US Army Corps
of Engineers
Walla Walla District

Lower Granite Lock and Dam

Snake River, Washington and Idaho

Sedimentation Feasibility Study

Phase I - Reconnaissance Level Analysis

August 1986

LOWER GRANITE LOCK AND DAM SEDIMENTATION
FEASIBILITY STUDY
PHASE I - RECONNAISSANCE LEVEL ANALYSIS

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1. INTRODUCTION.

a. Background.

(1) The Lower Granite Lock and Dam project, located on the Snake River, was completed in 1975 and provides slack-water navigation to the cities of Lewiston, Idaho, and Clarkston, Washington. The project includes a levee system to protect large areas of industrial, commercial, and residential properties in the Lewiston area from inundation by waters impounded behind Lower Granite Dam (Plate 1). It was known at the time of Lower Granite project design that sediment accumulation would eventually become a problem affecting levee adequacy and navigation.

(2) An initial sedimentation study (Special Projects Memorandum No. 359 entitled "Sediment Study on Clearwater River, Walla Walla District" dated 27 October 1971) was accomplished with minimal data. Rather than using that report as a basis for an immediate large expenditure of funds to provide levee protection for conditions projected 50 years into the future, it was thought to be more economical to consider initial levee heights for conditions projected over a much shorter time and during that time collect additional sediment data. A similar analysis could then be made with more confidence in the results because the study would reflect a larger and more detailed sample of basic sediment data.

(3) Since that time additional sediment data have been collected. Due to sediment deposits to date and because of anticipated continued sediment accumulation over the project life, review studies of the adequacy of the Lower Granite project levees and its effect on navigation have been underway since project completion. The most critical concern

is the area protected by the Lewiston levee system. Based on a working document entitled "Lower Granite Project, Snake River, Washington and Idaho, Sedimentation Study - Interim Report" dated February 1984, it is estimated that by the year 2035 the standard project flood (SPF) of 420,000 cubic feet per second (cfs) would overtop the levees by about 2 feet.

(4) The levee system was designed and constructed to provide a minimum of 5 feet of freeboard. Current investigations have revealed that because of sediment deposition occurring since 1975, the current elevation of the Lewiston levee would only provide about 2 feet of freeboard during the SPF. These investigations also indicate that with present deposition, 5 feet of freeboard can be maintained up to a flow of approximately 360,000 cfs (500-year flood).

b. Purpose and Scope.

(1) A two-phase study is underway to develop a long-term flood control plan for the Lewiston-Clarkston area. This study is a reconnaissance level study (Phase I) designed to make a broad economic, environmental, social, and cultural evaluation of possible alternatives and identify those that should be studied further. In addition, the need for interim measures to be taken prior to final solution are identified.

(2) The Phase II portion of the study will concentrate on the alternatives identified in the Phase I study as warranting further study. Detailed studies would be made of the selected alternative, and recommendations made regarding a long-term solution.

(3) All cost estimates associated with the Phase I study are preliminary in nature for comparative purposes based essentially on existing information.

2. PRIOR REPORTS AND STUDIES.

The following is a listing of design memoranda and special reports that have been prepared and published regarding the levee system and past sedimentation studies.

a. Design Memorandum 29.1, East Lewiston Levee, with endorsements, dated 4 August 1972.

b. Design Memorandum 29.2, West Lewiston Levee, with endorsements, dated 28 April 1972.

c. Design Memorandum 29.3, North Lewiston Levee, with endorsements, dated 5 August 1969.

d. Design Memorandum 39, Lake Sedimentation Ranges, with endorsements, dated 17 July 1975.

e. Special Projects Memorandum No. 359 entitled "Sediment Study on Clearwater River, Walla Walla District" dated 27 October 1971, prepared by Hydrologic Engineering Center (HEC), Davis, California.

f. Special Projects Memorandum No. 453 entitled "Sediment Study for Lower Granite Reservoir, Walla Walla District" dated 3 December 1975, prepared by HEC.

g. U.S. Geological Survey, Idaho District, Water Resources Investigation Open File Report 80-960 entitled "Sediment Transport in the Snake and Clearwater Rivers in the Vicinity of Lewiston, Idaho" dated August 1980.

h. U.S. Army Corps of Engineers, Walla Walla District, report entitled "Lewiston-Clarkston Dredging and Disposal Report" dated October 1981.

i. An interim report dated February 1984 entitled "Lower Granite Project, Snake River, Washington and Idaho, Sedimentation Study - Interim Report" was submitted to higher authority on 14 February 1984. This report has not yet been approved.

j. A report entitled "Lower Granite Project, Snake River, Washington and Idaho, Sedimentation Study - FY 86 Interim Dredging" dated June 1985 was submitted to higher authority on 3 July 1985 and approved. This report presented justification for interim dredging to be implemented in 1986 to maintain the current levee freeboard and indicated that future interim dredging would be required until a long-term solution could be implemented.

3. ONGOING HYDRAULIC AND SEDIMENT STUDIES.

a. Description.

(1) Over the past 11 years, hydrology and sedimentation studies have been continuing in an effort to monitor and evaluate the effects of sediment deposition upon flood control and navigation. These studies were described in the 1984 interim report referred to in paragraph 2.i. above and are continuing to further evaluate the sedimentation process of the Lower Granite reservoir. The actual sediment accumulation since project construction is being documented by annual measurement of about 100 sediment ranges in the Lower Granite reservoir. Ongoing studies are evaluating sedimentation rate, location of deposition, and predicted sedimentation over the life of the project.

(2) Recent hydraulic studies have concentrated on resolving discrepancies in the sediment range measurement, defining the magnitude of reservoir sedimentation to date and its effects on the Lewiston levee design freeboard, and evaluating the effects of various dredging and in-water disposal alternatives and alternatives involving modifications to the structure or operation of Lower Granite Dam.

(3) A brief description of currently ongoing studies and their results is presented in the following paragraphs.

b. Effects of Sedimentation Since Lower Granite Project Completion.

Yearly sediment range resurveys indicate that as of December 1985 about 22 million cubic yards (mcy) of sediment have been deposited in the Snake and Clearwater branches of the reservoir since 1975. The further downstream that the sediment is deposited, the less impact it has on raising the water surface profile of the reservoir along the levee system. It is estimated that the present pattern and rate of sediment deposition below Snake RM 120 will have little effect on the water surface at the confluence for at least 60 years into the future.

c. Prediction of Sedimentation Over Life of the Project.

(1) Sediment transport studies have been made using a movable-bed model (HEC-6). The interim sediment report submitted in February 1984 presents a summary of the expected sedimentation effects on flood profiles over a 60-year period. In these studies, some problems were encountered when attempting to calibrate the model against sediment range survey data, particularly in the deep portion of the reservoir downstream of the confluence. Many of these calibration problems now appear to have been caused by inaccurate measurements of the sediment ranges. In 1984, significant improvements to sedimentation monitoring were initiated including better calibration of sediment range sounding equipment. A total of 71 ranges (44 on the Snake River, 3 at the mouth of the Clearwater River, and 24 on the Clearwater River) were initially installed. Twenty-four additional sediment ranges were established in the spring of 1984 on the Snake and Clearwater Rivers and six more on the Clearwater River in 1985. It is apparent that these efforts will bring the measured sedimentation rates and distribution much closer to those calculated by the HEC-6 model and, consequently, the confidence of the prediction of future sedimentation predicted in the interim report has substantially increased.

(2) The effect of present sedimentation on flood control was evaluated based on 1984 sediment range surveys. The maximum drawdown possible at the confluence of Snake and Clearwater Rivers (RM 139.29) was computed assuming all spillway gates are opened and no powerhouse flow as shown on Figure 1. Also shown is the water level associated with 1984 bed and computed sediment inflow during the flood event. The sediment inflow computed by HEC-6 caused a relatively minor raise (only 1/2 foot) during the SPF and does not appear to be as serious as previously expected. Figure 1 also shows that planned freeboard (5 feet) can be maintained up to a flow of 360,000 cfs which is about a 500-year flood. At 420,000 cfs (SPF), only 1-1/2 feet of freeboard was computed. However, computations using recent data indicate that the present freeboard may be closer to 2 feet. As a rough rule of thumb, it can be assumed that without annual dredging of 800,000 cubic yards, 0.25 to 0.5 foot of freeboard will be lost each year due to sedimentation. This estimate is based on the observed loss of freeboard from 1975 to the present. By 1990 (possible initiation of construction) only about 3 feet of freeboard would be present at the 500-year level and the SPF could overtop the levee if no interim dredging is done. Assuming annual dredging of about 800,000 cubic yards is performed in the interim (before a permanent solution), the present levee freeboard would be maintained and the SPF level protection could be provided by raising the levee 3 feet.

d. Studies Relating to Dredging Alternatives.

(1) Backwater studies indicate that about 10 mcy of sediment would have to be dredged to regain the design water surface elevation of 738 at the confluence of the Snake and Clearwater Rivers under SPF conditions. Dredging 0.8 mcy along the left shoreline in the area of the Port of Clarkston would lower the SPF water surface elevation about 0.5 foot at the confluence. However, as more material is removed, the effect on the water level decreases. Computations indicate that dredging further downstream between Silcott Island and the Red Wolf Bridge would only be about one-half as effective.

(2) On the average, approximately 2 mcy of sediment enter the Lower Granite reservoir annually. About one-half of the sediment is either carried down into the noncritical area of the reservoir below RM 120 (see Plate 1) or passes through the reservoir. Of the total annual sediment inflow of 2 mcy, approximately 800,000 cubic yards are deposited in critical flow areas between Lewiston and RM 120. In order to maintain the present 2 feet of SPF freeboard on the levee system measured at the confluence of the Clearwater River, it is estimated that periodic dredging equivalent to approximately 800,000 cubic yards annually would be required.

e. Ongoing Interim Dredging Program.

(1) Beginning in 1986, an interim dredging program was initiated which would prevent further decay of the levee freeboard. A dredging window from 15 January 1986 to 15 March 1986 was established based on fishery conditions, and approximately 775,000 cubic yards of material was dredged. The FY 1986 dredging will increase the SPF freeboard on the levee by approximately 0.5 foot, it is anticipated that the gain will be negated by the sediment infill in the spring.

(2) Dredging was the only interim measure that was considered feasible because of its flexibility. Any dredging done during the interim period prior to long-term project construction would help the current situation and could easily be accounted for in the design of any long-term alternative. Also, at the time of interim design, studies for a long-term project had not yet progressed far enough to accurately design and construct any of the other structural alternatives.

(3) The FY 1986 interim dredging was done in an area of extensive silt and sand deposition in relatively shallow water along the left bank of the Snake River channel between Red Wolf Bridge and the confluence with Clearwater River. The limits of dredging range from RM 138.07 (just downstream of the Port of Clarkston) to the confluence of the Snake and

Clearwater Rivers. The general plan of the area is shown on Plate 2. The plan was to dredge to elevation 716 feet msl. The area dredged began near the left bank of the river and extended out until the excavation daylighted at elevation 716 or to the point where the dredging became too shallow to be practical. The dredged material consisted of silty sand and/or sands which had deposited in the area since the Lower Granite pool was raised in 1975.

(4) Dredged materials were disposed of on project lands near the Port of Wilma to minimize uncertain environmental impact. In-water disposal, both shallow and deep water, was initially considered; however, the environmental studies associated with this type of disposal have been lengthy and could not be completed in time for dredging in FY 1986.

