HARTMAN ASSOCIATES, INC.

THURSTON COUNTY

LAKE LAWRENCE RESTORATION PROJECT
FINAL DREDGE AND DISPOSAL
DESIGN REPORT

VOLUME 1 OF 2

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1.0 INTRODUCTION

1.1 Project Purpose

Lake Lawrence is located approximately 6 miles south of Yelm in Thurston County, Washington. The lake consists of two distinct basins commonly called the East Basin and the West Basin. The lake has approximately 330 acres of surface area, with approximately 276 acres in the East Basin and 54 acres in the West Basin. A canal, 150 feet wide and 500 feet long, connects the East and West Basins.[1]

The lake is used by local residents and the general public for recreation and aesthetic enjoyment. Over the last 20 years, the lake has exhibited progressively declining water quality reflected in dense blue-green algal blooms, low dissolved oxygen concentrations, and extensive growth of aquatic plants. (KCM,1991)

In December 1991, Kramer, Chin & Mayo, Inc. (KCM, 1991) completed the Lake Lawrence Phase I Restoration Analysis, Final Report. Phosphorus was determined to be the limiting nutrient for the blue-green algae blooms in the lake. Therefore, reducing phosphorus loading to the lake would improve the water quality by reducing the algae blooms. Dredging portions of the East and West Basins, to reduce the lake's internal phosphorus loading, formed the basis of the recommended in-lake restoration plan for Lake Lawrence. Organic sediment in water depths greater than 12 feet are considered to be hypolymnetic and to be the primary sediment source of internal phosphorus loading.

Further sediment core analysis in 1993, completed as part of Task 1, Sediment Sampling & Analysis, of this HAI Phase II study, concluded that there are no significant differences in phosphorus concentrations throughout the organic[2] sediment layer. Phosphorus is released from the organic sediment to the water column at the organic sediment-water interface. The amount of phosphorus being released into the water column is a function of the surface area of the phosphorus releasing organic sediment. Dredging the entire depth of phosphorus releasing organic sediment is required to aid in improving water quality. However, dredging a partial depth of the organic sediment is not expected to reduce the internal phosphorus loading, unless other remedial actions such as capping and/or lake alum treatment(s) are implemented in those areas, because the amount of surface area would remain unchanged.

Funding for the Lake Lawrence Restoration project is expected to be a combination of funding sources, such as grant money and lake district bonds.

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1 Phase I Restoration Analysis, Final Report, Kramer, Chin & Mayo, Inc., December 1991 (KCM,1991)

2 Lake Lawrence organic sediment is accumulated non-native material.

The Lake Lawrence Restoration project is divided into two phases: Phase 1 is the removal of the hypolymnetic sediment, the primary sediment source of internal phosphorus loading; and Phase 2 is the removal of nearshore organic sediment.

The objective of this Report is to develop a preferred in-lake restoration alternative that meets the following criteria:

- Reduces phosphorus loading to the lake by removal of specific areas of phosphorus releasing organic sediment from the lake.
- Provides a staged restoration plan that may be implemented in increments.
- Provides the greatest reduction in phosphorus loading by the most practicable method.
- Minimizes adverse impacts to the lake community, including consideration of factors such as affect on lake water level, timing of dredging, affect on recreational use of lake, noise levels, and duration of project.
- Provides improved lake access by removal of accumulated organic sediment from lake nearshore areas.

1.2 Summary of Findings

Table 1 summarizes the findings of the analysis of the treatment alternatives against the selection criteria. This analysis is discussed in Section 3.2.

Table 1. Alternative Analysis Findings Summary

Selection Criteria	Dredge/Centrifuge Dewatering System	Dredge/Confined Upland Dewatering System	Dredge with Slurry Land Application Disposal
Time Required to Complete the Project	**least dredging time requirement**		
Project Timing (Impact on Lake Recreational Use)	**least recreational impact**		
Upland Land Required	**least upland acreage required**		

Selection Criteria	Dredge/Centrifuge Dewatering System	Dredge/Confined Upland Dewatering System	Dredge with Slurry Land Application Disposal
Noise and Traffic Impact on Community:	**least impact**		
Lake Level Impact	**least total lake water level impact**		
Chemical Use Requirement			**least impact**
Cost		**least cost**	

The Dredge/Centrifuge Dewatering System is selected as the preferred treatment alternative for the Lake Lawrence Restoration project based upon the comparison which is discussed in detail in Section 3.2. The negative water level impact for the land application alternative was considered significant enough to eliminate this alternative from further consideration, and the feasibility level estimate of probable cost was not refined further.

In April 1995, a sub-bottom profiling of Lake Lawrence was undertaken to determine the volume of hypolymnetic organic sediment to be removed. As discussed in Section 2.4, approximately 4.1 million CY of hypolymnetic sediment would have to be removed to clear the organic sediment from the 49 acres in the East Basin where the non-organic sediment bottom could be defined.[3] To dredge this volume of sediment would cost on the order of $47 million and take 12 years.[4] This is beyond the Lake Association's financial capability.

In addition, as discussed in Section 2.3, the expected water quality benefit of 20% to 25% reduction in internal phosphorus loading as a result of the hypolymnetic dredging does not meet the project goals of 50% to 80%.

Therefore, the dredging design is limited to the Phase 2 portion of the project, removal of the nearshore organic sediment, and the Phase 1 portion of the project, hypolymnetic dredging, has been eliminated.

3 Reference Section 2.4.

4 Reference Appendix J.

2.0 PROJECT BACKGROUND

2.1 Sediment Characterization

The Lake Lawrence drainage basin is predominated by glacial upland soils of the Everett and Fitch series (KCM, 1991). On the lake bottom, these materials are covered with fine organic sediment which has been deposited over non-organic soils. The Lake Lawrence organic bottom sediment is characterized as fine organic sediment with low solids content and high water content.

Based upon sediment sampling data in the Phase I report (KCM, 1991), subsequent sediment core samples in 1993, and a column settling test, Lake Lawrence sediment is primarily characterized as follows:

- 50% volatile solids
- 10% in-situ solids
- 1.03 in-situ specific gravity
- 1.9 solids specific gravity
- 1000 mg/kg (dry wt) total phosphorus

2.2 Organic Phosphorus Releasing Sediment Distribution

Thurston County completed bottom elevation surveys of Lake Lawrence on April 3, 1993 (Figure 1). Based upon the April 1993 bathymetric data and sediment core data from the Phase I report, cross sections of the lake bottom were developed for a preliminary dredging volume estimate. The following assumptions were made in using this data to calculate the volume of material to be dredged:

- Where the core penetration was less then 8.2 feet (2.5 meters), it was assumed that the core passed through the entire organic phosphorus releasing sediment deposit to the underlying non-organic material.

- Where the core penetration equaled or exceeded 8.2 feet (2.5 meters), it was assumed that the phosphorus releasing sediment deposits are thicker than 8.2 feet and the underlying non-organic material was not reached.

- In areas where the non-organic material was not reached with the core samples, phosphorus releasing sediment deposits were assumed to be too thick to be economically removed.

Figure 1

APRIL 1993 LAKE LAWRENCE BATHYMETRIC SURVEY

- One foot overdepth over the entire area to be dredged was allowed[5] to assure that phosphorus releasing sediment deposits would be removed.

Based on this data and these assumptions, cross sections and a map showing the estimated organic sediment deposit thickness in the East Basin were plotted. The estimated organic sediment deposit thickness is presented in Figure 2. This preliminary estimate was developed based on data that was collected for a different purpose. When the core samples were collected, determining the depth of the organic sediment was not contemplated as a purpose. The number of core samples was limited, an average of 1 sample per 7-8 lake acres. See Figure 3 for core sample locations.

In an effort to better define the thickness of the organic sediment and to determine the elevation of the non-organic sediment bottom of Lake Lawrence, Blue Water Engineering surveyed Lake Lawrence on April 19 - 20, 1995. A discussion of the survey equipment and methodology used is included in Appendix E. The new bathymetric survey is included as Figure 4.[6]

The radar equipment provided the primary source of data to determine the elevation of the non-organic lake bottom. This equipment is capable of measuring the elevation of the "harder" non-organic bottom through approximately 20 feet of "softer" organic sediment. The radar was unable to detect a non-organic bottom over 127 acres or 38% of the total lake area. The hypolymnetic area of the lake is 169 acres and the survey equipment was able to measure the non-organic bottom over 49 acres (29%) of this area. Figure 5 shows the radar printout for a typical section in the East Basin. Figure 6 illustrates the organic sediment thickness calculated from the April 1995 data and shows the area where the sediment thickness remains undefined.[7]

2.3 Dredging Areas and Water Quality Improvement Goals

The Phase I dredging goal was to improve Lake Lawrence water quality by partial removal of organic sediment from the lake bottom sediment in water depths greater than 12 feet. Partial dredging was predicated on the assumption that the phosphorus levels in the sediment would decline deeper within the organic sediment (i.e., that the phosphorus level of "1" at the surface of the sediment would decrease to "0.5" half way through the

