68	629.66	0.03
2290	2000.00	1143.00	1170.00	1146.53	1170.00	0.000000	0.14	13934.61	651.25	0.00
2290	3000.00	1143.00	1170.00	1146.87	1170.00	0.000000	0.22	13935.09	651.25	0.00
2290	5000.00	1143.00	1170.00	1147.47	1170.01	0.000001	0.36	13936.60	651.26	0.00
2290	8000.00	1143.00	1170.01	1148.20	1170.01	0.000003	0.57	13939.62	651.27	0.00
2290	10000.00	1143.00	1170.01	1148.67	1170.02	0.000005	0.72	13942.56	651.28	0.01
1950	2000.00	1145.50	1170.00	1147.62	1170.00	0.000000	0.19	10672.19	530.63	0.00
1950	3000.00	1145.50	1170.00	1148.25	1170.00	0.000001	0.28	10672.38	530.63	0.00
1950	5000.00	1145.50	1170.00	1149.33	1170.00	0.000002	0.47	10672.84	530.63	0.00
1950	8000.00	1145.50	1170.00	1150.84	1170.01	0.000006	0.75	10673.55	530.63	0.01
1950	10000.00	1145.50	1170.00	1151.19	1170.02	0.000009	0.94	10674.39	530.64	0.01
1290	2000.00	1143.00	1170.00	1145.51	1170.00	0.000000	0.19	10533.64	458.00	0.00
1290	3000.00	1143.00	1170.00	1145.86	1170.00	0.000001	0.28	10533.69	458.00	0.00
1290	5000.00	1143.00	1170.00	1146.47	1170.00	0.000002	0.47	10533.58	458.00	0.00
1290	8000.00	1143.00	1170.00	1147.23	1170.01	0.000005	0.76	10533.13	458.00	0.01
1290	10000.00	1143.00	1170.00	1147.66	1170.01	0.000008	0.95	10532.86	457.99	0.01
810	2000.00	1125.00	1170.00	1130.83	1170.00	0.000000	0.18	11208.40	403.00	0.00
810	3000.00	1125.00	1170.00	1131.85	1170.00	0.000001	0.27	11208.35	403.00	0.00
810	5000.00	1125.00	1170.00	1133.49	1170.00	0.000001	0.45	11208.11	403.00	0.00
810	8000.00	1125.00	1170.00	1135.31	1170.01	0.000004	0.71	11207.42	402.99	0.01
810	10000.00	1125.00	1170.00	1136.28	1170.01	0.000006	0.89	11206.83	402.99	0.01
510	2000.00	1130.00	1170.00	1134.51	1170.00	0.000000	0.14	13924.88	475.00	0.00
510	3000.00	1130.00	1170.00	1135.63	1170.00	0.000000	0.22	13924.88	475.00	0.00
510	5000.00	1130.00	1170.00	1136.34	1170.00	0.000001	0.36	13924.77	475.00	0.00
510	8000.00	1130.00	1170.00	1137.20	1170.00	0.000002	0.57	13924.25	474.99	0.00
510	10000.00	1130.00	1170.00	1137.69	1170.01	0.000003	0.72	13923.90	474.99	0.01
300	2000.00	1125.00	1170.00	1125.93	1170.00	0.000000	0.09	21555.05	521.82	0.00
300	3000.00	1125.00	1170.00	1126.22	1170.00	0.000000	0.14	21555.11	521.82	0.00
300	5000.00	1125.00	1170.00	1126.71	1170.00	0.000000	0.23	21555.24	521.82	0.00
300	8000.00	1125.00	1170.00	1127.33	1170.00	0.000001	0.37	21555.24	521.82	0.00
300	10000.00	1125.00	1170.00	1127.69	1170.00	0.000001	0.46	21555.43	521.82	0.00
180	2000.00	1125.00	1170.00	1127.25	1170.00	0.000000	0.11	18447.44	538.50	0.00
180	3000.00	1125.00	1170.00	1127.88	1170.00	0.000000	0.16	18447.44	538.50	0.00
180	5000.00	1125.00	1170.00	1126.90	1170.00	0.000000	0.27	18447.37	538.50	0.00
180	8000.00	1125.00	1170.00	1130.20	1170.00	0.000001	0.43	18447.17	538.50	0.00
180	10000.00	1125.00	1170.00	1130.94	1170.00	0.000002	0.54	18447.04	538.50	0.00

Reservoir W.L. At El. 1170.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
8350	1613.00	1166.40	1170.51	1168.17	1170.66	0.000911	3.16	510.08	127.90	0.22
8350	2419.00	1166.40	1170.97	1168.72	1171.25	0.001436	4.25	569.54	128.73	0.38
8350	4032.00	1166.40	1171.93	1169.63	1172.46	0.002118	5.81	694.09	130.46	0.68
8350	6452.00	1166.40	1173.20	1170.83	1174.07	0.002732	7.49	861.11	132.75	1.06
8350	8065.00	1166.40	1173.94	1171.52	1175.04	0.003027	8.40	960.14	134.09	1.29
8280	1613.00	1164.30	1170.53	1166.16	1170.61	0.000263	2.19	735.24	123.43	0.09
8280	2419.00	1164.30	1171.01	1166.72	1171.16	0.000461	3.04	794.79	124.27	0.18
8280	4032.00	1164.30	1172.00	1167.68	1172.30	0.000813	4.39	918.53	126.00	0.35
8280	6452.00	1164.30	1173.30	1168.92	1173.85	0.001241	5.95	1083.72	128.28	0.62
8280	8065.00	1164.30	1174.06	1169.66	1174.78	0.001483	6.83	1181.48	129.60	0.79
8210	1613.00	1166.00	1170.46	1167.68	1170.58	0.000589	2.69	600.05	138.31	0.15
8210	2419.00	1166.00	1170.90	1168.20	1171.10	0.000975	3.67	659.95	139.07	0.28
8210	4032.00	1166.00	1171.81	1169.08	1172.21	0.001538	5.12	787.23	140.66	0.52
8210	6452.00	1166.00	1173.02	1170.20	1173.73	0.002094	6.72	959.90	142.79	0.84
8210	8065.00	1166.00	1173.74	1170.88	1174.64	0.002370	7.59	1062.82	144.05	1.04
7810	1613.00	1164.00	1170.18	1167.65	1170.29	0.000855	2.67	605.06	191.40	0.17
7810	2419.00	1164.00	1170.40	1168.29	1170.62	0.001559	3.74	646.57	193.04	0.32
7810	4032.00	1164.00	1170.99	1169.27	1171.43	0.002583	5.29	762.26	197.54	0.62
7810	6452.00	1164.00	1172.02	1170.31	1172.71	0.003134	6.66	969.11	205.34	0.92
7810	8065.00	1164.00	1172.69	1170.85	1173.51	0.003227	7.27	1109.51	210.48	1.05
7190	1613.00	1162.00	1170.05	1164.77	1170.09	0.000150	1.66	970.57	167.92	0.05
7190	2419.00	1162.00	1170.10	1165.37	1170.20	0.000327	2.47	980.32	168.44	0.12
7190	4032.00	1162.00	1170.28	1166.32	1170.53	0.000830	3.99	1010.84	170.06	0.31
7190	6452.00	1162.00	1170.69	1167.49	1171.24	0.001752	5.97	1080.52	173.71	0.67
7190	8065.00	1162.00	1171.03	1168.17	1171.81	0.002346	7.08	1139.71	176.75	0.93
6690	2000.00	1160.50	1170.02	1162.68	1170.04	0.000054	1.14	1755.63	282.64	0.02
6690	3000.00	1160.50	1170.04	1163.31	1170.09	0.000143	1.70	1761.94	282.82	0.05
6690	5000.00	1160.50	1170.11	1164.30	1170.23	0.000383	2.81	1782.09	283.39	0.15
6690	8000.00	1160.50	1170.28	1165.58	1170.57	0.000905	4.37	1829.49	284.72	0.36
6690	10000.00	1160.50	1170.43	1166.29	1170.87	0.001318	5.34	1871.91	285.91	0.53
6130	2000.00	1158.00	1170.01	1159.83	1170.02	0.000012	0.65	3097.24	335.07	0.01
6130	3000.00	1158.00	1170.03	1160.36	1170.05	0.000027	0.97	3103.26	335.16	0.02
6130	5000.00	1158.00	1170.09	1161.22	1170.13	0.000073	1.60	3122.45	335.45	0.04
6130	8000.00	1158.00	1170.22	1162.27	1170.32	0.000179	2.53	3167.75	336.12	0.10
6130	10000.00	1158.00	1170.35	1162.86	1170.50	0.000269	3.12	3208.44	336.73	0.16
5280	2000.00	1157.00	1170.01	1160.28	1170.01	0.000011	0.59	3412.99	385.85	0.01
5280	3000.00	1157.00	1170.01	1160.75	1170.02	0.000024	0.88	3415.72	385.87	0.01
5280	5000.00	1157.00	1170.04	1161.56	1170.07	0.000065	1.46	3424.53	385.95	0.04
5280	8000.00	1157.00	1170.09	1162.49	1170.17	0.000164	2.32	3445.36	386.13	0.09
5280	10000.00	1157.00	1170.14	1163.02	1170.27	0.000252	2.89	3464.59	386.30	0.14
4780	2000.00	1154.50	1170.00	1156.68	1170.01	0.000004	0.46	4366.04	340.01	0.00
4780	3000.00	1154.50	1170.01	1157.16	1170.02	0.000009	0.69	4367.74	340.03	0.01
4780	5000.00	1154.50	1170.03	1157.97	1170.05	0.000025	1.14	4373.30	340.09	0.02
4780	8000.00	1154.50	1170.06	1158.94	1170.11	0.000064	1.82	4386.26	340.22	0.05
4780	10000.00	1154.50	1170.10	1159.47	1170.18	0.000099	2.27	4398.30	340.35	0.08

Reservoir W.L. At El. 1170.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
10480	1613.00	1180.00	1183.21	1183.21	1184.43	0.021835	8.88	181.64	73.34	3.35
10480	2419.00	1180.00	1184.01	1184.01	1185.54	0.021275	9.92	243.84	81.68	3.93
10480	4032.00	1180.00	1185.35	1185.35	1187.27	0.019082	11.12	362.48	94.05	4.54
10480	6452.00	1180.00	1186.81	1186.81	1189.33	0.018107	12.74	506.45	102.64	5.49
10480	8065.00	1180.00	1187.72	1187.72	1190.51	0.017029	13.39	602.43	107.98	5.82
9940	1613.00	1168.10	1173.45	1170.88	1173.78	0.002483	4.58	351.62	71.35	0.72
9940	2419.00	1168.10	1174.59	1171.70	1175.07	0.002922	5.56	434.69	73.73	1.00
9940	4032.00	1168.10	1176.40	1173.12	1177.17	0.003552	7.06	571.47	77.50	1.51
9940	6452.00	1168.10	1178.51	1174.90	1179.69	0.004229	8.73	739.45	81.89	2.16
9940	8065.00	1168.10	1179.68	1175.93	1181.13	0.004588	9.63	837.25	84.34	2.56
9800	1613.00	1168.10	1173.24	1170.40	1173.46	0.001673	3.73	432.18	87.05	0.48
9800	2419.00	1168.10	1174.37	1171.11	1174.69	0.001972	4.56	530.94	88.38	0.67
9800	4032.00	1168.10	1176.17	1172.32	1176.69	0.002414	5.83	691.59	90.49	1.03
9800	6452.00	1168.10	1178.27	1173.85	1179.10	0.002914	7.29	884.63	92.96	1.51
9800	8065.00	1168.10	1179.45	1174.74	1180.47	0.003193	8.11	994.91	94.35	1.81
9680	1613.00	1169.20	1172.34	1171.63	1173.01	0.009679	6.60	244.28	82.16	1.75
9680	2419.00	1169.20	1173.40	1172.36	1174.22	0.008196	7.26	333.00	85.05	1.94
9680	4032.00	1169.20	1175.07	1173.61	1176.17	0.007382	8.42	478.71	89.59	2.36
9680	6452.00	1169.20	1177.02	1175.18	1178.51	0.007131	9.79	659.19	94.90	2.93
9680	8065.00	1169.20	1178.13	1176.06	1179.85	0.007107	10.54	765.54	97.90	3.27
9525	1613.00	1166.40	1172.41	1168.85	1172.59	0.000699	3.40	474.02	84.83	0.23
9525	2419.00	1166.40	1173.45	1169.60	1173.73	0.000927	4.30	562.60	86.89	0.35
9525	4032.00	1166.40	1175.09	1170.89	1175.59	0.001278	5.70	707.96	90.18	0.58
9525	6452.00	1166.40	1177.02	1172.49	1177.84	0.001669	7.29	885.50	94.03	0.90
9525	8065.00	1166.40	1178.10	1173.40	1179.13	0.001878	8.16	988.60	96.20	1.09
9385	1613.00	1165.80	1172.35	1168.27	1172.50	0.000530	3.11	518.45	86.00	0.19
9385	2419.00	1165.80	1173.36	1169.02	1173.61	0.000738	3.99	606.22	88.11	0.30
9385	4032.00	1165.80	1174.96	1170.29	1175.41	0.001074	5.37	750.26	91.46	0.51
9385	6452.00	1165.80	1176.85	1171.91	1177.60	0.001463	6.97	926.27	95.40	0.81
9385	8065.00	1165.80	1177.91	1172.83	1178.86	0.001676	7.84	1028.55	97.62	1.00
9200	1613.00	1168.80	1171.59	1170.96	1172.22	0.006139	6.35	253.91	94.08	1.01
9200	2419.00	1168.80	1172.44	1171.64	1173.25	0.005681	7.22	334.93	96.00	1.20
9200	4032.00	1168.80	1173.80	1172.77	1174.96	0.005484	8.63	467.45	99.06	1.56
9200	6452.00	1168.80	1175.41	1174.20	1177.04	0.005546	10.26	629.11	102.66	2.02
9200	8065.00	1168.80	1176.31	1175.02	1178.24	0.005635	11.15	723.03	104.70	2.30
8675	1613.00	1166.60	1170.62	1168.54	1170.83	0.001276	3.67	438.93	112.85	0.30
8675	2419.00	1166.60	1171.17	1169.12	1171.53	0.001876	4.83	501.25	113.86	0.50
8675	4032.00	1166.60	1172.28	1170.13	1172.92	0.002531	6.41	628.82	115.89	0.82
8675	6452.00	1166.60	1173.73	1171.41	1174.74	0.003052	8.08	798.36	118.53	1.22
8675	8065.00	1166.60	1174.57	1172.17	1175.82	0.003292	8.97	898.72	120.07	1.45
8525	1613.00	1163.30	1170.67	1165.23	1170.73	0.000170	1.95	827.29	118.68	0.07
8525	2419.00	1163.30	1171.25	1165.82	1171.37	0.000298	2.70	896.62	119.70	0.13
8525	4032.00	1163.30	1172.41	1166.81	1172.65	0.000527	3.89	1036.79	121.73	0.26
8525	6452.00	1163.30	1173.92	1168.11	1174.35	0.000811	5.28	1222.34	124.37	0.46
8525	8065.00	1163.30	1174.80	1168.88	1175.37	0.000973	6.05	1332.18	125.90	0.59

Reservoir W.L. At El. 1170.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
12730	1613.00	1218.40	1221.21	1220.46	1221.63	0.007715	5.17	312.23	130.92	1.14
12730	2419.00	1218.40	1221.94	1221.01	1222.48	0.007534	5.91	409.05	137.42	1.39
12730	4032.00	1218.40	1223.06	1221.94	1223.84	0.007670	7.08	569.09	147.53	1.84
12730	6452.00	1218.40	1224.41	1223.12	1225.48	0.007780	8.32	775.92	159.65	2.34
12730	8065.00	1218.40	1225.14	1223.80	1226.40	0.007952	9.00	895.93	166.22	2.65
12450	1613.00	1215.00	1217.25	1217.21	1218.16	0.022112	7.68	210.00	106.96	2.70
12450	2419.00	1215.00	1217.82	1217.82	1219.04	0.022372	8.84	273.71	113.88	3.34
12450	4032.00	1215.00	1218.87	1218.87	1220.45	0.020336	10.10	399.17	126.41	3.99
12450	6452.00	1215.00	1220.09	1220.09	1222.13	0.019138	11.47	562.39	140.44	4.76
12450	8065.00	1215.00	1220.80	1220.80	1223.09	0.017864	12.16	663.47	144.00	5.10
12265	1613.00	1210.00	1212.90	1212.90	1213.92	0.023720	8.11	198.94	97.36	2.98
12265	2419.00	1210.00	1213.57	1213.62	1214.83	0.023139	8.98	269.24	110.73	3.46
12265	4032.00	1210.00	1214.48	1214.70	1216.25	0.025370	10.66	378.16	128.74	4.57
12265	6452.00	1210.00	1215.47	1215.91	1217.91	0.027274	12.53	514.95	145.08	5.93
12265	8065.00	1210.00	1215.96	1216.60	1218.89	0.029194	13.74	586.78	151.28	6.93
12100	1613.00	1205.00	1207.95	1208.20	1209.59	0.028382	10.28	156.98	61.51	4.45
12100	2419.00	1205.00	1208.86	1209.09	1210.82	0.024732	11.21	215.73	66.64	4.90
12100	4032.00	1205.00	1210.51	1210.64	1212.78	0.020254	12.08	333.77	79.12	5.21
12100	6452.00	1205.00	1212.46	1212.46	1214.94	0.017709	12.63	510.95	102.53	5.39
12100	8065.00	1205.00	1213.39	1213.39	1216.09	0.017454	13.19	611.38	113.68	5.73
11990	1613.00	1200.00	1202.72	1203.51	1205.42	0.049942	13.18	122.35	49.81	7.45
11990	2419.00	1200.00	1203.49	1204.51	1206.98	0.048344	14.99	161.35	52.55	8.96
11990	4032.00	1200.00	1204.83	1206.30	1209.39	0.043506	17.14	235.23	57.39	10.66
11990	6452.00	1200.00	1206.64	1208.25	1211.86	0.039846	18.32	352.09	72.45	11.53
11990	8065.00	1200.00	1207.65	1209.32	1213.12	0.037416	18.76	429.91	81.35	11.76
11590	1613.00	1195.00	1198.04	1197.42	1198.66	0.010345	6.34	254.36	97.36	1.68
11590	2419.00	1195.00	1198.88	1198.11	1199.67	0.009806	7.12	339.86	104.96	1.97
11590	4032.00	1195.00	1200.25	1199.26	1201.30	0.009309	8.19	492.08	118.15	2.40
11590	6452.00	1195.00	1201.89	1200.68	1203.20	0.009013	9.19	702.27	138.46	2.82
11590	8065.00	1195.00	1202.80	1201.47	1204.25	0.008867	9.69	832.53	149.67	3.04
11270	1613.00	1192.00	1195.71	1194.59	1196.14	0.005971	5.26	306.41	102.38	1.10
11270	2419.00	1192.00	1196.53	1195.27	1197.12	0.006372	6.16	392.84	108.60	1.42
11270	4032.00	1192.00	1197.83	1196.40	1198.69	0.006906	7.46	540.41	118.48	1.93
11270	6452.00	1192.00	1199.33	1197.79	1200.55	0.007481	8.88	726.90	129.89	2.56
11270	8065.00	1192.00	1200.16	1198.59	1201.60	0.007749	9.64	837.01	135.47	2.92
10990	1613.00	1190.00	1192.17	1192.17	1193.15	0.023305	7.93	203.28	102.36	2.87
10990	2419.00	1190.00	1192.81	1192.81	1194.05	0.021630	8.94	270.47	107.48	3.37
10990	4032.00	1190.00	1193.86	1193.86	1195.54	0.020003	10.39	388.02	115.90	4.14
10990	6452.00	1190.00	1195.17	1195.17	1197.34	0.018390	11.81	546.37	126.19	4.92
10990	8065.00	1190.00	1195.93	1195.93	1198.36	0.017600	12.52	644.06	131.50	5.31
10850	1613.00	1185.00	1188.67	1187.80	1189.22	0.008375	5.95	271.30	97.74	1.44
10850	2419.00	1185.00	1189.57	1188.55	1190.25	0.008237	6.65	363.77	109.35	1.70
10850	4032.00	1185.00	1190.84	1189.75	1191.81	0.008228	7.91	509.55	117.34	2.21
10850	6452.00	1185.00	1192.38	1191.05	1193.72	0.007989	9.30	693.76	121.66	2.79
10850	8065.00	1185.00	1193.23	1191.80	1194.81	0.008064	10.10	798.40	124.04	3.17