(5) Interim dredging of approximately 1,190,000 cubic yards is planned for FY 1987 (contingent on available funds) including the removal of approximately 390,000 cubic yards within the navigation channel, turning basin, and Port of Lewiston berthing area on the Clearwater River, and 800,000 cubic yards within the Snake River below the confluence of the Clearwater River.

4. PROBLEMS AND NEEDS.

a. Since 1975, the sediment deposition at the confluence of the Snake and Clearwater Rivers has progressively raised the SPF water surface profile, resulting in the losses of freeboard on the Lewiston levees. Backwater computations (using a fixed-bed model) based on fall 1985 sediment range surveys indicate that the levee, in some areas, would provide only about 2 feet of freeboard during the peak of an SPF (Figures 2 and 3). The levees were designed to provide a minimum of 5 feet of freeboard. The buildup of sediment has been much faster than anticipated at the time of project completion and faster than predictions based on computer sediment transport modeling (HEC-6). This rapid buildup is due, at least in part, to several recent very high runoff years. Additional unusually high runoff periods could severely compound the existing levee inadequacies.

b. The flood risk in having only about 2 feet of freeboard is high because of uncertainties such as the accuracy of hydraulic computations including sediment infill during a flood event, unpredictable problems in passing water through Lower Granite Dam, and uncertainties involved in upstream reservoir regulation during major flood events. Currently, the levees would provide 5 feet of freeboard up to a flow of 360,000 cfs (500-year flood).

c. Overtopping of the Lewiston levees would result in flooding the downtown Lewiston area up to a depth of approximately 13 feet, with possible loss of life. Estimates were made to determine the extent of damage associated with levee overtopping. The SPF under pre-Lower Granite project conditions would have caused $62 million damage. If project levees were now overtopped, the damage would be an estimated $140 million. It should be noted that these damages are "rough" estimates not based on detailed surveys and inventories, and are not intended for use in an economic analysis but for informational purposes. Damage estimates are based on February 1985 price levels. Damages estimated for pre-project conditions indicate the significant effect the project has on potential flood damages if adequate levee freeboard is not maintained.

d. The SPF for the Snake River, upstream and downstream from the confluence with the Clearwater River, is 295,000 cfs and 420,000 cfs, respectively. The Clearwater SPF upstream of the confluence is 150,000 cfs. The peak flood on the Snake River, above the confluence, was 195,000 cfs on 18 June of 1974. For the Clearwater River, just above the confluence, the peak flood was 131,000 cfs on 16 June 1974. Higher flows on the Clearwater River have been recorded; however, those flows occurred prior to the construction of Dworshak Dam on the North Fork Clearwater River which became operational in 1972 and provides partial flood control regulation for the Clearwater River. Other branches of the Clearwater River remain uncontrolled.

5. ALTERNATIVE SOLUTIONS CONSIDERED.

a. Objectives

(1) The formulation of a plan to reestablish the original design flood freeboard for the Lewiston-Clarkston levee system requires the consideration of various alternative solutions. In an effort to select the best plan, each alternative was evaluated with respect to technical, economic, environmental, and social criteria. In this Phase I study, the most feasible alternatives will be identified to be studied further.

(2) Technical criteria involve the use of sound engineering methodology and judgment to assure that the selected plan would provide the designated flood protection. The plan must also be "implementable," (i.e., capable in all ways of being carried to completion).

(3) Environmental criteria are considered in the project evaluation. However, it is often difficult to compare and weigh environmental losses and benefits because economic quantification is inappropriate or impossible. Nevertheless, impacts are identified and considered in plan formulation. Environmental effects include impacts to fish and wildlife resources, recreation, aesthetics, cultural resources, and water quality. These include effects during construction and over the long term after the project is completed.

(4) Social criteria must be consistent with state, regional, and local criteria for land use and development and must serve to preserve the local culture. Minimizing social impacts must be considered in the formulation of a plan.

(5) The current schedule is to complete the long-term solution study (Phases I and II) in calendar year 1987. Depending on which measure is selected for a long-term solution and the process required to

obtain approval and funding, implementation could take many years to achieve. Because of the current freeboard inadequacies of the Lewiston levees and the possibility that freeboard could decrease faster than anticipated, it has been determined that continued interim dredging is essential to assure that the situation does not deteriorate further.

b. Alternative Description and Evaluation.

(1) Land Treatment.

(a) A study was conducted by the West National Technical Center of the Soil Conservation Service (SCS) to evaluate the feasibility of implementing a land treatment program for the upstream drainage basin. The study is of reconnaissance level, encompassing the drainage basin above Lewiston-Clarkston limited by Hells Canyon Dam on the Snake River and Dworshak Dam on the North Fork Clearwater River. The following items were evaluated as part of the study:

1. Inventory of the area by subbasin according to similar drainage area land use and/or sediment runoff.

2. Breakdown of sediment contribution by land use for each subbasin including forest, range, and agricultural lands.

3. Estimated average annual water runoff from each subbasin.

4. Estimated average annual sediment runoff from each subbasin for both before and after land treatment.

5. Average annual cost of land treatment including administrative costs.

6. Implementation schedule.

(b) The results of the study will be included in the Phase II detailed level study report as discussed in paragraph 1.b. In summary, it was estimated that approximately 56 percent of the sediment delivered to Lower Granite Reservoir could be treated under current USDA programs if appropriate sponsorship funding and personnel are available. Figure 4 is a cost curve for land treatment showing total average annual costs versus amount of sediment reduction into Lower Granite reservoir. As shown in Figure 4, the total average annual cost of land treatment ranges from $13 per cubic yard for a 100,000-cubic-yard annual sediment reduction up to about $24 per cubic yard for a 600,000-cubic-yard annual sediment reduction.

(c) There would be offsite beneficial effects as a result of the land treatment; however, they would be relatively minor. A summary of the offsite benefits as estimated by the SCS is listed below:

Type of Benefit	Offsite Benefit
Reduced Cost of M&I Water Treatment	$ 0.30 per cy
Reduced Damage to Steelhead Fishing	0.55 per cy

(2) In-reservoir Structures.

(a) In-reservoir structures include structures such as levees, groins, or jetties constructed in the reservoir designed to either increase or decrease flow velocities in efforts to restrict or encourage sedimentation in particular areas. Through the use of such structures, the areas of sediment accumulation can be controlled. Such an alternative, however, is limited to control of sediment in localized areas such as in front of port facilities and does not contribute towards a solution to the overall sediment problem. In addition, these structures would generally reduce the conveyance of the river and result in a reduction of upstream levee freeboard.

(b) One suggestion is to maintain general control of sediment deposition in the reservoir by narrowing of the existing channel from RM 120 upstream to the confluence to maintain velocities high enough to keep the sediment in suspension through this reach. In order to be effective, this reach of the reservoir would have to be converted into a uniform channel with a hydraulic gradient much steeper than the existing reservoir. In essence, this will happen naturally if no action is taken. The rise in water surface in the levee area which would accompany the alternative would overtop the levees during the SPF unless the levees were raised. There is no apparent benefit from structurally modifying the channel over a natural modification.

(3) Lowering Spillway Crest of Lower Granite Dam.

(a) The objective of lowering the spillway crest of Lower Granite Dam is to lower the water surface profile of the reservoir during the SPF, thereby increasing freeboard on the levee system. The most practical and economical way to accomplish this was determined to be by lowering the crest of the existing spillway as opposed to construction of a second spillway with a lower crest in the area of the north shore embankment. The estimated construction cost of lowering the existing spillway crest is $76 million.

(b) The maximum reduction in water surface attainable through lowering the spillway during the SPF would only be about 2 feet at the confluence of the Clearwater River. This reduction would occur if the spillway at Lower Granite Dam were lowered approximately 20 feet. This would not, by itself, provide sufficient freeboard for the SPF.

(4) Removal of Lower Granite Dam.

(a) The removal of Lower Granite Dam was also suggested as a means of alleviating the sediment problem in the Lewiston-Clarkston area. With the removal of the dam, the Lewiston-Clarkston area would no longer be in the backwater of a reservoir and the flow velocities would increase substantially, providing ideal conditions for self cleaning of the sediment throughout the critical sediment area. The sediments would eventually be transported downstream and deposited into the Little Goose reservoir. The immediate impact on the levee freeboard of the dam removal would be minimal, lowering the water surface of the SPF in the Lewiston-Clarkston area by only about 2 feet. However, some of the lost freeboard would be regained. Because the reservoir area would be reverted to free-flowing river, existing sediment in the channel bed would be transported downstream out of the problem area during high flow periods.

(b) Various degrees of project removal were considered, ranging from merely removal of the dam embankment section up to complete removal of dam-related structures. Removal of the dam embankment only was estimated to cost approximately $300 million, whereas complete removal of the dam, spillway, powerhouse, and navigation lock with restoration of the dam area back to a near natural state was estimated to cost approximately $900 million. By either removal of the embankment or complete removal of the dam, commercial slack-water navigation up to the Lewiston-Clarkston area as it exists today would be essentially eliminated unless a series of low-lift locks were constructed to gain the over 100-foot rise in elevation. Substantial modifications to the port facilities would also be required. In addition to the loss of navigation, average annual power benefits of $180 million would be lost. The power loss included an estimated average annual energy loss of 3,000 MWh and a dependable capacity loss of 468 MW. On the basis of loss of navigation and power alone, further consideration of removing Lower Granite Dam was dropped.

(5) <u>Periodic Lowering of Lower Granite Reservoir Level.</u>

(a) This corrective measure would consist of lowering the level of Lower Granite reservoir during periods of high sediment runoff. Modifications consist of lowering the existing spillway crest approximately 48 feet at an estimated cost of $130 million. Such a procedure would shift the reservoir backwater downstream, thus increasing flow velocities in the problem area. The higher velocities would carry the sediment below the problem area, depositing it in noneffective flow areas. Theoretically, if the reservoir water level were drawn down about 80 feet to RM 120 (about elevation 651), essentially all future sedimentation would be deposited below RM 120 causing no adverse impact on freeboard on the levee system. The present spillway configuration of Lower Granite Dam limits drawdown of the head of the reservoir down to about RM 131 (about elevation 681). Any further drawdown would require major modification of Lower Granite spillway.

(b) High sediment runoff is the result of high surface water runoff in the drainage basins. The major portion of sediment transport takes place during the spring runoff period. The spring runoff for the Snake and Clearwater Basins occurs from about mid-April to mid-July with peak flows occurring on about 1 June. It has been estimated that if the reservoir were lowered to an elevation that would approximate a backwater effect at Lewiston for a reservoir with its headwaters at RM 120 during the winter freshet (probably about 6 weeks), the major portion of the incoming sediment would be transported downstream to below RM 120 which would be out of the critical area. It is felt that sediment depositing in the critical area prior to this period would be flushed downstream during the winter freshet. Such an operation would create the same effect in the deep water area as if the material were dredged and disposed of in that area. One advantage would be that the sediment would be transported naturally during the same period when the river is already turbid as opposed to being dredged in January-March when the river is relatively clear.

(c) Because of the drastic drawdown required to provide an effective corrective measure, consideration must be given to the potential for reservoir slides and railroad and highway fill failures due to rapid drawdown and dewatering of fills. As a result, maximum drawdown limits and rates would have to be established and followed as part of the drawdown procedure. Considering the drawdown and refill periods, the total period that the reservoir would be below normal operating levels would be at a minimum of about 2 months. During the 2-month period, river navigation above Lower Granite Dam would be halted and all power generation curtailed.

