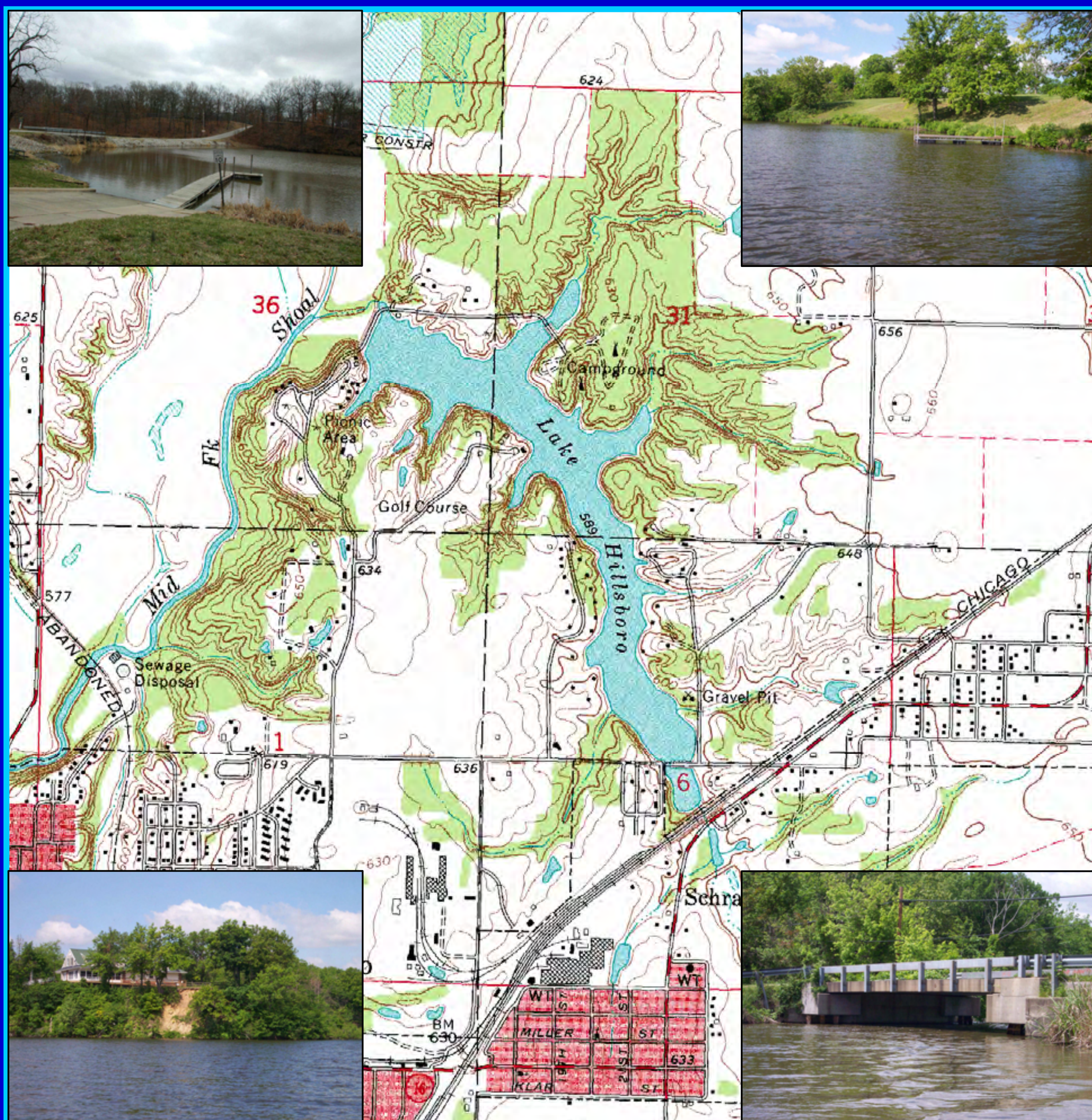
## Illinois EPA Clean Lakes Program

# Clean Lakes Study Review and Implementation Report for Lake Hillsboro, Montgomery County, Illinois

## July 2007

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# Clean Lakes Study Review and Implementation Report for Lake Hillsboro, Montgomery County, Illinois

## Introduction and Phase I Study Review

In April 2007, HDR│Cochran & Wilken, Inc. (HDR│CWI) entered into a contract with the City of Hillsboro to review the completed Phase 1 Diagnostic/Feasibility Study of Lake Hillsboro and provide recommendations for the implementation of restoration alternatives for extending the usable lifespan of the lake. The primary objectives of the Phase 1 Report recommendations were intended to reduce sediment and nutrient delivery to the lake, improve aquatic habitat and overall water quality, and improve recreational opportunities (Zahniser Institute, undated). A summary and review of the Phase 1 Diagnostic/Feasibility Study of Lake Hillsboro previously completed is provided in the following paragraphs.

The Phase 1 Clean Lakes Study reported that Lake Hillsboro is a 108 acre reservoir located in the central portion of Montgomery County, Illinois. The major tributary that feeds into the lake is an unnamed tributary of Middle Fork Shoal Creek. Lake Hillsboro is managed and owned by the City of Hillsboro, and used for recreation purposes such as swimming, boating, fishing, hiking, and camping. The lake is also used as a supplemental water supply for the City of Hillsboro. The Lake Hillsboro watershed is approximately 4,470 acres and is comprised primarily of agricultural land uses such as cropland and pasture (85 percent).

The Phase I Clean Lakes Study reported limnological data for the purpose of identifying water quality impairments. Three in-lake monitoring locations were established with Site 1 located at the northwestern end of the lake near the water supply intake, Site 2 located in the center of the lake, and Site 3 located upstream at the southeastern end of the lake. Specific water quality impairments identified in the study included turbid water, high phosphorus levels, low dissolved oxygen levels, and internal nutrient release (Zahniser Institute, undated). In order to provide a better understanding of the water quality impairments present at Lake Hillsboro, select water quality data from the previous study are summarized briefly in the following paragraphs.

Secchi transparency depth measurements at Lake Hillsboro were consistently less than two feet during the Phase 1 monitoring period (May 2001 - April 2002). Poor water clarity or turbidity was attributed to excessive suspended solids and algal populations within the water column. The Secchi readings during the 2001 – 2002 sampling period averaged approximately 20 inches at Site 1 near the dam to 15 inches at Site 3 located in the upper portion of the lake.

The lake experienced low dissolved oxygen (DO) levels at Site 1 during extended periods of the summer in 2001. During the summer stratification period, anoxic conditions (i.e., DO concentrations less than 1.0 mg/l) were present at Site 1 at water depths greater than 9 to 11 feet. The surface summer DO concentrations at Site 1 ranged from 6 to 18 mg/l. In addition to turbid water and low DO concentrations, phosphorus and nitrogen concentrations were elevated. Samples collected during the Phase 1 period indicated that high total phosphorus (TP) and total nitrogen (TN) concentrations were present throughout the lake. The water quality standard for total phosphorus of 0.05 mg/l was exceeded at Lake Hillsboro during the entire monitoring year with a mean TP concentration of approximately 0.3 mg/l during the summer. The inorganic nitrogen levels (nitrate-nitrite and total ammonia nitrogen concentrations) greatly exceeded 0.30 mg/l, a threshold known to be sufficient to stimulate excessive algal growth.

The Phase 1 Report indicated that Lake Hillsboro was eutrophic during 2001, but the Trophic State Index (TSI) was not specifically reported. After re-evaluating the water quality data, it is more likely that the lake was exhibiting hypereutrophic conditions during the productivity season (May – September 2001). Based on the graphs in the report, the annual mean values were estimated to be 20 inches for Secchi transparency at Site 1 and 17 inches at Site 3, 50 ug/L for Chlorophyll *a* at Site 1 and 60 ug/l at Site 3, and 300 ug/l for total phosphorus at each site. According to Carlson's TSI, a Secchi depth of 20 inches would correspond to eutrophic conditions (TSI ~70), whereas Chlorophyll *a* concentration of 60 ug/l (TSI >70) and a total phosphorus concentration of 300 ug/L (TSI ~85) would correspond to hypereutrophic conditions. TSI values between 50 and 70 indicate eutrophic conditions and values greater than 70 indicate hypereutrophic conditions. Based on the estimated TSI values, Lake Hillsboro exhibited consistent hypereutrophic conditions at Site 3 and eutrophic to hypereutrophic conditions at Site 1.

The aquatic plant community (i.e., macrophytes and phytoplankton or algae) and other biological resources within Lake Hillsboro appeared to be unbalanced during the Phase 1 sampling period. The aquatic macrophyte survey included terrestrial, wetland, and some aquatic species. While several emergent and floating aquatic macrophyte species were noted, submerged species were not observed during the survey. Based on the water clarity at Lake Hillsboro, these findings were not surprising and indicate that the aquatic macrophyte population could be improved. The phytoplankton population during the Phase 1 period was dominated by cyanophytes (nuisance blue-green algae), which have the ability to out-complete other more beneficial algal groups and can cause taste and odor problems for the public water supply. Several blue-green algal species reached “bloom” densities (greater than or equal to 1 million units per liter) in samples that were collected during the summer of 2001. This is supported by elevated chlorophyll levels during the summer productivity period. These imbalances in the aquatic plant populations can impact fish habitat and spawning areas within the lake.

The hydrologic budget suggests that inputs (i.e., inflow from runoff and precipitation) to the lake were overestimated and outputs (i.e., outflow from spillway discharge, water supply withdrawal, and evaporation) were underestimated. The Phase 1 total inputs and outputs of water during the May 2001 – April 2002 monitoring period were calculated at 19,256 and 8,461 acre-feet, respectively. Actual rainfall totals for the Phase 1 period (50.6 inches) strongly suggest that the initial Phase 1 hydrologic estimates (18,595 acre-feet from the watershed and tributaries and 661 acre-feet from precipitation that fell directly onto the lake) were significantly overestimated. Re-calculated hydrologic inputs based on Phase 1 precipitation totals were estimated to be approximately 4,147 acre-feet for watershed runoff and tributaries and 455 acre-feet for direct precipitation to the lake.

Nutrient (i.e., phosphorus and nitrogen) and sediment budgets were also developed by Zahniser during the Phase 1 monitoring period. The initial Phase 1 nutrient budgets suggest that most of the incoming phosphorus (82 percent) and nitrogen (74 percent) is retained and assimilated into biomass (i.e., algal blooms). Similarly, almost all the sediment (93 percent) entering the lake is retained and deposited at the bottom of the lake. It is important to note that the overestimates in the initial hydrologic budget inputs likely skewed and offset subsequent nutrient and sediment budgets, which were presumed to be based on the hydrologic budget.

As noted in the Phase 1 Report, shoreline erosion can increase overall lake sedimentation, impact aquatic plant and fish habitat, and reduce the value of shoreline property. The results of the initial Phase 1 shoreline erosion survey were reviewed and reconfirmed in the field. The 2007 survey noted an approximate total of 10,000 linear feet of eroded shoreline. Severely (bank heights >8.0 feet) and moderately (bank heights >3.0 feet and <8.0 feet) eroded shoreline accounted for 1,508 and 2,855 linear feet, respectively. These findings differ from the Phase 1 Study results, which indicated that there were approximately 300 feet of severe and 2,522 feet of moderate shoreline erosion present at Lake Hillsboro. The 754 feet of shoreline noted in the Phase 1 Report as being protected with riprap was observed to be 1,492 feet plus an additional 578 feet were found to be protected with other materials.

Previous estimates of volume loss throughout the lake have been calculated by NRCS and Hurst-Rosche Engineers using bathymetry, original lake bottom contour mapping, and depth finding equipment. Based on a sediment survey conducted by the NRCS in 1995 and bathymetric mapping performed by the Zahniser Institute in 2002, the Phase 1 Study reported that Lake Hillsboro has lost approximately 36 to 40 percent of its original capacity due to sedimentation. In order to more accurately determine the amount and location of sediment deposition throughout the lake, an updated sedimentation survey was completed by HDR|CWI in May 2007. Results of the sedimentation survey showed that only 15% of the lake's total original capacity has been lost to sedimentation. It is possible that previous estimates of volume loss may have been overestimated.