Reservoir W.L. At El. 1175.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
3990	2000.00	1149.00	1175.00	1152.93	1175.00	0.000001	0.30	6670.89	382.50	0.00
3990	3000.00	1149.00	1175.00	1153.80	1175.00	0.000003	0.45	6671.12	382.50	0.00
3990	5000.00	1149.00	1175.00	1155.42	1175.01	0.000007	0.75	6671.64	382.50	0.01
3990	8000.00	1149.00	1175.01	1157.25	1175.03	0.000018	1.20	6672.99	382.51	0.02
3990	10000.00	1149.00	1175.01	1158.03	1175.04	0.000029	1.50	6674.30	382.52	0.03
2990	2000.00	1147.00	1175.00	1150.46	1175.00	0.000001	0.20	10147.58	650.00	0.00
2990	3000.00	1147.00	1175.00	1151.52	1175.00	0.000001	0.30	10147.82	650.00	0.00
2990	5000.00	1147.00	1175.00	1152.87	1175.00	0.000004	0.49	10148.13	650.00	0.00
2990	8000.00	1147.00	1175.00	1154.25	1175.01	0.000009	0.79	10149.01	650.00	0.01
2990	10000.00	1147.00	1175.00	1155.00	1175.02	0.000014	0.99	10149.88	650.01	0.01
2290	2000.00	1143.00	1175.00	1146.53	1175.00	0.000000	0.12	17218.91	662.50	0.00
2290	3000.00	1143.00	1175.00	1146.87	1175.00	0.000000	0.17	17219.24	662.51	0.00
2290	5000.00	1143.00	1175.00	1147.47	1175.00	0.000001	0.29	17219.96	662.53	0.00
2290	8000.00	1143.00	1175.00	1148.20	1175.01	0.000002	0.46	17221.74	662.57	0.00
2290	10000.00	1143.00	1175.01	1148.67	1175.01	0.000003	0.58	17223.44	662.61	0.00
1950	2000.00	1145.50	1175.00	1147.62	1175.00	0.000000	0.15	13368.82	545.00	0.00
1950	3000.00	1145.50	1175.00	1148.25	1175.00	0.000000	0.22	13368.88	545.00	0.00
1950	5000.00	1145.50	1175.00	1149.33	1175.00	0.000001	0.37	13369.08	545.01	0.00
1950	8000.00	1145.50	1175.00	1150.84	1175.01	0.000003	0.60	13369.48	545.02	0.00
1950	10000.00	1145.50	1175.00	1151.19	1175.01	0.000005	0.75	13369.95	545.03	0.01
1290	2000.00	1143.00	1175.00	1145.51	1175.00	0.000000	0.16	12828.75	460.00	0.00
1290	3000.00	1143.00	1175.00	1145.86	1175.00	0.000000	0.23	12828.69	460.00	0.00
1290	5000.00	1143.00	1175.00	1146.47	1175.00	0.000001	0.39	12828.58	460.00	0.00
1290	8000.00	1143.00	1175.00	1147.23	1175.00	0.000003	0.62	12828.24	460.00	0.00
1290	10000.00	1143.00	1175.00	1147.66	1175.01	0.000004	0.78	12828.02	460.00	0.01
810	2000.00	1125.00	1175.00	1130.83	1175.00	0.000000	0.15	13228.45	405.00	0.00
810	3000.00	1125.00	1175.00	1131.85	1175.00	0.000000	0.23	13228.40	405.00	0.00
810	5000.00	1125.00	1175.00	1133.49	1175.00	0.000001	0.38	13228.20	405.00	0.00
810	8000.00	1125.00	1175.00	1135.31	1175.00	0.000002	0.60	13227.66	405.00	0.00
810	10000.00	1125.00	1175.00	1136.28	1175.01	0.000003	0.76	13227.31	405.00	0.01
510	2000.00	1130.00	1175.00	1134.51	1175.00	0.000000	0.12	16324.94	485.00	0.00
510	3000.00	1130.00	1175.00	1135.63	1175.00	0.000000	0.18	16324.94	485.00	0.00
510	5000.00	1130.00	1175.00	1136.34	1175.00	0.000001	0.31	16324.82	485.00	0.00
510	8000.00	1130.00	1175.00	1137.20	1175.00	0.000001	0.49	16324.41	485.00	0.00
510	10000.00	1130.00	1175.00	1137.69	1175.00	0.000002	0.61	16324.23	485.00	0.00
300	2000.00	1125.00	1175.00	1125.93	1175.00	0.000000	0.08	24171.02	524.55	0.00
300	3000.00	1125.00	1175.00	1126.22	1175.00	0.000000	0.12	24171.02	524.55	0.00
300	5000.00	1125.00	1175.00	1126.71	1175.00	0.000000	0.21	24171.09	524.55	0.00
300	8000.00	1125.00	1175.00	1127.33	1175.00	0.000000	0.33	24171.09	524.55	0.00
300	10000.00	1125.00	1175.00	1127.69	1175.00	0.000001	0.41	24171.21	524.55	0.00
180	2000.00	1125.00	1175.00	1127.25	1175.00	0.000000	0.09	21168.75	550.00	0.00
180	3000.00	1125.00	1175.00	1127.88	1175.00	0.000000	0.14	21168.68	550.00	0.00
180	5000.00	1125.00	1175.00	1128.90	1175.00	0.000000	0.24	21168.68	550.00	0.00
180	8000.00	1125.00	1175.00	1130.20	1175.00	0.000001	0.38	21168.48	550.00	0.00
180	10000.00	1125.00	1175.00	1130.94	1175.00	0.000001	0.47	21168.41	550.00	0.00

Reservoir W.L. At El. 1175.0'

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
8350	1613.00	1166.40	1175.04	1168.17	1175.07	0.000077	1.46	1107.98	136.06	0.04
8350	2419.00	1166.40	1175.08	1168.72	1175.16	0.000171	2.17	1114.29	136.14	0.08
8350	4032.00	1166.40	1175.23	1169.63	1175.42	0.000449	3.56	1133.79	136.40	0.22
8350	6452.00	1166.40	1175.55	1170.83	1176.02	0.001020	5.48	1178.11	136.99	0.52
8350	8065.00	1166.40	1175.82	1171.52	1176.51	0.001446	6.63	1215.55	137.48	0.75
8280	1613.00	1164.30	1175.04	1166.16	1175.06	0.000043	1.23	1309.40	131.32	0.03
8280	2419.00	1164.30	1175.09	1166.72	1175.14	0.000096	1.84	1315.89	131.40	0.06
8280	4032.00	1164.30	1175.24	1167.68	1175.38	0.000253	3.02	1335.96	131.67	0.15
8280	6452.00	1164.30	1175.59	1168.92	1175.93	0.000586	4.67	1381.42	132.27	0.35
8280	8065.00	1164.30	1175.88	1169.66	1176.38	0.000841	5.68	1419.70	132.78	0.52
8210	1613.00	1166.00	1175.03	1167.68	1175.06	0.000057	1.29	1250.34	146.31	0.03
8210	2419.00	1166.00	1175.08	1168.20	1175.13	0.000126	1.93	1256.52	146.38	0.06
8210	4032.00	1166.00	1175.21	1169.08	1175.36	0.000333	3.16	1275.64	146.61	0.17
8210	6452.00	1166.00	1175.50	1170.20	1175.88	0.000768	4.89	1319.31	147.13	0.41
8210	8065.00	1166.00	1175.76	1170.88	1176.31	0.001101	5.95	1356.46	147.57	0.60
7810	1613.00	1164.00	1175.02	1167.65	1175.04	0.000041	1.00	1620.07	228.12	0.02
7810	2419.00	1164.00	1175.05	1168.29	1175.08	0.000091	1.49	1626.39	228.27	0.04
7810	4032.00	1164.00	1175.14	1169.27	1175.23	0.000243	2.45	1646.28	228.75	0.11
7810	6452.00	1164.00	1175.34	1170.31	1175.57	0.000570	3.81	1693.56	229.88	0.26
7810	8065.00	1164.00	1175.53	1170.85	1175.86	0.000825	4.65	1735.77	230.88	0.38
7190	1613.00	1162.00	1175.01	1164.77	1175.02	0.000021	0.84	1914.33	212.52	0.01
7190	2419.00	1162.00	1175.02	1165.37	1175.04	0.000048	1.26	1916.33	212.54	0.03
7190	4032.00	1162.00	1175.05	1166.32	1175.11	0.000132	2.10	1922.53	212.62	0.07
7190	6452.00	1162.00	1175.12	1167.49	1175.29	0.000329	3.33	1937.59	212.79	0.18
7190	8065.00	1162.00	1175.18	1168.17	1175.45	0.000503	4.13	1951.47	212.96	0.28
6690	2000.00	1160.50	1175.00	1162.68	1175.01	0.000010	0.61	3264.54	322.52	0.01
6690	3000.00	1160.50	1175.01	1163.31	1175.02	0.000022	0.92	3266.31	322.54	0.01
6690	5000.00	1160.50	1175.03	1164.30	1175.06	0.000061	1.53	3271.83	322.60	0.04
6690	8000.00	1160.50	1175.07	1165.58	1175.16	0.000154	2.44	3285.30	322.75	0.10
6690	10000.00	1160.50	1175.11	1166.29	1175.25	0.000237	3.03	3297.79	322.90	0.15
6130	2000.00	1158.00	1175.00	1159.83	1175.01	0.000003	0.41	4831.36	360.01	0.00
6130	3000.00	1158.00	1175.01	1160.36	1175.01	0.000007	0.62	4833.08	360.02	0.01
6130	5000.00	1158.00	1175.02	1161.22	1175.04	0.000019	1.03	4838.39	360.06	0.02
6130	8000.00	1158.00	1175.06	1162.27	1175.10	0.000048	1.65	4851.41	360.15	0.04
6130	10000.00	1158.00	1175.09	1162.86	1175.16	0.000074	2.06	4863.45	360.24	0.06
5280	2000.00	1157.00	1175.00	1160.28	1175.00	0.000002	0.37	5382.49	402.51	0.00
5280	3000.00	1157.00	1175.00	1160.75	1175.01	0.000006	0.56	5383.42	402.52	0.00
5280	5000.00	1157.00	1175.01	1161.56	1175.02	0.000015	0.93	5386.22	402.56	0.01
5280	8000.00	1157.00	1175.03	1162.49	1175.06	0.000039	1.48	5393.15	402.65	0.03
5280	10000.00	1157.00	1175.04	1163.02	1175.10	0.000061	1.85	5399.59	402.74	0.05
4780	2000.00	1154.50	1175.00	1156.68	1175.00	0.000001	0.33	6108.94	357.50	0.00
4780	3000.00	1154.50	1175.00	1157.16	1175.01	0.000003	0.49	6109.50	357.51	0.00
4780	5000.00	1154.50	1175.01	1157.97	1175.02	0.000009	0.82	6111.16	357.52	0.01
4780	8000.00	1154.50	1175.02	1158.94	1175.05	0.000023	1.31	6115.27	357.56	0.02
4780	10000.00	1154.50	1175.03	1159.47	1175.07	0.000035	1.63	6119.15	357.59	0.04

Reservoir W.L. At El. 1175.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
10480	1613.00	1180.00	1183.21	1183.21	1184.43	0.021835	8.88	181.64	73.34	3.35
10480	2419.00	1180.00	1184.01	1184.01	1185.54	0.021275	9.92	243.84	81.68	3.93
10480	4032.00	1180.00	1185.35	1185.35	1187.27	0.019082	11.12	362.48	94.05	4.54
10480	6452.00	1180.00	1186.81	1186.81	1189.33	0.018107	12.74	506.45	102.64	5.49
10480	8065.00	1180.00	1187.72	1187.72	1190.51	0.017029	13.39	602.43	107.98	5.82
9940	1613.00	1168.10	1175.42	1170.88	1175.59	0.000867	3.25	496.64	75.46	0.33
9940	2419.00	1168.10	1175.88	1171.70	1176.20	0.001593	4.55	531.12	76.41	0.64
9940	4032.00	1168.10	1176.99	1173.12	1177.65	0.002816	6.53	617.64	78.73	1.26
9940	6452.00	1168.10	1178.73	1174.90	1179.86	0.003933	8.51	757.87	82.36	2.05
9940	8065.00	1168.10	1179.82	1175.93	1181.22	0.004415	9.51	848.28	84.62	2.49
9800	1613.00	1168.10	1175.37	1170.40	1175.47	0.000542	2.60	619.81	89.55	0.21
9800	2419.00	1168.10	1175.78	1171.11	1175.99	0.001020	3.68	656.57	90.03	0.42
9800	4032.00	1168.10	1176.82	1172.32	1177.27	0.001671	5.37	751.38	91.26	0.85
9800	6452.00	1168.10	1178.52	1173.85	1179.30	0.002694	7.11	907.85	93.26	1.42
9800	8065.00	1168.10	1179.59	1174.74	1180.58	0.003065	8.00	1008.53	94.52	1.75
9680	1613.00	1169.20	1175.21	1171.63	1175.38	0.001088	3.28	491.74	89.98	0.35
9680	2419.00	1169.20	1175.46	1172.36	1175.80	0.002132	4.70	514.30	90.66	0.72
9680	4032.00	1169.20	1176.17	1173.61	1176.92	0.004127	6.96	578.95	92.58	1.53
9680	6452.00	1169.20	1177.49	1175.18	1178.79	0.005859	9.17	703.60	96.17	2.53
9680	8065.00	1169.20	1178.40	1176.06	1180.01	0.006400	10.17	792.87	98.66	3.02
9525	1613.00	1166.40	1175.21	1168.85	1175.29	0.000195	2.24	719.29	90.43	0.09
9525	2419.00	1166.40	1175.46	1169.60	1175.63	0.000399	3.26	742.09	90.93	0.19
9525	4032.00	1166.40	1176.17	1170.89	1176.56	0.000862	5.00	806.71	92.34	0.43
9525	6452.00	1166.40	1177.48	1172.49	1178.22	0.001446	6.95	929.00	94.95	0.81
9525	8065.00	1166.40	1178.38	1173.40	1179.36	0.001736	7.94	1015.31	96.75	1.03
9385	1613.00	1165.80	1175.20	1168.27	1175.26	0.000158	2.09	771.66	91.95	0.08
9385	2419.00	1165.80	1175.43	1169.02	1175.57	0.000327	3.05	793.11	92.44	0.16
9385	4032.00	1165.80	1176.09	1170.29	1176.43	0.000726	4.72	854.61	93.82	0.38
9385	6452.00	1165.80	1177.33	1171.91	1178.02	0.001264	6.63	972.94	96.42	0.73
9385	8065.00	1165.80	1178.20	1172.83	1179.10	0.001545	7.63	1057.39	98.24	0.94
9200	1613.00	1168.80	1175.10	1170.96	1175.22	0.000406	2.70	598.00	101.98	0.14
9200	2419.00	1168.80	1175.23	1171.64	1175.47	0.000855	3.96	610.77	102.26	0.30
9200	4032.00	1168.80	1175.60	1172.77	1176.20	0.001963	6.21	649.34	103.11	0.74
9200	6452.00	1168.80	1176.39	1174.20	1177.60	0.003484	8.82	731.16	104.88	1.44
9200	8065.00	1168.80	1176.99	1175.02	1178.59	0.004214	10.15	794.67	106.23	1.86
8675	1613.00	1166.60	1175.05	1168.54	1175.10	0.000108	1.69	956.92	120.95	0.05
8675	2419.00	1166.60	1175.12	1169.12	1175.21	0.000238	2.51	964.66	121.07	0.11
8675	4032.00	1166.60	1175.31	1170.13	1175.57	0.000612	4.08	988.51	121.43	0.29
8675	6452.00	1166.60	1175.75	1171.41	1176.35	0.001329	6.19	1042.18	122.23	0.66
8675	8065.00	1166.60	1176.12	1172.17	1176.97	0.001823	7.42	1087.15	122.91	0.94
8525	1613.00	1163.30	1175.06	1165.23	1175.08	0.000036	1.18	1364.84	126.36	0.02
8525	2419.00	1163.30	1175.13	1165.82	1175.18	0.000080	1.76	1373.99	126.48	0.05
8525	4032.00	1163.30	1175.35	1166.81	1175.48	0.000208	2.88	1402.15	126.87	0.13
8525	6452.00	1163.30	1175.85	1168.11	1176.15	0.000466	4.40	1465.15	127.74	0.31
8525	8065.00	1163.30	1176.26	1168.88	1176.70	0.000655	5.31	1517.53	128.45	0.44