(d) As a result of the operation, there would be substantial adverse impacts on the fish, wildlife, and recreation aspects of the project if drawn down during the May-June period. The resident fishery would be impacted severely because of dewatering of the spawning beds in the shallow areas along the shore of the reservoir during the prime spawning season. Such an operation would essentially eliminate the resident fishery in the river. The resident goose population would also be severely affected because of the inability of the young geese to traverse the mud flats to the river for watering.

(e) Currently, the navigation system is shut down during the last 2 weeks in March for scheduled maintenance of the lock facilities. Efforts have been made recently to move the scheduled lock outage from March to June. This effort was abandoned, however, because of conflicts with shipping schedules of the port facilities. In the event a 1-month outage would be required during the drawdown period for sedimentation, commercial river navigation would be even more severely impacted.

(f) Approximately 528,000 MWh of energy would be lost annually during the drawdown period. Assuming an energy value of 20.70 mills per kWh (POL date of 1991), an estimated $11 million in power benefits would be foregone annually.

(g) Although this alternative could be effective in controlling sediment accumulation, it does not appear to be an acceptable alternative because of the severe impacts during the drawdown period.

(6) Sedimentation Sumps.

(a) Sedimentation sumps were considered as a means of directing sedimentation to specific areas in order to facilitate a dredging and disposal operation. A sump would consist of the excavation of a large depression in a section of river channel in order to increase the flow area, thereby reducing flow velocities and encouraging sedimentation. The main purpose of a sump would be to collect the sediment in a specific area for the convenience of dredging and disposal. The dredging operation would be confined to a particular area, simplifying the procedure. Even with the sediment sump, dredging throughout other areas of the channel would still more than likely be required.

(b) Total dredging volume would be increased because sediment normally deposited in noneffective flow areas (without sump) would be deposited in the sump. Since these noneffective areas have only minor effects on the backwater curve, they would not require dredging under any other alternative plan. Also, the bulk of the in-water disposal areas are located below RM 120 which means that material dredged from the sump would have to be hauled a long distance for disposal.

(c) The advantage of confining the dredging operation to one area would have a cost advantage; however, it would not offset the added cost due to increased dredging volumes and longer haul distances. Because of the overall increase in costs, the sedimentation sump alternative was eliminated from further consideration.

(7) Upstream Sediment Storage.

(a) This alternative involves construction of an upstream sediment storage facility to reduce incoming sediment to the Lower Granite reservoir. Since 80 percent of the incoming sediment is estimated to originate in the Snake River Basin above Lewiston-Clarkston, a sediment storage reservoir on the Snake River would be effective.

(b) Ideally, such a storage project should be located as low in the drainage basin as possible in order to intercept as much runoff as possible. A reservoir approximately the same size as the once authorized Asotin project would be adequate. That project consisted of a dam approximately 105 feet high with a total reservoir storage of 207,000 acre-feet. Total construction cost of the project including a 540-MW powerplant is currently estimated at $350 million. Costs do not include substantial costs that would be incurred for mitigation of fish and wildlife impacts. Based on preliminary power studies, average annual power benefits over the life of the project are estimated to be $110 million, assuming a power on line date of year 1995. Hydropower facilities would be required for this alternative to have economic justification.

(c) Because of the characteristics and remoteness of the reservoir, no levees or other structures critical to water surface would be required. Consequently, sediment problems similar to that on the Lower Granite project are not anticipated with any upstream sediment storage project.

(d) This alternative would eliminate sediment problems from the Snake River for a long period of time (probably in excess of 100 years). Material passing through the dam would also pass through Lower Granite Dam or deposit in the deeper area where it would not cause problems. This alternative would have to be implemented in combination with another alternative (i.e., levee raise plus dredging, dredging only, etc.) to accomplish the desired objective.

(e) The once authorized Asotin Dam was deauthorized on 31 December 1975 by Public Law 94-199 because of its location with respect to the Hells Canyon National Recreation Area (NRA). The 33-mile reach of Snake River extending from the upper end of Lower Granite Reservoir up to the limits of the Hells Canyon NRA (Washington-Oregon border, RM 176) was studied by the National Park Service for inclusion in the National System of Wild and Scenic Rivers. As part of that report, it was recommended that the 11-mile section of river between the existing NRA boundary and the Grande Ronde River be designated as "scenic river" and the 22-mile section of river between the Grande Ronde River and the town of Asotin, Washington, be designated as "recreation river." To date, no action has been taken on that recommendation.

(f) There is currently a bill before Congress (Senate Bill S-1803) which proposes extending the NRA boundaries essentially the same as recommended by the National Park Service. If such a bill is enacted into law, sediment storage on the Snake River would be precluded.

(g) Because of public sentiment and environmental considerations, it is estimated that 15 to 20 years after initial funding would be required before the project could be placed into operation. Other measures would be required in the interim.

(h) Construction of a dam and reservoir project upstream of the town of Asotin on the Snake River would be very effective in reducing sediment deposited in Lower Granite reservoir from the Snake River. Some dredging would still be required to remove sediment carried in by the Clearwater River. Dredging, or a small levee raise, would still be required to regain the lost freeboard. The principal benefit for justification would be power production. Because of past public opposition that resulted in deauthorization of the Asotin project and the amount of time required for implementation, upstream sediment storage would be a viable alternative for the mid or long term. Serious consideration should be given to such an alternative.

(8) Periodic Dredging and Disposal.

(a) This alternative includes dredging and disposal of sediment from the Snake and Clearwater Rivers in the vicinity of Lewiston-Clarkston extending downstream to about RM 120. Sediment accumulation below RM 120 would have minimal impact on raising the water surface level in the area of the levee system during the SPF conditions. Approximately 10 mcy of material would have to be removed initially in order to reestablish the original 5-foot freeboard on the levee system during the SPF. In addition, periodic dredging equivalent to 800,000 cubic yards annually would be required in order to maintain that freeboard. Dredging methods would include suction, clamshell, and/or dragline depending on the type of material to be excavated and the location of the disposal areas.

(b) Methods of disposal that were evaluated included on-land in the Lewiston-Clarkston area, shallow water in noneffective flow areas essentially all along the reservoir, and deep water disposal below RM 120 (Plate 3). On-land disposal sites immediately adjacent to the river were found to have limited total storage capacity. However, as pumping distances increase for in-water disposal of suction dredged material and/or haul distances increase for barging of sediment for in-water disposal, the feasibility of pumping or hauling sediment up to perched lands above the reservoir becomes increasingly more economical. Studies are continuing to further evaluate this aspect of land disposal.

(c) Pumping sediment up to perched lands above the reservoir presents a problem if the lands are fee-owned lands allocated to wildlife management. Since mitigation requirements under the Lower Snake River Fish and Wildlife Compensation Plan have not yet been met for many terrestrial species, the burial of productive areas with sand and silt, similar to that done at the Wilma disposal site in 1986, will render the areas useless to wildlife. This may require acquisition of additional off-project lands in order to replace lost habitat and meet mitigation requirements. Currently, no authorization for acquisition of additional lands exists.

(d) Shallow water disposal would be limited to relatively noneffective flow areas in the river channel and for the most part filled to elevation 726, or 12 feet below normal operating pool elevation 738. It was assumed that the 12-foot depth would be adequate to allow barging and bottom dumping the material directly into place. One exception to this procedure was in the disposal of approximately 4,500,000 cubic yards in two disposal areas located adjacent to the Port of Clarkston and directly across the river from the Port of Lewiston (see Plate 3). For these two disposal areas, it was assumed that sediment would be deposited up to about elevation 746, or 8 feet above normal operating pool elevation 738. An added benefit of disposing in these areas is to reduce the effective flow area, thereby increasing the flow velocity and decreasing sediment deposition in the areas in front of the Port of Clarkston and Port of Lewiston. In doing so, however, the water surface and flow velocities would be increased which would be detrimental.

(e) Deep water disposal would be limited to the area downstream of RM 120 and below elevation 640. Elevation 640 is approximately the existing invert elevation of the river channel at RM 120. The following table summarizes the available shallow water and deep water disposal areas:

ESTIMATED DISPOSAL AREA CAPACITY

Type		Capacity
Shallow Water Disposal		
Snake River		144,000,000 cy
RM 107 to RM 121.5 1/	134,300,000	
RM 126 to RM 130 1/	1,700,000	
RM 130.5 to RM 133.5 1/	4,600,000	
RM 134.6 to RM 135.8 1/	300,000	
RM 137.2 to RM 139.5 2/	3,100,000	
Clearwater River (RM 1 to RM 2) 2/		1,400,000 cy
Deep Water Disposal		
RM 107 to RM 120		28,000,000 cy
	TOTAL	173,400,000 cy

1/ Assumed fill to elevation 726 or 12 feet below normal operating pool elevation 738.

2/ Assumed fill to about elevation 746 or 8 feet above normal operating pool elevation 738.

(f) Any in-water disposal will require raising of the levee system in order to account for the accumulative effect of disposal on raising the water surface profile during floodflow conditions.

(g) A dredging and disposal operation could have adverse impacts on the in-water aquatic resources of the reservoir which would have to be evaluated before such an alternative could be implemented. Studies are currently underway to evaluate the existing fishery activity in eight selected disposal areas within the reservoir including five shallow water and three deep water areas. Disposal in shallow water areas presents a situation which, in most cases, is unacceptable to the resource agencies managing anadromous fish. Shallow water areas are important resting and feeding areas for juvenile salmonid migrating to the ocean, and reducing the number and size of these areas could have substantial effects on salmonid populations.

(h) Assuming shallow water disposal, the estimated cost for dredging and disposal of 10 million cubic yards of material is $46 million. Assuming deep water disposal, the estimated cost would be $53 million. Estimated cost for the annual dredging of 800,000 cubic yards of sediment is $3 million to $4 million per year.

(i) From an economic standpoint, a dredging and disposal operation appears to be feasible either alone or in conjunction with other alternatives. Further studies are required, however, to evaluate total costs and impacts of in-water disposal and feasibility of perched on land disposal sites.

(9) Raise Levees.

(a) Three-Foot Levee Raise.

Raising of the existing levee system was considered as an alternative to meet both short- and long-term requirements. To meet short-term requirements, a levee raise of approximately 3 to 4 feet was evaluated for purposes of reestablishing the 5-foot freeboard lost to the existing sediment accumulation of about 10 mcy. Such a levee raise would have to be used in conjunction with other alternatives such as periodic dredging over the long term in order to provide for future sedimentation. As part of the evaluation, four methods of levee raising were considered including: (1) raising of the embankment, (2) interlocking steel piles with cap, (3) precast interlocking concrete panels, and (4) cast-in-place concrete panels. The precast interlocking concrete panels were found to be the most acceptable from both an economic and aesthetic standpoint. Such a levee raise would meet the freeboard requirements for the project and at the same time would have minimal adverse environmental impacts. It is anticipated that use of the access points to the river along the levee system such as the existing community boat dock facility at Lewiston could be maintained by use of removable wall sections along the area which would be put into place during periods of anticipated high flow. Provisions would also have to be worked out to accommodate existing bridges. Because of the low profile of the wall, impacts from an aesthetic standpoint would be minimal and the existing levee park area would not be affected. Such a wall would require only minimal modifications to the existing utilities and pumping plant facilities along the levee system. The Snake River Road would be raised 3 feet where it crosses the west levee and the wall would be tied into existing topography. A layout of this plan is shown on Plate 4. The estimated cost for a 3-foot precast concrete floodwall is approximately $5 million to $6 million.