**Description and Analysis of Restoration Alternatives**

Pursuant to the information collected during the Phase 1 study period, potential alternatives for water quality improvement were developed by Zahniser and presented within the Phase 1 Report (undated). The primary alternatives with the most significant cost implications recommended for implementation by the City of Hillsboro included: 1) Sediment Removal (dredging) to be performed in the south end of lake (161,333 cy), at an estimated cost of $1,613,330 and in several smaller coves at an estimated cost of $60,000 to $150,000 per cove; 2) Shoreline Stabilization of approximately 10,484 linear feet of eroded shoreline (including slight erosion) at a total estimated cost of $431,360, or stabilization in smaller annual increments of 1,500 feet each year; 3) Installation of an Aeration System near the water intake structure at an estimated cost of $200,000; and 4) Construction of a Wetland Detention System east of South (actually Smith) Road at an estimated cost of $250,000.

Other alternatives that were less significant in cost, were to be implemented in cooperation with NRCS/SWCD, or dependent on future land owner cooperation included: 1) Stream Bank Stabilization; 2) Conservation Practices in the Watershed (i.e. riparian buffers, grassed waterways, filter strips, conservation tillage, etc.); 3) Construction of Shallow Water Wetlands and/or Storm Water Wetlands in the watershed; 4) Lake Education Programs to enhance public understanding and perception of lake and watershed water quality relationships; and 5) Reviewing and Updating City Ordinances (related to the lake).

Since the alternatives that are directly within City control (i.e., on City property) are the most feasible for immediate implementation, additional field work and analysis was completed by HDR│CWI in order to adequately evaluate and prioritize those alternatives best suited for reducing sedimentation, improving water quality, increasing water quantity, and extending the usable life span of the lake.

**Restoration Alternative: Shoreline Stabilization**

The uncontrolled erosion of shoreline areas is a source of sediment and nutrient loadings to Lake Hillsboro. There are a number of factors that contribute to shoreline erosion, including easily erodible shoreline soil types, exposure to waves generated by prevailing winds, fluctuating water levels, and a lack of near shore aquatic macrophytes and/or rock breakers. Shoreline erosion impairs lake usage and access by adding turbidity and decreasing lake storage capacity. The loss of shoreline soils may also jeopardize the stability of infrastructure, such as bridges, roads, docks, etc. In addition, shoreline loss reduces the extent and value of shoreline property and the overall aesthetic appeal of the lake.

In 2007, HDR│CWI reconfirmed the initial shoreline erosion survey completed by Zahniser during the Phase 1 study period in order to assist the City of Hillsboro with overall prioritization of needs. The 2007 survey found a total of 9,996 linear feet (1.9 miles) of shoreline along the lake to have some degree of erosion. Severely (bank heights >8.0 ft) and moderately (bank heights >3.0 ft and <8.0 ft) eroded shoreline accounted for 1,508 and 2,855 linear feet, respectively, while slightly (bank heights >1.0 ft and <3.0 ft) eroded shoreline accounted for 5,633 linear feet (see Figure 1). Approximately 2,000 feet of riprap, concrete, and wood has been placed in an attempt to stabilize the eroded shoreline and reduce erosion. Most of the stabilized locations appeared to be successful measures. In addition to the general observations and measurements, the areas exhibiting the greatest need of stabilization were documented and photographed (see Representative Photographs in Appendix). One area that should be noted is located on the west side of the lake beneath the golf course country club. The bank heights in this area are drastic (approximately 25 to 30 feet high) and unstable. This area should be monitored closely and may need measures put in place at the top of the bank in addition to shoreline stabilization at the toe to prevent future mass wasting events that could be detrimental to any structures located close to the edge of the bank.

Over the 89-year history of Lake Hillsboro, approximately 36,500 tons of soil has been eroded from the shoreline areas. These shoreline erosion estimates equate to an average annual loading of approximately 410 tons/year. The total tons of delivered soil were calculated using a dry unit weight of 100 pounds per cubic-ft for undisturbed, native soil densities. The estimated loading to Lake Hillsboro based on the 2007 shoreline survey was estimated by extending the eroded bank into the lake at a projected slope of 3:1 (3 foot horizontal to 1 foot vertical) to form a typical triangular end area. Then, the length of the eroded shoreline in linear feet was multiplied by the projected end area for each degree of classification of erosion.

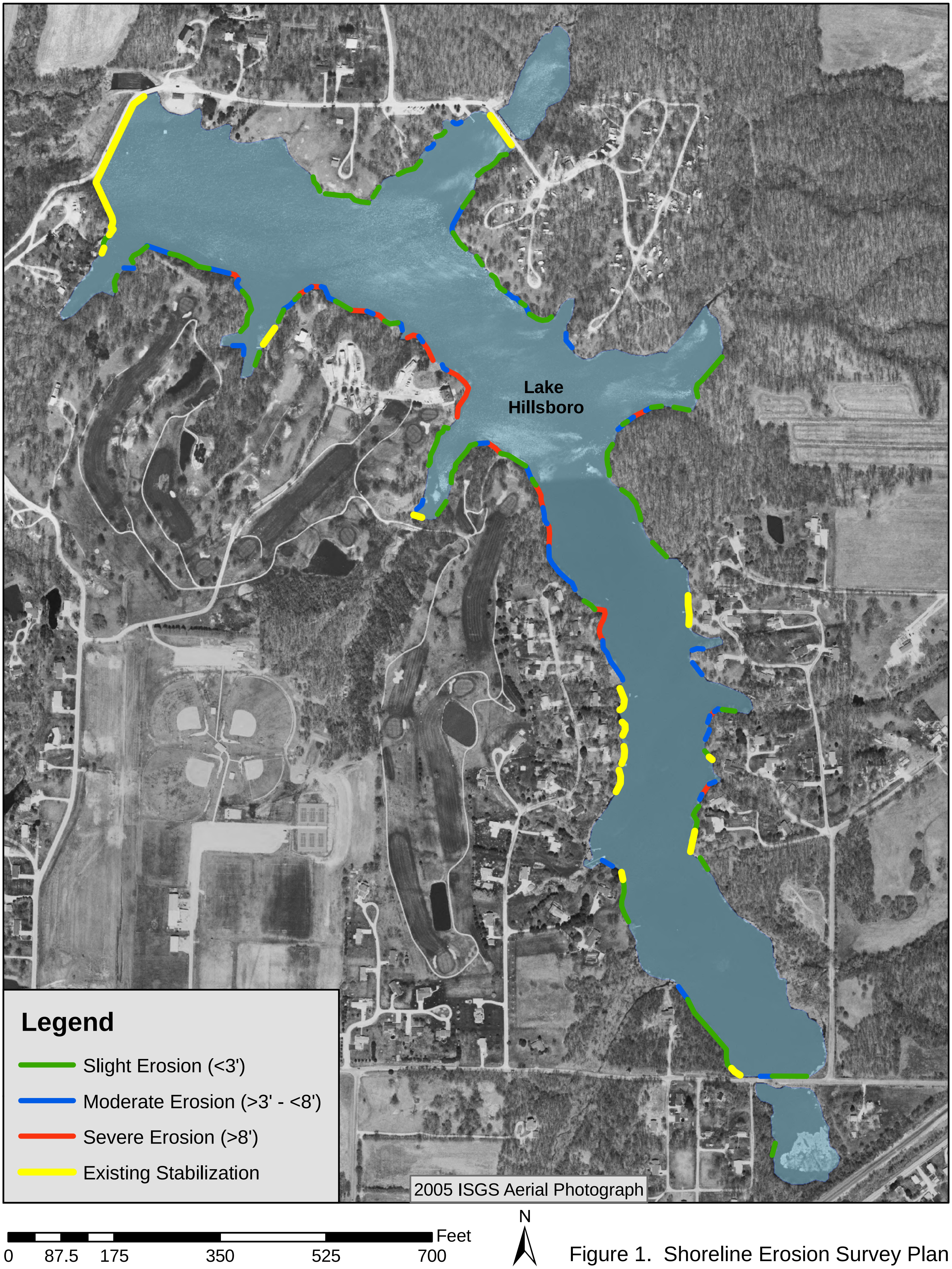



Figure 1. Shoreline Erosion Survey Plan

Summary of Findings and Proposed Actions for Shoreline Stabilization

As previously mentioned, there have been segments of shoreline at Lake Hillsboro that have been stabilized with riprap revetments and off-shore riprap, breakwater structures. Despite these minor shoreline stabilization efforts, a significant amount of eroded shoreline within the lake is in need of protection and stabilization. Technology has resulted in the development of many products to control erosion and older methods have been improved. The following were considered when deciding the best approach for stabilizing Lake Hillsboro shoreline: riprap (both crushed stone and rounded glacial stone) with filter rock or filter fabric, erosion mats, plastic and natural geowebs, gabions, and native plantings.

For the impacted areas with moderately and severely eroded shorelines, riprap is the recommended alternative to address the erosion problems at Lake Hillsboro. The advantages of riprap include its reliable longevity, ease of installation and relatively inexpensive cost over large areas. All riprap should be installed using either filter stone or filter fabric to prevent washout from behind the installed riprap. Shoreline stabilization work on this scale will require a Joint Application Permit from the Army Corps of Engineers, the Illinois Environmental Protection Agency, and the Illinois Department of Natural Resources, particularly for riprap placed as fill material beneath the normal water level.

Riprap should be placed along the undercut bank of the shoreline two feet below and two feet above normal pool (spillway elevation) at a 2:1 slope. Once the toe of the slope is protected from further undercutting by structural stabilization methods, the eroded slope will gradually slough until a state of equilibrium is reached. If a shallow, gently sloping littoral zone is present, an offshore breakwater may be feasible and would allow natural establishment of native plant species to provide additional soil stabilization and nearshore habitat. Representative photographs of shoreline stabilization options are provided in Figure 2. The estimated cost of riprap stabilization using A-grade, gradation RR4 broken stone riprap with filter fabric is approximately $60 per linear foot installed. Estimates of probable costs for shoreline stabilization at Lake Hillsboro are listed in Table 1.

Figure 2. Examples of Riprap Shoreline Protection

Shoreline Revetment

Offshore Breakwater

Table 1. Estimate of Probable Cost to Stabilize Eroded Shoreline

| Task Description | Length of Shoreline | Stabilization Method | Estimated Cost |
|---|---|---|---|
| Severe Erosion Areas (> 8') | 1,508 LF | Riprap ($60/LF) | $90,480 |
| Moderate Erosion Areas (3' - 8') | 2,855 LF | Riprap ($60/LF) | $171,300 |
| Mobilization & Site Prep. | | | $20,000 |
| Estimated Shoreline Stabilization Cost | | | $281,780 |
| Estimating Contingency (5%) | | | $14,089 |
| Engineering Design and Permitting (15%) | | | $42,267 |
| **Total Estimate of Probable Cost for Shoreline Stabilization** | | | $338,136 |

Aside from physical stabilization of moderately and severely eroded shoreline, areas that have been identified as slightly eroded should be closely monitored. This will prevent severe erosion in the future and allow for prioritization of areas that will need to be stabilized at a later date. In some cases, it is possible for extensive shoreline erosion to occur in a very short period of time; however, mass wasting events could be prevented by closely monitoring susceptible areas.

Loading reductions from the proposed shoreline stabilization actions were estimated using the Illinois EPA's Spreadsheet program entitled "Estimating Pollutant Load Reductions for Nonpoint Source Pollution Control BMP's." Table 2 summarizes the estimated annual loading reductions from the stabilization of prioritized shoreline areas.

Table 2. Estimated Loading Reductions for Shoreline Stabilization

| **Classification of Eroded Shoreline** | **Linear Feet** | **Sediment (tons/yr)** | **Phosphorus (Lbs/yr)** | **Nitrogen (Lbs/yr)** |
|---|---|---|---|---|
| Moderate (3 to 8 ft. bank heights) | 2,855 | 291 | 291 | 582 |
| Severe (> 8 ft. bank heights) | 1,508 | 385 | 385 | 769 |
| Total | 4,363 | 676 | 676 | 1,351 |

**Restoration Alternative: Sediment and Nutrient Control Basin**

Sediment and nutrient control basins can be an effective measure for controlling and isolating sediment and nutrients prior to being transported further downstream in a lake system. Construction of a wetland system with a detention pond to be located east of South Road was suggested in the Phase I Report in order to reduce sedimentation and nutrient loadings; however, a similar type of system is currently in place south of Smith Road (Figure 3). Currently, this location is owned by the City and acts as a sediment detention basin with a wetland area.