5 This allowance is to compensate for equipment and operation inaccuracies during the dredging process.

6 Note that 0 = 417.56′ in the 1993 survey and 0 = 417.87′ in the 1995 survey, a difference of 0.31′.

7 The "undefined" area is organic sediment with depths greater than 20 feet.

Figure 2

ESTIMATED LAKE LAWRENCE ORGANIC SEDIMENT THICKNESS BASED ON 1991 AND 1993 CORE SAMPLING DATA

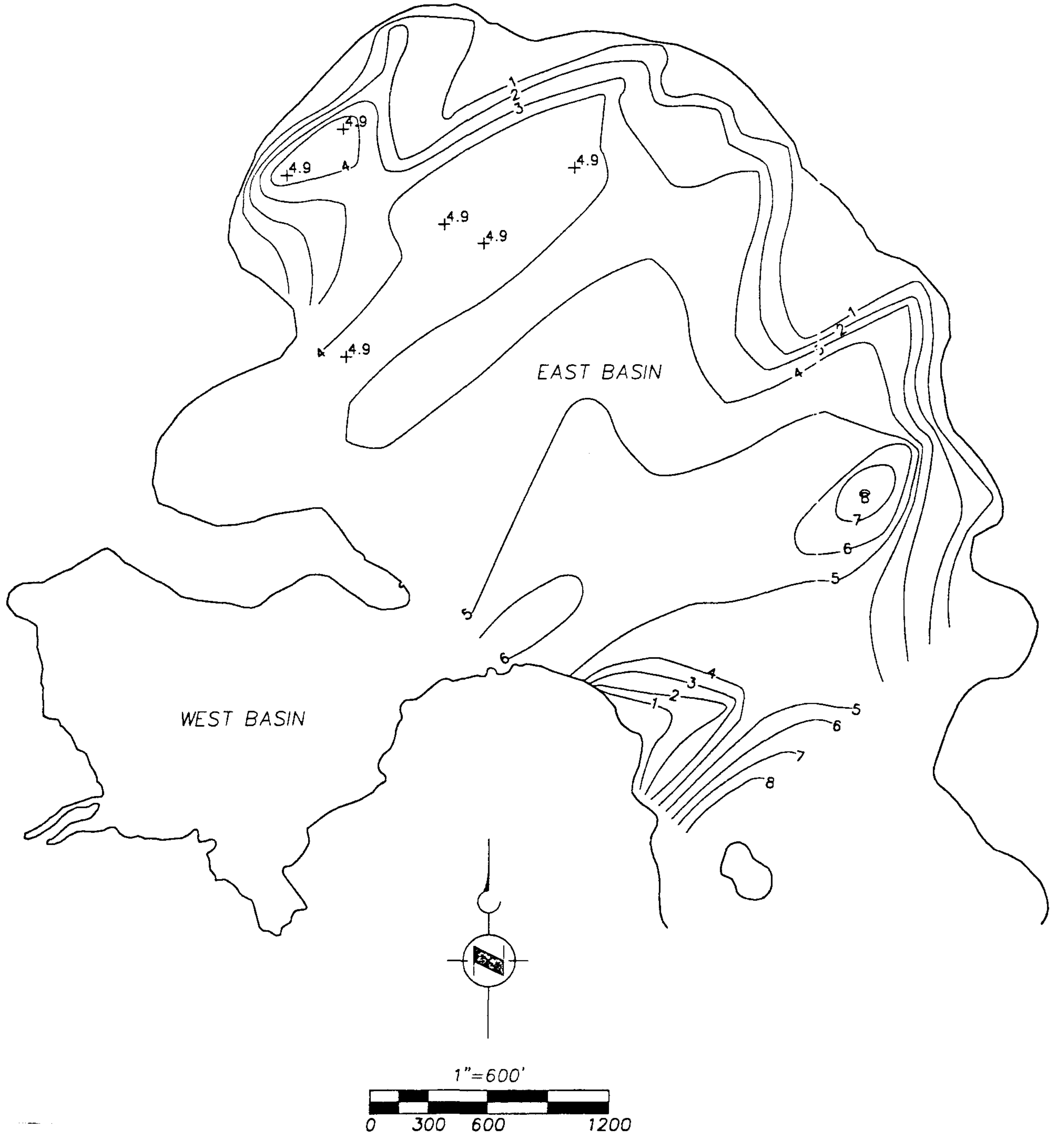
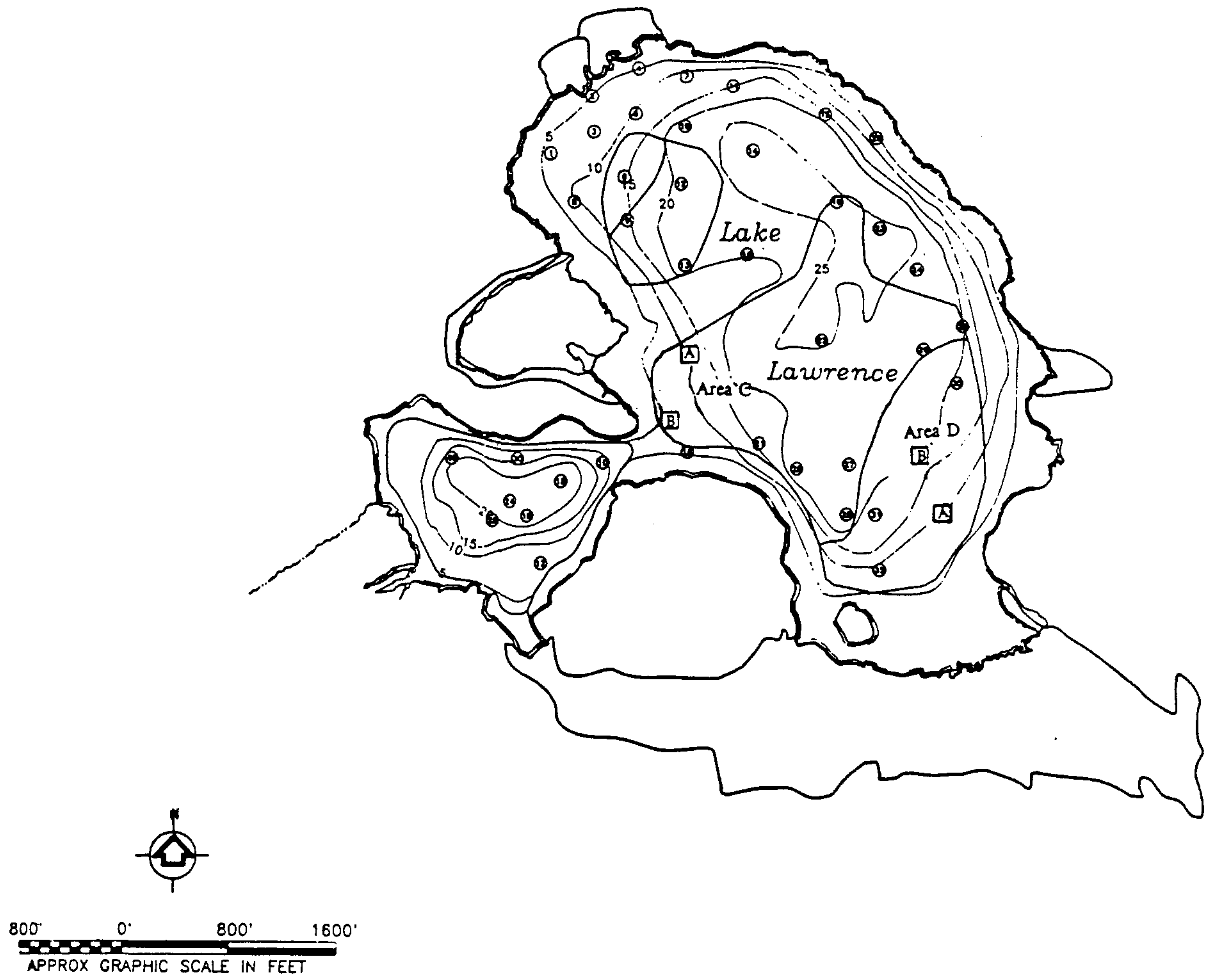


Figure 3

SEDIMENT CORE SAMPLE LOCATIONS



LEGEND

- ● Sediment Core Sampling Point-Phase I
- □ Sediment Core Sampling Point-Phase II

Figure 4

APRIL 1995 LAKE LAWRENCE BATHYMETRIC SURVEY

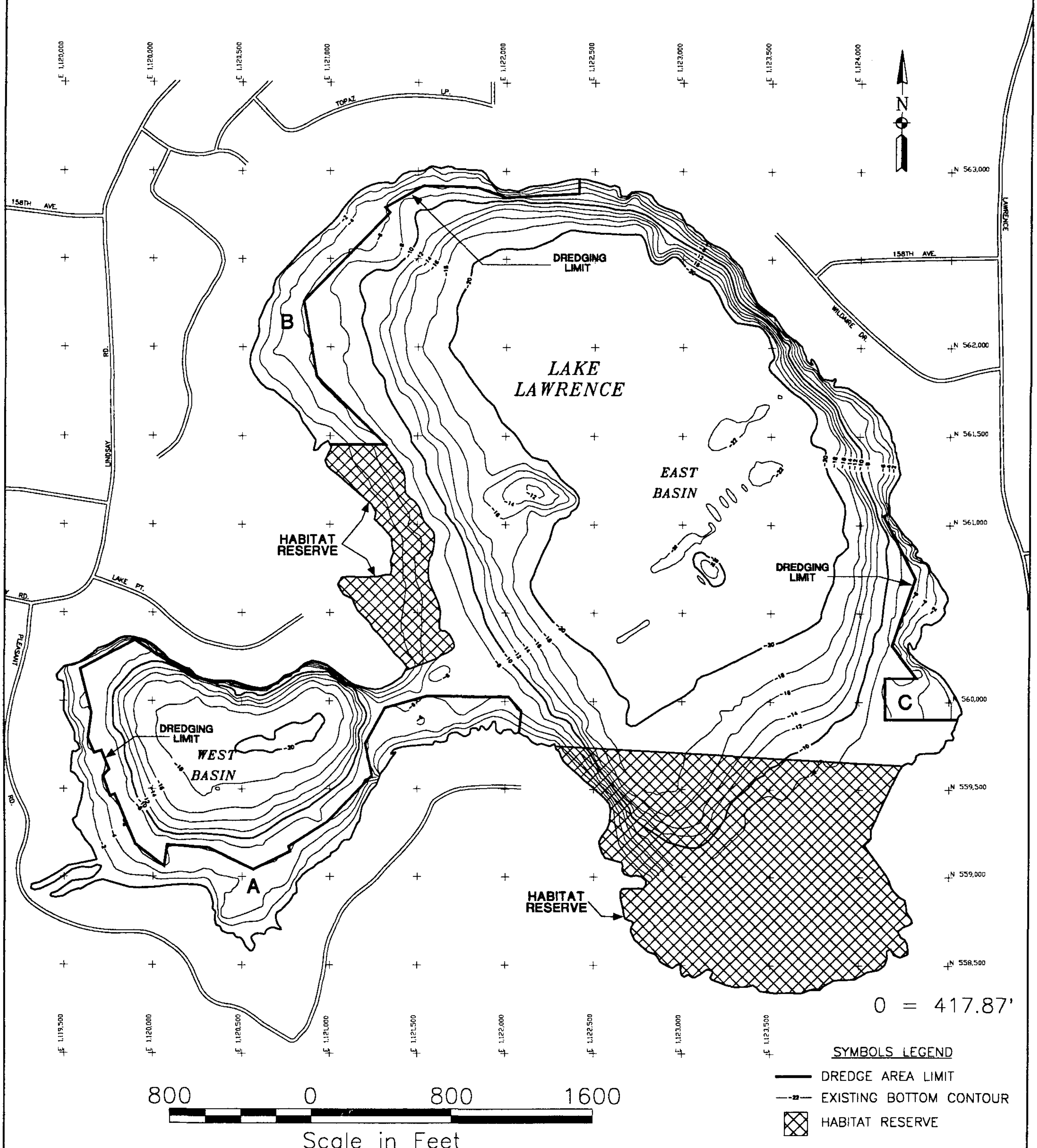


FIGURE 5. TYPICAL EAST BASIN RADAR PRINTOUT (SECTION B - B)