(b) Seven-Foot Levee Raise.

To meet long-term requirements, raising of the levee system was considered in order to compensate for the present and future sediment accumulation. The levee raise that was evaluated for this study was based on sedimentation and backwater information presented in the sedimentation study interim report dated February 1984 as discussed in paragraph 3.i. Predicted water surface profiles from the February 1984 interim report are presented in Figures 5 and 6. The relationship between the water surface profiles and top of the levee system is also shown.

(c) For the evaluation, it was assumed that the levee embankment section would be raised on the landward side maintaining the same design standards as the original design. Raising the levees on the riverward side was considered but was found to be more costly and impractical. The levee raise averages approximately 7 feet. This levee raise is referred to as the 7-foot levee raise in the remainder of this report. A typical section of the levee raise is shown on Plate 4. The location of the existing and raised levee system is also shown on Plate 4. This 7-foot levee raise would require the addition of approximately

1,200 feet of levee along the east Lewiston levee. The Camas Prairie Railroad Bridge, State Route 12 bridge across the Snake River, and Memorial Bridge across the Clearwater River would have to be raised 6, 2, and 7 feet, respectively. Also, three pump stations would require additional pumps, motors, and discharge lines, utilities would have to be upgraded, and marinas and port facilities would have to be modified.

(d) The estimated cost for a 7-foot levee raise is approximately $40 million.

c. Interim Protection.

(1) The levees were originally designed to provide 5 feet of freeboard. The FY 1986 interim dredging measure will maintain the existing 2 feet of freeboard for the SPF assuming an additional 1/2 foot of sediment deposited in 1985. Based on predicted sediment rates, even with the FY 1986 interim dredging, under some conditions all freeboard for the SPF could be lost prior to the implementation of a long-term plan if additional interim measures are not taken. As mentioned in section 4, damages and potential loss of life associated with a levee overtopping could be catastrophic. Therefore, interim flood prevention measures should be implemented to at least maintain the current level of freeboard on the levees until a long-term solution can be implemented. At the present, it has been determined that the full 5 feet of freeboard could be maintained for the SPF if the levees were raised on a temporary and emergency basis.

(2) Of the alternatives being investigated for long-term solutions the only two that are suitable for interim protection are dredging and emergency levee raise. Any form of emergency levee raise would involve sandbagging which could interfere with any form of permanent levee raise. Maintenance dredging could be easily accommodated in a long-term solution. As previously mentioned, in order to maintain the current level of protection, annual excavation of approximately 800,000 cubic yards of material would be required.

(3) Separate studies and reports will be prepared on an annual basis to determine the optimum location for dredging and location of disposal sites until a long-term solution is implemented.

6. DISCUSSION AND CONCLUSIONS.

a. Numerous alternatives were considered as solutions or partial solutions to the levee freeboard problem caused by the accumulation of sediment. A list of the alternatives is presented on Table 1 showing a summary of estimated costs, impacts, and limitations.

b. Although land treatment of the drainage area is included in the table as a corrective measure, the final results of the analysis are not yet complete. The results of the land treatment analysis will be included in the Phase II portion of the sedimentation study. Land treatment should also be further addressed as an alternative.

c. In-reservoir structures designed to control the areas of sedimentation were found to be counterproductive in maintaining or increasing freeboard on the levee system since backwater surface profiles could actually be raised with such a measure. Such an alternative is effective only for localized control of sediment deposition and cannot be considered viable as a long-term solution to the problem.

d. Lowering the spillway crest of Lower Granite Dam by 20 feet at a cost of about $76 million was found to have only limited effect on lowering the water surface at the levee system. Such an alternative would defer dredging for approximately 4 years at a cost of from $3 million to $4 million for each of the 4 years. It was determined that the same freeboard could be gained more economically by some other means such as dredging or levee raise.

e. Removal of Lower Granite Dam at an estimated cost of from $300 million to $900 million would be totally effective in eliminating the sediment problem. However, such an alternative would permanently eliminate barge transportation to the Lewiston-Clarkston area and cause an annual $180 million in power losses. These power losses include an estimated annual energy loss of 3,000 MWh and dependable capacity loss of 468 MW. Because of the resulting severe impacts and general unacceptance by local and regional interests, such an alternative is not considered feasible.

f. Periodic lowering of the Lower Granite reservoir level by about 80 feet at an estimated cost of $130 million could be extremely effective in controlling sediment accumulation in the reservoir. However, with such an operation, the project would be inoperable for approximately 2 months, closing down all navigation to the Lewiston-Clarkston area and eliminating all power generation during that period. Severe environmental impacts along the reservoir would also take place during the 2-month drawdown period. Because of the resulting severe impacts and general unacceptance by local and regional interests, such an alternative is not considered feasible.

g. Sedimentation sumps were found to be ineffective because they could actually increase the amount of dredging required and would increase haul distances to available disposal areas. This is due to the collection of sediment in the sump that would normally be deposited in ineffective flow areas.

h. Upstream sediment storage could effectively reduce the inflow of sediment in the Lower Granite reservoir by about 80 percent. Along with sediment control, a sediment reservoir could supply economical hydropower and, with power facilities, would likely be feasible when additional power is needed in the future. There is presently strong local and regional public agency opposition to such a storage project; however, when further impact studies are completed on other alternatives such as periodic dredging and disposal, the sediment storage reservoir may become more acceptable.

i. Periodic dredging and disposal appears to be a cost effective method in controlling the impacts of sediment accumulation on the levee freeboard. Dredging and disposal is considered as the basic alternative to the sediment problem in that all of the other alternatives being considered would have to be supplemented by periodic dredging since they are not a total solution in themselves.

j. Raising of the Lewiston levee system was found to have economic feasibility, especially up to about a 3- to 4-foot raise. Such a limited raise could be accomplished very economically with limited impacts by means of a precast concrete floodwall. Any levee raise would still require periodic dredging in order to maintain the required freeboard on the levee. A levee raise higher than about 4 feet would require raising of the embankment section, causing considerable disruption and impacts on the adjacent areas. Further studies on raising of the levees are warranted.

k. Annual dredging and levee raising (3 to 4 feet) do not by themselves fully solve the sedimentation problem. However, they are attractive as a means of regaining and maintaining levee freeboard because of apparent low costs, assuming in-water disposal is allowed. Combining these alternatives would provide a plan that is worthy of further investigation.

7. RECOMMENDATIONS.

It is recommended that the following alternatives and their combinations be further investigated in the Phase II feasibility study.

a. Land treatment program for the upstream drainage basin to reduce sediment inflow to Lower Granite Reservoir.

b. Upstream sediment storage.

c. Periodic dredging and disposal to reclaim the lost freeboard and annually maintain levee freeboard. Both in-water and on-land disposal should be investigated.

d. Raising of the Lewiston levee system.