Reservoir W.L. At El. 1175.0

HEC-RAS Plan: Imported Pla Reach: 1 8/1/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Shear Chan
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(lb/sq ft)
12730	1613.00	1218.40	1221.21	1220.46	1221.63	0.007715	5.17	312.23	130.92	1.14
12730	2419.00	1218.40	1221.94	1221.01	1222.48	0.007534	5.91	409.05	137.42	1.39
12730	4032.00	1218.40	1223.06	1221.94	1223.84	0.007670	7.08	569.09	147.53	1.84
12730	6452.00	1218.40	1224.41	1223.12	1225.48	0.007780	8.32	775.92	159.65	2.34
12730	8065.00	1218.40	1225.14	1223.80	1226.40	0.007952	9.00	895.93	166.22	2.65
12450	1613.00	1215.00	1217.25	1217.21	1218.16	0.022112	7.68	210.00	106.96	2.70
12450	2419.00	1215.00	1217.82	1217.82	1219.04	0.022372	8.84	273.71	113.88	3.34
12450	4032.00	1215.00	1218.87	1218.87	1220.45	0.020336	10.10	399.17	126.41	3.99
12450	6452.00	1215.00	1220.09	1220.09	1222.13	0.019138	11.47	562.39	140.44	4.76
12450	8065.00	1215.00	1220.80	1220.80	1223.09	0.017864	12.16	663.47	144.00	5.10
12265	1613.00	1210.00	1212.90	1212.90	1213.92	0.023720	8.11	198.94	97.36	2.98
12265	2419.00	1210.00	1213.57	1213.62	1214.63	0.023139	8.98	269.24	110.73	3.46
12265	4032.00	1210.00	1214.48	1214.70	1216.25	0.025370	10.66	378.16	128.74	4.57
12265	6452.00	1210.00	1215.47	1215.91	1217.91	0.027274	12.53	514.95	145.08	5.93
12265	8065.00	1210.00	1215.96	1216.60	1218.89	0.029194	13.74	586.78	151.28	6.93
12100	1613.00	1205.00	1207.95	1208.20	1209.59	0.028382	10.28	156.98	61.51	4.45
12100	2419.00	1205.00	1208.86	1209.09	1210.82	0.024732	11.21	215.73	66.64	4.90
12100	4032.00	1205.00	1210.51	1210.64	1212.78	0.020254	12.08	333.77	79.12	5.21
12100	6452.00	1205.00	1212.46	1212.46	1214.94	0.017709	12.63	510.95	102.53	5.39
12100	8065.00	1205.00	1213.39	1213.39	1216.09	0.017454	13.19	611.38	113.68	5.73
11990	1613.00	1200.00	1202.72	1203.51	1205.42	0.049942	13.18	122.35	49.81	7.45
11990	2419.00	1200.00	1203.49	1204.51	1206.98	0.048344	14.99	161.35	52.55	8.96
11990	4032.00	1200.00	1204.83	1206.30	1209.39	0.043506	17.14	235.23	57.39	10.66
11990	6452.00	1200.00	1206.64	1208.25	1211.86	0.039846	18.32	352.09	72.45	11.53
11990	8065.00	1200.00	1207.65	1209.32	1213.12	0.037416	18.76	429.91	81.35	11.76
11590	1613.00	1195.00	1198.04	1197.42	1198.66	0.010345	6.34	254.36	97.36	1.68
11590	2419.00	1195.00	1198.88	1198.11	1199.67	0.009806	7.12	339.86	104.96	1.97
11590	4032.00	1195.00	1200.25	1199.26	1201.30	0.009309	8.19	492.08	118.15	2.40
11590	6452.00	1195.00	1201.89	1200.68	1203.20	0.009013	9.19	702.27	138.46	2.82
11590	8065.00	1195.00	1202.80	1201.47	1204.25	0.008867	9.69	832.53	149.67	3.04
11270	1613.00	1192.00	1195.71	1194.59	1196.14	0.005971	5.26	306.41	102.38	1.10
11270	2419.00	1192.00	1196.53	1195.27	1197.12	0.006372	6.16	392.84	108.60	1.42
11270	4032.00	1192.00	1197.83	1196.40	1198.69	0.006906	7.46	540.41	118.48	1.93
11270	6452.00	1192.00	1199.33	1197.79	1200.55	0.007481	8.88	726.90	129.89	2.56
11270	8065.00	1192.00	1200.16	1198.59	1201.60	0.007749	9.64	837.01	135.47	2.92
10990	1613.00	1190.00	1192.17	1192.17	1193.15	0.023305	7.93	203.28	102.36	2.87
10990	2419.00	1190.00	1192.81	1192.81	1194.05	0.021630	8.94	270.47	107.48	3.37
10990	4032.00	1190.00	1193.86	1193.86	1195.54	0.020003	10.39	388.02	115.90	4.14
10990	6452.00	1190.00	1195.17	1195.17	1197.34	0.018390	11.81	546.37	126.19	4.92
10990	8065.00	1190.00	1195.93	1195.93	1198.36	0.017600	12.52	644.06	131.50	5.31
10850	1613.00	1185.00	1188.67	1187.80	1189.22	0.008375	5.95	271.30	97.74	1.44
10850	2419.00	1185.00	1189.57	1188.55	1190.25	0.008237	6.65	363.77	109.35	1.70
10850	4032.00	1185.00	1190.84	1189.75	1191.81	0.008228	7.91	509.55	117.34	2.21
10850	6452.00	1185.00	1192.38	1191.05	1193.72	0.007989	9.30	693.76	121.66	2.79
10850	8065.00	1185.00	1193.23	1191.80	1194.81	0.008064	10.10	798.40	124.04	3.17

APPENDIX C

SUMMARY OF HEC-RAS OUTPUT
FOR
MIDDLE FORK OF THE AMERICAN RIVER
DOWNSTREAM FROM RALSTON AFTERBAY DAM

HEC-RAS Plan: Appendix C Reach: 1

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl	Shear Chan (lb/sq ft)
0.0	2000.0	1104.0	1106.37	1104.98	1106.45	0.001218	2.28	0.26	0.18
0.0	3500.0	1104.0	1107.56	1105.41	1107.67	0.000961	2.64	0.25	0.21
0.0	5000.0	1104.0	1108.41	1105.79	1108.55	0.000960	3.02	0.26	0.25
0.0	8000.0	1104.0	1109.77	1106.45	1109.97	0.001005	3.66	0.27	0.34
1.0	2000.0	1098.0	1103.69	1103.69	1105.24	0.017017	10.00	1.02	3.15
1.0	3500.0	1098.0	1105.52	1105.52	1106.70	0.017554	8.71	1.00	2.58
1.0	5000.0	1098.0	1106.27	1106.27	1107.57	0.017086	9.14	1.00	2.76
1.0	8000.0	1098.0	1107.34	1107.34	1108.93	0.015847	10.12	1.00	3.15
1.3	2000.0	1093.0	1096.00	1097.29	1100.18	0.068205	16.39	1.93	9.35
1.3	3500.0	1093.0	1097.41	1098.93	1102.01	0.045131	17.21	1.66	9.08
1.3	5000.0	1093.0	1098.74	1100.22	1103.36	0.034810	17.25	1.51	8.54
1.3	8000.0	1093.0	1100.96	1102.26	1105.36	0.026104	16.84	1.35	7.66
1.7	2000.0	1093.0	1097.65	1095.14	1097.82	0.001158	3.26	0.28	0.30
1.7	3500.0	1093.0	1099.09	1096.01	1099.36	0.001426	4.22	0.32	0.46
1.7	5000.0	1093.0	1100.28	1096.73	1100.65	0.001572	4.89	0.35	0.59
1.7	8000.0	1093.0	1101.88	1097.99	1102.48	0.001969	6.18	0.40	0.89
2.0	2000.0	1093.0	1096.94	1095.63	1097.31	0.003831	4.91	0.49	0.75
2.0	3500.0	1093.0	1098.17	1096.61	1098.75	0.004286	6.11	0.54	1.07
2.0	5000.0	1093.0	1099.30	1097.41	1099.98	0.004765	6.63	0.57	1.24
2.0	8000.0	1093.0	1100.81	1098.97	1101.71	0.004849	7.62	0.59	1.53
3.0	2000.0	1091.0	1094.31	1093.64	1094.76	0.007229	5.38	0.63	1.00
3.0	3500.0	1091.0	1095.11	1094.48	1095.84	0.008363	6.86	0.71	1.50
3.0	5000.0	1091.0	1095.76	1095.16	1096.74	0.009095	7.97	0.76	1.91
3.0	8000.0	1091.0	1096.79	1096.26	1098.26	0.010031	9.71	0.83	2.64
4.0	2000.0	1087.0	1091.44	1090.28	1091.93	0.009862	5.62	0.72	1.16
4.0	3500.0	1087.0	1092.58	1091.82	1093.10	0.007423	5.78	0.65	1.13
4.0	5000.0	1087.0	1093.40	1092.45	1093.98	0.006527	6.09	0.63	1.18
4.0	8000.0	1087.0	1094.47	1093.41	1095.23	0.006507	6.99	0.65	1.45
5.0	2000.0	1081.0	1085.19	1085.19	1086.82	0.016460	10.22	1.00	3.23
5.0	3500.0	1081.0	1087.10	1087.10	1088.75	0.016260	10.30	1.00	3.26
5.0	5000.0	1081.0	1088.21	1088.21	1089.94	0.016123	10.55	1.00	3.37
5.0	8000.0	1081.0	1090.09	1089.70	1091.73	0.011611	10.28	0.88	2.98
6.0	2000.0	1077.0	1081.43	1080.02	1082.00	0.004448	6.07	0.54	1.06
6.0	3500.0	1077.0	1082.57	1081.26	1083.61	0.006128	8.17	0.65	1.80
6.0	5000.0	1077.0	1083.44	1082.36	1084.95	0.007524	9.87	0.74	2.52
6.0	8000.0	1077.0	1084.76	1084.16	1087.26	0.009988	12.68	0.87	3.93
6.5	2000.0	1077.0	1080.81	1078.83	1080.94	0.001328	2.92	0.29	0.26
6.5	3500.0	1077.0	1081.96	1079.56	1082.18	0.001498	3.72	0.32	0.39
6.5	5000.0	1077.0	1082.92	1080.16	1083.21	0.001594	4.32	0.34	0.49
6.5	8000.0	1077.0	1084.50	1081.14	1084.92	0.001707	5.21	0.37	0.67
7.0	2000.0	1077.0	1079.93	1078.87	1080.17	0.003418	3.94	0.44	0.52
7.0	3500.0	1077.0	1081.02	1079.53	1081.37	0.003137	4.76	0.45	0.68
7.0	5000.0	1077.0	1081.93	1080.11	1082.38	0.003015	5.39	0.46	0.81
7.0	8000.0	1077.0	1083.43	1081.09	1084.07	0.002950	6.38	0.47	1.04
8.0	2000.0	1076.0	1078.60	1077.94	1079.08	0.007112	5.55	0.64	1.05
8.0	3500.0	1076.0	1079.39	1078.78	1080.20	0.008769	7.24	0.73	1.64
8.0	5000.0	1076.0	1080.04	1079.51	1081.15	0.009738	8.46	0.79	2.13
8.0	8000.0	1076.0	1081.16	1080.76	1082.74	0.011342	10.08	0.88	2.88
9.0	2000.0	1074.0	1076.18	1075.80	1076.60	0.009442	5.17	0.69	1.01
9.0	3500.0	1074.0	1077.02	1076.43	1077.59	0.007926	6.07	0.68	1.23
9.0	5000.0	1074.0	1077.68	1076.97	1078.41	0.007511	6.83	0.68	1.45
9.0	8000.0	1074.0	1078.82	1077.88	1079.81	0.007000	7.96	0.69	1.79

HEC-RAS Plan: Appendix C Reach: 1

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl	Shear Chan (lb/sq ft)
10.0	2000.0	1071.0	1074.27	1073.30	1074.58	0.004859	4.44	0.52	0.68
10.0	3500.0	1071.0	1075.29	1074.13	1075.71	0.004729	5.21	0.54	0.86
10.0	5000.0	1071.0	1076.03	1074.77	1076.58	0.004610	5.91	0.55	1.03
10.0	8000.0	1071.0	1077.22	1075.74	1078.00	0.004734	7.10	0.58	1.37
11.0	2000.0	1069.0	1072.35	1071.21	1072.58	0.003697	3.92	0.46	0.53
11.0	3500.0	1069.0	1073.31	1071.97	1073.65	0.003998	4.72	0.49	0.71
11.0	5000.0	1069.0	1074.08	1072.58	1074.51	0.004062	5.23	0.51	0.83
11.0	8000.0	1069.0	1075.33	1073.57	1075.88	0.003935	5.96	0.52	1.00
12.0	2000.0	1068.0	1069.85	1069.85	1070.60	0.020122	6.94	0.99	1.90
12.0	3500.0	1068.0	1070.56	1070.56	1071.59	0.017941	8.17	0.99	2.36
12.0	5000.0	1068.0	1071.14	1071.14	1072.43	0.016917	9.12	1.00	2.74
12.0	8000.0	1068.0	1072.13	1072.13	1073.83	0.015529	10.48	1.00	3.30
13.0	2000.0	1066.0	1068.21	1067.58	1068.57	0.006487	4.77	0.59	0.82
13.0	3500.0	1066.0	1068.90	1068.27	1069.49	0.007916	6.20	0.68	1.27
13.0	5000.0	1066.0	1069.38	1068.85	1070.24	0.009491	7.45	0.76	1.75
13.0	8000.0	1066.0	1070.27	1069.82	1071.55	0.010869	9.07	0.84	2.43
13.5	2000.0	1064.0	1066.49	1066.39	1067.04	0.017116	5.93	0.90	1.44
13.5	3500.0	1064.0	1067.15	1066.98	1067.89	0.014482	6.91	0.88	1.74
13.5	5000.0	1064.0	1067.77	1067.48	1068.63	0.012256	7.44	0.84	1.86
13.5	8000.0	1064.0	1068.86	1068.32	1069.88	0.009710	8.12	0.79	2.00
13.7	2000.0	1059.0	1061.48	1061.48	1062.53	0.018189	8.24	1.00	2.39
13.7	3500.0	1059.0	1062.50	1062.50	1063.91	0.016414	9.55	1.00	2.91
13.7	5000.0	1059.0	1063.33	1063.31	1065.03	0.015497	10.47	1.00	3.29
13.7	8000.0	1059.0	1065.48	1064.68	1066.67	0.017413	8.75	1.00	2.59
14.0	2000.0	1055.0	1060.40	1057.24	1060.54	0.000868	3.00	0.25	0.25
14.0	3500.0	1055.0	1061.97	1058.21	1062.20	0.001050	3.87	0.28	0.38
14.0	5000.0	1055.0	1062.84	1059.01	1063.20	0.001394	4.80	0.33	0.56
14.0	8000.0	1055.0	1064.21	1060.37	1064.83	0.001996	6.33	0.41	0.93
15.0	2000.0	1055.0	1059.22	1058.06	1059.77	0.005319	5.91	0.58	1.07
15.0	3500.0	1055.0	1060.76	1059.26	1061.28	0.007304	5.78	0.65	1.12
15.0	5000.0	1055.0	1061.55	1060.61	1062.15	0.006152	6.23	0.62	1.20
15.0	8000.0	1055.0	1062.87	1061.50	1063.62	0.005170	6.95	0.60	1.35
16.0	2000.0	1054.0	1057.87	1056.54	1058.18	0.003809	4.45	0.47	0.64
16.0	3500.0	1054.0	1059.07	1057.50	1059.50	0.003953	5.27	0.50	0.84
16.0	5000.0	1054.0	1059.77	1058.24	1060.37	0.004761	6.21	0.56	1.12
16.0	8000.0	1054.0	1061.19	1059.46	1061.93	0.005059	6.91	0.59	1.34
17.0	2000.0	1052.0	1054.76	1054.27	1055.42	0.009348	6.52	0.73	1.43
17.0	3500.0	1052.0	1055.84	1055.46	1056.53	0.010950	6.64	0.78	1.53
17.0	5000.0	1052.0	1056.67	1056.04	1057.40	0.008400	6.84	0.71	1.49
17.0	8000.0	1052.0	1057.53	1056.96	1058.61	0.009711	8.36	0.79	2.09
18.0	2000.0	1051.0	1053.70	1052.72	1053.95	0.004151	4.02	0.48	0.56
18.0	3500.0	1051.0	1054.49	1053.44	1054.89	0.004999	5.10	0.55	0.84
18.0	5000.0	1051.0	1055.35	1054.02	1055.77	0.005997	5.24	0.59	0.92
18.0	8000.0	1051.0	1056.03	1055.26	1056.70	0.006898	6.56	0.66	1.34
19.0	2000.0	1049.0	1051.67	1051.67	1052.27	0.022323	6.18	1.00	1.64
19.0	3500.0	1049.0	1052.23	1052.23	1053.05	0.019497	7.29	0.99	2.03
19.0	5000.0	1049.0	1052.69	1052.69	1053.72	0.018208	8.12	1.00	2.35
19.0	8000.0	1049.0	1053.86	1053.47	1054.90	0.011097	8.17	0.83	2.09
20.0	2000.0	1044.0	1048.55	1047.78	1049.23	0.008519	6.63	0.71	1.43
20.0	3500.0	1044.0	1049.96	1049.09	1050.75	0.008051	7.12	0.71	1.57
20.0	5000.0	1044.0	1051.05	1050.01	1051.87	0.007542	7.29	0.70	1.60
20.0	8000.0	1044.0	1052.83	1051.38	1053.65	0.005495	7.26	0.62	1.47

HEC-RAS Plan: Appendix C Reach: 1

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Froude # Chl	Shear Chan (lb/sq ft)
21.0	2000.0	1043.0	1047.41	1045.62	1047.70	0.002874	4.28	0.42	0.57
21.0	3500.0	1043.0	1048.82	1046.72	1049.21	0.002990	5.03	0.45	0.73
21.0	5000.0	1043.0	1049.90	1047.57	1050.38	0.003051	5.56	0.46	0.85
21.0	8000.0	1043.0	1051.88	1048.89	1052.44	0.002699	5.95	0.45	0.91
22.0	2000.0	1042.0	1046.78	1044.81	1047.05	0.002373	4.23	0.39	0.53
22.0	3500.0	1042.0	1048.01	1045.88	1048.47	0.002988	5.45	0.46	0.82
22.0	5000.0	1042.0	1048.89	1046.73	1049.54	0.003571	6.45	0.51	1.11
22.0	8000.0	1042.0	1050.81	1048.15	1051.52	0.005028	6.75	0.58	1.29
22.8	2000.0	1041.5	1044.32	1044.32	1045.58	0.017913	9.01	1.01	2.73
22.8	3500.0	1041.5	1045.69	1045.69	1046.82	0.018075	8.53	1.00	2.52
22.8	5000.0	1041.5	1046.32	1046.32	1047.72	0.016586	9.50	1.00	2.90
22.8	8000.0	1041.5	1047.37	1047.37	1049.26	0.015264	11.02	1.00	3.54
23.7	2000.0	1039.0	1041.39	1040.50	1041.67	0.004269	4.23	0.49	0.61
23.7	3500.0	1039.0	1042.41	1041.16	1042.82	0.003933	5.10	0.50	0.80
23.7	5000.0	1039.0	1043.29	1041.73	1043.80	0.003712	5.73	0.50	0.93
23.7	8000.0	1039.0	1044.78	1042.73	1045.47	0.003472	6.67	0.51	1.15
24.5	2000.0	1037.0	1039.12	1039.12	1040.05	0.018653	7.74	0.99	2.20
24.5	3500.0	1037.0	1040.01	1040.01	1041.29	0.016830	9.07	0.99	2.71
24.5	5000.0	1037.0	1040.74	1040.74	1042.31	0.015809	10.06	1.00	3.12
24.5	8000.0	1037.0	1041.97	1041.97	1044.01	0.014510	11.46	1.00	3.71

APPENDIX D

GATE AND VALVE MANUFACTURER PROPOSALS

RODNEY HUNT

November 15, 1996

FAX TO: **Bechtel**
fax # 415-768-5561
Douglas Adams

From: **Rodney Hunt Company**
Paul Brunelle

Re: **72"x90" Heavy Duty sluice gate with a SCUBA actuator**

Dear Douglas,

As I had indicated to you via my fax yesterday, the use of a 72"x90" sluice gate is the best suited for your application. I would recommend that the specification include the use of full guide containment to act as increased support for the gate disk in the full open position. The gate would be mounted on the downstream face of the concrete dam, incorporating a grout pad between the gate frame and concrete wall.