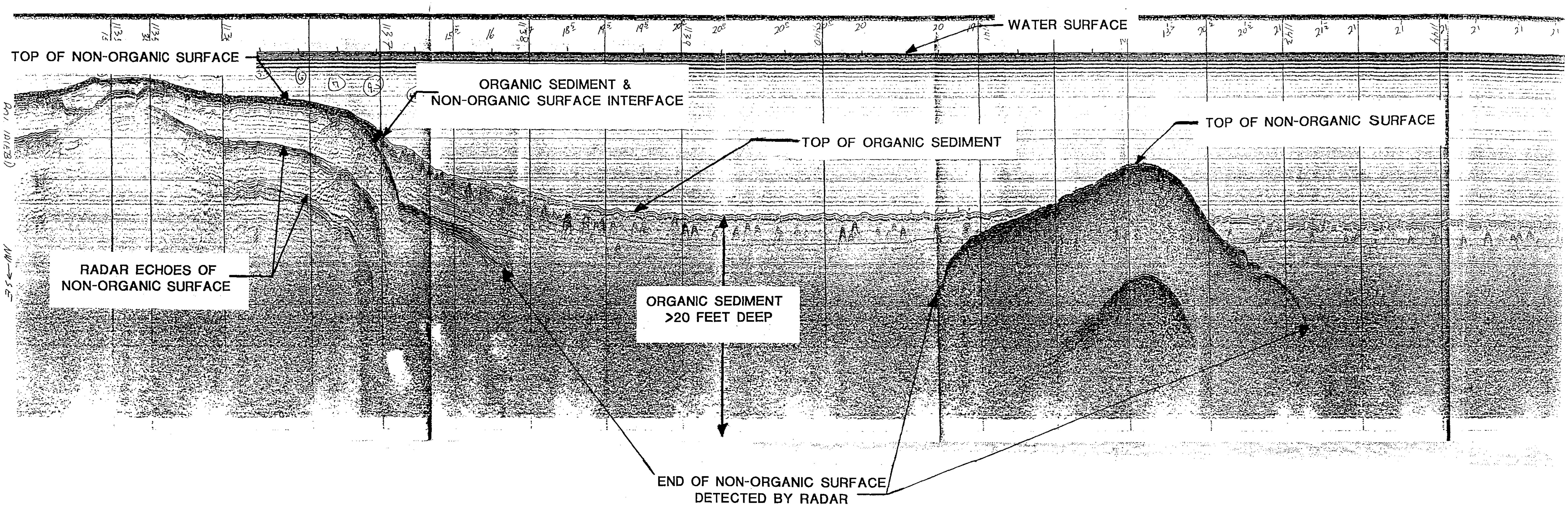
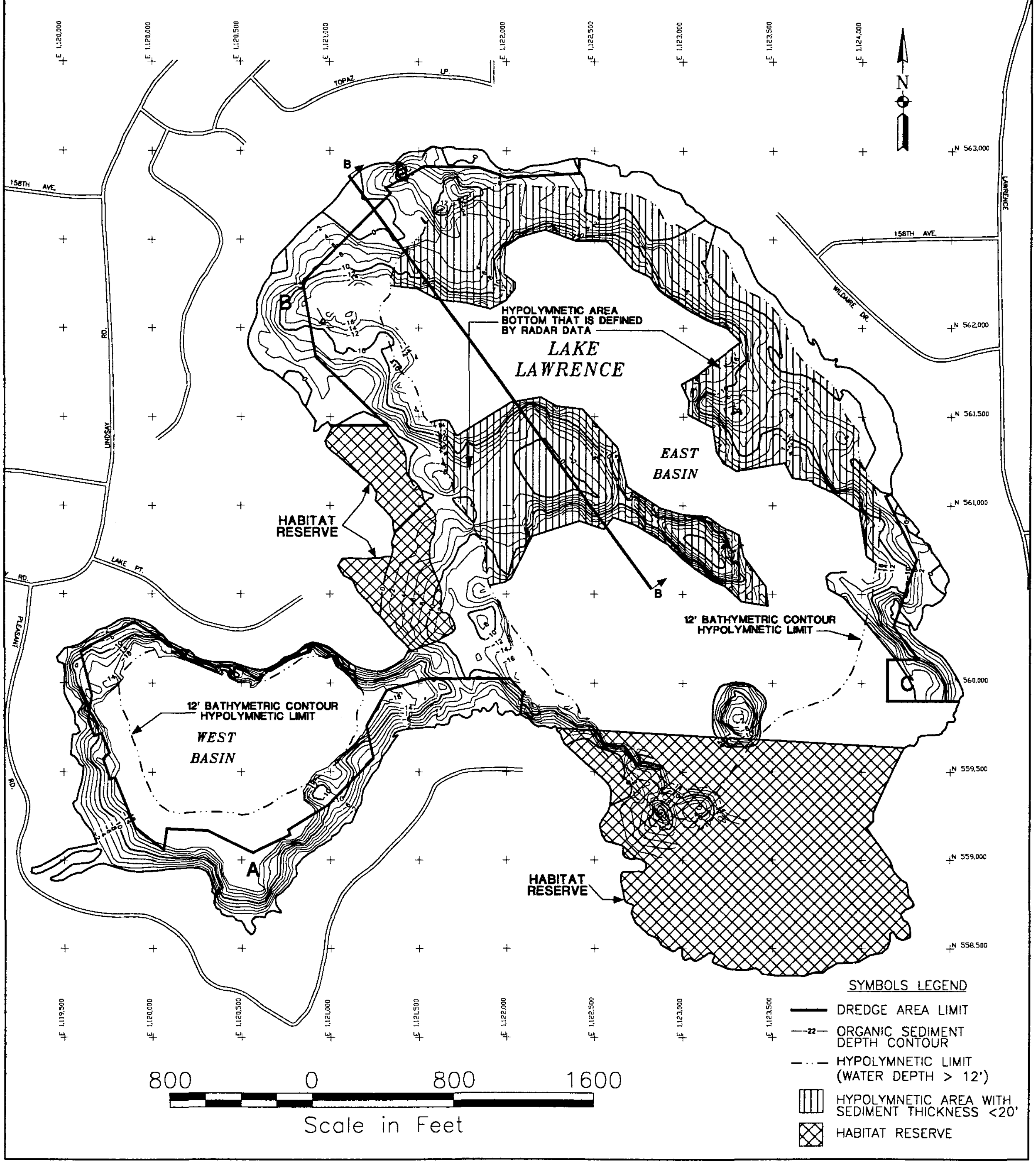


Figure 6

APRIL 1995 LAKE LAWRENCE ORGANIC SEDIMENT DEPTH SURVEY



sediment thickness.) Reducing the lake's nutrient loading rate was expected to reduce the algal blooms and thus improve water quality.

Sediment core samples were collected in 1993 as part of Phase II and analyzed in conjunction with the core data from the KCM 1991 Report. This analysis concluded that the phosphorus release potential of the organic sediment did not decrease with partial dredging of the organic phosphorus releasing sediment.[8] The release of phosphorus into the water column is a function of organic sediment surface area rather than organic sediment depth. Therefore, no water quality benefit is received unless the full depth of organic sediment dredging is accomplished which reduces the surface area releasing phosphorus.

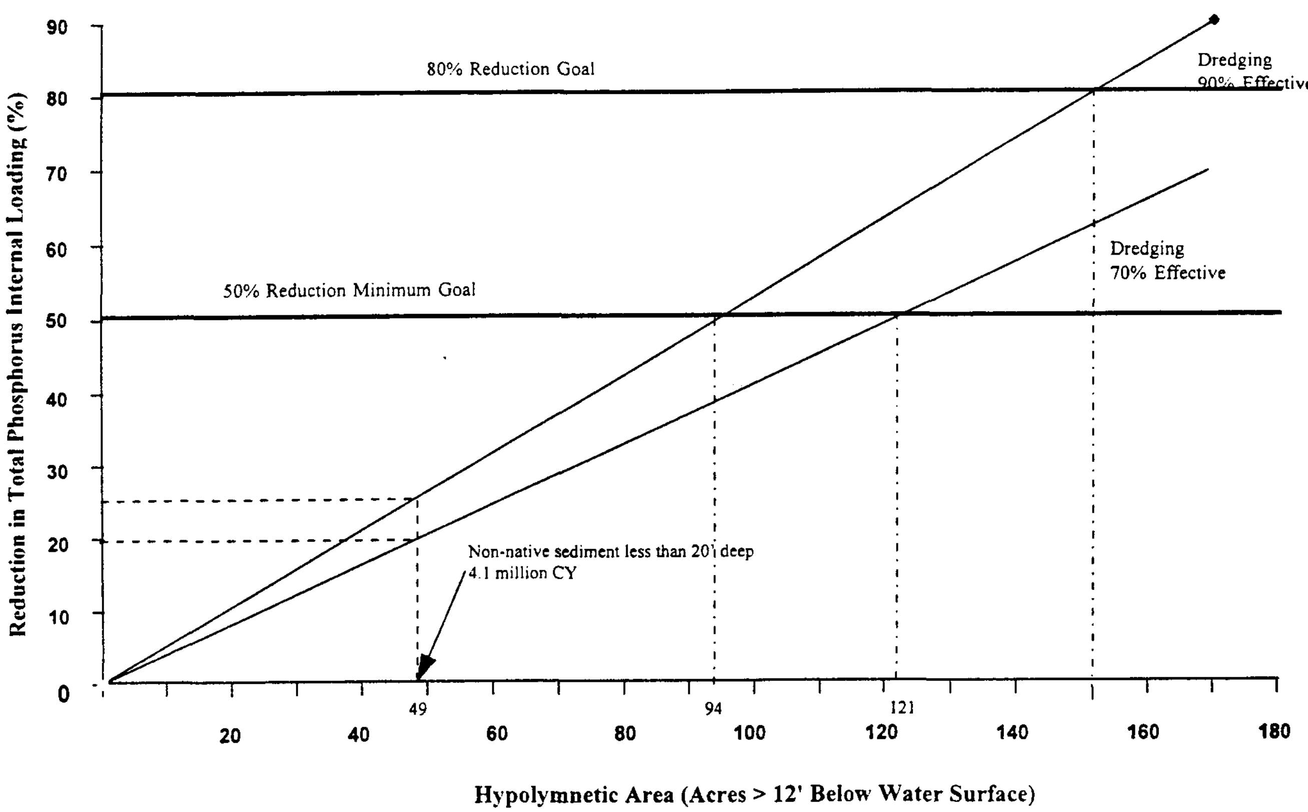
The Phase I, KCM 1991, dredging goal for water quality improvement was 50% to 80% reduction in internal phosphorus loading of Lake Lawrence. As discussed above, dredging the organic hypolymnetic sediment to non-organic sediment bottom is required to reduce phosphorus loading. The hypolymnetic area of Lake Lawrence is approximately 169 acres. Using Parametrix's analysis[9] and the 1995 survey data, the minimum area of hypolymnetic sediment that must be removed to achieve the water quality goals can be calculated. Assuming that dredging is 70% to 90% effective in reducing the phosphorus loading, then 94 to 121 acres of hypolymnetic sediment must be removed to achieve the minimum 50% reduction in internal phosphorus loading and more than 150 acres must be dredged for 80% reduction in internal loading, as shown in Figure 7. The hypolymnetic area which has sediment thickness of less than 20 feet and where the non-organic bottom elevation can be determined is 49 acres, as shown in Figure 6. Dredging this area is calculated to provide 20% to 25% reduction in internal phosphorus loading. This is significantly less than the project goal of 50% to 80%.