TABLE 1

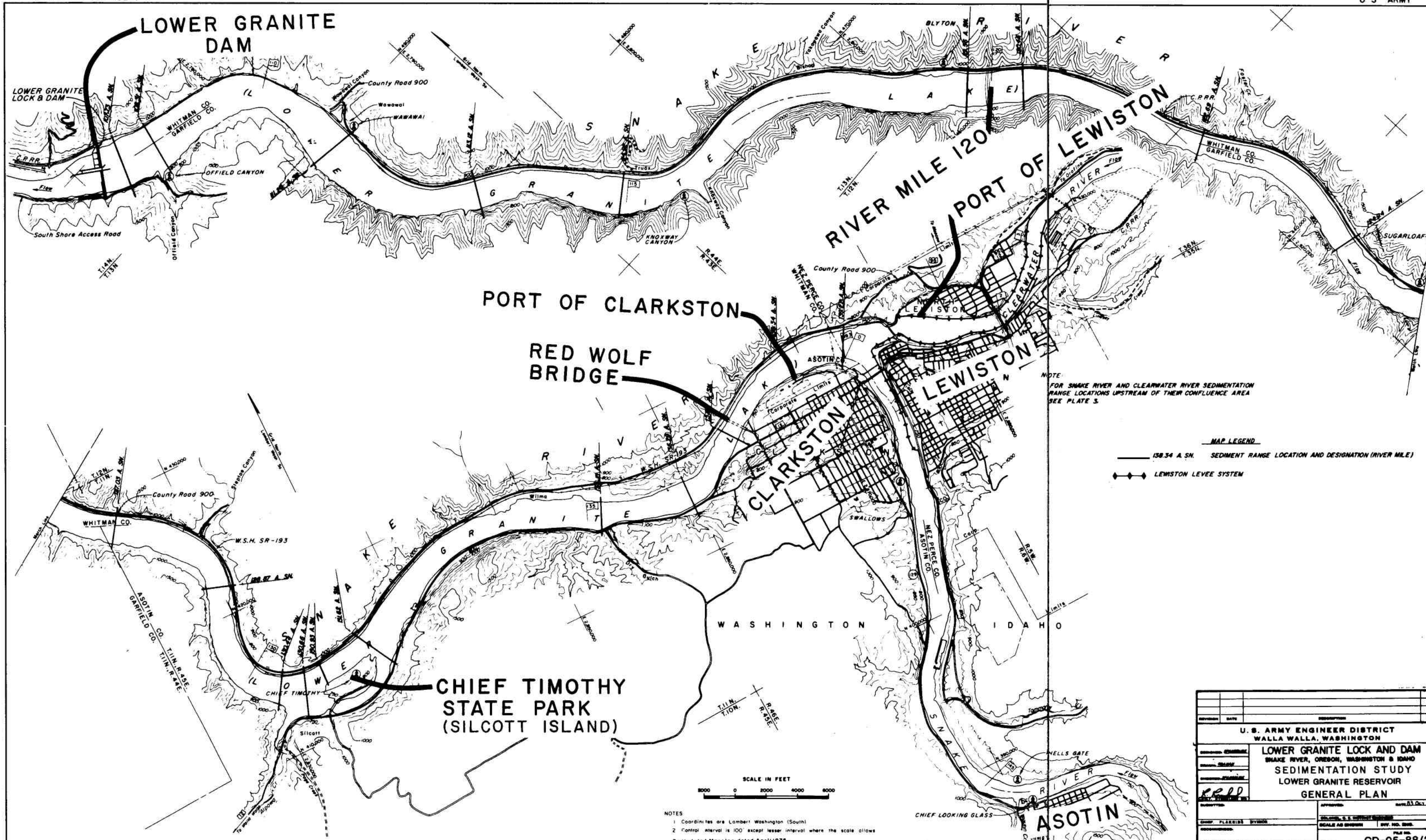
LOWER GRANITE SEDIMENTATION STUDY
SUMMARY OF ALTERNATIVES

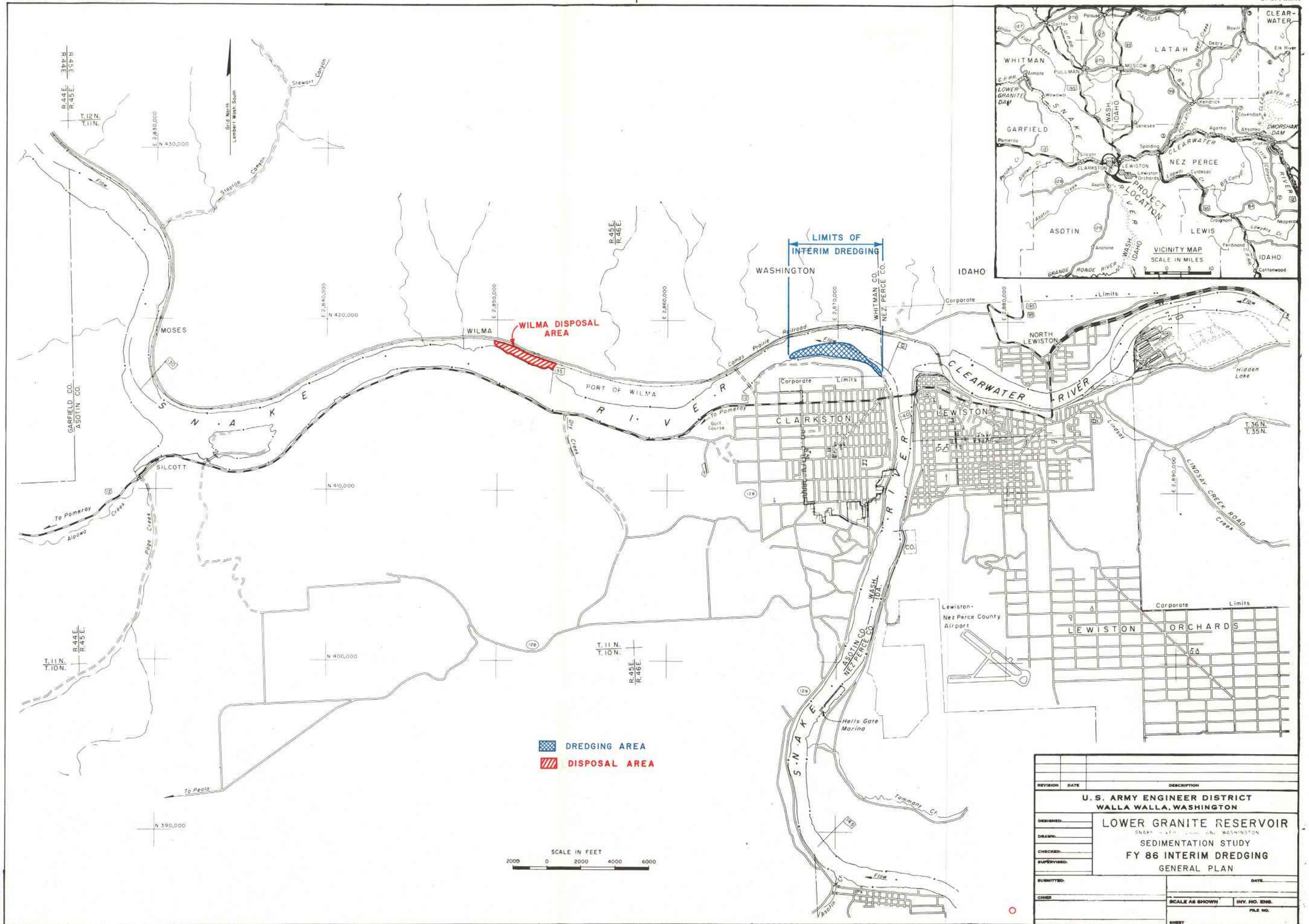
Alternative	Estimated Construction Cost - $1,000,000	Impacts on Sediment Problem	Other Impacts: Positive	Other Impacts: Negative	Comments
1. Land treatment of drainage basin	1/	1/	1/	1/	Results of the study by the Soil Conservation Service will be included in the Phase II study.
2. In-reservoir structures	2/	Provides limited control of where sediment will be deposited.	None	The structures located in the reservoir could impede river navigation and recreation.	Does not appear to be a viable solution to the total sediment problem. Could be feasible for protection of particular areas such as a port facility.
3. Lowering spillway crest of Lower Granite Dam	76	Would gain about 2 feet freeboard maximum on the levee system.	Would increase versatility of project operation.	None	It was found that raising the levee system or dredging was more economical.
4. Removal of Lower Granite Dam	300-900	Would eliminate freeboard problem.	1. Would restore 40+ miles of free-flowing river. 2. Would eventually reinstate natural spawning beds for resident and migratory fish.	1. Would eliminate navigation from Lower Granite Dam up to Lewiston, Idaho. 2. Would cause an average annual power loss of $180 million. 3. Would cause an average annual energy loss of 3000 MWh. 4. Would eliminate essentially all boat-related recreation. 5. Would cause severe visual impacts in the entire reservoir area.	Would require Congressional action.
5. Periodic lowering of Lower Granite Reservoir.	130	A large portion of the incoming sediment would be carried downstream out of the problem area.	---	1. Would cause severe impacts on resident fishery spawning beds. 2. Would severely impact rearing of goslings along the reservoir. Access to the river for watering would be curtailed. 3. Would cause an average annual power benefit loss of $15 million. 4. Would cause an average annual energy loss of 250 MWh. 5. Would cause a loss of at least 2 months per year of commercial navigation. . Would cause severe negative visual impact in the Lewiston-Clarkston area.	1. May require Congressional action. 2. Would still require annual maintenance dredging but at a reduced rate.

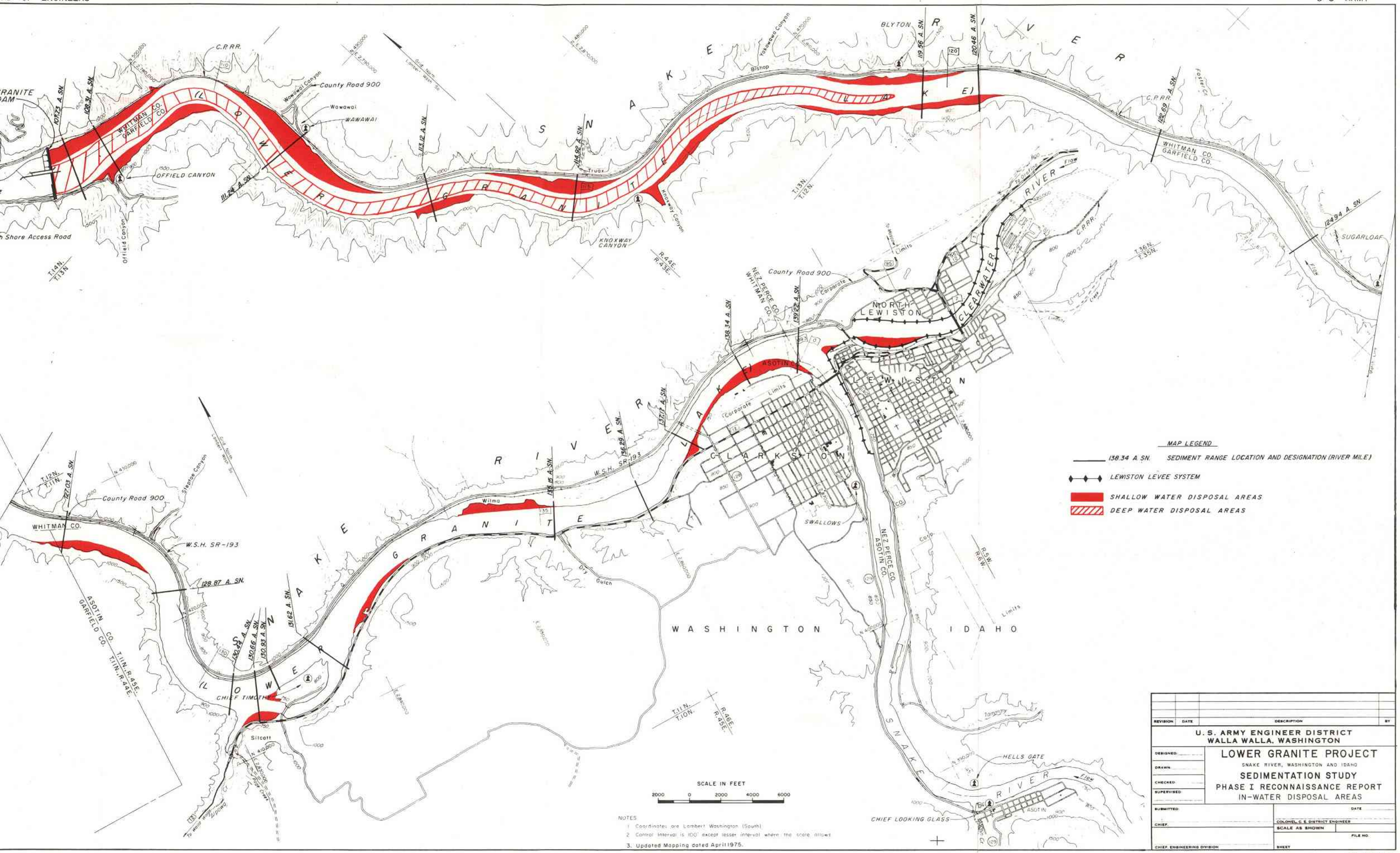
TABLE 1 (cont'd)

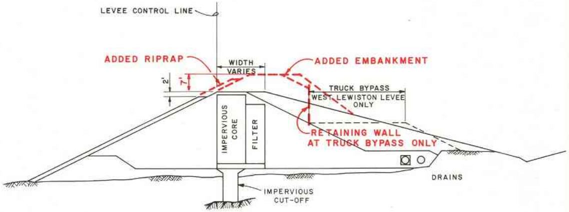
Alternative	Estimated Construction Cost - $1,000,000	Impacts on Sediment Problem	Other Impacts: Positive	Other Impacts: Negative	Comments
6. Sedimentation sumps	2/	Provides limited control of sediment into specific areas.	Would limit impacts from dredging to preselected areas.	---	Only aids the dredging operation itself.
7. Upstream sediment storage	350	Would reduce incoming sediment into the reservoir by about 80 percent.	Would provide economical hydroelectric power with benefits of about $110 million annually.	1. Would eliminate 35 miles of free-flowing river. 2. Would eliminate natural spawning beds for resident and migratory fish.	1. Would require Congressional action. 2. There is strong local and regional opposition to such a storage project. 3. Would still require maintenance dredging of about 160,000 c.y. annually.
8. Periodic dredging and disposal	3 - 4 Annually	Dredging of 800,000 c.y. annually would maintain a given level of freeboard.	---	1. Dredging and disposal would cause adverse impacts to the river fishery. Disposal in shallow water areas disturbs juvenile salmonids migrating downstream by disrupting resting and feeding areas. 2. If land disposal is on Government land dedicated to wildlife production, replacement lands may be necessary.	Would require dealing with the existing 10,000,000 c.y. of existing sediment.
9. Three-foot levee raise	5 - 6	Reestablishes original design freeboard on levee system.	---	1. Could cause access problems to the reservoir if removable wall sections cannot be used. 2. Would adversely impact aesthetics and usability of the levee area for recreation related use.	1. Appears to be most economical means of reestablishing design freeboard due to existing sediment. 2. Would require maintenance dredging of about 300,000 c.y. per year.
10. Seven-foot levee raise	40	Would provide adequate levee height to maintain design freeboard on the levee system for about 30 years.	---	1. Would alter the size and shape of the levee park area. 2. Would require raising of most bridges.	1. Would require intermittent dredging in the navigation channel. 2. Would require annual dredging after the 30-year life of the 7-foot levee raise in order to maintain levee freeboard. 3. Would require periodic dredging in certain areas for the first 30 years and annual dredging of about 300,000 c.y. annually after 30 years.

1/ Not available
2/ Not evaluated because it was found to be ineffective.