The electro-hydraulic actuator SCUBA would be above the 500 year tailwater level, and would be complete with a handpump. The power being pretty dependable at this Hydro site would not necessitate the need for any accumulators.

The sluice gate, with bronze tongue covers and guide liners, with the necessary extension stem to get the operating level at about elevation 1144.00', and including the special wall bracket and the SCUBA, and the proper number of intermediate stem guides would result in the following:

Estimating Price....................$74,200.00

I hope that this helps in your preliminary design work. If I can be of any further assistance, please do not hesitate to contact me.

Yours truly,

Paul Brunelle

cc: J M SQUARED

To: Bech[tel] Mr. Douglas Adams 12 pages
From: Paul Brunelle @ Rodney Hunt

GATE PROGRAM DESIGN OUTPUT

Quote #:
Project: Middle Fork DAM, CA
Item # 1 Plan sheet #
Equipment #
Location: DAM OUTLET STRUCTURE

User: BRUNELLE
Date: 96/11/14
Time: 13:31:27

Re: Fax of Nov 13 to our Tom McAndrew

→ (1) 72 x 96 Series 120 Sluice gate HEAVY Duty
Score no. : 2131-0003000 Drawing no. : C1268205
Self contained : N Inverted operation: N
Rising stem : Y Glydaseal : N
Floor elevation (ft) : 43
Centerline elevation (ft) : 0
Centerline to floor (ft) : 43

SLUICE GATE OPERATING LOAD

Friction factor : .35
Disc weight : 8000
Wedge friction : .5
Angle of gate : 33
Stuffing box : N
Bullnose disc : N
Downpull : Y

		Seating	Unseating
Head :	Design	102	(37)
	Operating	90	90
Force :	Raising	105080	105080
	Lowering	96370	96370

100'

Rod seal : 250
Stuffing box : 0
Stem+rod force: 1087
Maximum load : 105080
MOL : 106417

Notes: This is best suited to be a Sluice gate Installation mounted on the face of the DAM, and using electro-Hydraulic (Scuba)
P Brunelle

HYDRAULIC OPERATOR

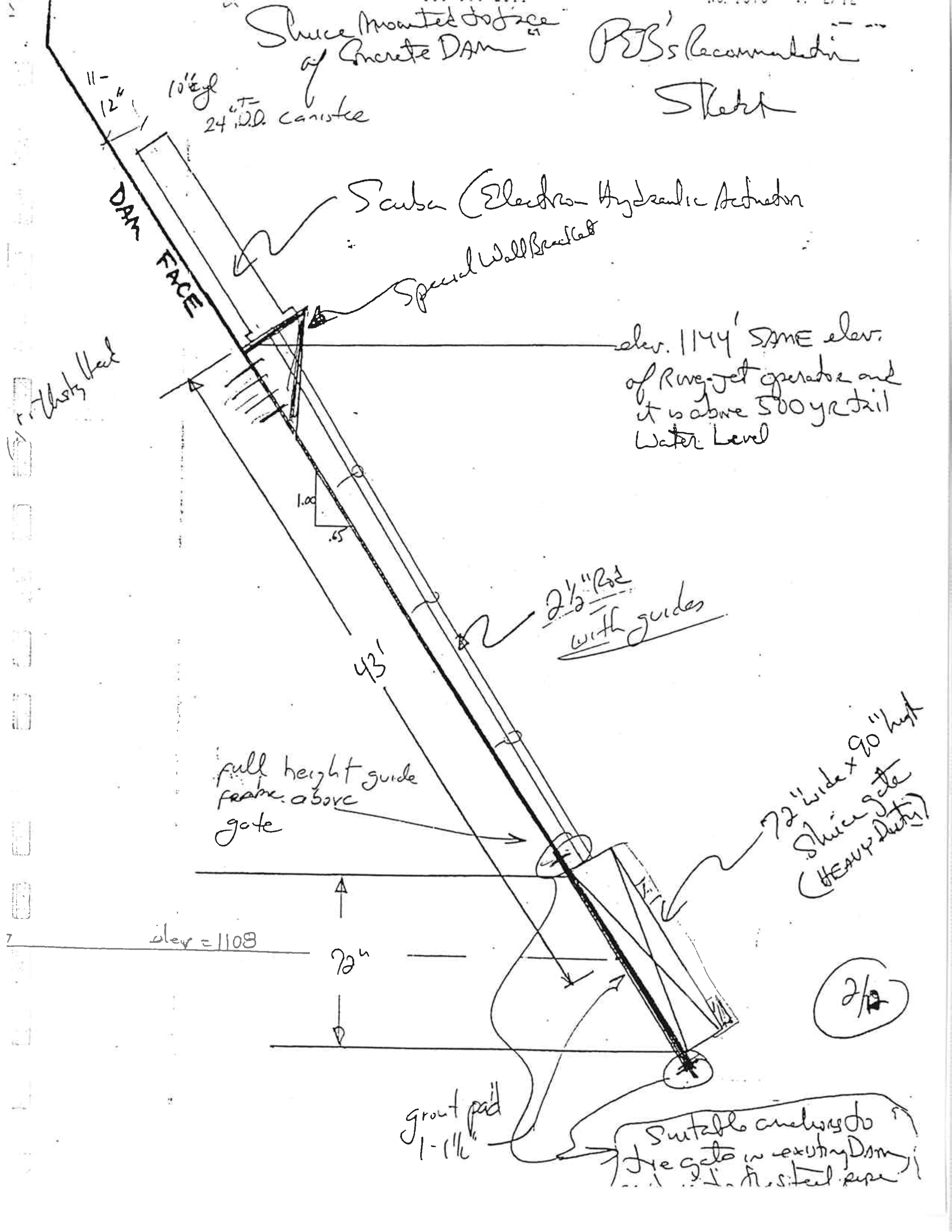
Cylinder, rod : 10 B,2.5 R
Rod stick out : 18 in. retracted
Tail rod diam. : 0 in
Output : 157080 lbs
Pressure : 2000 psi
Design load SF : 1.25
Rod drill out : 0

NON SELF-CONTAINED FRAME

Floor thickness : 12
Hoist grout pad : 1
Grout/flange proj: 0
Stem to wall : 9.5
Disc travel : 97.38
Open elevation : 3.83
Centerline to nut: 38

Wall bracket : Y
Offset pedestal : N
Guide length : 0
Thread elevation : 43.04

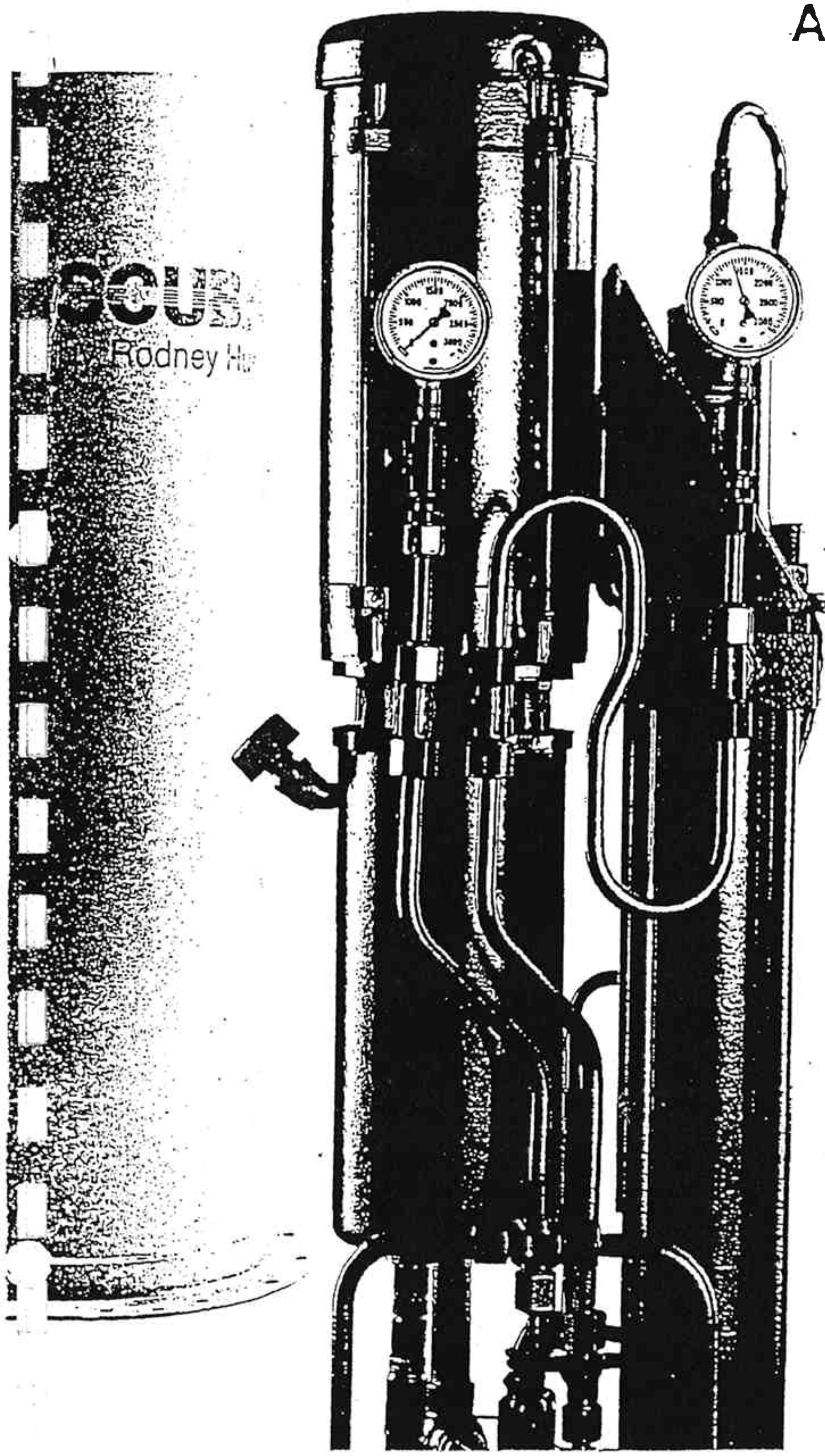
2 min operation possible
this is adjustable


Sluice mounted to face of Concrete DAM
PJB's Recommendation Sketch
11-12"
10" cyl
24" O.D. canister
DAM FACE
Scuba (Electro-Hydraulic Actuator
Special Wall Bracket
elev. 1144' SAME elev. of Ring-jet operator and it is above 500 yr tail Water Level
1.00
.65
2½" Rod with guides
43'
full height guide frame above gate
72" wide x 90" high Sluice gate (HEAVY Duty)
elev = 1108
72"
grout pad 1-1½"
Suitable anchors to tie gate in existing Dam

Rodney Hunt

SCUBA™

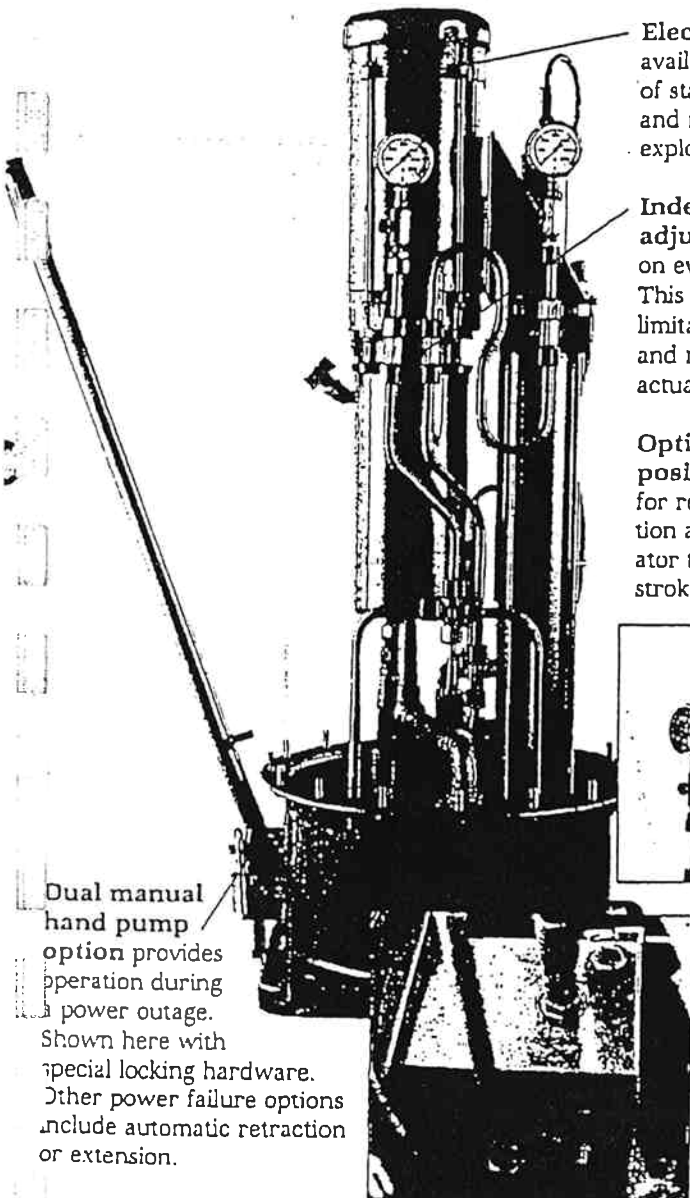
ACTUATORS

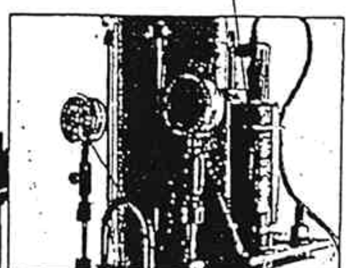


Self-
Contained
Universal
Bi-Directional
Actuators

Simple, Low Maintenance Power Actuation

SCUBA™. Provides Self-Contained, Low-Maintenance Actuation.





Electric motors are available in a wide variety of standard voltages, phases, and ratings. Photo shows an explosion-proof motor.

Independent, dual thrust adjustments are standard on every SCUBA actuator. This permits separate thrust limitation for the extension and retraction stroke of the actuator.

Optional continuous position feedback allows for remote position indication and control of the actuator throughout its entire stroke.

Dual manual hand pump option provides operation during a power outage. Shown here with special locking hardware. Other power failure options include automatic retraction or extension.

Stainless steel case, grade A pressure gauges provide indication for initial adjustments and monitoring of system's operating characteristics.

A variety of covers is available for every application.

Stainless steel tubing with silver brazed, O-ring face seal fittings provide a leak-free system.

Manifold cartridge valving eliminates the need for line mounted valves. Optional hand pump manifold illustrated.

The SCUBA actuator differs from traditional manual and electric actuators. SCUBA units are designed to be completely self-contained, and appropriate for a wide range of applications.

Key Benefits:

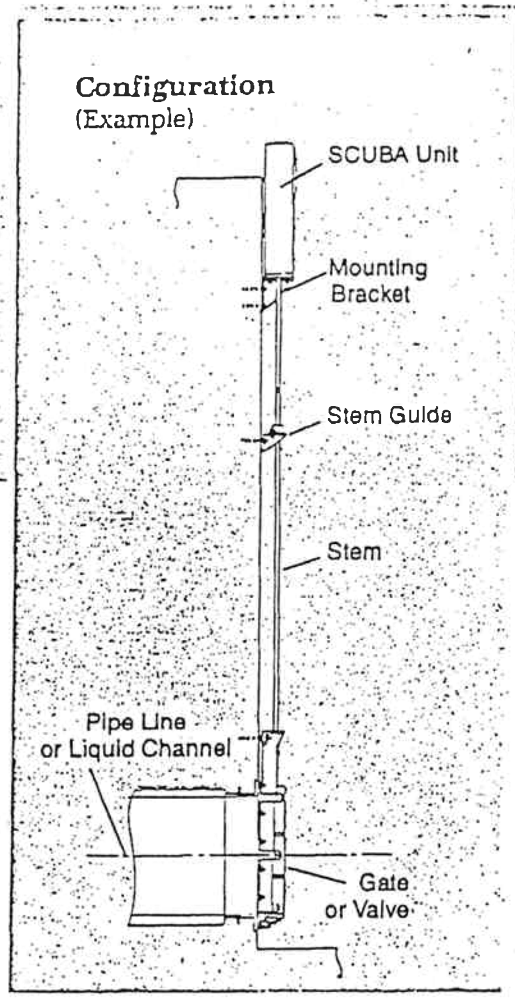
- Self-Contained: All actuator components installed on a common base.
- Cost Effective: Reduced installation, maintenance and operating costs.
- Easy Installation: One mechanical connection. No field piping. Straightforward wiring.
- Rugged Design: 1 1/4" base plate. Stainless steel cover available.
- High Efficiency: Negligible mechanical losses. No screw stem friction or wear.
- Low Maintenance: No routine maintenance required.

Standard and Custom Options

- Optional Covers: Covers available to meet most applications (such as weathertight and submersible).
- Hazardous Environments: Explosion-proof and intrinsically safe components permit installation in hazardous environments.
- Power Failure Operation: Able to fully retract or extend upon loss of electrical power.
- Position Feedback: End of travel and continuous position feedback is available.

4/12

Where Are SCUBA™ Units Used?



Combined Sewer Overflow Regulation

SCUBA's self-contained and rugged construction makes it ideally suited for the wet, corrosive and hazardous environment of combined sewer overflow regulator chambers.

Modulating Service

Reduced mechanical wear and maintenance costs make a SCUBA unit the logical choice for modulating service.