As a result of in-lake sediment and water depth measurements, it was determined that the area south of Smith Road has: 1) approx. 3,000 cu. yds. of accumulated sediment; 2) approx. 40 percent less capacity than it's original storage capacity; 3) water depths of only 3 feet or less; and 4) sediment thickness measurements over 2 feet in some areas. The sediment deposition pattern indicates that the existing roadway embankment with a bridge opening has functioned effectively over the 90 year life of the lake. As sediment continues to be transported into the lake, the relative sediment trapping efficiency of the roadway embankment and existing bridge opening will gradually decrease unless corrective measures are taken.

While the previously proposed system may enhance the trapping efficiency of the current basin south of Smith Road, it is likely that enhancing this area by removing sediment and increasing the diversity of native wetland plants would have a similar benefit. It would also be beneficial to further deepen this area by removing several feet of the underlying native soils. The added depth would provide increased trapping efficiency and extend longevity for the sediment and nutrient control basin.

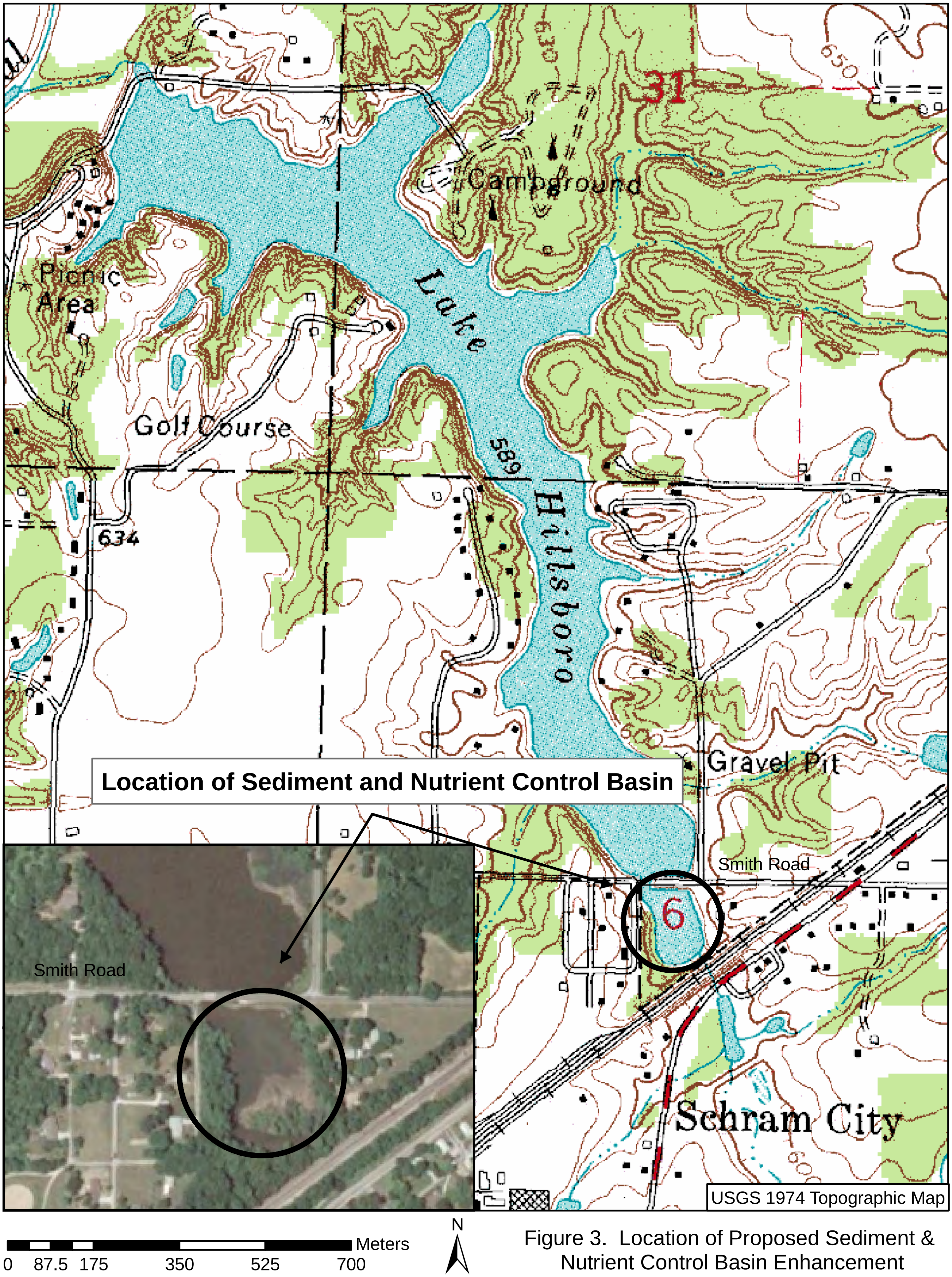



Figure 3. Location of Proposed Sediment & Nutrient Control Basin Enhancement

Probable tasks and costs for enhancement of the area south of Smith Road are listed in Table 3. The proposed sediment removal effort excludes the wetland area so that sediment trapping is enhanced and the opportunity for nutrient uptake is increased.

Table 3. Estimate of Probable Sediment and Nutrient Control Basin Enhancement

| **Sediment Removal Work Task** | **Quantity** | **Estimated Cost Range** |
|---|---|---|
| Basin Enhancement ($8.00/cy) | 7,610 cu.yds. | $60,880 |
| Dredge Mobilization and Demobilization | 1 Lump Sum | $35,000 |
| Polymers / Flocculants for Effluent Water ($1.00/cy) | 1 Lump Sum | $7,610 |
| Construct Sediment Retention/Dewatering * Facility | 1 Lump Sum | $25,000 |
| Native Plantings | 1 Lump Sum | $10,000 |
| Subtotal | | **$138,490** |
| Estimating Contingency (10%) | | $12,849 |
| Engineering and Permitting (15%) | | $19,274 |
| Illinois EPA Permit Fees (i.e. dredging, stormwater) | 1 Lump Sum | $2,109 |
| **Total Estimated Cost for Basin Enhancement** | | **$172,721** |
| Probable Site Reclamation Cost * | 1 Lump Sum | $25,000 |

* This cost is included only if the sediment basin enhancement work is completed as a stand alone project. If completed with lake dredging efforts, the dredged sediment could be placed in one storage facility.

Since sedimentation rates in most Illinois agricultural watersheds have typically decreased over the past 10 to 15 years as a result of the implementation of various conservation practices (e.g., grass waterways, vegetative buffers, conservation farming), the rate of future sediment deposition is likely to decrease. By selectively removing accumulated sediment in the basin and extending the depth several feet below the original bottom depth, the longevity and function of the current sediment and nutrient basin would be greatly increased. Estimated loading reductions for sediment removal and future sediment and nutrient trapping are listed in Table 4. Loading reductions for sediment removal activities were estimated using the mean sediment, phosphorus and nitrogen concentrations listed in the Phase I Report (Zahniser, undated) and a typical mean dry bulk density for sediment (40 lbs/CF (1,080 lbs/CY)). Loading reductions based on the functionality of a sediment and nutrient control basin on a yearly basis were calculated using the sediment and nutrient inflows reported by Zahniser (undated).

Table 4. Estimated Loading Reductions for Sediment and Nutrient Control Basin

| Parameters | Units | Sediment Removal Loading Reductions | Sediment and Nutrient Basin Loading Reductions * |
|---|---|---|---|
| Volume Removed | CY | 7,610 | NA |
| Sediment | Lbs/CY | 1,080 | NA |
| Phosphorus | mg/kg | 1,232 | NA |
| Nitrogen | mg/kg | 8,553 | NA |
| Sediment | Lbs | 8,218,800 | 3,680,013 |
| | Tons | 4,109 | 1,840 |
| Phosphorus | Lbs | 20,669 | 15,066 |
| | Tons | 10 | 46 |
| Nitrogen | Lbs | 143,495 | 91,023 |
| | Tons | 72 | 8 |

* Assumes a 50% trapping efficiency.

**Restoration Alternative: Sediment Removal**

<u>In-Lake Sedimentation Survey</u>

In May 2007, an in-lake sedimentation survey of Lake Hillsboro was completed by HDR│CWI in order to determine the extent of sediment deposition and loss of water storage capacity. Existing water depths and accumulated sediment thicknesses were measured along various cross-section transects and points throughout the lake. Figure 4 displays locations of lake segments, transect lines, and sediment core samples. The original capacity, existing capacity, and percent capacity loss were estimated using the survey data and are listed in Table 5. Cross sections that show existing water depth and sediment deposition measurements for the surveyed transects are in the Appendix.

It is important to note that two locations have functioned to prevent a large amount of sediment from entering the lake. One location is the small area south of Smith Road at the southern end of the lake. This area has trapped sediment and has allowed a delta to form in a way that has resulted in a small established wetland in the southeast corner. The second location that has benefited the lake is a very large area upstream of the lake that appeared to be a reservoir at one time (i.e., Big Four Reservoir). According to aerial photography, it is likely that sediment deposition has occurred upstream of the lake in this area. Without these two areas historically functioning as sediment traps, the amount of accumulated sediment in Lake Hillsboro would be much higher and capacity loss would be more significant.

Table 5. Sedimentation Survey Results

| Segment | Original Capacity | Existing Capacity | Sediment Deposited | Percent of Capacity Loss |
|---|---|---|---|---|
| | (cubic yards of water) | | (cubic yards) | |
| 2A | 18,295 | 9,697 | 8,598 | 47.0% |
| 3A | 67,030 | 41,815 | 25,215 | 37.6% |
| 4A | 83,938 | 61,275 | 22,663 | 27.0% |
| 7A | 151,479 | 117,197 | 34,282 | 22.6% |
| 8A | 129,721 | 104,683 | 25,038 | 19.3% |
| 9A | 146,754 | 119,980 | 26,773 | 18.2% |
| 14A | 428,336 | 369,486 | 58,850 | 13.7% |
| 23A | 725,127 | 657,838 | 67,289 | 9.3% |
| 24A | 91,588 | 84,051 | 7,537 | 8.2% |
| **SubArea A** | **1,842,268** | **1,566,023** | **276,246** | **15.0%** |
| 5B | 666 | 413 | 253 | 38.0% |
| 6B | 5,113 | 4,097 | 1,016 | 19.9% |
| **SubArea B** | **5,779** | **4,510** | **1,269** | **22.0%** |
| 10C | 10,342 | 8,540 | 1,802 | 17.4% |
| 11C | 36,168 | 31,793 | 4,375 | 12.1% |
| **SubArea C** | **46,510** | **40,334** | **6,177** | **13.3%** |
| 15D | 24,572 | 23,718 | 855 | 3.5% |
| 16D | 50,086 | 47,684 | 2,402 | 4.8% |
| **SubArea D** | **74,658** | **71,401** | **3,257** | **4.4%** |
| 21E | 1,906 | 1,746 | 160 | 8.4% |
| 22E | 14,526 | 13,218 | 1,308 | 9.0% |
| **SubArea E** | **16,432** | **14,964** | **1,468** | **8.9%** |
| 18F/20F | 576 | 444 | 132 | 23.0% |
| 19F | 1,256 | 975 | 282 | 22.4% |
| 17F | 5,934 | 4,896 | 1,038 | 17.5% |
| **SubArea F** | **7,191** | **5,871** | **1,320** | **18.4%** |
| 13G | 5,414 | 4,057 | 1,357 | 25.1% |
| 12G | 32,696 | 25,823 | 6,874 | 21.0% |
| **SubArea G** | **38,110** | **29,880** | **8,231** | **21.6%** |
| **Total** | **2,039,388** | **1,738,327** | **301,061** | **14.8%** |