8 Reference ENVIROVISION, September 1993, "Lake Lawrence Sediment Characteristics and their Phosphorus Release Potential" in Appendix D. Page 3 of the ENVIROVISION Report shows sediment core sample locations, and the ENVIROVISION Report includes summary data from the core samples.

9 Reference Parametrix, Inc., July 1993, "Lake Lawrence Phosphorus Loading Uncertainty Analysis" and January 21, 1994, technical memorandum "Revised P Loading Reduction Estimates for Lake Lawrence Dredging" in Appendix C.

Figure 7

ESTIMATED REDUCTION IN TOTAL PHOSPHORUS INTERNAL LOADING RESULTING FROM LAKE LAWRENCE DREDGING



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2.4 Organic Sediment Dredging Volume

The organic sediment in Lake Lawrence has such a small natural angle of repose that it is not practical to attempt to dredge a hole into the sediment. The organic sediment lies essentially flat throughout the lake and if the organic sediment is removed from one area to an elevation below the adjacent organic sediment surface, the adjacent sediment would be expected to slide into the newly created hole. Therefore, in order to remove the organic sediment from the 49 acres of hypolymnetic sediment where the non-organic bottom can be measured, a layer of organic sediment from across the "undefined" area would have to be removed to keep the newly exposed non-organic bottom from being recovered by organic sediment sliding down the cut slopes. In order to expose the non-organic sediment bottom in the area shown in Figure 6, approximately 4.1 million in-situ CY must be dredged. Phase 1 dredging of the hypolymnetic sediment is not considered to be reasonable for the following reasons:

1) As discussed in Appendix J, Phase 1, Hypolymnetic Dredging, dredging 4.1 million CY greatly exceeds the Lake Association financial capabilities.

2) As discussed in Section 2.3, the expected water quality benefit that would result from this dredging does not meet project goals.

The nearshore dredging, Phase 2, is to remove organic sediment above the 6 foot bathymetric contour. The principal benefit of the nearshore dredging is to restore lake access and use which has been severely restricted by shoaling of the organic sediment. However, boat prop wash in the shallow depths, in the East and West Basins, release a statistically significant concentration of phosphorus into the water[10] and removal of the shallow sediment is expected to result in a reduction of phosphorus loading to the lake. One foot of overdepth is included in the volume calculations for both equipment tolerances and to ensure removal of all project organic (non-native) sediment. The dredging volume from the areas shown on plan sheet 1 of 2, Appendix K, are as follows:

[10] Reference Parametric, Inc. January 20, 1994, technical memorandum, "Sediment and Phosphorus Resuspension from Recreational Boats in Lake Lawrence" in Appendix C, which compares Lake Lawrence conditions to similar lakes where data regarding this phenomena has been collected.

Table 2. Dredging Volume[11]

Nearshore Dredging Area (Refer to Figure 4)	Required Dredging Volume (CY)	Allowable 1′ Overdepth Dredging Volume (CY)	Total Nearshore Sediment Volume (CY)
A	60,000	22,000	82,000
B	18,000	6,000	24,000
C	10,000	4,000	14,000
Total	88,000	32,000	120,000[12]

2.5 Upland Site Availability Summary

Upland staging and disposal sites or staging areas are required by all of the project alternatives considered, although the amount of upland area required varies. No wetland reconnaissance of the potential upland disposal sites has been accomplished.

2.5.1 Upland Staging and Disposal Site Alternatives
Sites 7 & 9 (Figure 8) were preliminarily selected for further consideration as disposal sites in the June 1993, "Preliminary Disposal Site Identification Report," prepared by HAI (Appendix B). These sites were selected over other potential disposal sites surrounding Lake Lawrence because they had the largest capacities, and were expected to be able to contain the large dredging volume anticipated for the single dredging project being designed at that time.

The owner of Site 7 has not been available for contact. Therefore, for the purpose of this report, Site 7 was not considered as a practicable alternative.

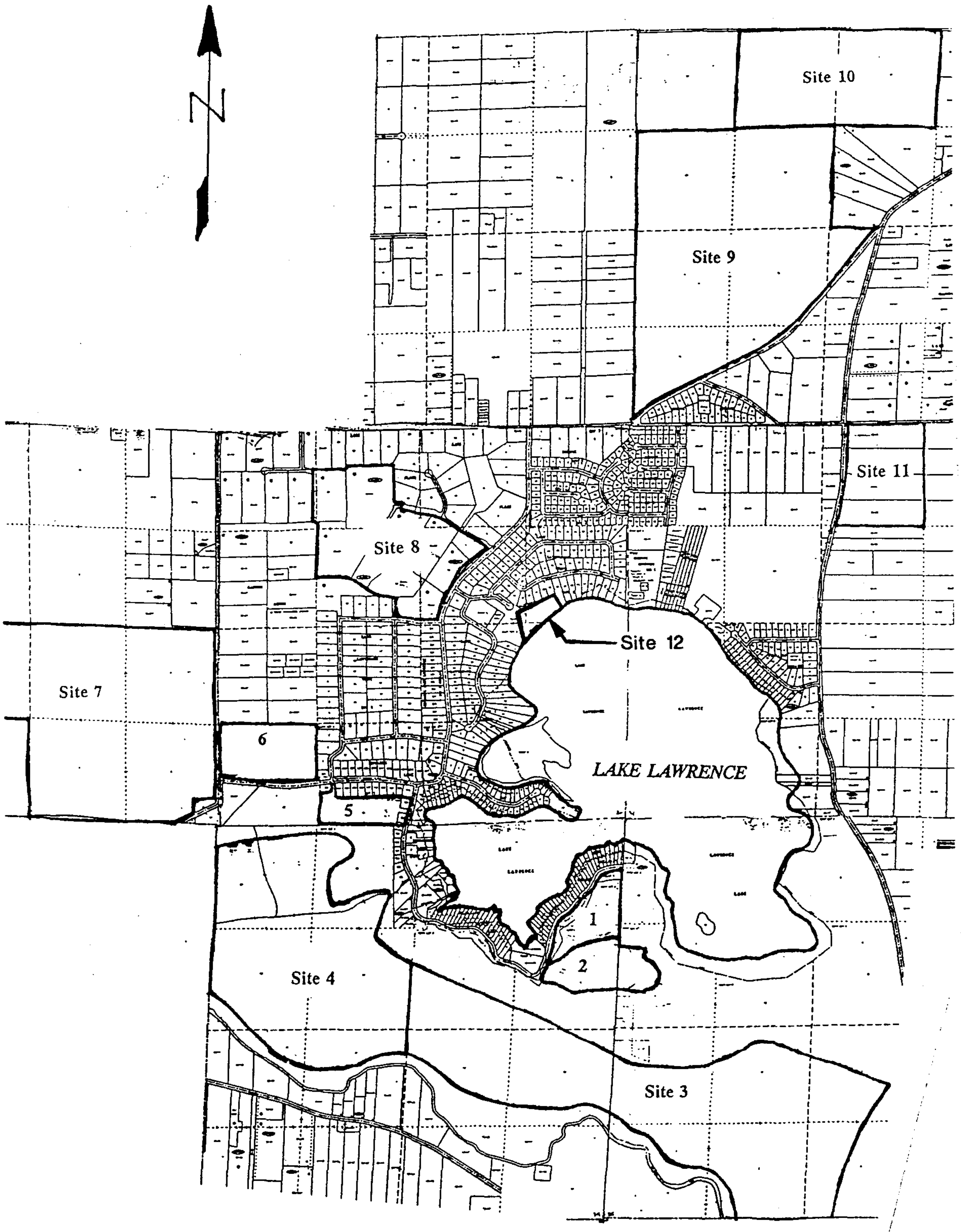
The owner of disposal Site 9 has been contacted and may be agreeable to further discussions regarding use of this site. Disposal Site 9 is located north of the East

11 Area B at the edge of the reserve and the southern edge of Area C require that the dredge make a bank cut in the organic sediment. This sediment is unlikely to hold these banks, and the sediment will infill back into these edges. The dredging quantity accounts for an the sediment feeding to the dredge at a 20:1 slope on these edges.

12 To remove nearshore sediment at the 7′ depth with 1′ overdepth, the quantity increases to 168,000 CY.

Figure 8

POTENTIAL UPLAND STAGING AND DISPOSAL SITES



Basin. The site area consists of approximately 190 acres. It is relatively flat; has been logged and planted with tree seedlings. The owner would like to return the site to this use after the disposal operation and considers the dredged sediment to be beneficial. The site size and its preferred use would allow possible slurry land application at this site, as well as a dewatering disposal site. The minimum distance from the disposal site to the East Basin shoreline is approximately 6,000 feet. Access would require crossing 12 - 20 private and County right-of-ways. Moderate clearing and grubbing activity would be required and some large trees would need to be removed from this site.

Consideration of a multiple dredging cycle project and use of different dewatering technologies allowed for smaller disposal sites to be reevaluated. Sites 5 and 8, which were eliminated in the original screening, were reconsidered.

Site 5 is located south of the West Basin. It is not large enough for a confined disposal dewatering site, but could be used as part of a slurry land application program or as a temporary handling site or stockpile site for a dredge/centrifuge dewatering system.