Corrosive Installations

SCUBA units are supplied with Rodney Hunt's standard epoxy paint system which protects the unit in most corrosive applications. For extremely corrosive environments, SCUBA units can be supplied with stainless steel covers.

Submersible Locations

A submersible SCUBA unit can be specified for operation in an underwater location.

Hazardous Environments

SCUBA units can be supplied for installation in Class I, Division 1 hazardous locations by utilizing explosion-proof and intrinsically safe components.

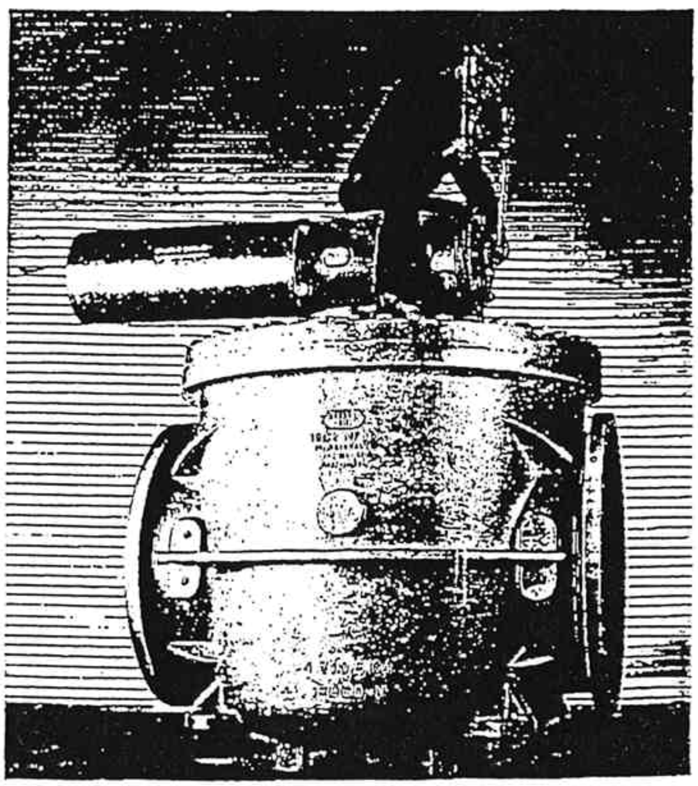
Emergency Power Failure Operation

Unlike electric actuators, SCUBA units can be supplied to automatically extend or retract upon a loss of electrical power. Emergency operation is often critical for influent chambers or pump stations.

Remote Installations

For very remote sites, SCUBA units can be supplied with manual pumps or 12 VDC motors for operation with a vehicle's battery system.

Can have a PLC to operate



A SCUBA unit can be used to operate large water and wastewater control valves like this 36" Rotovalve, destined for service in a municipal sewage treatment facility.

5/12

Specifications

The following is a sample specification for Rodney Hunt Company's SCUBA series of linear actuators. The sample specification is divided into distinct sections, each dealing with a particular aspect or feature of the SCUBA unit. The specifier is encouraged to read each section carefully and choose the appropriate subsection that best meets the application.

Although a SCUBA unit can be specified and designed for almost any type of application and configuration, only the standard features have been included here. If an application requires a special design consideration, application assistance is available from Rodney Hunt Company.

General: A complete electrohydraulic actuator system shall be furnished to operate the equipment specified. The design shall be directed, reviewed and approved by a Professional Engineer registered in the state of manufacture of the actuator system. It shall be equivalent in design and workmanship to the SCUBA unit, as manufactured by Rodney Hunt Company of Orange, Massachusetts.

It is the intent of this specification to encourage the use of the latest technological advances both in component selection and in system design concepts.

Actuator Construction: Each actuator shall be designed to be a single self-contained unit, requiring only electrical connections. The actuator shall be completely factory wired, assembled and tested.

The operating rod and any required operating stem shall be sized to safely withstand 1.25 times the actuator output at maximum system pressure and shall be sized so that L/r is less than 200; where "L" is the unsupported length and "r" is the radius of gyration. The operating rod shall be hard chrome plated. Any additional stem required shall be stainless steel.

All hydraulic tubing shall be 300 series stainless steel with O-ring face seal, sil-brazed fittings meeting the requirements of SAE J1453.

All electrical connections shall be made within conduit enclosures or junction boxes and be properly labeled. No live connections shall be exposed when the unit cover is removed. If analog signal wiring is required, it should be shielded and separated from the control and power wiring.

Actuator Cover *Select one:*
Drip-Proof Cover: The actuator cover shall be manufactured so that it protects the actuator from the entrance of rain.
Weather-Tight Cover: The actuator cover shall be manufactured so that it protects the actuator from windblown rain, splashing water, or hose-directed water.
Submersible Cover: The actuator cover shall be manufactured so that it will exclude water in a submerged condition.
Without Cover: The actuator shall be provided without a cover.

Cover Material *Select one:*
Steel: The actuator cover material shall be steel.
Stainless Steel: The actuator cover material shall be stainless steel.

Nominal Speed *Select one:*
12"/min.: The actuator shall extend and retract at a nominal speed of 12" per minute.
24"/min.: The actuator shall extend and retract at a nominal speed of 24" per minute.

Power Failure Operation *Select one:*
Automatic Extension: Upon a loss of electrical power, the actuator shall immediately and automatically fully extend at the normal operating speed.
Automatic Retraction: Upon a loss of electrical power, the actuator shall immediately and automatically fully retract at the normal operating speed.
Manual: Manual operation shall be provided, at a reduced speed, in the event that there is no electrical power available. All manual operation shall be possible without opening the actuator cover. No directional control valves will be allowed.
None Required: No power failure operation is required.

Actuator Environment *Select one:*
Non-Hazardous: The actuator shall be designed to be installed in a non-hazardous environment. All electrical components shall be rated NEMA 12 or better.
Hazardous: The actuator shall be designed to be installed in a Class I, Division 1 hazardous area. All components of the actuator shall be NEMA 7, Class I, Division 1 rated or wired for intrinsic safety.

Electrical Control Enclosure *Select one:*
NEMA 12: The separate electrical enclosure and all components mounted on its exterior shall be NEMA 12 rated.
NEMA 4X: The separate electrical enclosure shall be corrosion resistant and NEMA 4X rated. All components mounted on the exterior of the enclosure shall be NEMA 4 rated.
NEMA 7: The separate electrical enclosure and all components mounted on the exterior shall be NEMA 7 rated and designed for installation in a Class I, Division 1 hazardous environment.
Integral: The electrical enclosure shall be an integral part of the actuator cover. All necessary electrical control components shall be mounted on/in the integral enclosure.

Controls *Select all that apply:*
Local Extend/Retract: It shall be possible to extend, retract, and position the actuator using manually activated pushbuttons located on the control enclosure. It shall be possible to position the gate at any intermediate position.
Remote Extend/Retract: It shall be possible to position the actuator using two sets of normally open dry contacts provided from devices by others. Motion occurs while these contacts are closed and ceases when they are open.
Modulating: It shall be possible to position the actuator automatically using a single loop controller in order to match a variable 4-20 mAmp process signal. The controller shall be capable of proportional-integral-derivative (PID) control. The analog process variable signal to be monitored shall be provided from devices furnished by others.
Special Controls: Specify as required.

Position Indication *Select one:*
End of Travel: End of travel indicating lights, mounted on the control enclosure, shall be provided using proximity switches integrally mounted in the actuator.
Continuous Position Indication: The actuator shall be supplied with a 4-20 mAmp continuous position transducer. The actuator's position shall be displayed on an LED meter, mounted on the control enclosure.
End of Travel and Continuous Position Indication: The actuator shall be supplied with both a 4-20 mAmp continuous position transducer and end of travel proximity switches. The control enclosure shall be provided with an LED meter and indicating lights.
None Required: No position indication is required.

Electrical Power: The main electrical power source shall be:

[120-1Φ] [208-1Φ] [208-3Φ] [230-1Φ] [230-3Φ] [480-3Φ]

Testing: The actuator shall be thoroughly shop tested to verify that all modes of operation perform as required. Testing shall include verification of motor operating running amps and voltage; actuator operating speed and stroke; and verification of the extension and retraction thrust adjustments.

Painting: The actuator shall be painted with one coat of medium gray high-solids epoxy (5 mils), followed by one coat of medium gray aliphatic polyurethane (2 mils).

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RODNEY HUNT®

Model Selection

The SCUBA unit can be provided in a wide variety of standard models. Standard models provide a range of thrust outputs, electrical characteristics, and control features. Since each application is unique, the ideal SCUBA unit can easily be specified by following the instructions on the Model Selection Form provided with this brochure, or by calling Rodney Hunt Company at (508) 544-2511.

Units in custom sizes, voltages, or for special environmental conditions can be requested for unique applications. To keep costs to a minimum, a SCUBA model number should be created from the standard options listed on the Model Selection Form. However, if special design considerations must be incorporated, you are encouraged to discuss your needs with a Rodney Hunt application engineer.

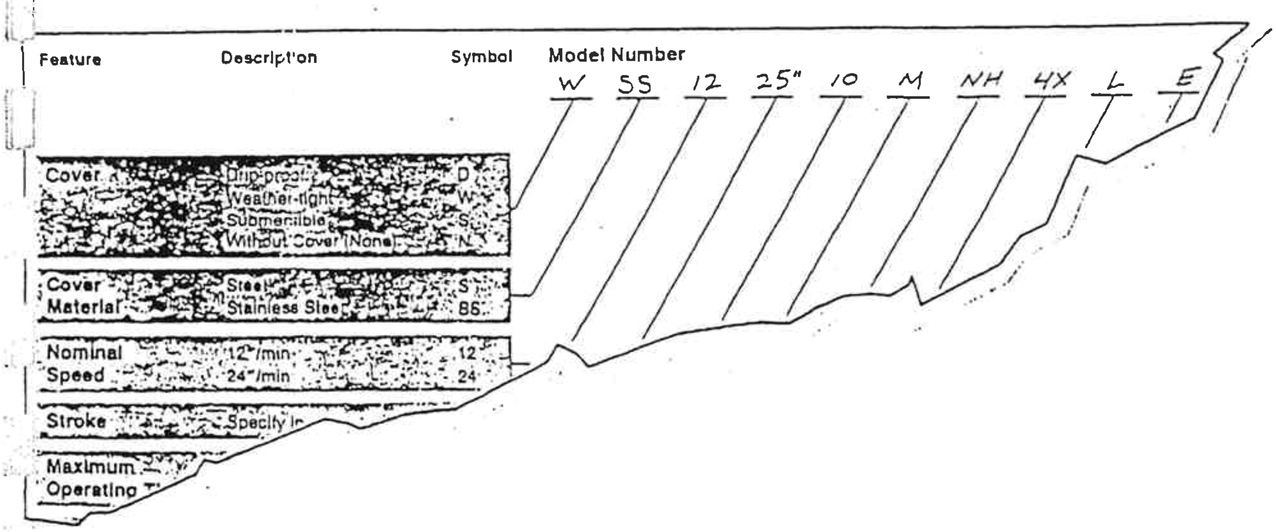
It's easy to specify a standard SCUBA unit. You build your SCUBA model number as you determine the features you wish to include.

For example: The standard options for the cover are drip-proof, weather-tight, submersible, or without cover. If you need your SCUBA unit to be weather-tight, you would indicate a W as the first symbol of your model number. Then you determine the cover material. Your options are steel and stainless steel. If you select stainless steel, the next notation in the model number would be SS. The remainder of the model number is determined in a similar fashion.

Each model number should identify the following features:

- Cover Type
- Cover Material
- Nominal Speed
- Stroke
- Maximum Operating Thrust
- Power Failure Operation
- Actuator Environment
- Electrical Control Enclosure
- Electrical Controls
- Position Indication
- Electrical Power

More complete descriptions of standard SCUBA characteristics can be reviewed in the Specifications section of this brochure.



7/12

RODNEY HUNT COMPANY
ORANGE, MASSACHUSETTS 01364
TEL: 508-544-2511 FAX: 508-544-7204

NAME:

COMPANY:

ADDRESS:

CITY:

STATE: ZIP:

PHONE: FAX:

PROJECT:

SCUBA™ ACTUATORS

Model Selection Form

Follow the easy instructions below to build your SCUBA Model Number, then mail or FAX this form to Rodney Hunt for quotation.

DATE:

Briefly describe your application:

Number of SCUBA units needed:

Feature	Description	Symbol
Cover	Drip-proof	D
	Weather-tight	W
	Submersible	S
	Without Cover (None)	N
Cover Material	Steel	S
	Stainless Steel	SS
Nominal Speed	12"/min	12
	24"/min	24
Stroke	Specify in Inches	—
Maximum Operating Thrust	Specify in thousands of pounds	—
Power Failure Operation	Automatic Extension	AE
	Automatic Retraction	AR
	Manual	M
	None Required	N
Actuator Environment	Non-Hazardous	NH
	Hazardous	H
Electrical Control Enclosure	NEMA 12	12
	NEMA 4X	4X
	NEMA 7	7
	Integral	I
Electrical Controls	Local	L
	Remote	R
	Modulating	M
	Special (Specify)	X
Position Indication	End of Travel	E
	Continuous	C
	End of Travel & Continuous	E/C
	None Required	N
Electrical Power	120 VAC, 1Φ	120/1
	208 VAC, 1Φ	208/1
	208 VAC, 3Φ	208/3
	230 VAC, 1Φ	230/1
	230 VAC, 3Φ	230/3
	480 VAC, 3Φ	480/3

Model Number: _ - _ - _ - _ - _ - _ - _ - _ - _ - _ - _

W-SS-12-25"-10-M-NH-4X-L/M-E-230/3

This example SCUBA actuator is designed to be installed in a non-hazardous environment with a stainless steel weather-tight cover. The actuator will move at 12" per minute, will have a stroke of 25 inches, and will produce a maximum operating thrust of 10,000 pounds. A manual hand pump is provided for power failure operations. The electrical controls are designed with a NEMA 4X enclosure and will allow the actuator to be either operated locally through pushbuttons or through modulating controls. End of travel proximity switches will provide indication on the control panel for full extension and full retraction. The actuator will be powered from a 230 VAC, three phase source.

(8/17)

NOELL STAHL UND MACHINENBAU GMBH

PREUSSAG
NOELL

Noell Stahl- und Maschinenbau GmbH

Postal address: D-97064 Würzburg
Address: Alfred-Nobel-Str. 20
D-97080 Würzburg
Germany

Telephone: (0931) 903-0
Telefax: (0931) 903-1000

TELEFAX

To : Bechtel
Attn. Mr Douglas Adams

FAX No. :

FROM : Noell-NST
DEPT. : V14/T4 Mr U. Trenkmann/ Mr H. Hoffmann
(O:\WINDOWS\WINWORD\ralston.doc\ed)

FAX NO. : 0931/903-1009
EXTENSION : 0931/903-1367

DATE : 20 November 1996
TOTAL PAGES : 4 inclusive cover sheet

Subject : Closure for Ralston Sluiceway

Dear Mr Adams,

After carefully studying your fax dated 13 November 1996, we would like to make the following comments and proposals regarding a solution with budgetary costs.

1 <u>Gate or valve</u>
In this case we would prefer a gate, as the risk of damaging or jamming caused by waterlogged material is decidedly lower for a gate than for a valve (internal ribs or guiding plates in the case of a valve).

2 <u>Design of gate</u>
The gate should be a sliding gate and should have a rectangular upstream sealing system.
In order to reduce the lifting and lowering forces, the gate should have Teflon seals and sliding strips (cladding with Teflon strips is possible).

3 To prevent distortion due to welding of the upstream DN 6' pipe, the gate frame should be designed in two parts (welding of steel pipe DN 6' and on bolted gate frame).

The solution for the gate frame depends on the possibility of a longitudinal load distribution from the closured valve onto the concrete of the dam, via the DN 6' steel pipe.

If it is not possible to distribute the load via the pipe, then a gate frame with its own anchoring system will be required. We have assumed that the longitudinal load distribution onto the concrete of the dam will be possible via the DN 6' pipe.

4 In this case, we would prefer an operating system with a stem. We propose to use the gate's own guiding system with a horizontal beam for the load distribution of stem forces due to lifting and lowering (see sketch for internal load distribution of frame).

5 The actuator should be a limitorque (or a Rotork or Auma) actuator, positioned on platform EL 1144 and should be suitable for both outdoor and remote controlled operation.

6 Please see the two attached sketches for details on our study.

7 For a budget quote we have estimated the following values.

- For the design work, including drawings, stress calculation, operating instructions, data sheets.

US$ 26,000.00

- For the manufacturing of gate and gate frame, driving system, including painting and transportation to site

US$ 96,000.00

- We have calculated following for the installation and commissioning of gate and actuator:

rough estimation for erection US$ 60,000.00

net total US$ 182,000.00

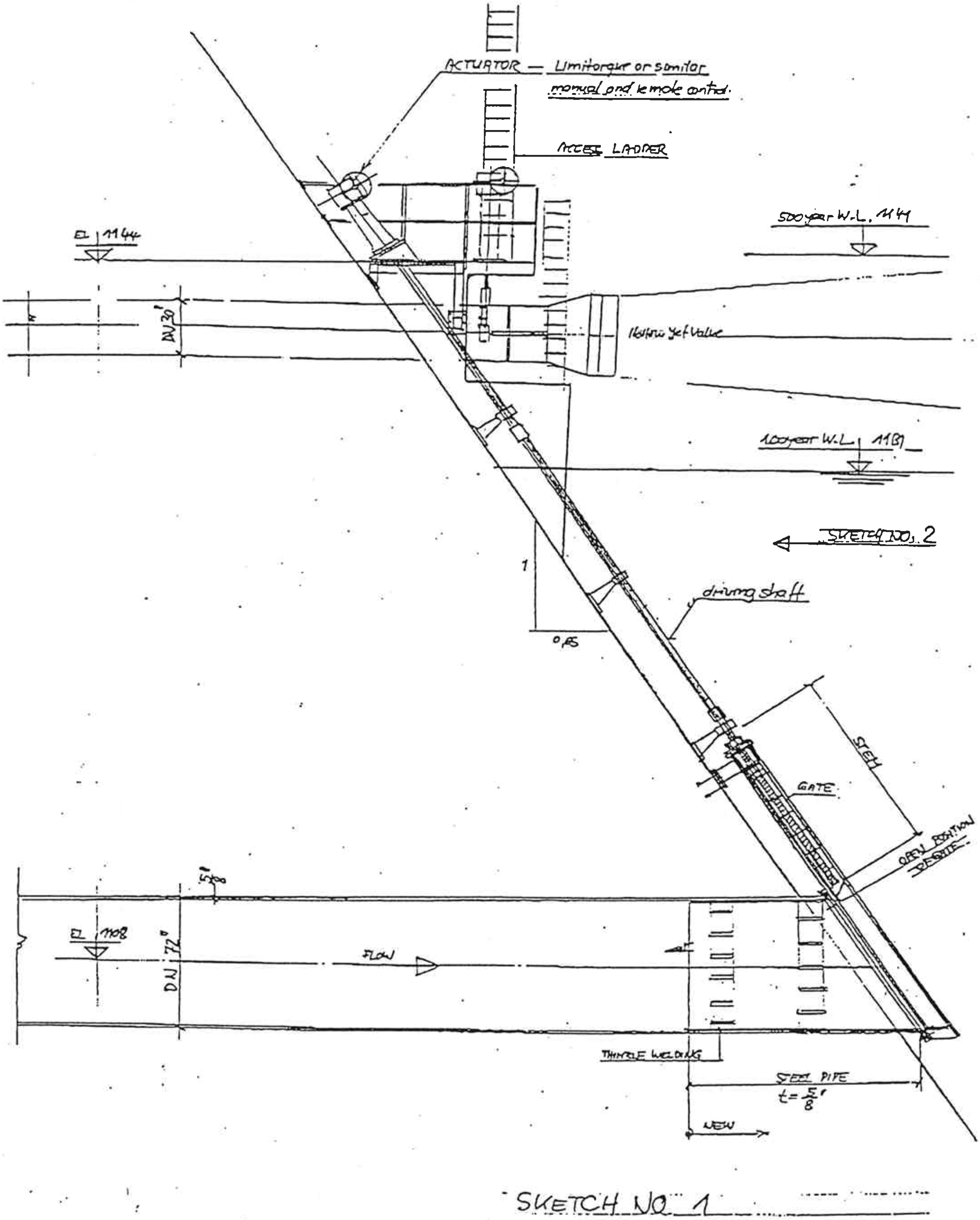
We would have to consider this job to be too small for us, and recommend local purchasing in this case.