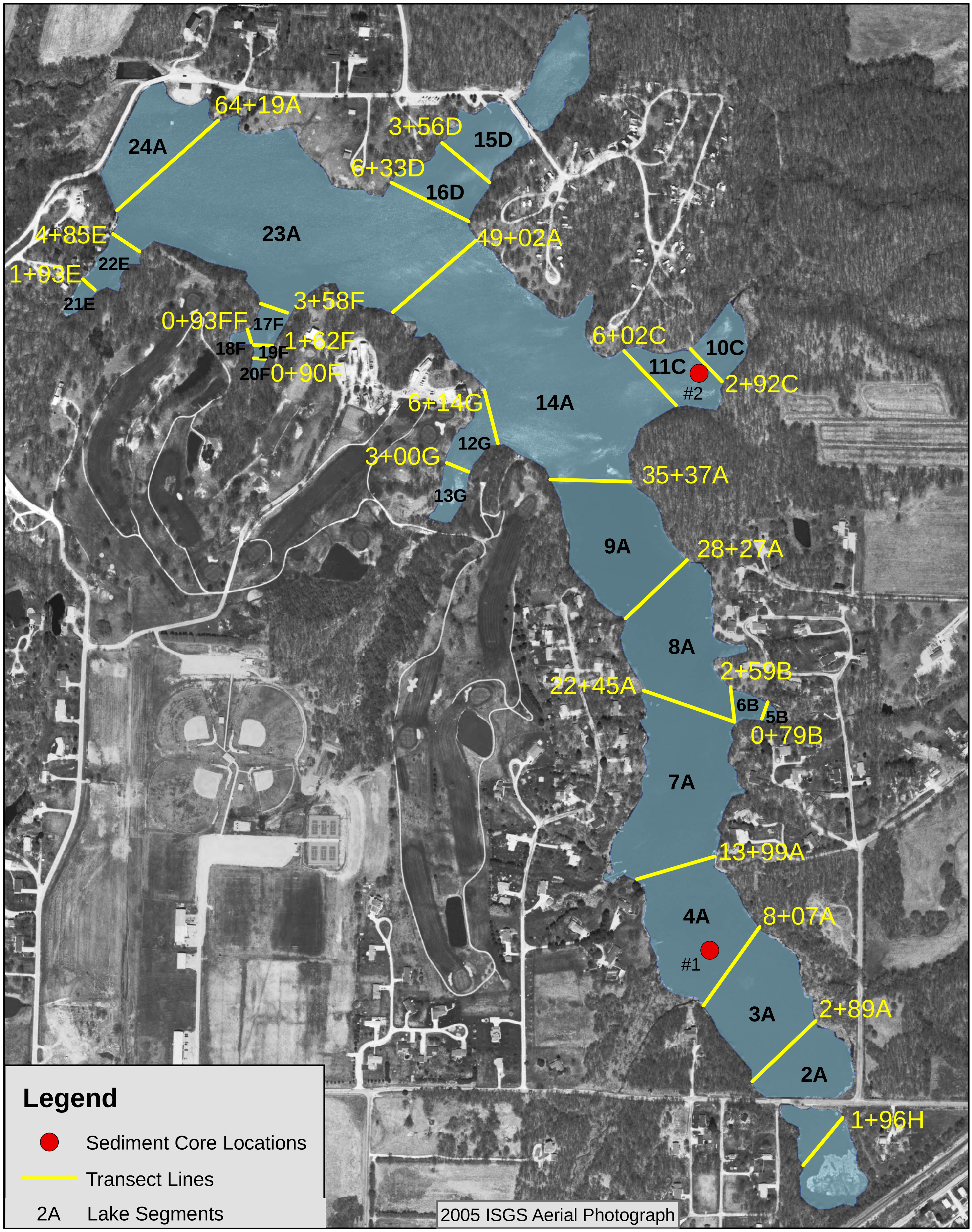



Figure 4. Sediment Survey Plan

As expected, the 2007 sedimentation survey indicated that the southern end and inlets of the lake had been impacted to the greatest degree, although several coves appear to be impacted as well. The accumulated sediments within these areas have impacted lake water quality through increased turbidity, reduced water depths, internal nutrient recycling from resuspension and/or anaerobic decomposition, which has had subsequent adverse effects on the aquatic plant communities and fish population. In addition, excessive sedimentation and shallow water depths have reduced lake access and overall recreational usage. The survey suggested that Lake Hillsboro contains approximately 300,000 cubic yards of accumulated sediment and has experienced an average sediment deposition rate of approximately 3,345 cubic yards per year over the 89 year life of the lake. Using the original volume estimate determined by HDR│CWI, this rate of sediment deposition has accounted for a water storage capacity loss of 14.8 percent over the history of Lake Hillsboro.

Sediment Removal Options

The major alternatives for removing sediment accumulation from within Lake Hillsboro include extended water level drawdown, mechanical dredging, and hydraulic dredging.

a. Lake Water Level Drawdown and Compaction

Lowering the water level and allowing the sediment to dry and consolidate is an alternative for restoring lost water depths in some lakes. However, this treatment alternative is generally a limited solution for excessive sediment deposits. In order to assure optimum drying and compaction, the water level would have to be substantially lowered for a sufficient period of time. According to a study completed by Fox et al. (1977), approximately 170 days of exposure to drying conditions would produce a sediment consolidation ranging from 7 to 50 percent, with water losses ranging from 40 to 50 percent. It would be anticipated that the sediment found in the upper arms of Lake Hillsboro would fall in the median range, and could thus be expected to consolidate approximately 25 percent. However, some of the anticipated consolidation could be reversed after refilling the lake and re-saturating the sediment.

In order to effectively reduce sediment volume in the upper end of Lake Hillsboro, water levels would have to be lowered approximately ten feet or more. A drawdown extended well into the spring or even into the summer would be difficult to implement and would negatively impact the recreational uses of the lake. Most importantly, Lake Hillsboro is an alternate public water supply and an extended drawdown could be detrimental to public need, particularly if a drought occurred during the anticipated refilling period.

b. Mechanical Dredging

There are several methods of mechanical dredging or excavation. The lake can be dredged at normal pool with a dragline, or the water level could be lowered enough to allow low ground pressure excavation equipment into the dry lakebed. There are several advantages to dry lakebed excavation as compared to hydraulic or dragline dredging, such as the elimination of excessive turbidity or resuspended solids, and a smaller quantity of material to remove due to consolidation and compaction. However, there are many disadvantages and problems that could be encountered. The length of time required for the sediment to dewater and consolidate sufficiently enough to support excavation equipment may take longer than expected if frequent rainfall events occur. Therefore, this option is not considered feasible, since watershed drainage would likely cause flooding problems within the dredging area and because Lake Hillsboro is used as an alternate public water supply that needs to remain at full pool for public need.

Another method of mechanical dredging could be accomplished with a dragline while the lake water level is at normal pool. This is accomplished by extending excavating equipment from shore, or by mounting the equipment on a barge. This method is most practical for small lakes or when a large quantity of rocks or debris is anticipated. Furthermore, the removal of accumulated lake sediment in this manner is inefficient and can leave high percentages of material behind. Offsite placement of the sediment is also very inefficient and labor intensive, since it must be handled several times. Once the sediment is removed from the lake, it must be placed on a barge or a truck and transported to the retention site. This repeated handling is generally not cost effective, and can result in sediment losses during transfer. Equipment access for the removal and placement of dredged sediment would also have a negative impact on the lake shoreline.  Therefore, mechanical dredging with a dragline would not be considered a feasible sediment removal method for Lake Hillsboro.

c. Hydraulic Dredging

Hydraulic dredging involves a centrifugal pump mounted on a pontoon or hull, which uses suction to pull the loose sediment off the bottom and pump it through a polyethylene pipeline to a sediment retention area.  Generally, a cutterhead is added to the intake of the suction line in order to loosen the accumulated or native sediment for easy transport and discharge.  A slurry of sediment and water, generally ranging between 10 and 15 percent solids (by weight), can be pumped for distances as much as 10,000 to 15,000 feet (or more) with the use of a booster pump(s).  The efficiently pumped sediment slurry must be discharged into a suitably constructed earthen dike-walled containment area with adequate storage capacity.  The sediment containment or retention area must be properly designed to allow sufficient retention time for the sediment particles to settle, and allow the clear decant or effluent water to flow through the outlet structure back to the lake.

One of the advantages of hydraulic dredging is the efficiency of sediment handling.  The removal, transport, and deposition are performed in one operation, which minimizes expenses and potential sediment losses during transport.  Another advantage is that the lake does not have to be drained, and most areas can remain open for public use.  Most hydraulic dredges are considered portable and are easily moved from one site to another.  They are extremely versatile and are capable of covering large areas of the lake by maneuvering with their spud anchorage system and moving the discharge pipeline when necessary.

Summary of Findings and Proposed Actions for Sediment Removal

Hydraulic dredging is recommended to remove the accumulated sediment in the upper portions of Lake Hillsboro.  Sediment removal at Lake Hillsboro will provide an effective improvement in water quality and recreational benefits by removing nutrient rich, accumulated sediment.  The removal of sediment will also improve and expand aquatic habitat for fish, macro-invertebrates, and other aquatic organisms.  A maximum dredge cut depth of at least 10 feet (or when the underlying hard, original lake bottom is reached) is strongly recommended in order to provide additional storage volume, extend the useful lifespan of the lake and provide a long-term water quality benefit to the lake.

The percentage of capacity loss for each sub-area and the relationship between water depth and sediment thickness were used to prioritize sub-areas for potential dredging. After eliminating those segments with adequate existing water depths (i.e., more than 8 to 10 feet), minimal sediment deposition (i.e., less than 2 feet) and minimal capacity loss, preliminary sediment removal recommendations were developed (Table 6). Dredging of six lake segments, including three segments in the main body and three segments within small coves, is recommended to restore an overall capacity of 3%. While a 3% overall gain may appear to be minimal, capacity restored in each of the targeted segments ranges from 17.5% to 47%. A proposed sediment removal plan is illustrated in Figure 5.

Table 6. Recommended Dredging Areas and Quantities

| Lake Segment | Amount of Sediment to Dredge (cu. yds.) | Capacity Restored |
|---|---|---|
| 2A | 8,598 | 47.0% |
| 3A | 25,215 | 37.6% |
| 4A | 22,663 | 27.0% |
| 5B | 1,016 | 38.0% |
| 20F | 132 | 17.5% |
| 13G | 6,874 | 21.0% |
| Total | 64,498 | 3.2% |

The sediment removed from the lake should be placed in an upland containment and dewatering site. This site should consist of flat or gently sloping land within two miles of the lake that drains back into the lake (i.e., within the watershed). Preferably, the land should be owned by the City of Hillsboro. If the City of Hillsboro does not own or have access to land within the lake's watershed to construct the detention facility, a cost effective option would be for the City to enter into an agreement with a cooperative landowner (e.g., purchase, lease, etc.) that would allow a retention site(s) to be constructed for storage and dewatering of dredged sediment.