LOWER GRANITE DAM
LOWER GRANITE LOCK & DAM
RIVER MILE 120
PORT OF LEWISTON
PORT OF CLARKSTON
RED WOLF BRIDGE
CLARKSTON
LEWISTON
CHIEF TIMOTHY STATE PARK (SILCOTT ISLAND)
ASOTIN
SNAKE RIVER
CLEARWATER
WASHINGTON
IDAHO
WHITMAN CO.
GARFIELD CO.
ASOTIN CO.
NEZ PERCE CO.
County Road 900
Offield Canyon
South Shore Access Road
Knoxway Canyon
Wawawai
Wilma
Swallows
Silcott
Chief Timothy
Hells Gate
Chief Looking Glass
Sugarloaf
Blyton
NOTE:
FOR SNAKE RIVER AND CLEARWATER RIVER SEDIMENTATION RANGE LOCATIONS UPSTREAM OF THEIR CONFLUENCE AREA SEE PLATE 3.
MAP LEGEND
138.34 A SN. SEDIMENT RANGE LOCATION AND DESIGNATION (RIVER MILE)
LEWISTON LEVEE SYSTEM
SCALE IN FEET
2000 0 2000 4000 6000
NOTES
1. Coordinates are Lambert Washington (South)
2. Contour interval is 100' except lesser interval where the scale allows
3. Updated Mapping dated April 1975.
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE LOCK AND DAM
SNAKE RIVER, OREGON, WASHINGTON & IDAHO
SEDIMENTATION STUDY
LOWER GRANITE RESERVOIR
GENERAL PLAN
GD-05-88/2

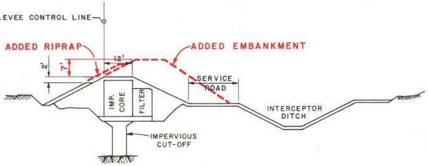

LIMITS OF INTERIM DREDGING
WILMA DISPOSAL AREA
WASHINGTON
IDAHO
WHITMAN CO.
NEZ PERCE CO.
WILMA
MOSES
PORT OF WILMA
SILCOTT
S N A K E R I V E R
CLEARWATER RIVER
CLARKSTON
LEWISTON
NORTH LEWISTON
LEWISTON ORCHARDS
Lewiston-Nez Perce County Airport
Hells Gate Marina
GARFIELD CO.
ASOTIN CO.
ASOTIN CO.
NEZ PERCE CO.
To Pomeroy
To Peola
Corporate Limits
VICINITY MAP
SCALE IN MILES
PROJECT LOCATION
DREDGING AREA
DISPOSAL AREA
SCALE IN FEET
2000 0 2000 4000 6000
REVISION DATE DESCRIPTION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE RESERVOIR
SEDIMENTATION STUDY
FY 86 INTERIM DREDGING
GENERAL PLAN
DESIGNED:
DRAWN:
CHECKED:
SUPERVISED:
SUBMITTED:
CHIEF
SCALE AS SHOWN
INV. NO. ENG.
FILE NO.
SHEET
DATE


MAP LEGEND
138.34 A.SN. SEDIMENT RANGE LOCATION AND DESIGNATION (RIVER MILE)
LEWISTON LEVEE SYSTEM
SHALLOW WATER DISPOSAL AREAS
DEEP WATER DISPOSAL AREAS
SCALE IN FEET
2000 0 2000 4000 6000
NOTES
1. Coordinates are Lambert Washington (South)
2. Control interval is 100' except lesser interval where the scale allows
3. Updated Mapping dated April 1975.
SNAKE RIVER
LOWER GRANITE LAKE
CLEARWATER RIVER
WASHINGTON
IDAHO
LEWISTON
NORTH LEWISTON
CLARKSTON
ASOTIN
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
LOWER GRANITE PROJECT
SNAKE RIVER, WASHINGTON AND IDAHO
SEDIMENTATION STUDY
PHASE I RECONNAISSANCE REPORT
IN-WATER DISPOSAL AREAS
SCALE AS SHOWN



TYPICAL SECTION

NOT TO SCALE

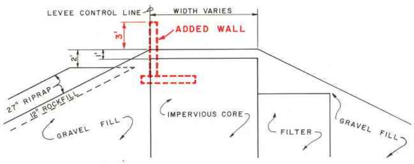


TYPICAL SECTION

NORTH AND EAST LEWISTON LEVEES

NOT TO SCALE

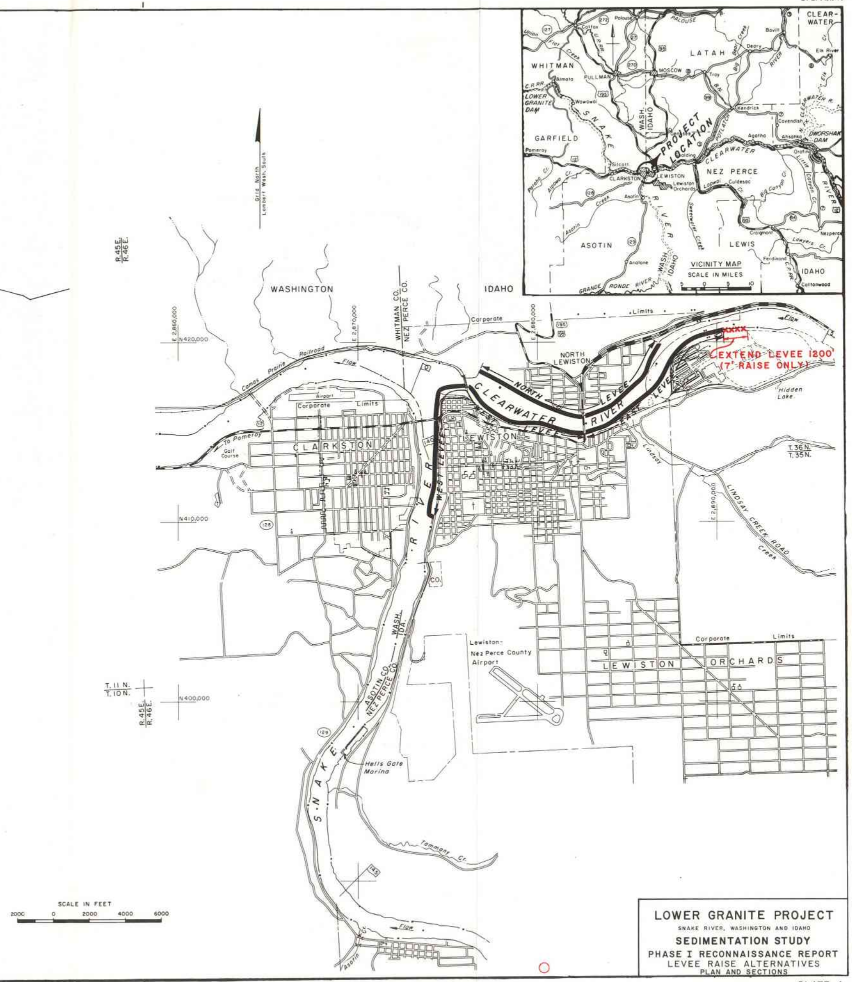
SEVEN FOOT LEVEE RAISE



TYPICAL SECTION

NOT TO SCALE

THREE FOOT LEVEE RAISE



LOWER GRANITE PROJECT

SNAKE RIVER, WASHINGTON AND IDAHO

SEDIMENTATION STUDY

PHASE I RECONNAISSANCE REPORT

LEVEE RAISE ALTERNATIVES

PLAN AND SECTIONS

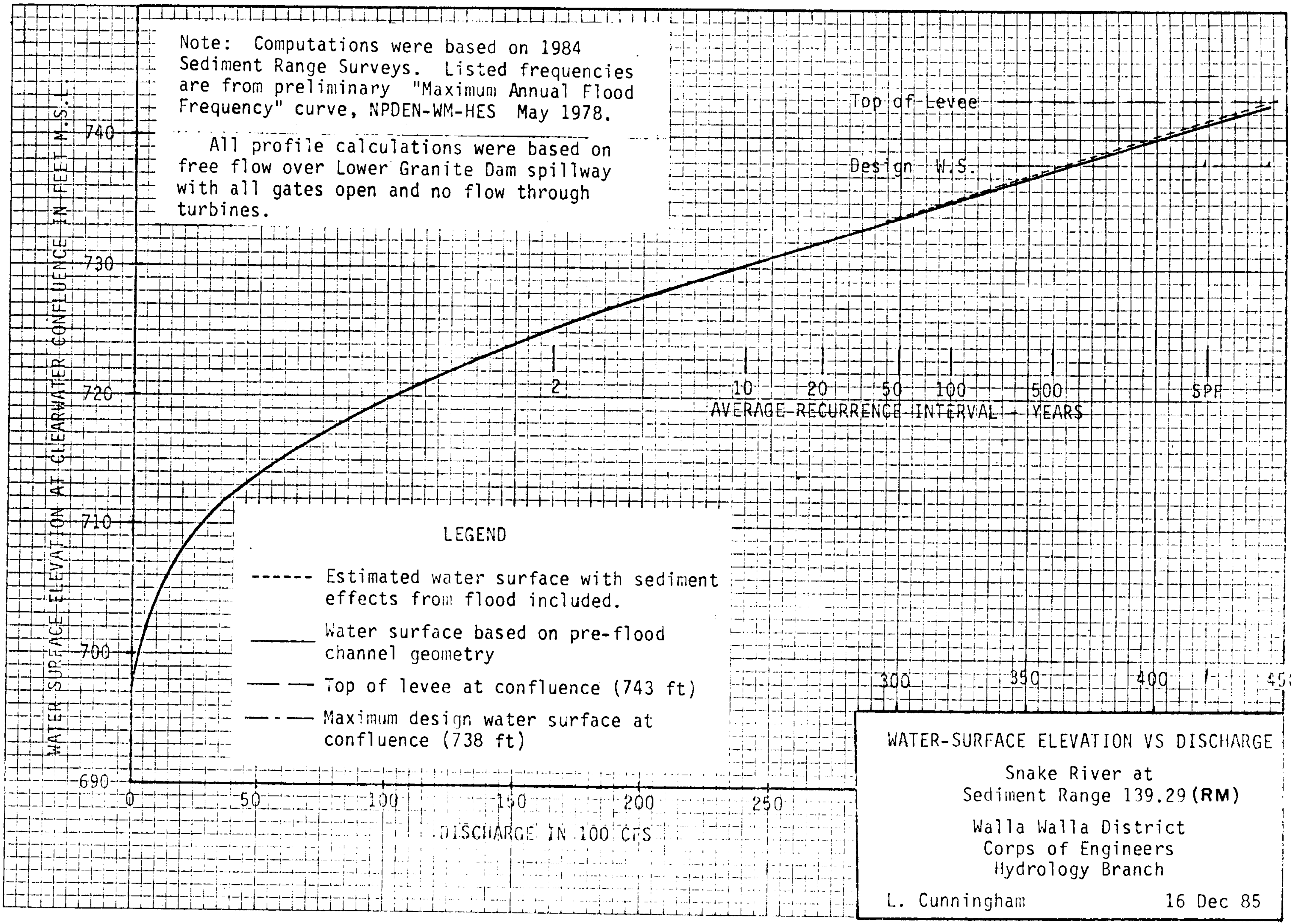
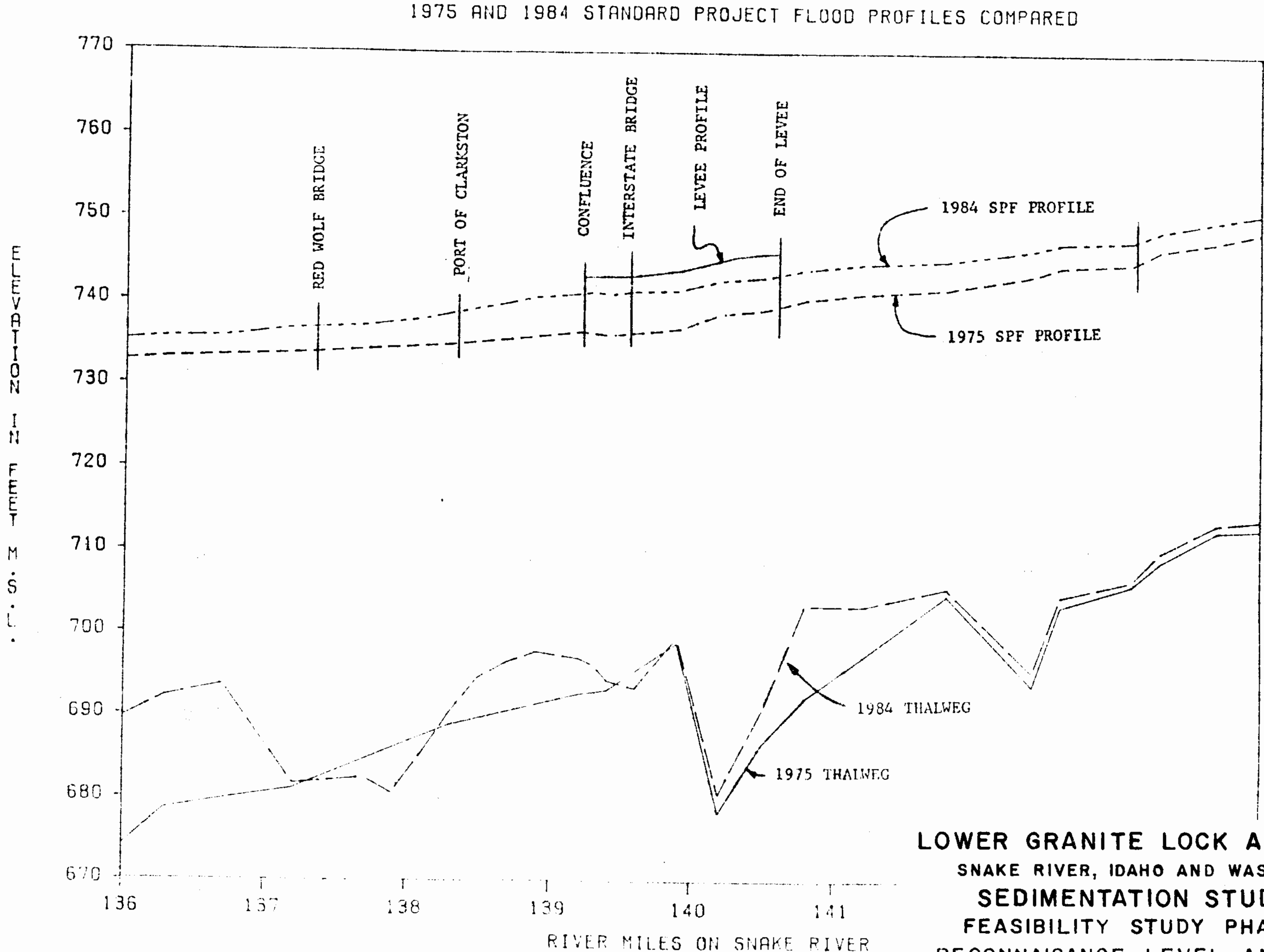