Site 8 is located west of the East Basin and is closer to the dredging areas than Site 9. The minimum distance from the disposal site to the East Basin shoreline is approximately 1600 feet. This site consists of approximately 14.5 acres[13] and is relatively flat. The site has been previously logged and cleared of debris. Use of this site will require that an additional site be obtained[14] to be used as an equipment staging area and that dewatered sediment be hauled from the site and not stockpiled. The size of this site would require that the dredged sediment be placed in thicker layers than at the larger sites. This could increase the time required to dewater the dredged sediment. This site is not considered to be suitable due to the limited size for upland dewatering.

Site 12, the Lake Lawrence West Community Association site located west of the East Basin has approximately 2 acres of flat area adjacent to the lake. The site is large enough to use for a temporary ponding area and equipment staging area for the dredge/centrifuge alternative. The Association has indicated that this is acceptable to them.

Upland site requirements of each alternative are discussed in Sections 3.3.6, 3.4.3, and 4.5.1.

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[13] This site was originally thought to be approximately 40 acres in previous analysis. However, it is understood that most of the site is now unavailable.

[14] Site 5 or the property across Lindsay Road could be used.

2.5.2 Confined Retention Facility and Chemical Additives

A retention facility is required for all of the Lake Lawrence project alternatives, either to settle suspended sediment from the dredge slurry for the confined disposal area dewatering alternative, to provide temporary storage for the slurry land application alternative, or to provide an intermediate sediment handling site for the dredge/centrifuge dewatering alternative.[15]

While retention implies permanent storage, this facility will not be a permanent site for sediment disposal for any of the alternatives. The dewatered sediment will ultimately be removed from the retention facility sites for all alternatives.

Based upon the lysimeter test data from the KCM 1991 Report (Appendix A), the disposal areas would be unlined.

For the confined disposal area dewatering alternative, a flocculant may be required to clarify the return water.[16] For the slurry land application alternative, adding flocculant would not be necessary, as the water would not be returned to the lake. The dredge/centrifuge alternative may require use of a flocculant to enhance the dewatering process.

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15 As discussed in Section 4, an upland site is not necessarily required for the centrifuge dewatering process and conditioning tanks can satisfy this requirement for some operations.

16 Based on the pilot test results, this is likely. The dredged sediment remained almost indefinitely in the slurry state. This was anticipated as a possibility, based on the column settling results.

3.0 LAKE RESTORATION ALTERNATIVES

3.1 Potential Treatment Alternatives

Dredging, capping, or dredging with capping as a single event were previously considered for the Lake Lawrence Restoration project to improve water quality.[17] These single dredging event alternatives did not address removal of the nearshore sediment. Non-dredging alternatives, such as flow aeration or alum treatment were not analyzed as part of the Phase II studies undertaken by HAI, as these alternatives had been determined by the KCM, 1991, Report to be less effective than dredging alternatives.

To find a cost effective solution based on dredging both nearshore and deep water sediment, phased dredging approaches were evaluated.[18, 19] Selection of the preferred alternative included analysis of three disposal alternatives:

- Dredged sediment disposal using slurry land application, discussed in Section 3.4
- Dredged sediment dewatered in confined disposal area, discussed in Section 3.3
- Dredged sediment mechanical dewatering system, using dredge/centrifuge, discussed in Section 4, as the preferred project alternative.

Regardless of the alternative selected for implementation, a confined disposal site (the size varies depending upon the alternatives) will be required. A summary of the available sites is included in Section 2.5.

3.2 Potential Treatment Alternative Selection Criteria

The three treatment alternatives, above, were compared based upon the following criteria:

- The length of time required to complete the project
- Project timing (when the dredging would be completed) and the resulting impact on recreational use of the lake. The greatest lake use is during the summer months.

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17 Reference HAI "Preliminary Treatment Alternative Design Report," dated September 10, 1993, in Appendix G.

18 Reference HAI "Preliminary Dredge and Design Report" dated November 24, 1993 with January 20, 1994 addendum in Appendix H.

19 Subsequent to this analysis, it was determined that dredging the hypolymnetic sediment was not practical based on the April 1995 survey data. Reference Section 2.4.

- The amount of upland land required for the treatment alternative and the availability of that land for project use. Upland site availability is discussed in Section 2.5.

- Noise and traffic impact on the community.

- Lake water level impact. The last several years have been unusually dry in the Lake Lawrence area and as a result, the existing lake water levels are lower than normal.

- Chemical additive requirement. This is an important consideration because existing County policy requires that the use of chemicals be demonstrated to be a necessary part of an integrated management program and that the risk to public health, ground water, and the environment be minimal.

- Cost. Due to the uncertainty of grant funding, the community desires a treatment alternative that can be potentially implemented by the community without outside assistance as they are able to raise funds for the project. As a result, the total project cost is considered to be less important than the sum of the other selection criteria.

The results as a comparison of the three alternatives based upon this criteria is summarized in the table below. Alternatives are discussed in detail in Sections 3.3, 3.4, and 4.0.

Table 3. Potential Treatment Alternative Selection Criteria Analysis Summary

Selection Criteria	Dredge/Centrifuge Dewatering System	Dredge/Confined Upland Dewatering System	Dredge with Land Application Disposal
Time Required to Complete the Project	<1 year: **least dredging time**	1- 2 years[20]	1 year
Project Timing (Impact on Land Recreational Use)	Dredging would be limited to the winter months (October through April): **least recreational impact**	Dredging would occur in 1-2 dredging increments during the summer months which would require dredge and floating pipeline to be in the lake during peak recreational periods.	Dredging could occur either during the winter or summer months.
Upland Land Required	Less than 2 acres along the shoreline: **least acreage required**	Approximately 30 acres	Approximately 30 acres for the holding pond and approximately 133 to 450 acres for the slurry application
Noise and Traffic Impact on Community:	Electric equipment operated 24 hours per day. In addition, approximately 60 ten-yard dump truck loads dewatered sediment per day for project total of 4,000 ten-yard dump trucks loads with 10 CY pup: **least impact**	Diesel equipment operated 10 hours per day and 2,000 ten-yard dump truck loads per dewatering episode (approximately 2 per year, of 6 week duration) for a project total of 4,000 ten-yard dump trucks with 10 CY pup	Diesel equipment operated 10 hours per day plus slurry pumping system.

20 1 year assumes 2 dredging/dewatering cycles per year and 2 years assumes 1 dredging/dewatering cycle per year due to wet weather.

Selection Criteria	Dredge/Centrifuge Dewatering System	Dredge/Confined Upland Dewatering System	Dredge with Land Application Disposal
Lake Level Impact	Total reduction in lake level, assuming no lake recovery is approximately 2 inches over 7 month dredging event: **least impact on lake water level**	Total reduction in lake level, assuming no lake recovery is approximately 3 inches or 1.5 inch per dredging events with 2 dredging events per year.	Total reduction in lake level, assuming no lake recovery with liquid slurry application is approximately 5 inches.
Chemical Use Requirement	Polymer could be required.	Flocculant could be required.	No chemical additives required: **least impact alternative**
Cost	$1,850,000 Summary information is included in Section 5 with estimate of probable cost data included in Appendix J.	$1,700,000 with County labor and County owned equipment: **least cost alternative** Estimate of probable cost data included in Appendix J.[21]	Feasibility level opinion of probable cost data included in HAI Report included in Appendix H[21]

3.3 Dredged Sediment Dewatering in Confined Disposal Area

The refinement of this alternative was discontinued based upon the community's decision that obtaining the required easements to locate and access the confined disposal site was not practical. The decision to use a County owned dredge with County labor was made at the beginning of the analysis based upon a long-term, multi-year project. The decision to eliminate the hypolymnetic dredging from the project, which reduced the project to a short-term dredging project, was made after the April 1995 survey information became available. This was after the decision was made by the community to pursue the dredge/centrifuge alternative. Therefore, the dredging quantities were revised but the basic assumption to use County owned equipment was not revisited.

3.3.1 Dredged Sediment Dewatering in Confined Area Description

This alternative uses standard dredging equipment to dredge the lake sediment and pump to a confined upland disposal site. In the upland site, surface water is removed from the disposal area and the dredged sediment is allowed to dry

[21] Opinion of probable cost not refined during final design and does not include some of the associated project costs included in the analysis for the selected alternative.

through transpiration and evaporation processes. This natural drying process is enhanced using trenching techniques until the sediment has sufficiently dried to be handled with standard earth moving equipment and can be removed from the disposal area.

3.3.2 Dredging Equipment

Lake Lawrence organic material is characterized by low solids content and high water content. Mechanical dredging equipment (clamshell dredge with haul barge) is not considered to be suitable for the Lake Lawrence material and the available disposal site alternatives (Section 2.5). Based upon our experience, mechanical dredging is not as cost effective as hydraulic dredging to place sediment having high moisture content and low percent solids to a remote disposal site. Hydraulic dredging (pipeline dredge) moves the sediment as a solids and water slurry.

A 10″ dredge is used as the basis of this design alternative. Its production rate of 300 in-situ CY per hour would meet project timing requirements and minimize operating, mobilization, and demobilization costs.

It is assumed, based on discussion with Thurston County, that for this alternative Thurston County would purchase and operate the dredge for this project for purposes of estimating probable costs. If this alternative were selected for implementation, then based upon the results of a bid solicitation for the work, the County and the Lake Association would determine the appropriateness of contracting or completing the work with County equipment. This alternative, as discussed in subsequent sections, is very labor intensive. As a result, it may be more cost effective to use County labor and equipment for the work than to contract for it. Each alternative is analyzed based upon the most cost effective method of completing the work, as identified during this design report. As a result the labor intensive, confined sediment pond dewatering alternative is based upon using County labor and equipment where the more capital intensive, mechanical dredge/centrifuge dewatering alternative is based upon Contractor equipment with Contractor labor.

3.3.3 Dredging Operation/Sequencing

The dredging would be completed as two dredging events per year.[22] The dredged sediment would be placed in the disposal area in approximately 2 foot lifts. The lifts will dewater[23] over a period of approximately 2-3 months of dry weather. The material would then be hauled off-site or stockpiled outside the disposal area to allow another lift of dredged material to be placed in the disposal area.[24]

During the dredging operation, floating pipeline would be routed across the lake to connect to the overland pipe to allow pumping and disposal. The amount of floating pipeline would vary depending upon the location of the dredge. The hydraulic dredge would maneuver with a system of anchors and wires. Due to the small lake size, recreational boating may be severely limited during the dredging operation. A section of partially submerged (3′ depth) pipeline can be installed to provide boat access across the lake. Floating pipeline could be stored on the lake when not in use.