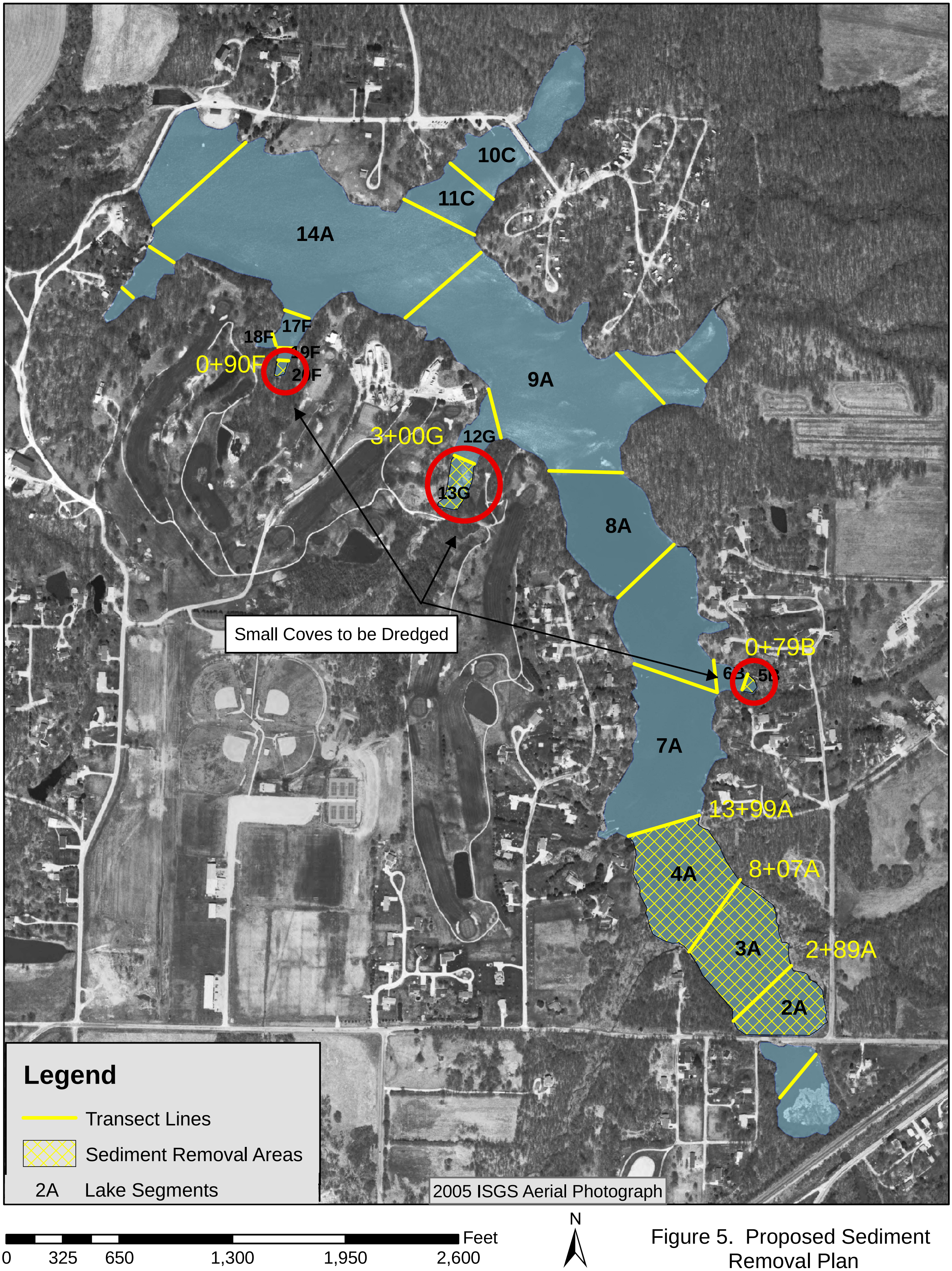



Figure 5. Proposed Sediment Removal Plan

The land utilized for sediment storage and dewatering could benefit from the reclaimed topsoil if the dried sediment is graded properly after the dredging project has been completed. For a project of this size, one to two years after dredging is complete is a normal time period to allow sufficient drying time prior to site grading and reclamation. The dredged sediments can also be land applied and beneficially reused as fertile agricultural soil and/or fill. Further evaluation and analysis will be required to find a suitable location(s) for a detention site(s).

The laboratory analyses of two sediment core samples collected by HDR|CWI indicated a very high percentage of fine grained silt and clay particles (see Appendix), which typically remain in suspension for long periods of time and re-suspend easily when agitated in shallow water. Although preliminary laboratory analysis indicated no elevated chemical constituents, a polymer or flocculent will likely be required during dredging in order to satisfy Illinois EPA effluent discharge requirements for total suspended solids (TSS) at the sediment storage and dewatering site. The flocculent would be a minimal additional cost to the overall dredging project.

The scope of engineering services for a typical dredging project include planning, design, permitting, bid document preparation and coordination of potential bidders, and construction phase oversight. Table 7 summarizes work tasks that would be required for a sediment removal project and an opinion of the estimated costs for completion based on removal of an estimated 64,498 cubic yards from Lake Hillsboro.

Table 7. Estimate of Probable Sediment Removal Costs

| **Sediment Removal Work Task** | **Quantity** | **Estimated Cost Range** |
|---|---|---|
| Dredging Lake Segments ($5.00/cy) | 64,498 cu. yds. | $322,490 |
| Dredge Mobilization and Demobilization | 1 Lump Sum | $50,000 |
| Polymers / Flocculants for Effluent Water ($0.50/cy) | 1 Lump Sum | $32,249 |
| Construct Sediment Retention/Dewatering Facility * | 1 Lump Sum | $75,000 |
| Subtotal | | **$479,739** |
| Contingency (10%) | | $47,974 |
| Engineering and Permitting (15%) | | $71,961 |
| Illinois EPA Permit Fees (i.e. dredging, stormwater) | 1 Lump Sum | $4,725 |
| **Total Estimated Cost for Dredging** | | **$604,399** |
| Probable Site Reclamation Cost | 1 Lump Sum | $50,000 |

* Approximately a 10 acre site

The preliminary estimate of probable cost for dredging all sediment within the impacted areas is $604,399. This includes higher costs that may be incurred due to longer pipeline distances and logistical challenges when dredging coves that are not in close proximity to the targeted sub-areas. It is important to note that if multiple small sediment storage sites are required, then overall project costs will be higher. Due to the variability in selection of a sediment dewatering site, costs for the land required for the retention site are not included with the opinions of probable cost listed in Table 3. The probable cost for site grading and reclamation is $50,000 and would likely be completed one to two years after dredging under a separate engineering/construction contract. More accurate costs can be determined after a detailed engineering design has been completed and prior to actual project implementation by requesting bids from several appropriately qualified dredging contractors.

The removal of approximately 64,498 cubic yards of accumulated sediment from Lake Hillsboro would restore approximately 13.0 million gallons or more than 3 percent of the lake's original 1918 volume. According to the Phase 1 Report, the City of Hillsboro uses an average of 1.3 million gallons of water per day for the public water supply. Removing the recommended volume of accumulated sediment would provide an additional 10 day supply of water for Hillsboro and the surrounding communities. This could be valuable considering Lake Hillsboro is used as an alternate water supply and can only be used for a limited amount of time due to its size.

Loading reductions for sediment removal were estimated using the mean sediment phosphorus and nitrogen concentrations listed in the Phase I Report (Zahniser, undated) and a typical mean dry bulk density for sediment (40 lbs/CF (1,080 lbs/CY)). Table 8 lists the estimated internal loading reductions from the removal of in-lake sediments (outlined in Table 6). These load reductions are substantial and will greatly benefit the water quality at Hillsboro by reducing turbidity and reducing nutrient availability under anoxic conditions.

Table 8. Estimated Loading Reductions for Proposed Sediment Removal

| Parameters | Units | Estimated Loading Reductions |
|---|---|---|
| Volume Removed | CY | 64,498 |
| Sediment | Lbs/CY | 1,080 |
| Phosphorus | mg/kg | 1,232 |
| Nitrogen | mg/kg | 8,553 |
| Sediment | Lbs | 69,657,840 |
| | Tons | 34,829 |
| Phosphorus | Lbs | 175,183 |
| | Tons | 88 |
| Nitrogen | Lbs | 1,216,183 |
| | Tons | 608 |

## Additional Management Considerations

Aeration and Destratification

Installation of an aeration system near the water intake structure was recommended in the Phase I Report in order to add oxygen to the lower portions of the lake. Artificial circulation of lakes during the summer thermal stratification period is a practice commonly used to improve water quality conditions (i.e., increase dissolved oxygen concentrations). The primary improvements in water quality that may be attained as a result of artificial aeration or circulation are reduced nutrient loading from bottom sediments, improved ecological diversity due to reduced blue-green algae dominance, increased oxygen levels, and chemical oxidation of substances in the entire water column.

Based on the Phase 1 water quality data, Site 1 (located near the dam and water supply intake) at Lake Hillsboro appears to thermally stratify at approximately 9 to 13 feet from June through mid September. The City of Hillsboro has reported some taste and odor issues associated with the public water supply; however, Glenn Shoals Lake is the primary water supply. In most public water supply lakes, taste and odor occurrences have been linked to high counts of blue-green algae within the lake. Aeration and destratification, as previously mentioned, can be effective in improving ecological diversity by restructuring the algae populations (i.e., reducing blue-green algal dominance and allowing for a more diverse and desirable algal population) and improving water quality by increasing dissolved oxygen concentrations and limiting nutrient release from anoxic bottom sediments. Given the public water supply issues, an artificial aeration or circulation system could be useful within the deep basin adjacent to the water supply intake. The limited use of the water intake at Lake Hillsboro and the fact that dominance of blue-green algae could possibly be reduced with other measures recommended in this report make artificial aeration a lower priority than other alternatives currently under consideration. However, water quality and phytoplankton counts should be continuously monitored and re-evaluated at a later date to determine if installation of an aeration and destratification system should be prioritized in the future.

Watershed Best Management Practices

As a proactive solution, increased soil conservation practices in the watershed should be promoted to reduce and minimize erosion and sediment delivery to the lake. This is especially important due to Lake Hillsboro being designated on the 303(d) list of impaired waters for elevated phosphorus levels. Since much of the phosphorus entering the lake is bound to sediment, any action that involves reducing or controlling sediment delivery will also control phosphorus levels. The local NRCS and Montgomery County SWCD have assisted the City of Hillsboro and various watershed stakeholders over the years in the implementation of various watershed best management practices (BMPs). BMPs serve to control erosion and runoff, resulting in reduced sediment and nutrient loading. Specific BMPs mentioned in the Zahniser Phase 1 Report included conservation practices such as field borders, riparian buffers and conservation tillage. As an example, allowing vegetative buffers to grow around areas of the golf course adjacent to the lake, if not already in place, would reduce nutrients transferred to the lake. Excess fertilizer carried in runoff is most likely the main contributor to the elevated phosphorus levels in the lake. Another possibility may consist of a modification to the structure that previously contained Big Four Reservoir, southeast of Lake Hillsboro, in order to create a sediment and nutrient control basin and wetland.

Although implementation of BMPs throughout the watershed may be difficult to quantify as a cost item, cooperative efforts directed towards the continued implementation of conservation practices throughout the watershed should be a high, long-term priority. In order to facilitate planning and implementation of specific BMPs strategically placed to provide maximum load reductions, development of a watershed implementation plan for Lake Hillsboro and Glenn Shoals Lake is recommended. This plan would be based on the US EPA's "Nine Elements of a Watershed Plan" and would encompass both watersheds with emphasis on areas closest to the lakes and tributaries. An estimated cost of $50,000 is recommended for completion of a combined Lake Hillsboro and Glenn Shoals Lake Watershed Implementation Plan that will serve to reduce sediment and nutrient loadings to both lakes and provide a vehicle for obtaining future funding through the US EPA Nonpoint Source Pollution Control Program (Section 319).

## Water Quality Monitoring

As restoration alternatives are implemented, it is important to have methods to measure progress. The City of Hillsboro is encouraged to conduct water quality monitoring to assess sources of pollutants and evaluate changes in water quality. Water quality monitoring will provide data and information to assist the City of Hillsboro in making future lake and watershed management decisions. For water bodies such as Lake Hillsboro where eutrophication and sediment are major problems, the US EPA (2005) recommends the following indicators to measure progress in reducing pollutants:

*Eutrophication:*

- Phosphorus loads
- Number of nuisance algal blooms
- Transparency of lake or Secchi transparency depth
- Frequency of taste and odor problems in water supply
- Hypolimnetic dissolved oxygen in lake

*Sedimentation:*

- Total suspended solid concentrations and loads
- Raw water quality at drinking water intake
- Frequency & degree of dredging of impoundments & water supply intakes

At a minimum, water quality should be measured through the Illinois EPA's volunteer lake monitoring program. Depending on the projects implemented and grants awarded, it is likely that additional post-implementation water quality monitoring will be required. The most beneficial data, however, will result from comprehensive measurement of water quality indicators on a consistent basis at more than one location. The approximate cost of a sampling program would be $15,000 per year.

It should be noted that the rate in which nutrient loads can be reduced is often dependent on the nature of the pollutants. Unlike pathogens, which tend to die off quickly once the source is removed, management practices and erosion controls designed to reduce phosphorus loadings often do not have immediate observed effects. In cases where phosphorus is the problem, it may take years to observe a response to watershed management practices.

Educational Programs

Informational and educational (I/E) programs improve and increase the public's reception to and awareness of various lake and watershed issues. Many I/E programs can be implemented throughout the community to get people involved in protecting their lake. Developing a pamphlet or brochure that summarizes the Lake Hillsboro restoration alternatives is one means of informing the public and should be strongly considered. The proposed brochure is intended to inform and educate the public about watershed and lake issues and encourage conservation practices among current and future generations. A total cost of approximately $5,000 to $10,000 should be allocated for this purpose.

Fisheries Management

According to a status report submitted by IDNR in 2002, Lake Hillsboro provides good fishing opportunities and the fish population has remained relatively stable over the years. The fishery will benefit from improved water quality (as a result of reduced sediment and nutrient inputs), continued stocking, and current fishing regulations; however, it is recommended that several fish attractors be installed to further enhance fish habitat and improve fishing opportunities. These structures could be installed in conjunction with shoreline stabilization and would cost approximately $5,000 to $10,000 including planning, engineering, and technical consultation.

**Prioritized Recommendations for Lake Hillsboro**

In summary, HDR│CWI recommends implementation of the restoration alternatives listed below in order to improve and increase the quantity and quality of water for the public water supply, improve water quality for lake aesthetics, and support a more balanced aquatic habitat for the fish population and surrounding ecosystem. In addition to these benefits, alternatives implemented will reduce phosphorus loadings to the lake and contribute to satisfying TMDL requirements.