Note: Computations were based on 1984 Sediment Range Surveys. Listed frequencies are from preliminary "Maximum Annual Flood Frequency" curve, NPDEN-WM-HES May 1978.
All profile calculations were based on free flow over Lower Granite Dam spillway with all gates open and no flow through turbines.
Top of Levee
Design W.S.
WATER SURFACE ELEVATION AT CLEARWATER CONFLUENCE IN FEET M.S.L.
740
730
720
710
700
690
2
10
20
50
100
500
SPF
AVERAGE RECURRENCE INTERVAL - YEARS
LEGEND
Estimated water surface with sediment effects from flood included.
Water surface based on pre-flood channel geometry
Top of levee at confluence (743 ft)
Maximum design water surface at confluence (738 ft)
0
50
100
150
200
250
300
350
400
450
DISCHARGE IN 100 CFS
WATER-SURFACE ELEVATION VS DISCHARGE
Snake River at
Sediment Range 139.29 (RM)
Walla Walla District
Corps of Engineers
Hydrology Branch
L. Cunningham
16 Dec 85

FIGURE 1



LOWER GRANITE LOCK AND DAM

SNAKE RIVER, IDAHO AND WASHINGTON

SEDIMENTATION STUDY

FEASIBILITY STUDY PHASE I

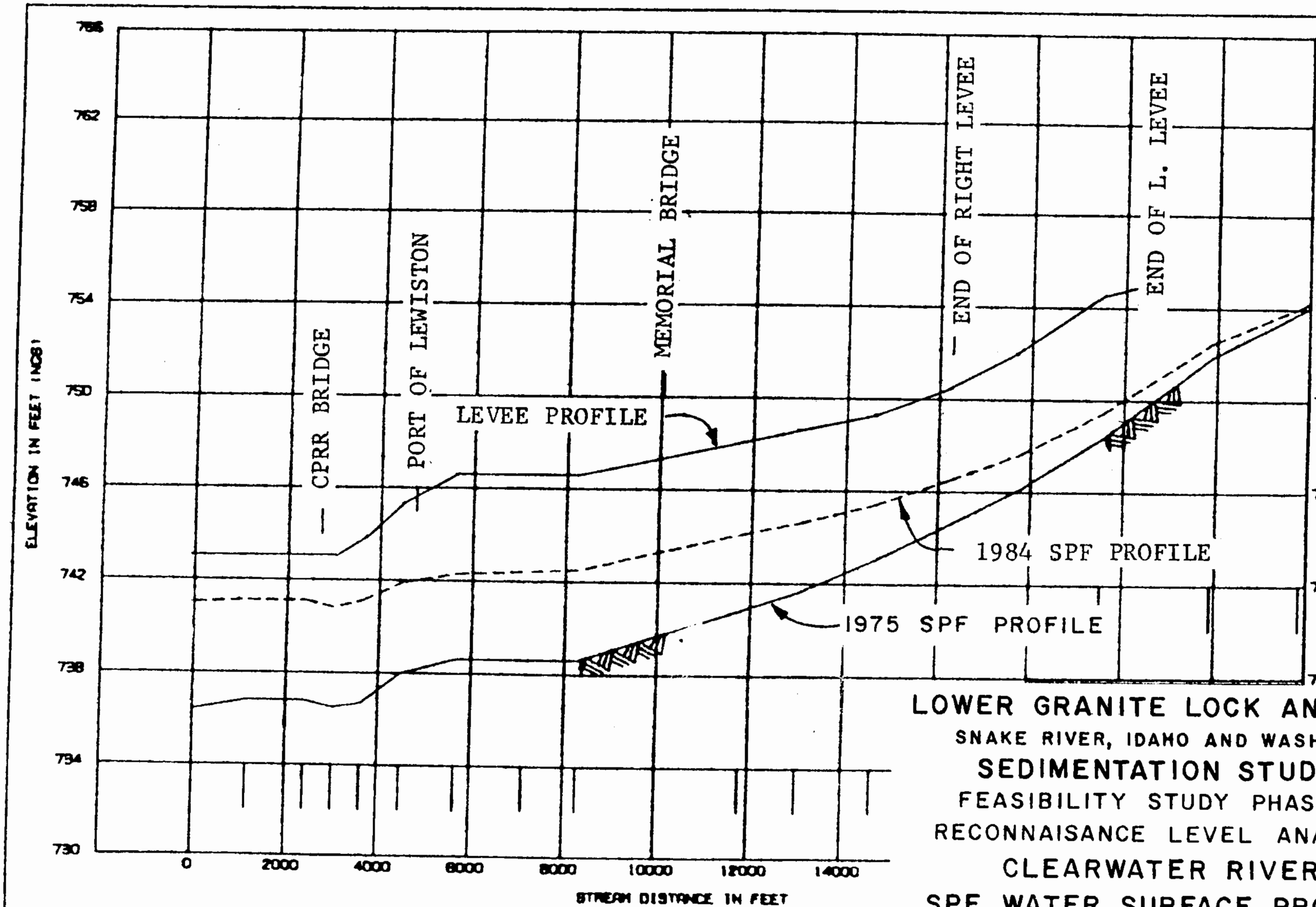
RECONNAISANCE LEVEL ANALYSIS

SNAKE RIVER

SPF WATER SURFACE PROFILE

FIGURE 2

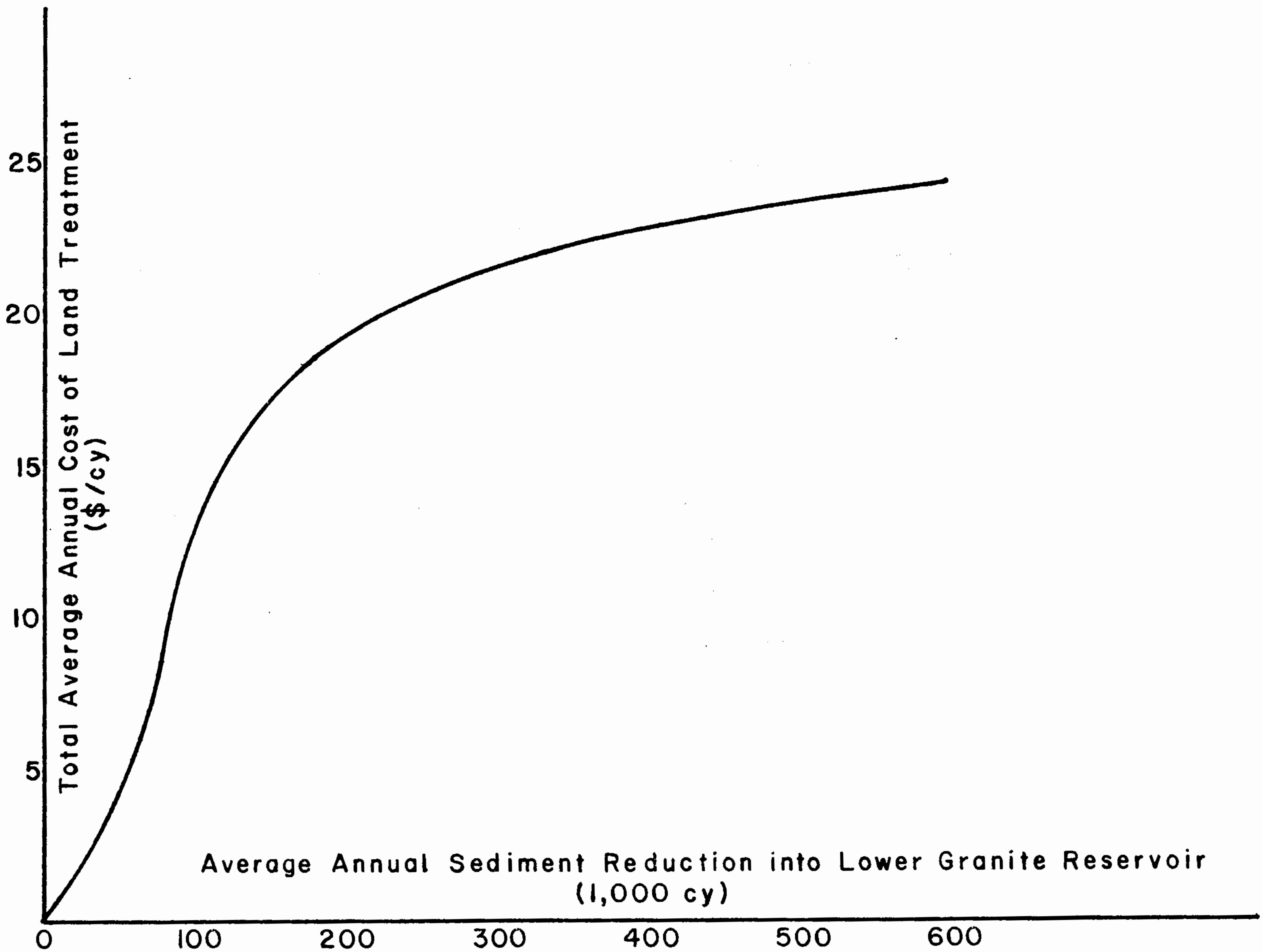
OPTION? C



LOWER GRANITE LOCK AND DAM
SNAKE RIVER, IDAHO AND WASHINGTON
SEDIMENTATION STUDY
FEASIBILITY STUDY PHASE I
RECONNAISANCE LEVEL ANALYSIS
CLEARWATER RIVER
SPF WATER SURFACE PROFILE