Dredging production is based upon dredging project operations with one shift working 10 hours per day, 4 days per week.[25] A booster pump(s) would be required. Each dredging event would remove 60,000 in-situ CY of sediment and require approximately 5 weeks with the proposed working schedule.

3.3.4 Land-based Excavation Equipment

It is the intent of the Lake Lawrence Restoration Project to remove the fine grain organic sediment to an elevation equal to the normal high water line along the shoreline. During low water periods, varying amounts of organic sediment is exposed between the water line and the normal high water line.

A hydraulic dredge could remove organic sediment to the normal high water line, provided necessary water depth is available to float the dredge and remove the organic sediment. However, this could require overdepth dredging and the removal of non-organic soil to obtain necessary water depth, which is not the project intent.

Land-based equipment could be used in those areas during periods of extreme low water when access is available to excavate organic sediment. However, the underlying non-organic glacial till presents a potential liquefaction problem. It

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22 A particularly wet year could reduce this to one dredging event.

23 Periodic trenching will be required to enhance the drying process.

24 Ultimate disposal of dewatered sediment for this alternative will be the same as for the dredge/centrifuge alternative, discussed in Section 4.5.2.

25 The project specifications allow a contractor to bid the work based on a 12 hour day (6 am to 6 pm) 5 days (M-F) a week for diesel equipment.

has a propensity to liquify as equipment moves back and forth over it. At best this would limit equipment effectiveness and at worst make it very difficult to work. Limited site access would limit the work to small equipment.

Some Lake Association members have obtained permits and have successfully removed sediment from the nearshore areas during low water periods at Lake Lawrence. The project specifications could provide for land-based equipment, alone or in combination with the dredge, to excavate nearshore sediment during low water periods if this were the preferred alternative.

3.3.5 Disposal Site Configuration and Operation

The disposal site would be configured to include the following elements and require approximately 35 acres:

- two 11.5 acre (within the toe of dike) primary disposal cells,
- 5 acre secondary disposal cell to collect and treat, if required, return water,
- 2 acre equipment staging area for County, and
- 5 acre dewatered sediment stockpiling area.

It is assumed that 2 dredging events would occur every year and that the dredged material would dewater in 2-3 months. The retention facility would be divided into 2 primary disposal cells and 1 secondary disposal cell. One primary disposal cell would be filled completely before dredged sediment is placed into the second primary disposal cell. This would allow the first portion of the dredged sediment to begin drying while the remainder of the dredging is completed.

Water would be released from the primary disposal area into the secondary disposal area a minimum of 10 hours[26] after dredging ends. At the beginning of each work day, after the dredged slurry from the previous day's dredging has had at least 10 hours to settle, the supernatant water from the primary disposal cell could be drained into the secondary disposal cell. If sufficient settling has not occurred over night, the dredged sediment slurry can be pumped into the primary disposal cell for one week (4 working days) and allowed to settle over the weekend and then the supernatant water from the primary disposal cell could be drained into the secondary disposal cell. If additional settling time is required, the full dredging event slurry can be pumped into the primary disposal cell, prior to draining the supernatant water after the required settling is completed.

The clarified supernatant water from each primary disposal cell would be drained into the secondary disposal area over an adjustable weir. The return water would

[26] Based on results of Column Settling test included in HAI reports included in Appendixes G and H.

be treated with a flocculant, if required, and then discharged into the lake by a dewatering pump.[27] After the sediment is dewatered, it would be stockpiled and then ultimately be removed from the disposal site.

3.3.6 Disposal Site Location

As discussed in Section 2.5, the only available disposal site with the required acreage is Site 9 (Figure 8). Use of this site would required obtaining 12-20 easements for the pipeline route from the lake to the site. The difficulty and expense of accessing the site is considered to be a major impediment to implementing this alternative.

Due to the anticipated length of the project using natural dewatering alternatives, it is possible that more than one disposal site would have to be developed, if the owner desired to use the site after the project is initiated.

3.3.7 Dredged Sediment Dewatering

The material will be actively dewatered using trenching techniques[28] to enhance the drying process. After a period of 2-3 months of dry weather, it is expected that the material will be sufficiently dewatered to be handled with conventional earth moving equipment and stockpiled or hauled away from the site. At this time, another layer of dredged material could be pumped into the disposal area.

3.3.8 Dewatered Sediment Disposal/Use

As also discussed in Section 4.5.2, after the sediment is dewatered, it could be used as a soil enhancement. Dewatered dredge sediment is first spread on the soil surface and subsequently incorporated into the upper soil layer by plowing or discing. Dewatered dredged sediment application has less handling costs than slurry application alternatives. The same application rate constraints exist for dewatered sediment application as for liquid dredge slurry, such as limiting quantity of material per application. However, dewatered dredge slurry application allows for more flexibility than with an irrigation system. It does not have to be applied immediately after dredging, allowing greater latitude in finding appropriate locations. Interested parties could remove the dewatered sediment from the disposal site and apply it to their property at their convenience.[29]

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27 The need for a dewatering pump would be determined during final design depending upon the disposal site location.

28 Reference "Disposal Area Trenching and Management Plan" prepared by HAI dated January 22, 1994, in Appendix B.

29 Reference Section 3.4 for discussion of slurry application.

3.3.9 Lake Level Impacts

A discussion of Lake Lawrence water level and potential recovery rates is included in Section 4.4.3. The following analysis considers only the immediate dredging impact and does not consider lake recovery which would decrease the effect.

During dredging, approximately an equal amount of water is added to the dredged sediment by the dredging process. The confined disposal area alternative allows most of the additional water added during dredging to be removed from the disposal area within approximately 12 hours and the dredged sediment essentially returns to its in-situ condition.[30] For this analysis, a conservative assumption would be that only 80% of the added water is returned to the lake. Therefore, the impact of the dredging is the void left in the lake with the removal of the dredged sediment and additional volume of water equal to 20% of the sediment volume. Based upon removing 120,000 in-situ CY of sediment and a 330 acre lake surface area, the total water level reduction is approximately 3 inches or 1.5 inches per episode.

3.3.10 Dredged Sediment Dewatering in Confined Area Conclusions

The dredged sediment dewatering in confined area alternative is not considered to be a viable project option due to the lack of available upland sites close to the dredging areas. No upland sites of sufficient size to handle the large confined dewatering pond or land application requirements are available within 1 mile[31] of the lake. Site 9, which is approximately 1.2 miles from the lake, would be the best site for this alternative, but it would require a large number of pipeline easements to access the site and moderately extensive site work to prepare the site. This is the most significant issue for this alternative.

3.4 Slurry Land Application of Dredged Sediment

The refinement of this alternative was discontinued based upon the community's decision that the resulting loss of water from the lake was too great to be considered further in a time of very low water levels, which the lake had been experiencing over the last several years.

3.4.1 Dredging and Disposal Area

With the slurry land application alternative, the dredging would be the same as discussed in Section 3.3. The sediment would be placed in a temporary holding area, similar to that discussed in Section 3.3. However, the sediment ponds could be smaller in area, with higher dikes, as the sediment would not be dewatered.

30 Based on the pilot test experience, a chemical flocculant will likely be required to separate the sediment from the slurry.

31 A booster pump may likely be required to move sediment from the lake to a disposal site within an approximate 1 mile radius. Sites at greater than 1 mile distance from the lake may required an additional booster pump. This increases the cost and the noise for the project.

Instead, the slurry would be pumped from the ponds, through the irrigation system described below.

3.4.2 Land Application Description

Land application is usually performed with sludge, a by-product of municipal waste water treatment.[32] Sludge characteristics include high percentage of water (93% to 99.5%), high organic content (78% to 85%), and high plant nutrient levels, such as nitrogen, phosphorus, and potassium. Because Lake Lawrence organic sediment characteristics are similar to sludge, land application of Lake Lawrence organic sediment is possible.[33]

There are three types of land application that could use nutrient rich dredged sediment as a soil conditioner: agricultural application, forest application, and land reclamation. Lake Lawrence dredged sediment could serve both as a soil conditioner and as a partial replacement for commercial fertilizers.

The success of land application depends upon site characteristics, application rates, and the application system. Site characteristics include depth to ground water, distance to surface water, slope of the site, soil permeability, soil pH, soil cation exchange capacity, and depth and type of bedrock. These factors would need to be assessed before the final design of a land application system.

3.4.3 Land Application Rates

Application rates are calculated based on agronomic rates (crop needs), allowable constituent concentrations, and soil characteristics. Crop needs and soil characteristics can be determined by contacting the local soil cooperative extension agent. For Lake Lawrence dredged sediment, the limiting constituent is assumed to be nitrogen because of its potential to impact groundwater.

The application rate is the primary factor to determine the required land area. In agricultural applications, the material is applied at low rates in frequent applications.[34] In forest application and land reclamation, large quantities of material are applied at infrequent intervals.[35] Cumulative application rates are similar for both applications.

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32 Environmental Protection Agency, Environmental Regulations and Technology, Use and Disposal of Municipal Waste Water Sludge, EPA 625/10-84-003, September 1984.

33 Reference Appendix F, page 18.

34 Environmental Protection Agency, Environmental Regulations and Technology, Use and Disposal of Municipal Waste Water Sludge, EPA 625/10-84-003, September 1984.

35 Cole, Henry & Nutter, Forest Alternative for Treatment and Disposal of Municipal Wastes, University of Washington Press, 1986.

Using nutrient loading as the limiting factor, an application rate of ~33 dry tons/acre/yr (900 in-situ CY/acre/yr) was calculated. This is based on a plant nitrogen uptake rate of 440 lbs/acre/yr. A 133 acre site would be required for 120,000 in-situ CY disposal based on this approach to determining the application rate.

With this application rate, disposal Site 9 (Figure 8) would have enough area to handle the sediment over a long term disposal operation. The preferred land application site would be a large site, currently being used for agriculture. If the dredged material required mechanical integration with the existing soils at the site, such as plowing, an agricultural site which has already been cleared would be less costly to use than a location such as disposal Site 9 which has brush and logging debris on the site. A given site could be used more than one time for this disposal method.

Lake Lawrence dredged sediment nutrient levels are lower than is typical for sludge. It may be that the application rate would be limited by the potential for dredged sediment to clog the upland soil and change existing soil characteristics (e.g., permeability). Based upon discussion with Dr. Cogger, WSU Research Center, and Dick Hetherington, EPA, it appears that there is no substantive guidance for determining application rates based on sediment loading. Using a two (2) inch sediment layer (dewatered slurry) to be placed and incorporated into the soil layer,[36] an area of approximately 450 acres would be required for one-time disposal, based upon this approach to determining the application rate. A pilot study is recommended to determine if sediment loading causes any adverse impacts to the land application disposal site.