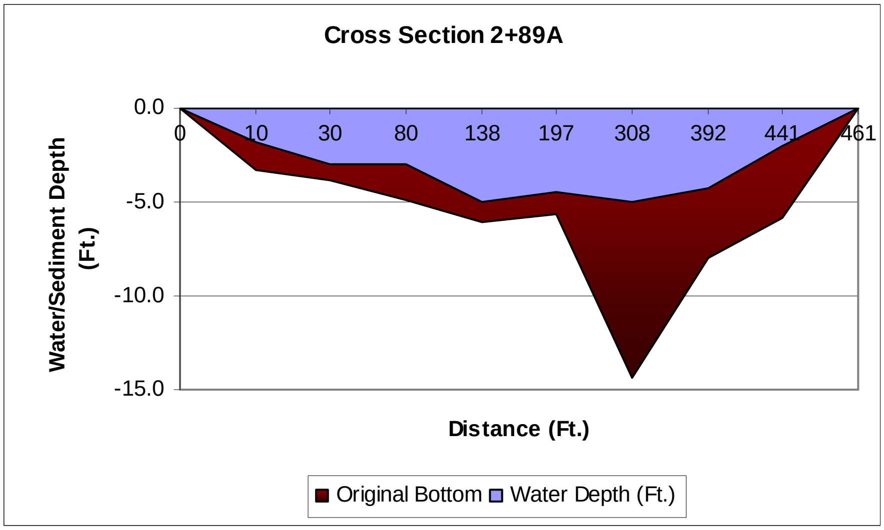
Promotion and implementation of watershed BMPs in conjunction with development of a watershed implementation plan, water quality monitoring, installation of fish habitat structures, and distribution of an education brochure are items that will enhance the outcome of major restoration alternatives. The major restoration alternatives should be prioritized in the following order: 1) the stabilization and protection of approximately 4,363 linear feet of eroded shoreline at an estimated cost of $338,136, 2) enhancement of the sediment and nutrient control basin by removing an estimated 7,610 cubic yards of sediment at a preliminary estimated cost of $197,721 (not including land acquisition costs for sediment storage, if required), and 3) the removal of approximately 64,498 cubic yards of accumulated sediment at a preliminary estimated cost of $654,399 (not including land acquisition costs for sediment storage, if required). Although an aeration and destratification system is considered to be a lower priority than the alternatives listed above, it should be considered for future implementation. Continuous management and implementation of restoration alternatives for Lake Hillsboro and its watershed can improve lake water quality, enhance aesthetic and recreational opportunities, enhance water storage capacity, and provide habitat for game fish and other wildlife. HDR│CWI would be pleased to assist the City in the design and implementation of these measures in an ongoing effort to restore Lake Hillsboro and extend the useable lifespan for many decades to come.