Please do not hesitate to contact us, should you have any further questions on this matter.

Yours sincerely,

i.V. U. Walkhof — i.A.
Mr U. Trenkmann — Mr H. Hoffmann

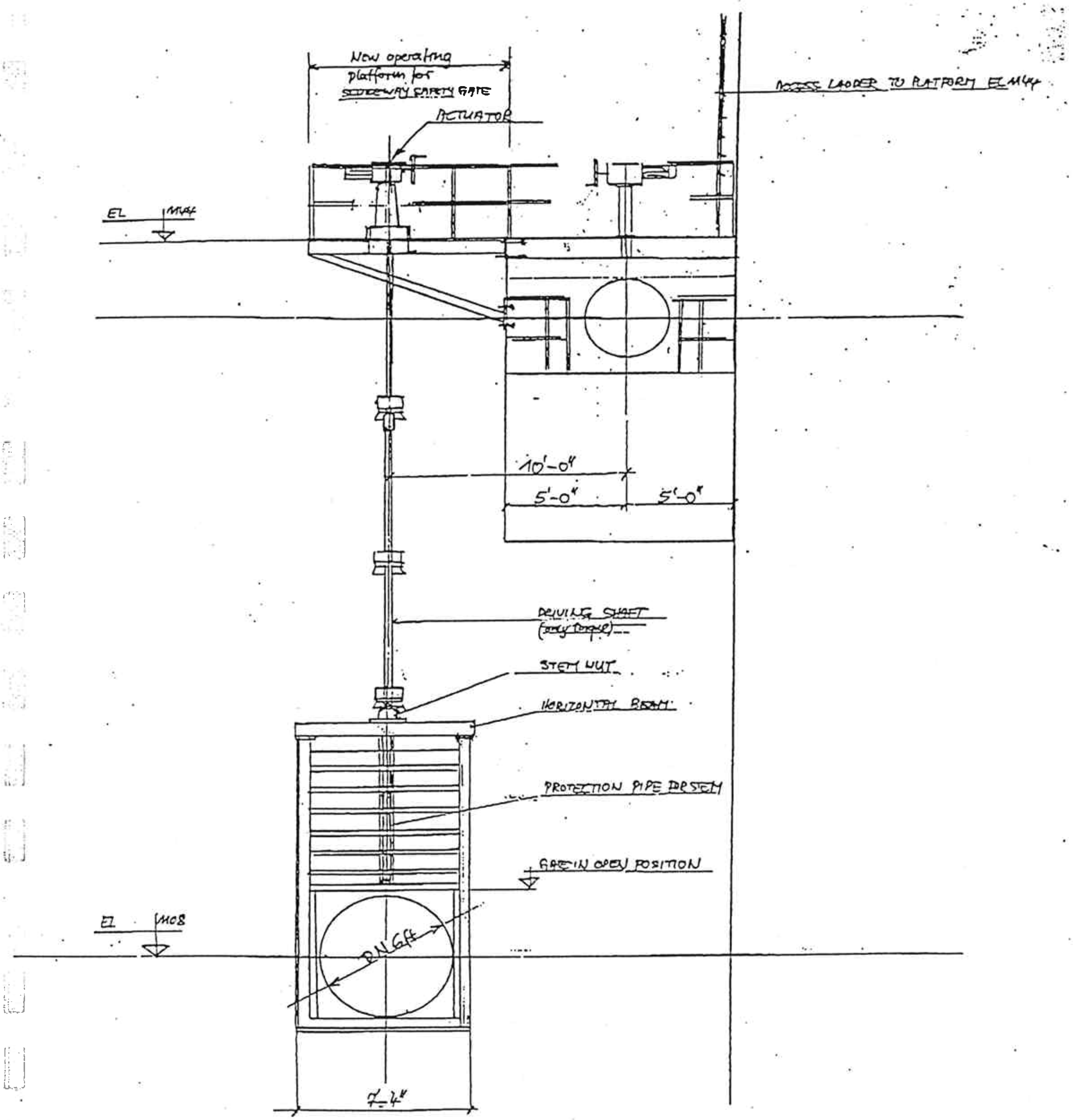
Enc.



SKETCH NO. 1

SAFETY GATE FOR RALSTON SLUICEWAY

RSI Dept. TK Hoffmann / NOV. 20. 1996



Design head H_D = 90 ft. ≙ 27.4 m
Closing time T = 10 min

SKETCH NO. 2

SAFETY GATE FOR RALSTON SLUICEWAY

NSL Dept. 14, Hoffmann / Nov. 20. 1996

FABRIVALVE

Associated Flow Controls, Inc. 30 Beta Court San Ramon, CA 94583
phone (510) 820-1216 fax (510) 820-9278

QUOTATION

DATE: 12/13/96
TO: DOUGLAS ADAMS
COMPANY: BECHTEL
PHONE: 415-768-6435 FAX: 415-768-5561

FROM: DARIN
REF: PER YOUR FAX DATED NOVEMBER 13,1996

DEAR: DOUGLAS
THANK YOU FOR ALLOWING ASSOCIATED FLOW CONTROLS, INC THE OPPORTUNITY TO PROVIDE YOU WITH THE FOLLOWING QUOTATION. PRICES QUOTED ARE BASED ON QUANTITY. IF QUANTITY SHOULD CHANGE, WE RESERVE THE RIGHT TO REQUOTE. TERMS ARE NET 30 DAYS. DELIVERY AND F.O.B. ARE AS FOLLOWS: FOB:
ESTIMATED SHIP DATE:

QTY.	SIZE	DESCRIPTION	NET EACH
1	72"	FABRI FIG> F134R304, 50CWF, BONNETED KNIFE GATE VALVE, BODY & BONNET: FABRICATED 304 STAINLESS STEEL, CARBON STEEL EXTERIOR	94,880.00
		FLANGES: CARBON STEEL 304 STAINLESS STEEL RAISED FACE	
		GATE: 304 STAINLESS STEEL	
		SEAT: 304 STAINLESS STEEL HARDFACED	
		STEM: 304 STAINLESS STEEL	
		PACKING: ACRYLIC	
		PACKING FOLLOWER: CARBON STEEL	
		TOPWORKS: CARBON STEEL	
		OPERATOR: ELECTRIC MOTOR	

		PRICE IS ESTIMATED ONLY. FIRM PRICE TO BE QUOTED UPON RECEIPT OF COMPLETE VALVE AND ACTUATOR SPECIFICATION	
		IF YOU HAVE ANY QUESTIONS PLEASE GIVE US A CALL	
		THANK YOU	
		DARIN McQUILLIAM	

FORM 134-K-1 8

FABRI-VALVE®

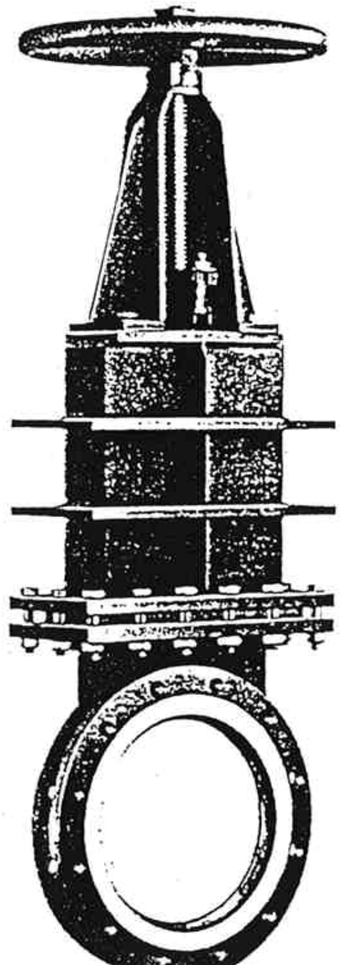
Figure

134

Bonnet–Type
Knife Gate Valve

Knife gate assures non-clogging shutoff on suspended solids • Stainless Steel Glide Ring yoke hub liners for reliable handwheel operation • Bonnet design eliminates leakage through the packing gland • Internal gate wiper cleans gate and minimizes material buildup in bonnet area • O-ring seating available for drip tight shutoff • Flush ports can be supplied on body and bonnet • Sizes 2" through 96" • Standard working pressure is 150 lb. CWP† thru 24" and 50 lb. CWP† thru 48" • Other working pressure designs available • ANSI class 150/125 flange drilling - all flange holes tapped •

†FOR REVERSE SHUTOFF PRESSURE RATING CONSULT FACTORY



MATERIAL SPECIFICATIONS

MATERIAL CODE	S	R	M
Gate	SS	SS	SS
Body Seal	SS	SS	SS
Body, Chest & Bonnet	SS	SS	MS
Body & Bonnet Flanges	SS	MS*	MS
Packing Gland	SS	MS/DI	MS/DI
Gland Bolts	SS	PS	PS
Stem	SS	SS	SS
Stemnut	B	B	B
Handwheel	MS/DI	MS/DI	MS/DI
Yoke	SS	MS	MS
Exterior Trim	SS	MS	MS

DI—Ductile Iron, PS—Plated Steel, MS—Mild Steel.
SS—Stainless Steel, type 304, 316 or 317 B—Bronze.

*With SS Machined Raised Face standard, also available with flat faced flanges.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

CRITICAL DIMENSIONS AND WEIGHTS

VALVE SIZE	2	3	4	6	8	10	12	14	16	18	20	24
Face to Face	1⅞	2	2	2¼	2¾	2¾	3	3	3½	3½	4½	4½
Handwheel Diameter	8	10	10	12	16	16	18	18	24	24	24	30
Centerline to Top, Open	22	24¼	27½	35¼	45¼	52¼	62½	62½	73½	81	90	103
Weight	40	61	77	110	190	260	370	440	600	715	825	1300

VALVE SIZE	30	36	42	48	54	60	72	84	96
Face to Face	3⅝	4⅛	5	5½					
Handwheel Diameter	30	36	MANUAL OR ELECTRIC GEAR OPERATIONS						
Centerline to Top, Open	106	140	177	189					
Weight	1850	2550	3450	4700	5950	7350	10,600	14,400	19,600

DIMENSIONS AVAILABLE ON APPLICATION

DIMENSIONS AND WEIGHTS VARY WITH PRESSURE RATING OVER 24" SIZE
DIMENSIONS SHOWN FOR 50 LB. C.W.P. OVER 24" SIZE

OPERATION • Handwheel (Standard) • Quick Lever • Air, Oil, or Water Cylinder • Electric Motor • Ratchet • Bevel Gear • Chainwheel • Others Upon Request

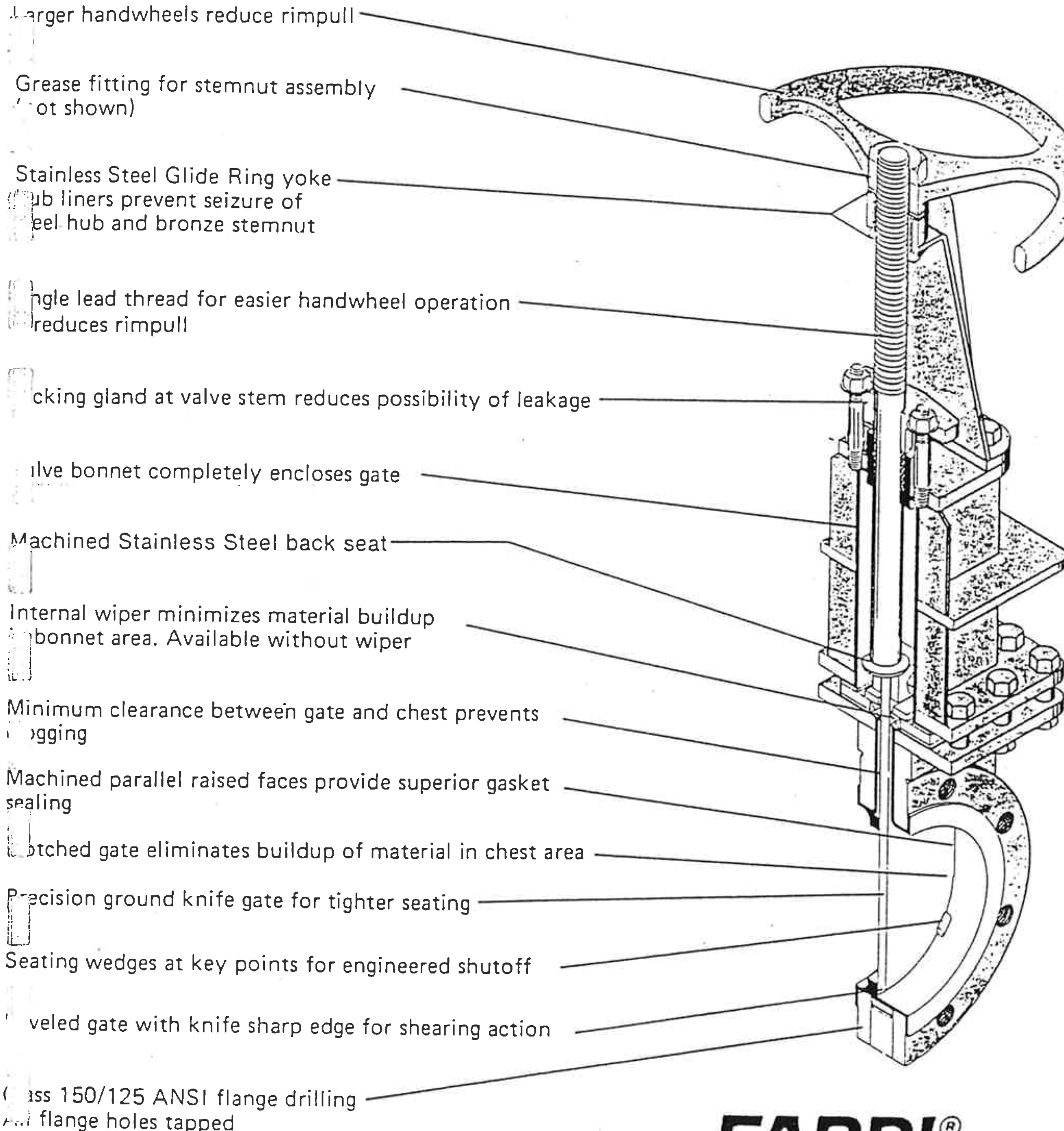
FABRI-VALVE®
Division of ITT Grinnell Valve Co., Inc.

Design Features

Figure

134

Bonnet – Type
Knife Gate Valve



FABRI-® VALVE

Division of ITT Grinnell Valve Co., Inc.
1110 Bankhead Ave., Amory, Mississippi 38821

GROVE VALVES

INTERNAL MEMORANDUM

DATE: Nov. 18, 1996

TO: Sales/ Bill Taylor

FROM: Don Judas

SUBJECT: Bechtel Civil Company Water Rescources Division, regarding valve at Ralston dam for Placer County Water Agency.

In reading the description of the scope of the valve, I would expect that they are looking at simple sluice gate arrangement.

Grove does not have such a valve.

We have in the past furnished a 72" G-4 gate valve for the Don Pedro Dam project. This valve was a class 150 conduit slab gate valve. I am attaching a copy of drawing of the valve as it was originally furnished with a Bevel Gear Operator with a side mounted hydraulic motor and then modified in 1989 with the installation of a hydraulic piston operator.

I would present this concept to the customer. If they are interested, then continue with a proposal.

I would expect this is more valve than they were expecting.

Let us know if you need any further information.