3.4.4 Land Application Systems

Liquid dredge slurry may be injected into the soil, or sprayed or spread over the soil surface. Typical methods to apply liquid slurry include using specially designed tankers, which spray a 7% solids slurry a distance of 120 feet, and using an irrigation spray system. Tanker application of liquid slurry was determined to be too expensive for disposal consideration based upon preliminary cost of tankers and the volume of slurry that each tank could haul.

A potential irrigation system for this project would include a storage pond, separator to remove debris from the dredge slurry, agitator to resuspend settled sediment, pump(s), irrigation pipeline, and reel & applicators with flex hose. This system would be portable. System component requirements would be refined in final design.

36 Personal communications with Dr. Craig Cogger, Washington State University Research Center, Puyallup, WA.

3.4.5 Lake Level Impacts

A discussion of Lake Lawrence water level and potential recovery rates is included in Section 4.4.3. The following analysis considers only the immediate dredging impact and does not consider lake recovery which would decrease the effect. The slurry land application alternative will remove water from the lake in addition to creating a void left by the dredged sediment. Essentially no water would be returned to the lake, as the water added to the sediment during the dredging process would be required to pump the sediment for the land application.

Assuming an equal amount of water is added to the dredged sediment during the dredging process, that 120,000 in-situ CY sediment is removed, and based upon a 330 acre lake surface area, the total lake reduction would be approximately 5 inches. If additional water is required to pump the sediment from the holding pond through the irrigation system, then this would increase the lake level reduction.

3.4.6 Land Application of Dredged Slurry Conclusions

This alternative would require extensive pipeline easement and a large area for the application of the slurry. An area between 133 and 450 acres would be required depending upon the approach used to determine the application rate. In addition, if land application of dredged slurry is implemented as a disposal option, the slurry would be applied directly onto the disposal site and no water would be returned to the lake. As discussed above, the agronomic application rate would dictate the amount of slurry to be placed on the disposal site, and as a result the volume of water that would be removed from the lake. Due to the significantly reduced lake levels which exist at this time, as a result of several unusually dry years, this alternative is not considered to be practicable at this time.

4.0 PROPOSED DREDGING AND CENTRIFUGE DEWATERING ALTERNATIVE

4.1 Dredging/Centrifuge Dewatering Alternative Selection Justification

The dredge/centrifuge dewatering alternative was selected as the preferred alternative for the Lake Lawrence Restoration Project because it has the least impact upon the lake community. The advantages of the dredge/centrifuge dewatering alternative over the natural dewatering alternative in a large confined upland disposal area include:

- The dredging/dewatering can be accomplished in the winter months instead of the high lake usage summer months.
- The centrifuge system requires limited upland area to process sediment, therefore a large acreage upland site is not required.
- The electrical centrifuge equipment reduces the project noise impacts.
- The centrifuge system returns more water to the lake than the other dewatering system.[37]
- The centrifuge system eliminates the significant problem of acquiring a large upland site and a numerous pipeline easements for an extended period of time.

4.2 Dredging/Centrifuge Dewatering Equipment

4.2.1 Descriptions of Operations

Centrifuge manufacturers and centrifuge/dredging companies were contacted to discuss centrifuge use to dewater the dredged sediment. Samples of the Lake Lawrence sediment were provided to centrifuge/dredging contractors and contractor representatives[38] visited the project site.

A typical dredge/centrifuge system consists of a suction dredge which removes the sediment from the lake bottom and pumps the slurry through a floating pipeline to dewatering equipment, usually located on shore. A centrifuge requires sediment that is free from debris and homogenous. As a result, the sediment is not pumped directly from the dredge into the centrifuge. The slurry is pumped from the dredge, through a screen to remove debris, and into a conditioning tank.

[37] The dredge/centrifuge system can obtain a lower more uniform moisture content and loses less moisture to evaporation because of the reduced drying time.

[38] Global Dewatering, Ltd., Edmonton, Canada, and Trimax Environmental Services, Edmonton, Canada.

The consistency of dredged slurry will vary significantly as sediment is dredged. In the conditioning tank, it is mixed to provide a more uniform consistency to feed into the centrifuge. From the conditioning tank, the slurry is pumped to a clarifier, where a polymer may be added to provide a more dense feed to the centrifuge.[39] The sediment is dewatered in the centrifuge, loaded into trucks, and removed from the site. This process is illustrated in Figure 9. The centrifuge will produce approximately 1,055 CY of dewatered sediment per day[40] based on 1,600 in-situ CY per day.[41] Information on the Global Dewatering, Ltd. dredge/centrifuge system is included in Appendix I. This system is used as the design dredge and dewatering system for this report.

Dredge/centrifuge systems generally operate at lower production rates than standard dredges. However, since they are electric powered, they are quieter than standard dredging equipment and can operate 24 hours a day in residential areas.[42] These systems are typically used in sludge pond applications which do not require dredging depths greater than 15-20 feet. A 3 phase, 480 volt, 300 amp electrical power supply is required for the dredge/centrifuge system.

The dredge/centrifuge system dredge is a 6 inch discharge dredge pump mounted on pontoons. The dredge pump operates on a system of cables and anchors and is remote controlled by an operator located on the shore. Its production rate is approximately 65 in-situ CY per hour.

4.2.2 Polymer Use

In order to provide return water which will meet water quality standards, a polymer may be required. Both contractors, after testing Lake Lawrence sediment, felt that a polymer could be required for this sediment.

Based upon the contractor sediment testing and the pilot test results, potential polymers have been selected. The selection of a specific polymer to enhance the dewatering process is considered to be a competitive advantage by the contractors. Therefore, their proposed polymer selections have been provided directly to the County and review agencies for their evaluation.

The polymer selected must comply with Thurston County's "Pest and Vegetation Management Policy" which requires that prior to use of chemicals on County

39 The polymer may also be added to the centrate as a secondary treatment to clarify the centrate.

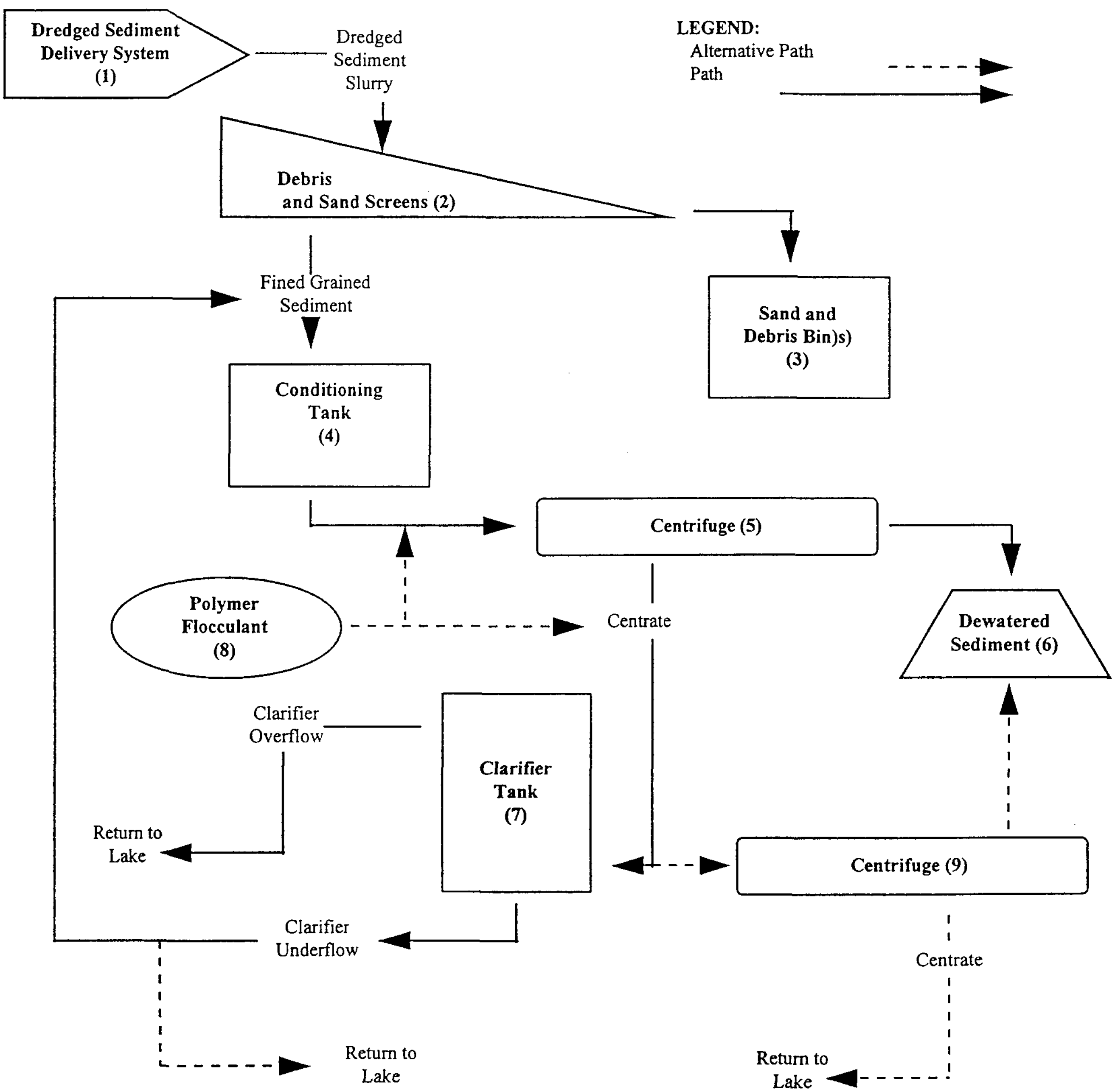
40 Based upon results of February 1995 pilot test at Lake Lawrence. See August 30, 1995 Centrifuge Production Fact Sheet, Appendix B.

41 Based upon the results of the February 1995 pilot test summarized in Appendix F.

42 Centrifuges operate at approximately 85 - 95 decibels.

Figure 9

TYPICAL DREDGE/ CENTRIFUGE PROCESS



projects, the chemical must be demonstrated to: 1) be part of an integrated solution, and 2) have minimal impact on public health, ground water, and the environment. Polymers which comply with the County policy are defined as meeting one of the following threshold criteria:

- National Sanitary Foundation (NSF) approved for use in drinking water treatments, or
- A naturally occurring product, and
- Will not adversely impact aquatic life in the lake.