# APPENDIX

Sediment Survey Cross-Sections

Laboratory Analyses of Sediment Core Samples

Representative Photographs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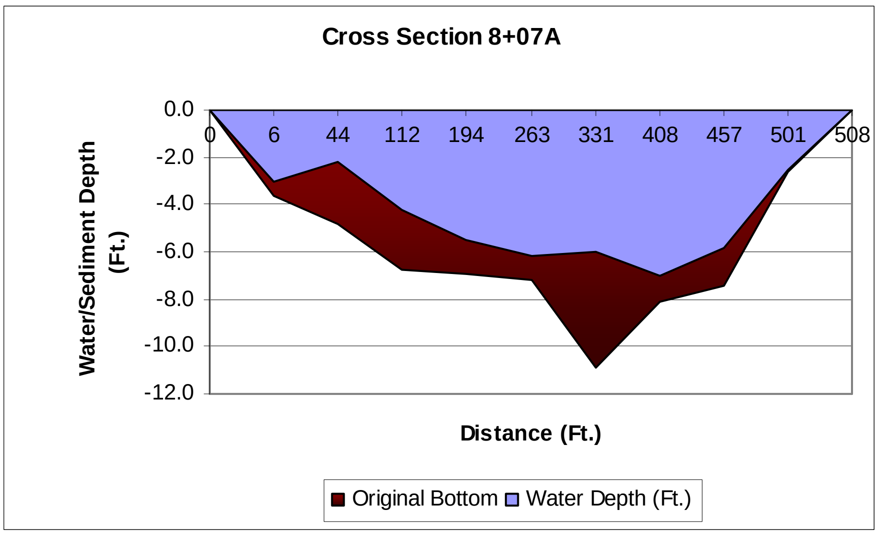
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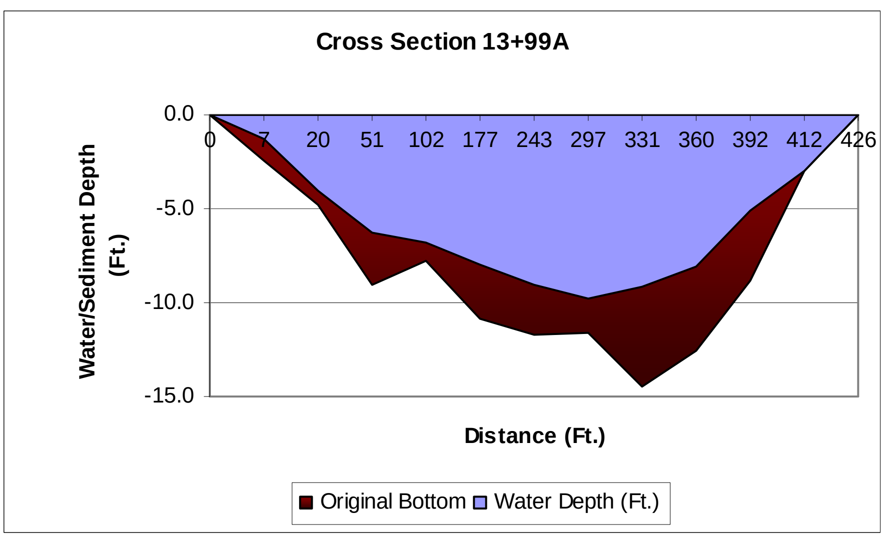
Water Depth (Ft.)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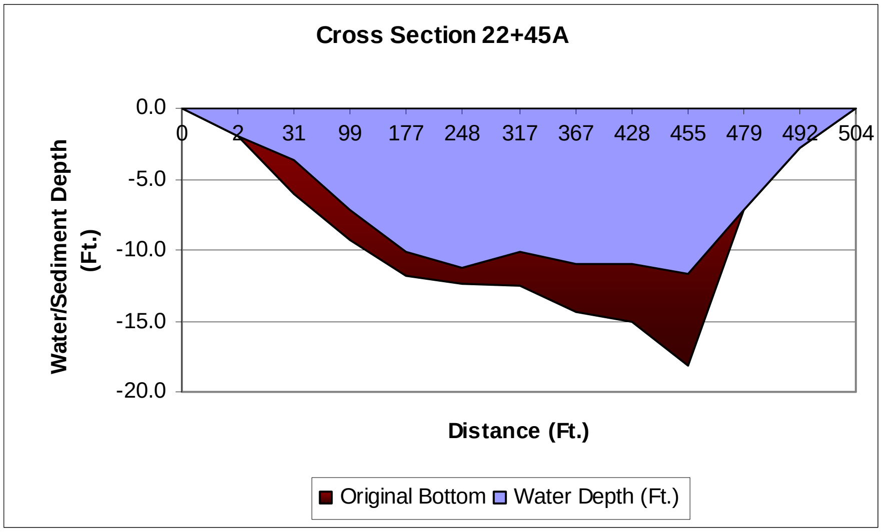
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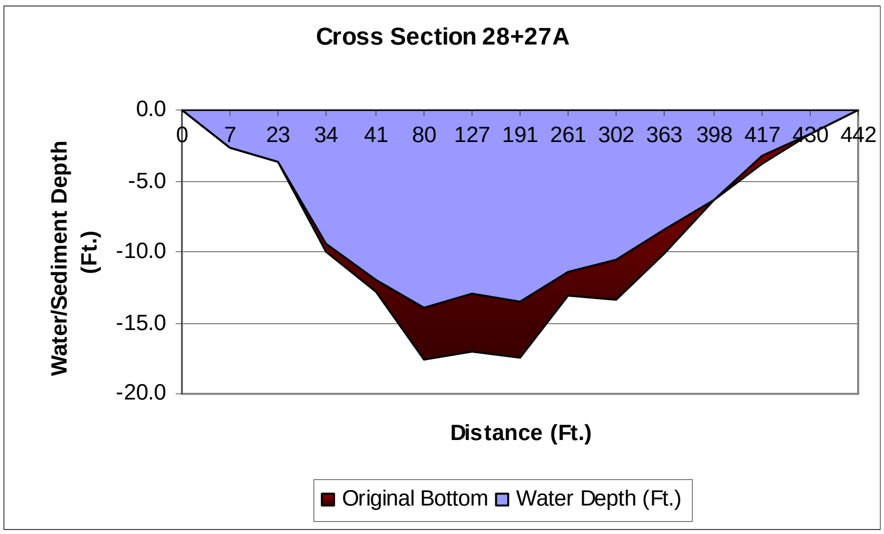
Water Depth (Ft.)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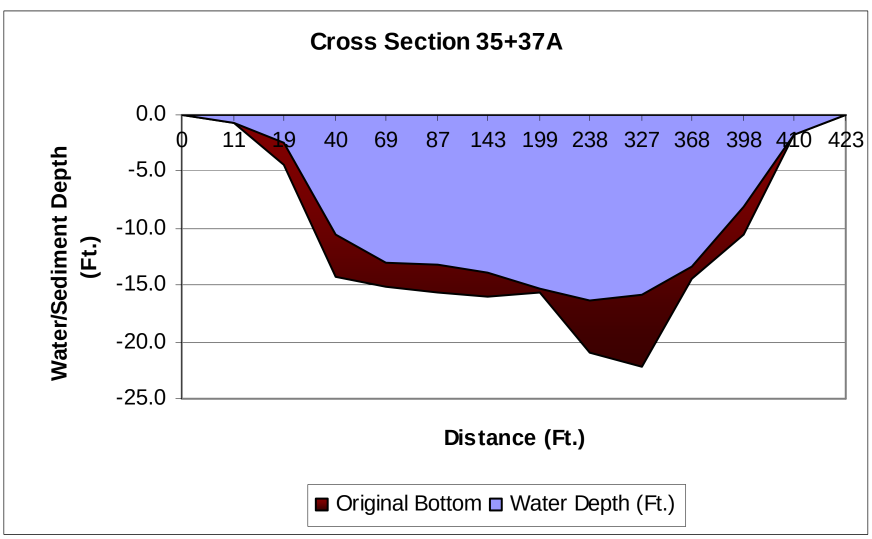
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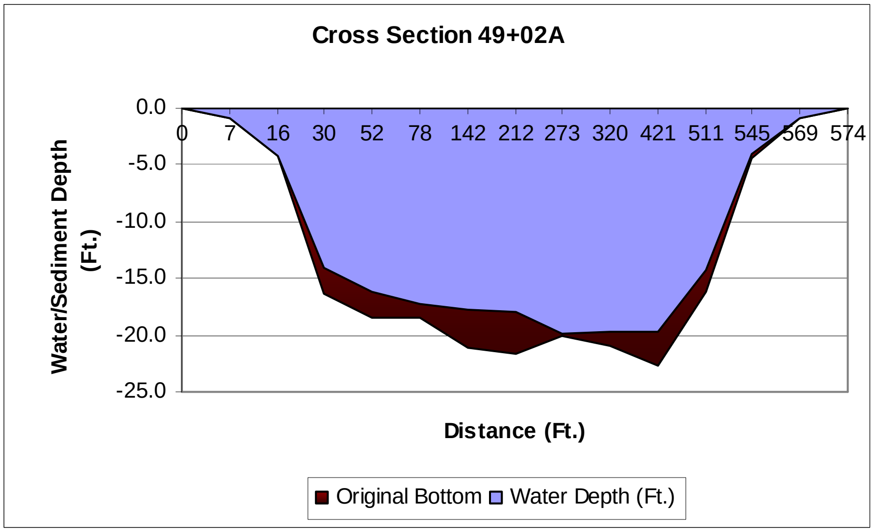
Original Bottom
Water Depth (Ft.)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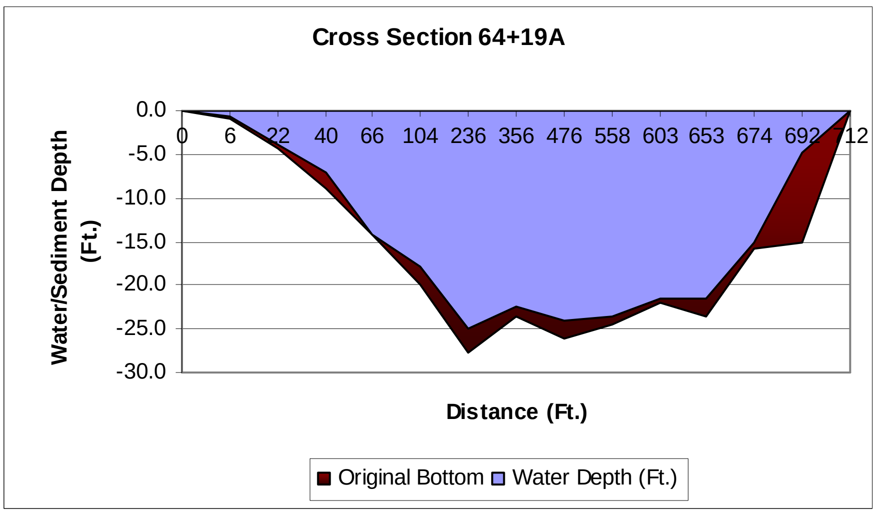
Original Bottom
Water Depth (Ft.)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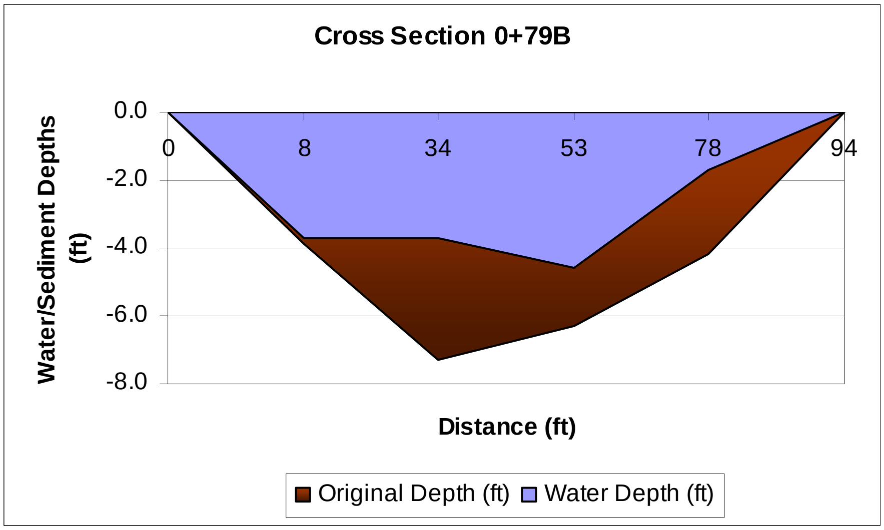
Original Bottom
Water Depth (Ft.)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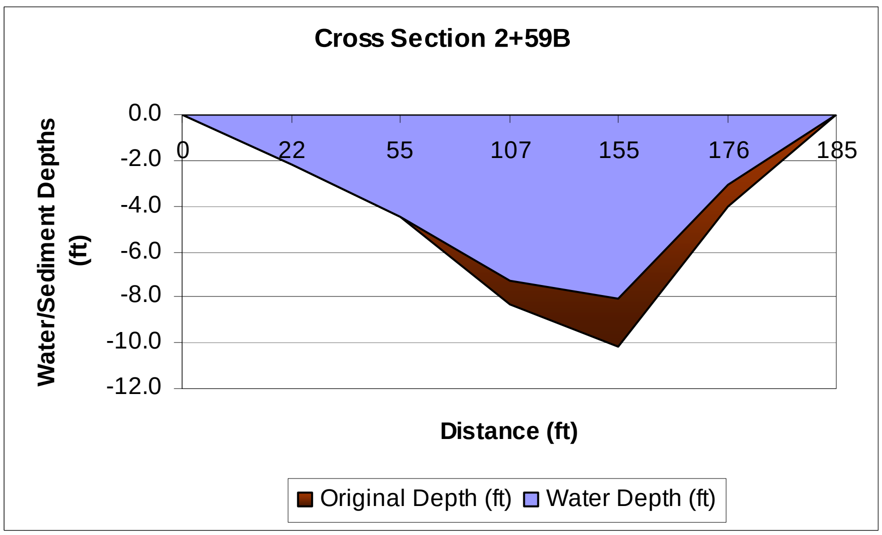
Water Depth (ft)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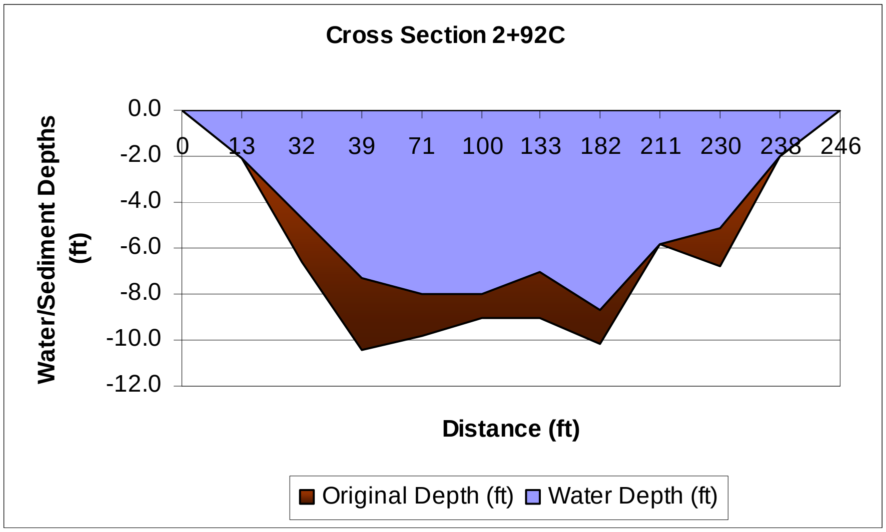
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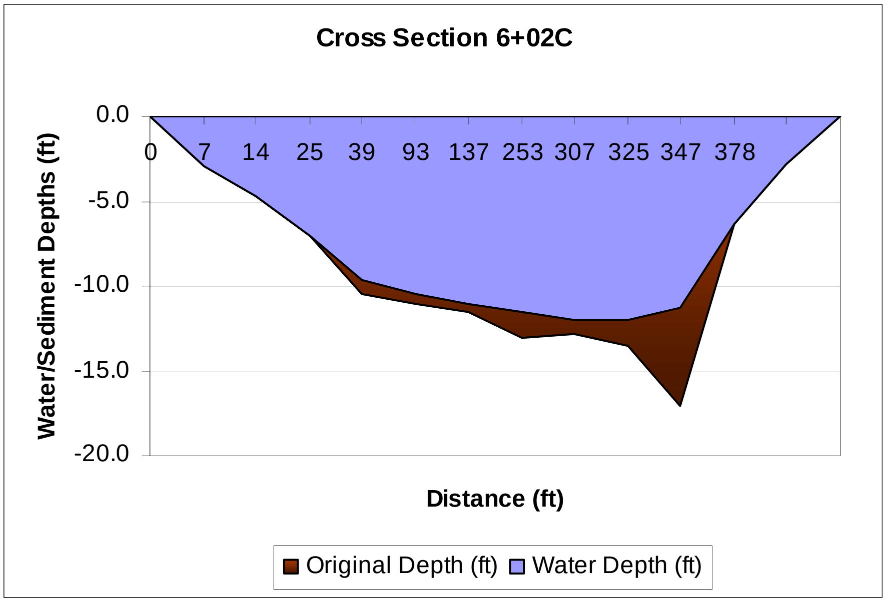
Water Depth (ft)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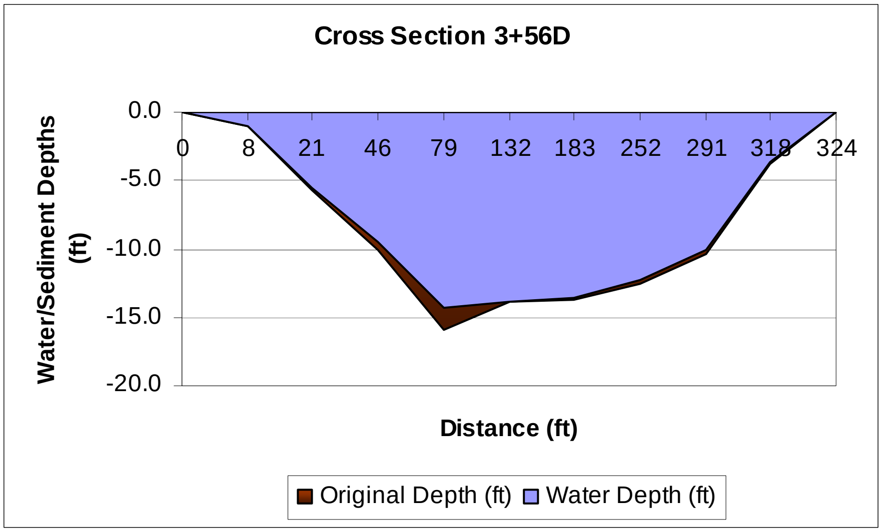

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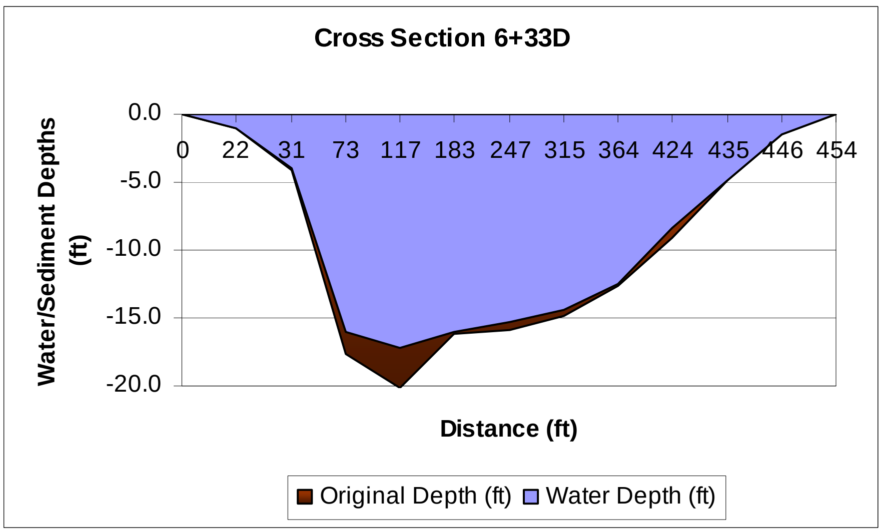