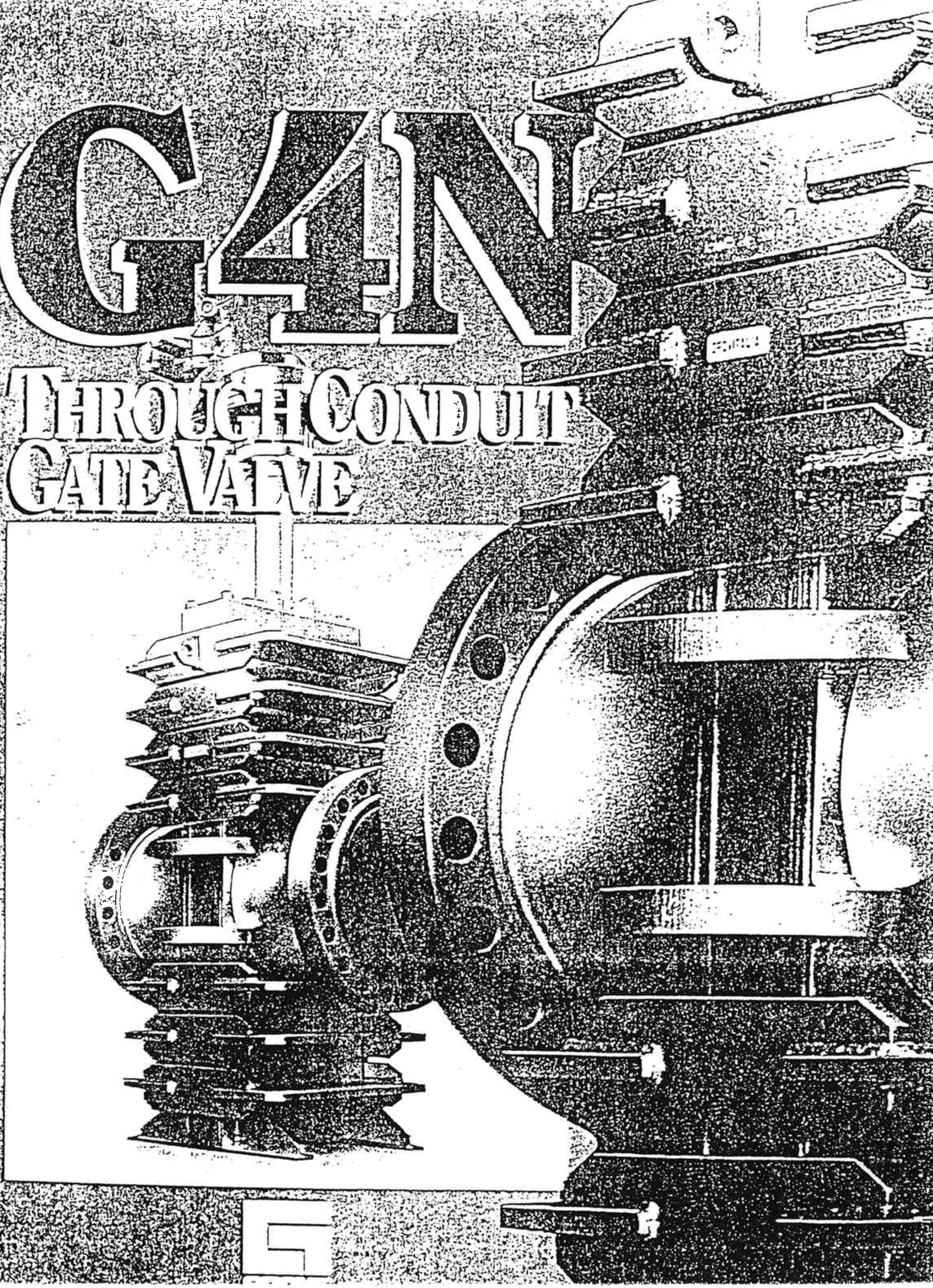
Regards,

Don Judas

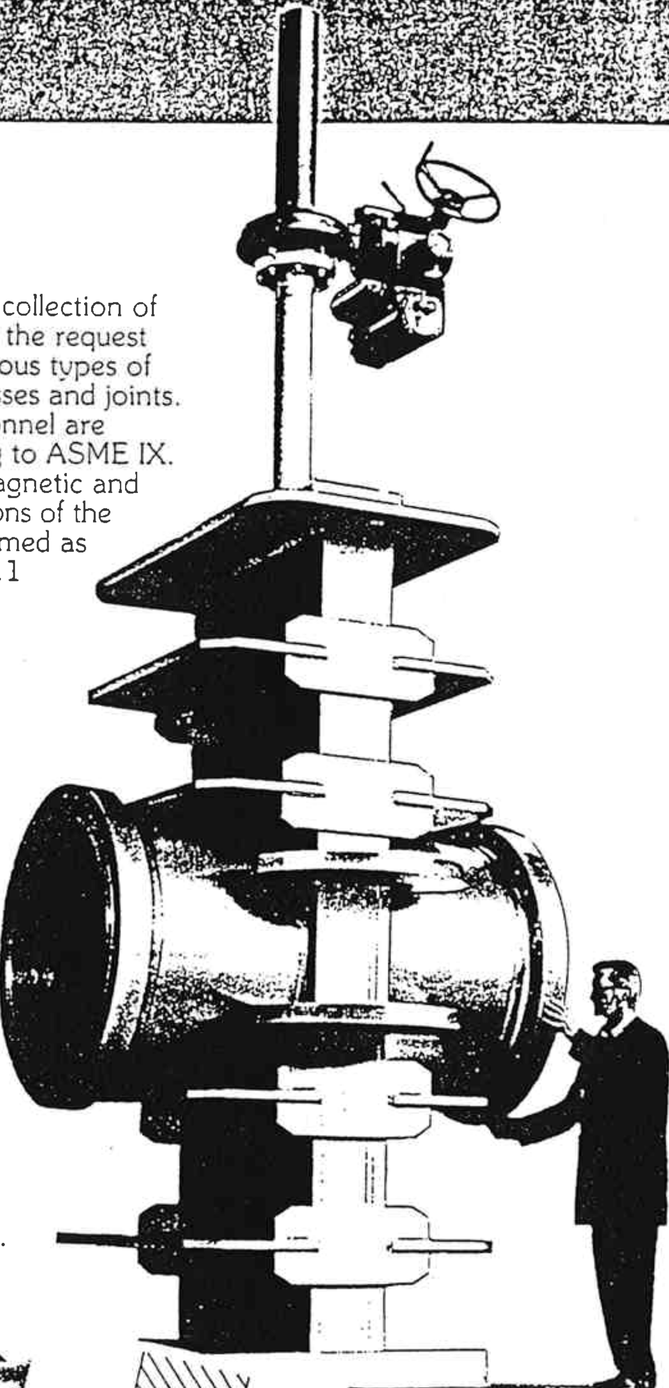
Enclosure:
Drawing M-16587-A Rev 6-17-70
Drawing M-16587-A Rev 3-1-89

G4N

THROUGH CONDUIT GATE VALVE



STANDARD DESIGN



VALVE CONSTRUCTION

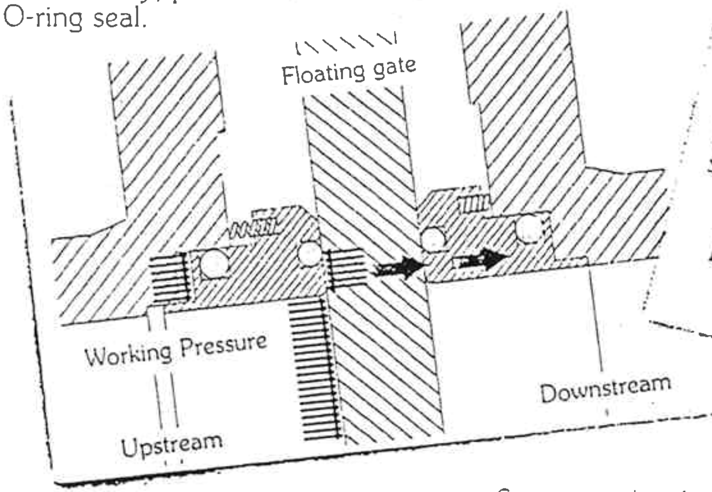
The body has a characteristic "rectangular body-ribbed" look, distinguishing it from other Grove gate valves.
The body is fabricated of welded steel plates and forged rolled ends. As the size and the pressure class increases, the valve body is reinforced with multiple welded ribs. The pressure retaining plates are sand-blasted and ultrasonically inspected. A wide collection of procedures covers the request for welding of various types of materials, thicknesses and joints. The welding personnel are qualified according to ASME IX. Non destructive magnetic and ultrasonic inspections of the welding are performed as per ASME VIII div. 1 app. VI/XII.

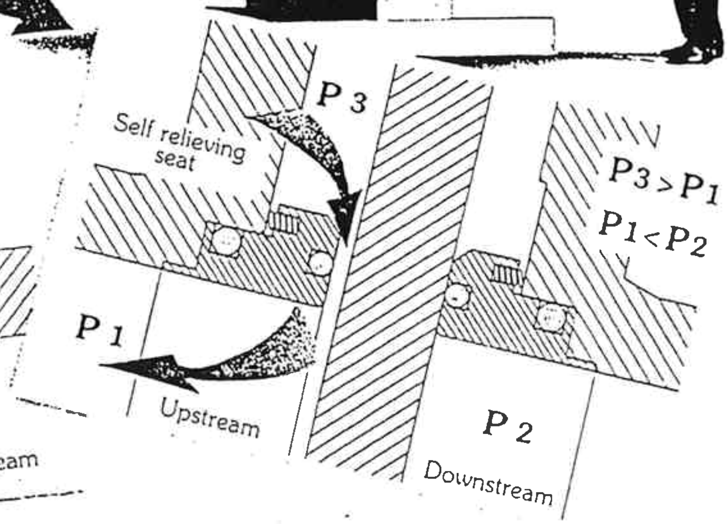
SEATS CONSTRUCTION

Both gate and seats are floating parts. The initial seal, at extremely low pressure differential, is obtained by the floating seats being forced against the gate by the spring force. When the gate is closed, the forces derived from the upstream working pressure push the gate tightly against the down stream seats. This results in upstream and downstream bubble-tight seals which works independently under all pressure conditions. When the gate is open, the unbalanced pressure principle assures that both upstream and downstream seats are forced against the gate thus assuring through conduit port without access between the line and the body cavity.
Sealing is performed by both a primary metal-to-metal seal and a secondary, protected O-ring seal.

SELF RELIEVING FEATURE

The seat design features an automatic internal body relief for protection against overpressure in the body cavity.
The overpressure, higher than the upstream line pressure, overcomes the piston effect force to move the seat away from the gate.





KURIMOTO LTD.

1055 West 7th Street, Suite 3200
Los Angeles, CA 90017

NIAC - Los Angeles

Fax

To:	Bechtel Corporation - Mr. Douglas Adams	**From:**	James Slocum
Fax:	**415-768-5561**	**Pages:**	**3**
1202-2 JAS		**Date:**	December 2, 1996
Re:	Closure for Ralston Sluiceway	**CC:**	

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

• **Comments:**

1) Our valve manufacturer, Kurimoto, Ltd. has reviewed Bechtel's inquiry of November 13, and would like to recommend their high pressure slide gate. We have attached a drawing of 1800mm (72") high pressure slide gate. We apologize for many Japanese words but the following are the main components:

1. Upper Stem Body
2. Lower Stem Body
3. Disk
4. Seat
5. Seat
6. Shaft
7. Nut
8. Liner
9. Upper Body
10. Plate
11. Bushing
12. V-Packing
13. Packing Retainer
14. Stand
15. 2nd Reducer
16. Angle Gage
17. Motor

December 2, 1996

2) Delivery is approximately 6 months after receipt of approval on manufacturing drawings. We will inform you of budgetary price tomorrow so please wait. Kurimoto has many experiences supplying high pressure slide gates so we will send Kurimoto catalogs to your attention for your reference.

Please contact me at (213) 688-0715 if you have any questions or comments.

Thank you.

Sincerely,

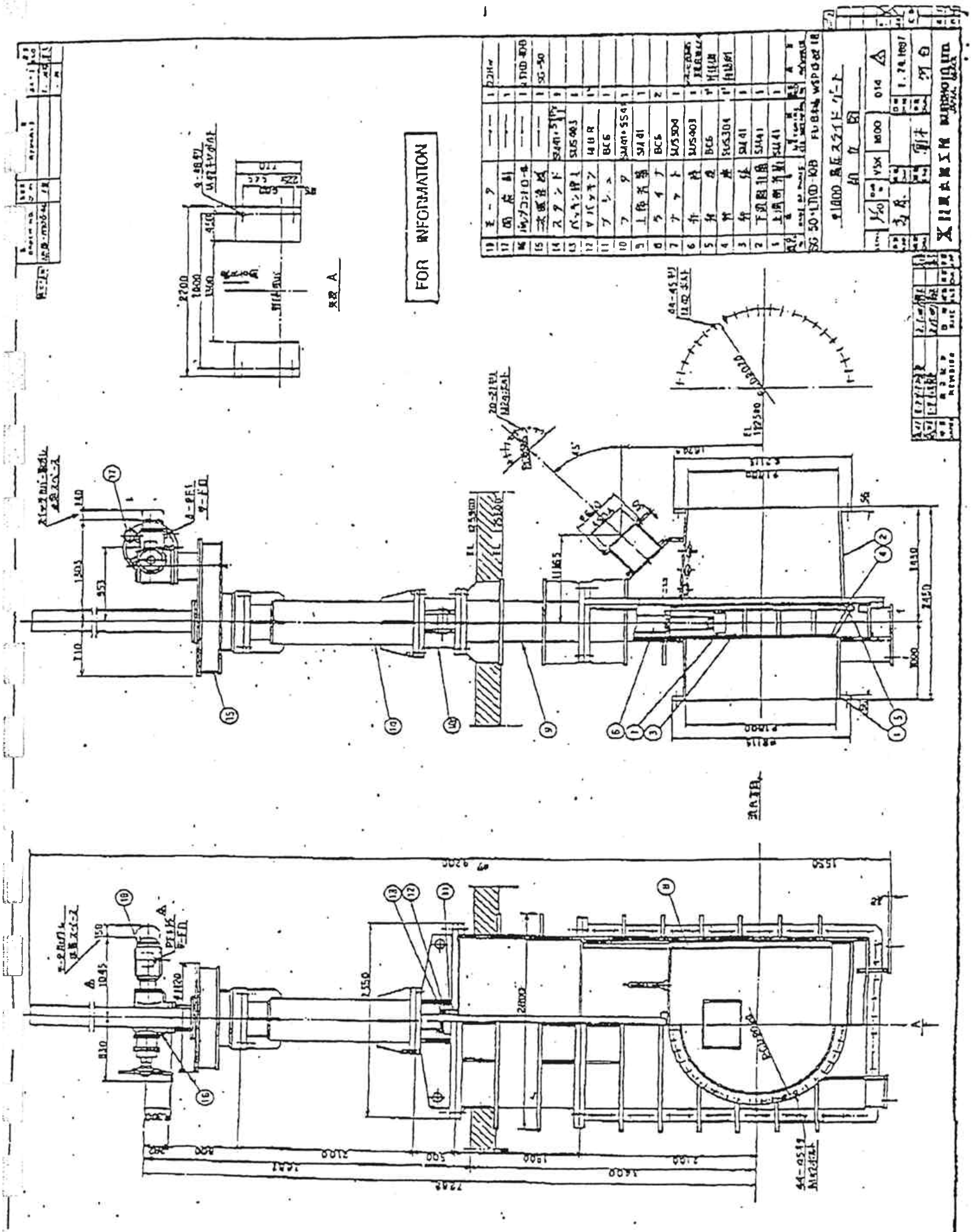
NISSHO IWAI AMERICAN CORPORATION

James Slocum
Engineering Sales Manager

FROM :NISSHO IWAI AMERICA   2136279660   1996.12-02   14:45   #775 P.03/03
P.2/2

'96-11-28 18:24 NISSHO IWAI OS IMAC 06-209-3432

1996-11-28 09:53 FROM (カ) クリモトテッコウ センボウ   TO   0662093432   P.02/02 2/2



APPENDIX E

COST ESTIMATES

Bechtel

Calculation Sheet

Originator FB Date 12-20-96 Calc. No. Rev. No.

Project Job No. 23218-003 Checked Date

Subject RALSTON DAM Sheet No. 1 of 7

MEMO TO. F. LOCHER

FROM: F. BYSTROWSKI

DATE: DECEMBER 20, 1996

SUBJECT: RALSTON DAM

a. SAFETY GATE FOR RALSTON DAM SLUICE WAY

b. CONCRETE TRAINING WALL AT POWERHOUSE

PRESENTED HEREWITH ARE THE ROUGH ORDER OF MAGNITUDE PRICES FOR CONSTRUCTION OF FACILITIES IN SUBJECT ABOVE. THESE ARE COSTS WHICH A CONTRACTOR WOULD EXPERIENCE. NO COSTS WERE ADDED FOR MANAGEMENT.

• SUBJECT (a)- SAFETY GATE FOR RALSTON DAM SLUICE WAY

PROCEDURE:

1. ALL WORK FOR DRILLING AND INSTALLING ANCHOR BOLTS TO BE DONE FROM A SKIP WITH AIR TRACK DRILL.
2. Crawler TRUCK CRANE ON TOP OF DAM TO SUSPEND SKIP OVER THE SIDE OF DAM.
3. AIR COMPRESSOR FOR AIR TRAC DRILL ON TOP OF DAM
4. Crawler ~~TRUCK~~ CRANE TO INSTALL THE SLUICE, DRIVE SHAFT, SPECIAL MOUNTING BRACKET, HYDRAULIC ACTUATOR, CONCRETE DECK EXTENSION AND NEW METAL RAILING ON TOP OF NEW CONCRETE DECK.

• SUBJECT (b.) CONCRETE TRAINING WALL

PROCEDURE:

1. IMPROVE ACCESS ROAD ON BANK TO EDGE OF RIVER
2. DREDGE BROKEN ROCK IN RIVER TO TOP OF ROCK TO INSTALL EARTHFILL COFFERDAM AND CONCRETE WALL
3. CONSTRUCT & REMOVE EARTH FILL COFFERDAM

Bechtel

Calculation Sheet

Originator: LHB | Date: 12-20-96 | Calc. No. | Rev. No.