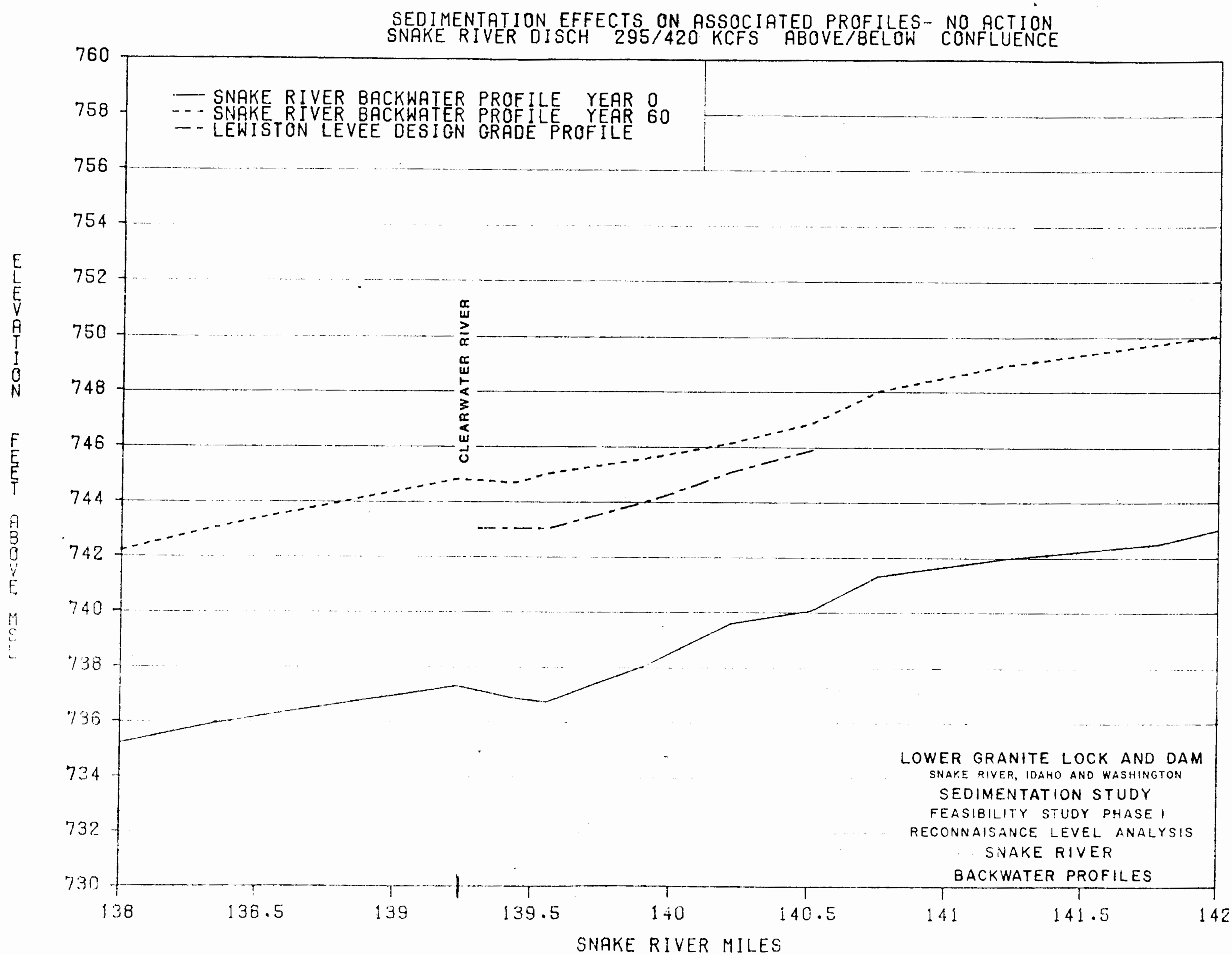
FIGURE 3

OT 1



LOWER GRANITE LOCK AND DAM
SNAKE RIVER, IDAHO AND WASHINGTON
SEDIMENTATION
FEASIBILITY STUDY PHASE I
RECONNAISANCE LEVEL ANALYSIS
LAND TREATMENT COSTS

FIGURE 4



SEDIMENTATION EFFECTS ON ASSOCIATED PROFILES- NO ACTION
SNAKE RIVER DISCH 295/420 KCFS ABOVE/BELOW CONFLUENCE
SNAKE RIVER BACKWATER PROFILE YEAR 0
SNAKE RIVER BACKWATER PROFILE YEAR 60
LEWISTON LEVEE DESIGN GRADE PROFILE
CLEARWATER RIVER
ELEVATION FEET ABOVE MSL
760
758
756
754
752
750
748
746
744
742
740
738
736
734
732
730
138
138.5
139
139.5
140
140.5
141
141.5
142
SNAKE RIVER MILES
LOWER GRANITE LOCK AND DAM
SNAKE RIVER, IDAHO AND WASHINGTON
SEDIMENTATION STUDY
FEASIBILITY STUDY PHASE I
RECONNAISANCE LEVEL ANALYSIS
SNAKE RIVER
BACKWATER PROFILES

FIGURE 5

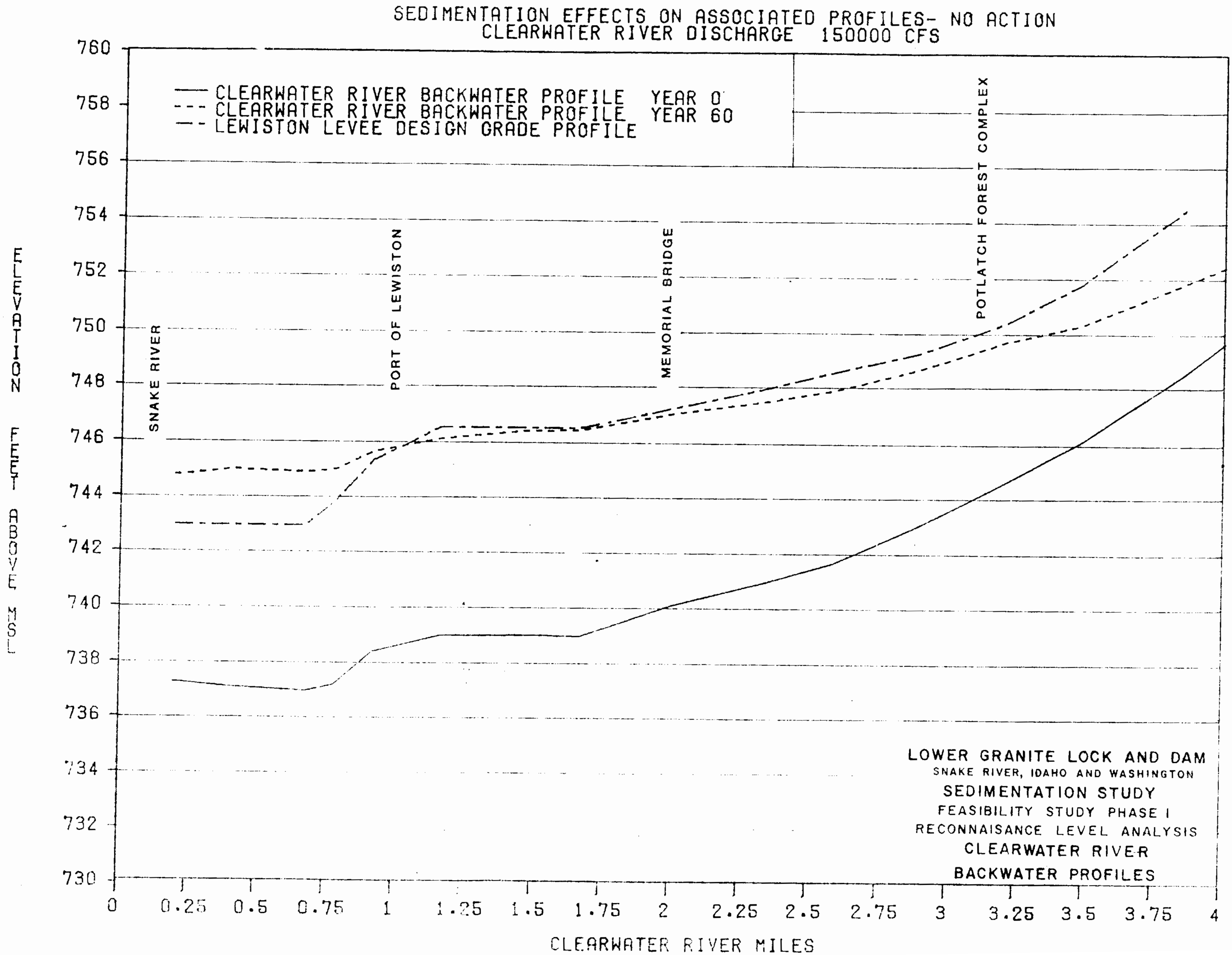

SEDIMENTATION EFFECTS ON ASSOCIATED PROFILES- NO ACTION
CLEARWATER RIVER DISCHARGE 150000 CFS
CLEARWATER RIVER BACKWATER PROFILE YEAR 0
CLEARWATER RIVER BACKWATER PROFILE YEAR 60
LEWISTON LEVEE DESIGN GRADE PROFILE
ELEVATION FEET ABOVE MSL
760
758
756
754
752
750
748
746
744
742
740
738
736
734
732
730
SNAKE RIVER
PORT OF LEWISTON
MEMORIAL BRIDGE
POTLATCH FOREST COMPLEX
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
2.75
3
3.25
3.5
3.75
4
CLEARWATER RIVER MILES
LOWER GRANITE LOCK AND DAM
SNAKE RIVER, IDAHO AND WASHINGTON
SEDIMENTATION STUDY
FEASIBILITY STUDY PHASE I
RECONNAISANCE LEVEL ANALYSIS
CLEARWATER RIVER
BACKWATER PROFILES

FIGURE 6