Two polymers were identified as feasible for dewatering Lake Lawrence sediment during centrifuge project design:

- Polyamine polymers, such as Cytec 577C, which is NSF approved for drinking water treatment and is actively used for this purpose.
- Flocculant combinations, such as chitosan and sodium alginate, which are naturally occurring products with low concern regarding environmental impacts.

The contractor will be required to obtain County for approval for any polymer proposed for use on the Lake Lawrence project, prior to award of a contract to complete the work.

4.3 Dredge/Centrifuge Pilot Test on Lake Lawrence Sediment

The Pilot Project Test Results for Dredging/Centrifuge Dewatering Technology report is included in Appendix F.

The purpose of this pilot study was to simulate lake dredging conditions to test the effectiveness of centrifuge dewatering with and without added flocculants or clarifying additives, and to evaluate the impact of dredging on the lake.

The original test objectives[43] were:

- Evaluate the effectiveness of centrifuge dewatering on Lake Lawrence sediment, including evaluating the sediment production rate.
- Characterize the quality of the returned centrate (discharge water), as well as any improvements in the centrate quality that occur with use of test flocculants.

[43] As revised from Clingman, T., written communication.

- Characterize the dewatered sediment cake in terms of moisture content and nutrient make-up to determine its value as a soil amendment.

- Determine the general extent and duration of in-lake impacts from both dredge cutter head operations and from discharge of the centrate on turbidity, noise, and waterfowl disturbance.

The pilot project accomplished its main objectives:

- Centrifuge dewatering was found to be effective only if an appropriate flocculant is used to aid the mechanical dewatering process;

- Centrate quality under properly running centrifuge operations is high and is not expected to cause unacceptable impact to in-lake water quality;

- The sediment cake by-product can be utilized as a soil amendment;

- Dredge cutter head activity appears to cause only localized short-term impacts.

As discussed in the Pilot Test report, Appendix F, page 14, bench tests on sediment samples were performed prior to the pilot testing and additional bench testing was completed after the pilot test. The methodology was essentially unchanged during both testing periods. However, after the pilot test, the contractor was better able to judge how representative the sample sediment is of the project sediment and therefore increase level of confidence in the results.

4.4 Dredging Design

4.4.1 Dredging Operation/Sequencing

The dredging will be limited to the months of October through April to reduce the impact on use of the lake by recreational boaters. During the dredging operation, floating pipeline will be routed across the lake to connect the dredge to the dewatering system. The dredge will maneuver with a system of anchors and wires. Due to the small lake size, recreational boating may be severely limited during the dredging operation. Completing the work during the winter months will reduce this impact. A section of partially submerged (3′ depth) pipeline will be installed to provide boat access across the lake. Floating pipeline will be stored on the lake when not in use. The dredge/centrifuge system will work 24 hours per day, 7 days per week.

There are numerous private boat docks, piers and other improvements along the shoreline within and adjacent to the nearshore dredging areas. The construction details are unknown for these structures, and they may be impacted by nearshore removal of organic sediment. The County will notify property owners adjacent to dredging areas prior to start of dredging, so that property owners can take necessary precautions to protect their structures. The contract specifications will need to address how to allocate risk of damage to these structures between the contractor and the County.

4.4.2 Volunteer Labor Force

Initially it was the Community's desire to supplement the contractor labor force with volunteer labor in an effort to reduce to project cost. However, based upon the Community's difficulty in sustaining a large volunteer labor pool for the lily removal program, this is no longer considered a practicable alternative.

4.4.3 Lake Level Impacts

The lake level impact depends upon a number of factors: the ratio of water to sediment in the slurry, the length of time before the water is returned to the lake, and the length of time required by the lake system to fill the void left by the removal of the sediment. The following analysis considers only the immediate impact of a dredging event and does not consider the cumulative effect of the multiple dredging events or estimate lake recovery time.

The dredge/centrifuge system will essentially immediately return all of the water removed from the lake in the dredge slurry. This process is considered to have no effect on the lake level. Any effect on the lake level will be caused by removing the sediment from the lake bottom and increasing the volume of the lake. Based upon the results of the pilot testing, approximately 79,200 CY of cake will be removed from the lake, based upon 120,000 in-situ CY. Based on 330 acre lake surface area, the total reduction in lake level would be approximately 2 inches. The 2 inches/year is well within the normal lake elevation fluctuations, as discussed below.

As a result of natural occurring events the lake level at Lake Lawrence varies as illustrated with the following data:

- The KCM, 1991, data includes lake level elevation changes for 1990. During the period of April 1990 through January 1991, the measured lake level decreased 1.47 feet during May through September and increased 1.57 feet the following November through January.

- Based upon personal communication with an LMD member, the lake level has varied over a range of approximately 4 feet during the last 20 years, with the average elevation at 2.5 feet of that 4 foot variance.

- USGS monitored the lake stage during 1974 and found that the lake dropped 1.4 feet from 3/15/94 to 8/29/94.[44]

[44] Water Supply Bulletin 42, Parts 1-6, Data on Selected Lakes in Washington.

- Unpublished Thurston County records show that in December 1993 the lake remained 3 feet below the outlet structure elevation of 417.87 above mean sea level (NGS82/91).

The lake recovery time from dredging will vary widely based upon antecedent conditions and rainfall.

4.5 Upland Site Requirements

4.5.1 Equipment Staging Area

The dredge/centrifuge system requires the following upland staging sites as shown in plan sheet 1 of 2, Appendix K:

- 2 locations (East and West Basin) for centrifuge dewatering system and conditioning tanks (20'x50')
- 1 additional location on the East Basin for conditioning tanks (15'X15')
- 2 dewatered sediment stockpile and staging areas (minimum 1 acre) for both East and West Basin operations

Equipment access would be required for these sites and an easement from the lake to the intermediate handling site for dredge pipeline would also be required.

4.5.2 Dewatered Sediment Stockpile Area

The dredge/centrifuge system will produce approximately 1,055 CY per day of dewatered sediment. A temporary stockpile area adjacent to the centrifuge dewatering system will be provided to the contractor. The dewatered sediment will be trucked from the stockpile area to a final disposal site. Based on the pilot test results, dewatered sediment is suitable as a soil amendment.[45]

[45] Reference Appendix F, page 19.

5.0 OPINION OF PROBABLE COST FOR PREFERRED ALTERNATIVE: DREDGE/CENTRIFUGE DEWATERING SYSTEM [46] PHASE 2: NEARSHORE DREDGING[47]

5.1 General

The opinion of probable cost developed for each of the alternatives is based upon HAI's opinion of the most cost effective method to implement that alternative. The upland confined disposal area dewatering option was very labor intensive, and is based upon a 1 year project. However, with wet summers, this project could stretch into 2 years. The option of probable cost is based upon County owned equipment and County labor. The selected alternative, the dredge/centrifuge dewatering system, is very capital intensive and is completed in a relatively short period of time, <1 year. This opinion of probable cost is developed based upon contractor owned equipment with the contractor labor force.

This probable cost for the selected alternative, dredge/centrifuge dewatering system has been subdivided into three major categories:

- Contractor Pre and Post-Dredge
- Dredge, Dewater, and Haul
- Project Administration

Total estimated project cost includes contingency and Washington State Sales Tax.

The basis for opinion of probable cost is based on a combination of actual cost where available, information from contractor's cost estimating guidelines, and HAI's professional judgement. Actual project costs may vary as a result of the market forces in effect at the time the project is implemented.

5.2 Contractor Pre and Post-Dredge

Contractor pre and post-dredge costs include those incurred by the contractor prior to the start of the project, such as mobilizing equipment, those associated with mobilization and demobilization of equipment to and from the site, and those resulting from returning the equipment staging areas to their original condition.

[46] Opinions of probable cost for the confined upland dewatering alternative is included in Appendix J; and for slurry land application in Appendix H, Preliminary Dredge and Design Report dated 11/24/93, Attachment 3.

[47] A discussion of dredging hypolymnetic sediment is included in Appendix J.

5.3 Dredge Dewater, and Haul

This section details the costs for dredging the lake sediment, transporting the dredged slurry to the dewatering equipment, dewatering the sediment, depositing the dewatered sediment in the stockpile area(s), hauling dewatered sediment from the stockpile site(s), and disposing of debris from screens.

Other project related costs include surveying costs to monitor dredging progress.

Dredge/centrifuge production rate is estimated at approximately 65 CY/hour.

The dewatered sediment is assumed to be hauled to a permanent disposal location within a 20 mile radius of the stockpile site(s). The sediment is hauled 8 hours per day using 1 loader. The truck driver will operate the loaders and the trucks will haul 20 CY per load at $3.50/CY.

5.4 Project Administration

This section includes acquiring easements for the upland equipment staging sites, project supervision, water quality monitoring, post-dredge surveying, post-dredge monitoring, and permit closeout costs.

Water quality monitoring costs are based on recent small project experience. This cost is highly variable and is dependent upon Department of Ecology (DOE) requirements. It is assumed that no special requirements will be imposed on the dredging activities in the permitting process. Surveying expenses are from performing pre-dredge and post-dredge surveys for each dredging event. Each survey is assumed to take a crew of three 3 days to complete. Intermediate progress surveys are assumed to require 1 day to complete.

Project supervision/inspection is based upon an individual with survey and dredging project experience spending 8 hours/day at the project at $30/hour. This individual will be responsible for representing the County and Lake Association interests at the project, monitoring the dredging progress, reviewing Contractor reports, and administering the dredging contract.

Lake post-dredge monitoring cost was based on Thurston County experience with other lake projects. This cost is highly variable and is dependent upon DOE requirements.

5.5 Opinion of Probable Cost Summary

The following is a summary of the opinion of probable costs for this project. Centrifuge manufacturer and contractor information, and in-house expertise were used to develop estimate. Details of the opinion of probable cost and present worth analysis are included in Appendix J.

Final Engineering (100% Plans and Specifications) THIS IS NOT A PROPOSAL FOR WORK. An estimate for this work cannot be made until agency comments from the EIS process are available for review. This cost is based upon "usual" comments and changes to 90% plans and specifications.	$7,000	
10% Contingency	700	
Category Subtotal		$7,700
Dredge, Dewater, and Haul Cost	$1,257,450	
20% Contingency	251,490	
Subtotal	1,508,940	
8% Sales Tax	120,715	
Category Subtotal		1,629,655
Project Administration	$111,100	
10% Contingency	11,110	
Category Subtotal		122,210
PROJECT TOTAL		$1,848,989
LMD Handling (1%) (Roll processing, Revenue collection, and Debt payment processing)		$18,490