Project | Job No. 23218-003 | Checked | Date

Subject: RALSTON DAM | Sheet No. 2 of 7

• QUANTITIES

1. SUBJECT (a.) – SAFETY GATE

.1 MOBILIZATION & DEMOBILIZATION		LS
.2 ANCHOR BOLTS, DRILLING & INSTALLING		
– SLUICE GATE @ 4' EMBED		
GATE 2(7'+9') = 32 FT		
@ 2'0" cc = 16 EA × 4 FT =	(16 EA)	64 LF
– SUPPORTS FOR DRIVE SHAFT @ 2' EMBED		
N & LENGTH = (4×2 EA) 2 FT =	(8 EA)	16 LF
– [illegible] MOUNTING BRACKETS @ 4' EMBED		
N & LENGTH = (4×2 EA) ×4 =	(8 EA)	32 LF
– TOTAL LENGTH		112 LF
.3 SLUICE GATE AND APPURTENANCES		1 EA
FURNISH – 1 EA		
INSTALL – 1 EA		
.4 DOWELS, EXISTING CONCRETE PLATFORM		
N = 10 LF @ 2' cc =		5 EA
.5 CONCRETE		
EV = (10×10.5×0.5) = 52.5 =		2 CY
.6 REINFORCING STEEL		
EW = 3% = 120 LB/CY × 2 CY =		240 LB
.7 REMOVE EXISTING HAND RAIL		10 LF
.8 METAL HAND RAILING, NEW		
EL = 10.5+10 = 20.5 USE 21		21 LF
.9 SUPPORTS FOR NEW CONCRETE DECK		2 EA

Bechtel

Calculation Sheet

Originator: JRB | Date: 12-20-96 | Calc. No.: | Rev. No.:

Project: | Job No.: 23218-003 | Checked: | Date:

Subject: Ralston Dam | Sheet No.: 3 of 7

Total Price

Subject (a.) Safety Gate for Ralston Sluice Way

1.	Mobilization and Demobilization	(LS)	$10,000
2.	Anchor Bolts	112 LF @ 75/LF	8,400
3.	Sluice Gate & Appurtenances		
	- Furnish = $74,200 x 1.4 =		103,880
	- Install = 15 (days) [(1 @ 100 + 6 @ 35) x 8] x 1.4 =		52,000
4.	Demolish existing platform	5CY @ 50	250
5.	Concrete	2CY @ 1000	2,000
6.	Reinforcing Steel	240 LB @ 1.25	300
7.	Handrail existing, remove	10 LF @ 50	500
8.	Metal Handrail, New	21 LF @ 150	3,150
9.	Supports, New concrete deck	2CY	500
	Sub-Total Price		180,900
	Contingency	10% ±	18,100
	Total Price		$199,000

Say $200,000

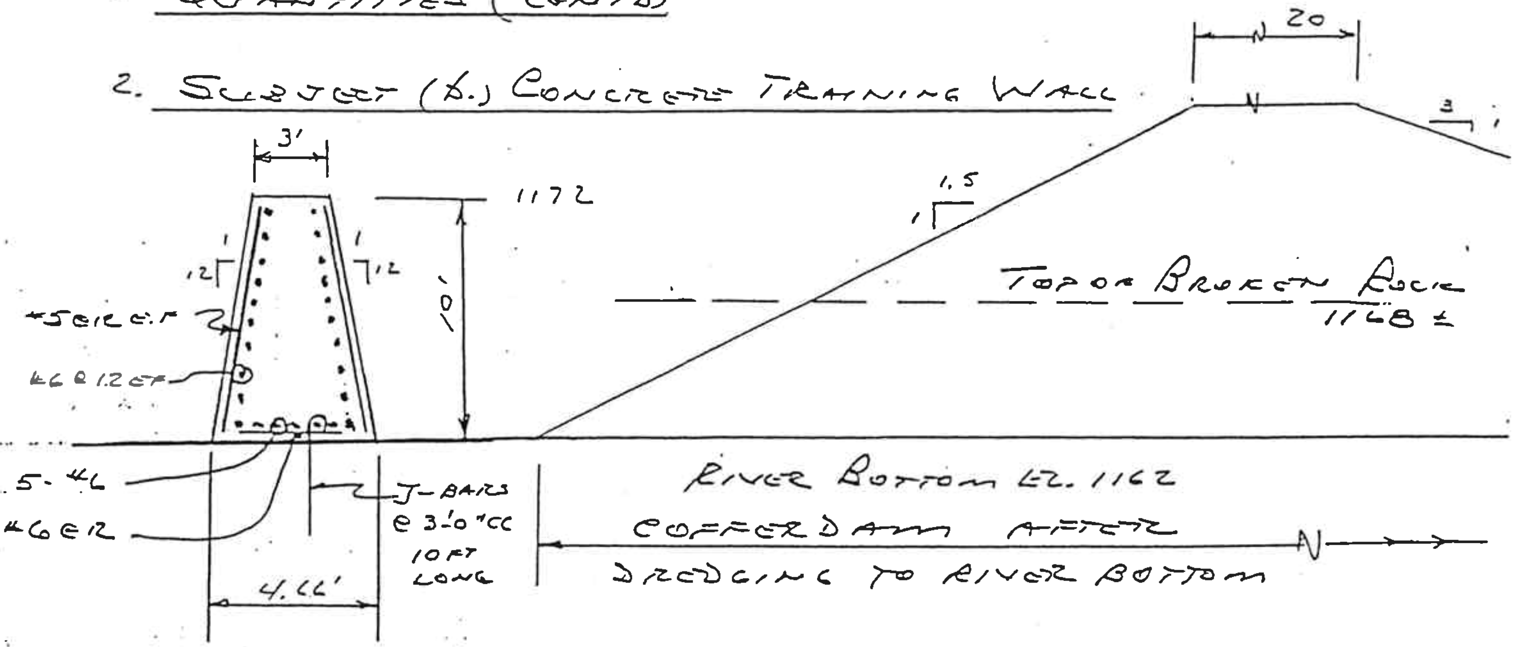
Bechtel

Calculation Sheet

Originator: LMB
Date: 12-23-96
Calc. No.:
Rev. No.:
Project:
Job No. 23218-003
Checked:
Date:
Subject: Ralston Dam
Sheet No. 4 of 7

• Quantities (Cont'd)

2. Subject (b.) Concrete Training Wall



Procedure

1. Dredge broken rock on bottom from El. 1162 to El 1168. Use clamshell/grapple/tongs bucket
2. Width of dredging from shore to be wide enough to contain an earth fill cofferdam from Elev 1162 to El. 1176
3. Stockpile dredge rock on edge away from cofferdam but do not block river. Haul to a stockpile as required
4. Construct earth fill cofferdam to El 1176
5. Pump out area within cofferdam
6. Clean off top of rock
7. Install J-Bars
8. Construct Training Wall
9. Cut cofferdam down to Elev. 1168
10. Backfill with rock to face of training wall. Top of backfill El. 1168.

Bechtel

Calculation Sheet

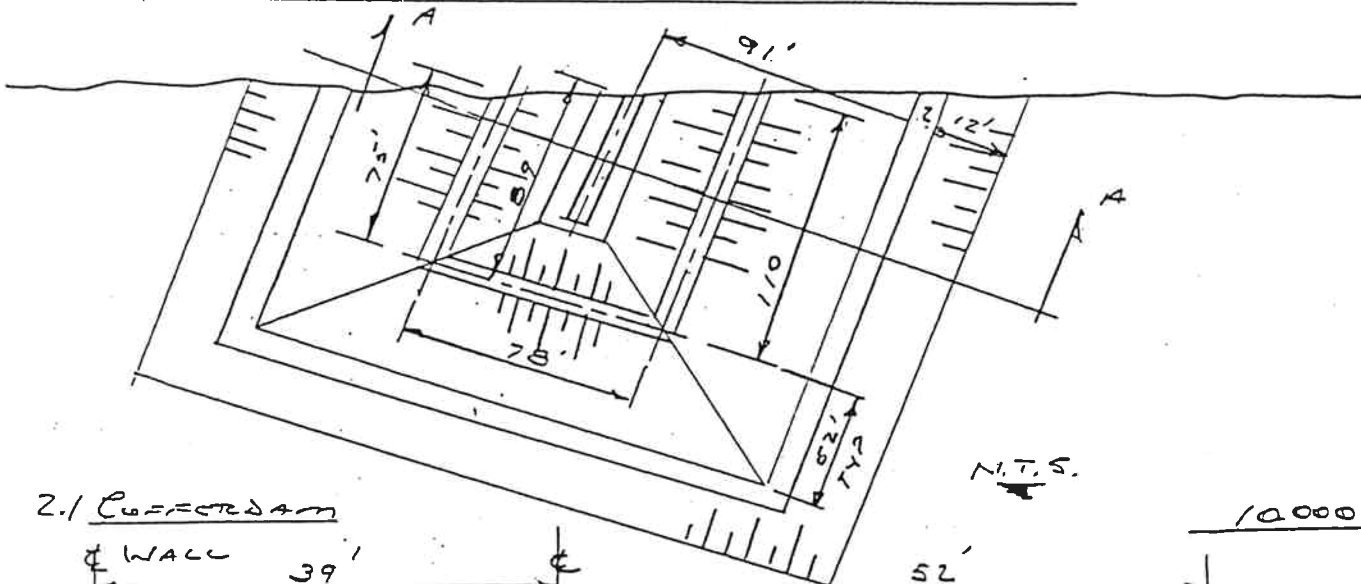
Originator: HRB   Date: 12-23-96   Calc. No.:   Rev. No.:

Project: Job No.: 23218-003   Checked: Date:

Subject: RALSTON DAM   Sheet No.: 5 of 7

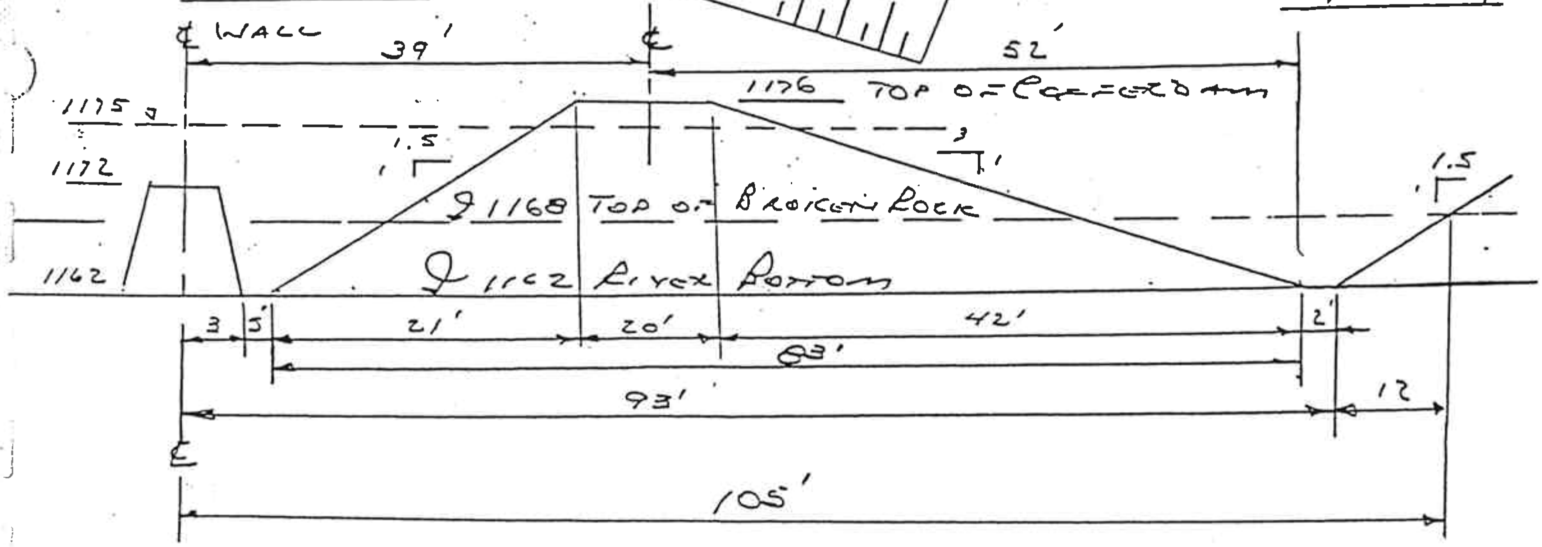
- QUANTITIES (CONT'D)

2. SUBJECT (b.) CONCRETE TRAINING WALL



2.1 COFFERDAM

10000 CY



SECTION A-A

LENGTH OF COFFERDAM

L_c 1/2 [(75+78+110) + (127+182+162)] = 1/2 [263 + 471]

L_c = 367'

VOL/LF = [1/2 (20 + 83) × 14 × 1] = 721 = 27 CY/LF

EV = 367 × 27 = 9,909   USE 10000 CY

Bechtel

Calculation Sheet

Originator: LHB Date: 12-23-96 Calc. No.: Rev. No.:
Project: Job No.: 23218-003 Checked: Date:
Subject: RALSTON DAM Sheet No.: 6 of 7

- QUANTITIES (CONT'D)

2. SUBJECT (6) (CONT'D)

2.2 DREDGING, EL 1162 TO EL 1168 — 6800 CY

AREA @ EL 1162

$A_{1162} = 1/2(129 + 164) \times 186 = 27249\ FT^2$

AREA @ EL. 1168

$A_{1168} = 1/2(141 + 176) \times 210 = 33285$

$EV = 1/2(27249 + 33285) \times 6 = 181,602 = 6726$

SAY 6800

2.3 CONCRETE — 71 CY

$VOL/LF = 1/2(3 + 4.66) \times 10 \times 1 = 38.3 = 1.42\ CY/LF$

$EV = 50 \times 1.42 = 71\ CY$

2.4 REINFORCING STEEL

	#5	#6	TOTAL
2[51 × 10]	1020		
2[50 × 10]		1000	
5×50		250	
51 × 4		204	
TOTAL LENGTH	1020	1454	
UNIT WT/LF	×1.043	× 1.502	
TOTAL WEIGHT	1064	2184	3248#
			46#/CY

2.5 J-BARS — 260 LF

FNDN AREA = 50 × 4.66 = 233 SF

AREA PER BAR 3×3 9 SF/BAR

TOTAL NO BARS 233/9 = 26 EA

Calculation Sheet

Originator: JAB   Date: 10-23-96   Calc. No.:   Rev. No.:

Project: Job No.: 23218-003   Checked: Date:

Subject: Ralston Dam   Sheet No.: 7 of 7

• QUANTITIES (CONT'D)

.2 SUBJECT (6.) ABOVE – CONCRETE TRAINING WALL

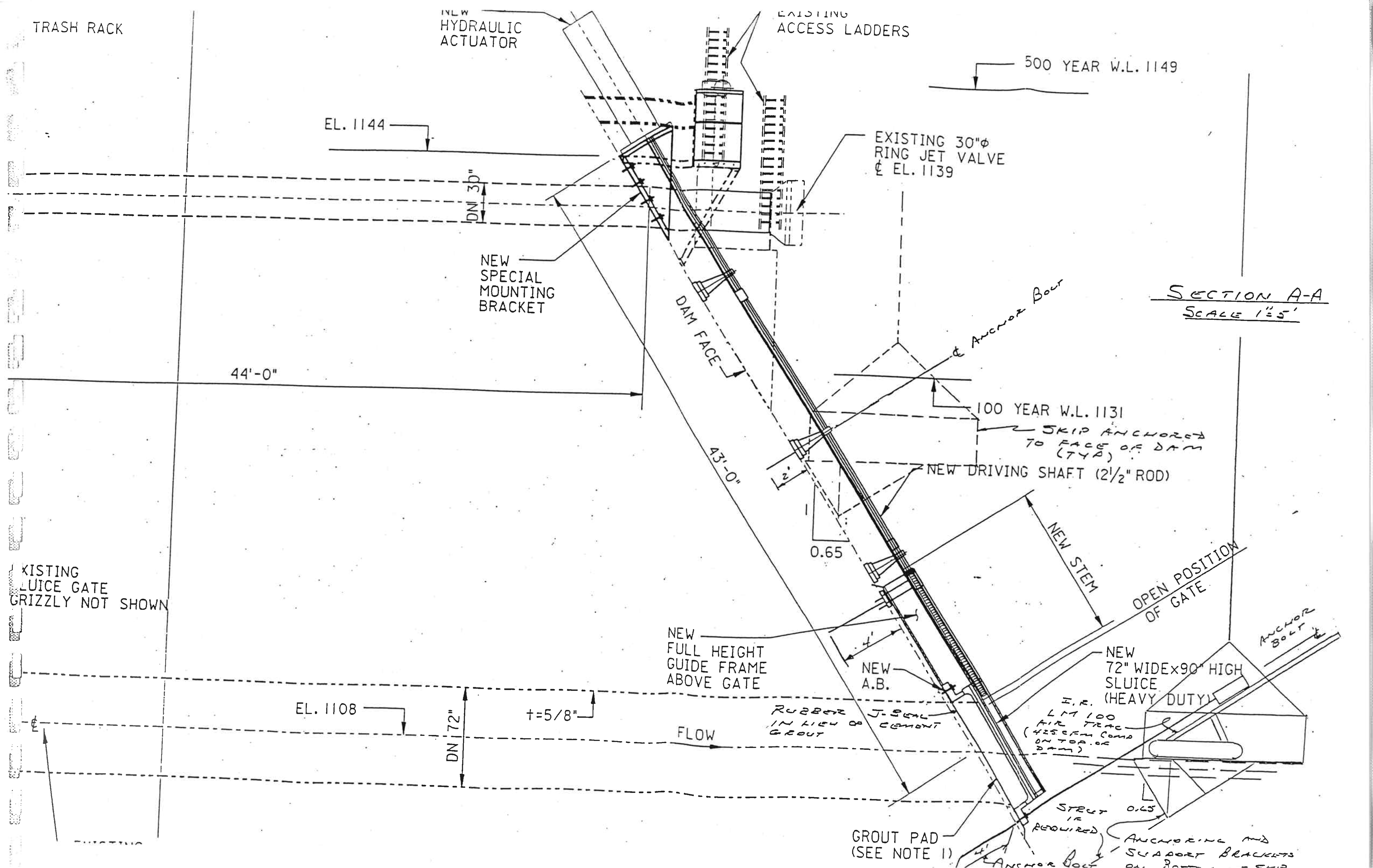
2.6 TOTAL QUANTITIES

1.	MOBILIZATION & DEMOBILIZATION		LS
2.	DREDGING : EL. 1162 TO EL 1168		6800 CY
3.	COFFERDAM EL. 1162 TO EL 1176		10000 CY
4.	DEWATERING & PUMPING		LS
5.	J-BARS		260 LF
6.	CONCRETE		71 CY
7.	REINFORCING STEEL		3248 LB
8.	BACKFILL	(ALLOW)	1000 CY

2.7 TOTAL PRICE

.1	MOB AND DEMOB	LS	$5,000
.2	DREDGING EL1162-EL1168	6800CY @ 25–	170,000
.3	COFFERDAM	10000CY @ 10–	100,000
.4	DEWATERING & PUMPING	LS	10,000
.5	J-BARS	260LF @ 50–	13,000
.6	CONCRETE	71CY @ 800–	56,800
.7	REINFORCING STEEL	3248LB @ 1.25	4,060
.8	BACKFILL	1000CY @ 10–	10,000–

SUB TOTAL PRICE		368,860
CONTINGENCY	5%	18,140
TOTAL PRICE		$387,000


TRASH RACK
HYDRAULIC ACTUATOR
ACCESS LADDERS
500 YEAR W.L. 1149
EL. 1144
EXISTING 30"φ RING JET VALVE ℄ EL. 1139
DN 30"
NEW SPECIAL MOUNTING BRACKET
SECTION A-A
SCALE 1"=5'
℄ ANCHOR BOLT
DAM FACE
44'-0"
100 YEAR W.L. 1131
SKIP ANCHORED TO FACE OF DAM (TYP)
2'
NEW DRIVING SHAFT (2½" ROD)
43'-0"
0.65
NEW STEM
OPEN POSITION OF GATE
GRIZZLY NOT SHOWN
NEW FULL HEIGHT GUIDE FRAME ABOVE GATE
4'
NEW A.B.
NEW 72" WIDE x 90" HIGH SLUICE (HEAVY DUTY)
ANCHOR BOLT
EL. 1108
t=5/8"
DN 72"
FLOW
RUBBER J-SEAL IN LIEU OF CEMENT GROUT
I.R. LM 100 AIR TRAC (425 CFM COMP ON TOP OF DAM)
STRUT IF REQUIRED
0.65
GROUT PAD (SEE NOTE 1)
ANCHORING AND SUPPORT BRACKETS
ANCHOR BOLT