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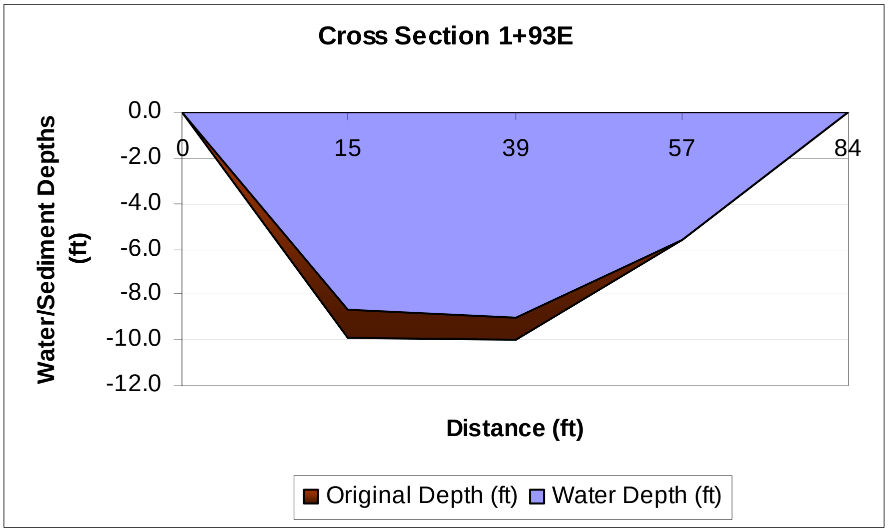
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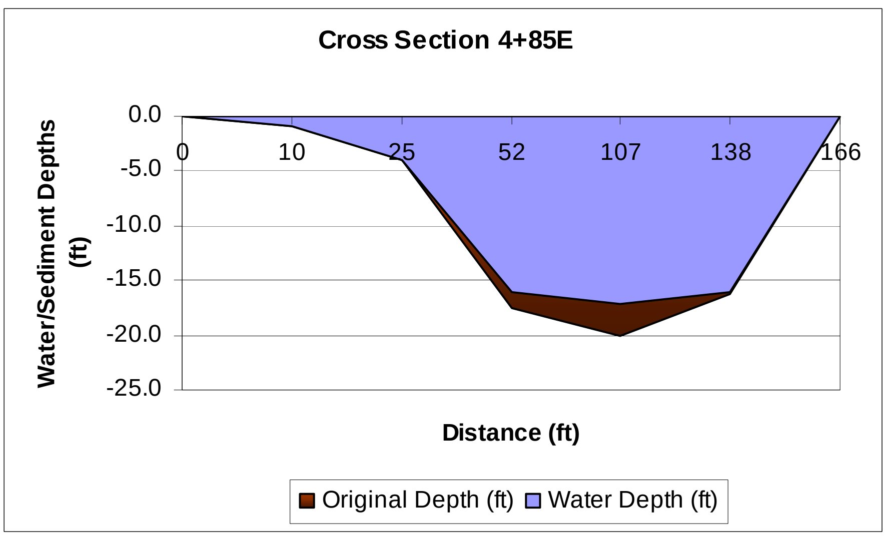
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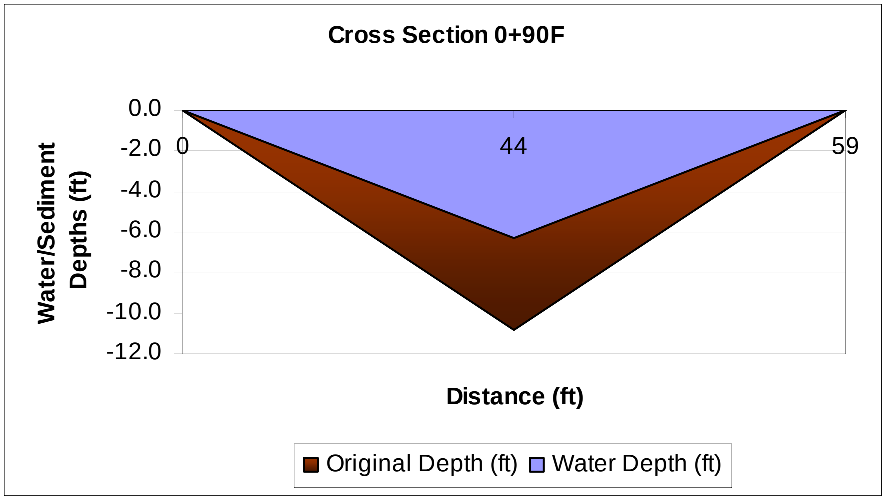
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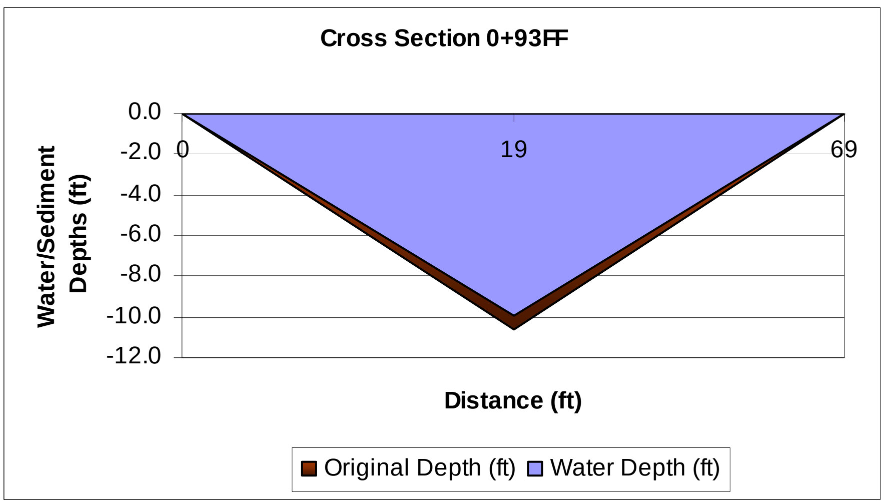
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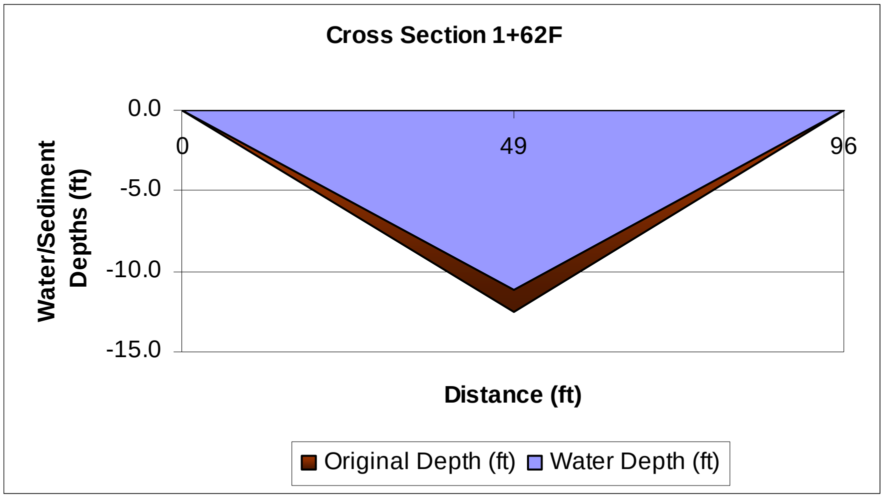
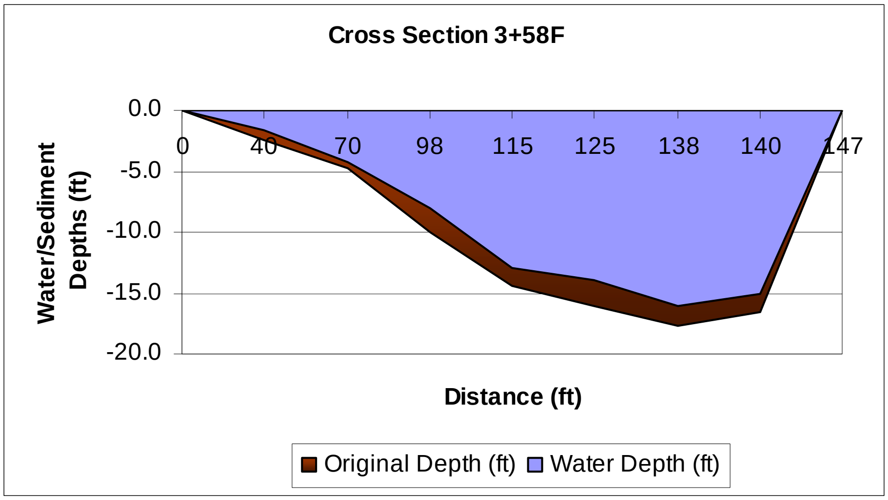
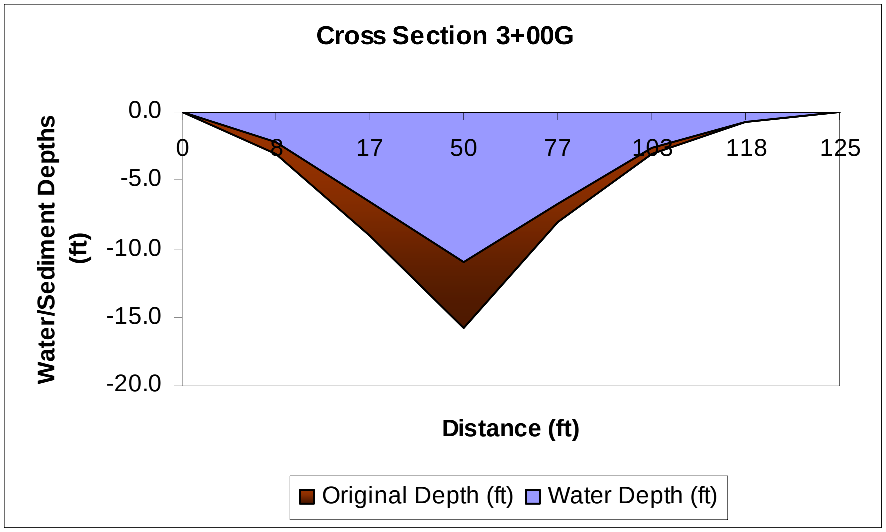
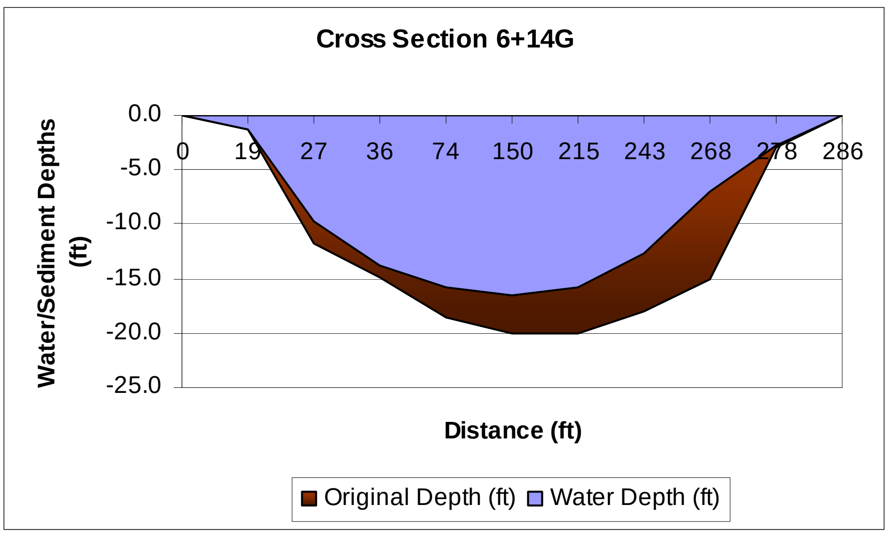
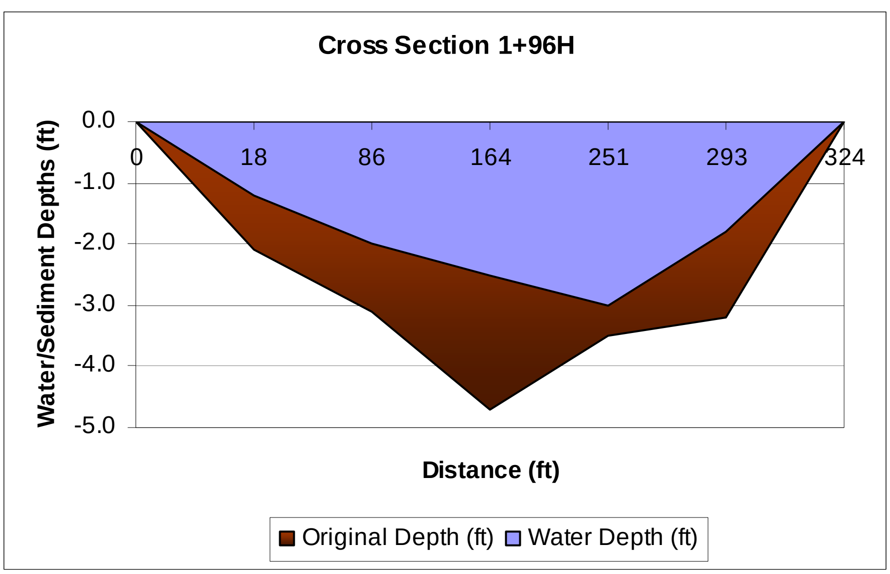
Original Depth (ft)
Water Depth (ft)


Cross Section 1+62F
0.0
-5.0
-10.0
-15.0
0
49
96
Water/Sediment Depths (ft)
Distance (ft)
Original Depth (ft)
Water Depth (ft)


Cross Section 3+58F
0.0
-5.0
-10.0
-15.0
-20.0
0
40
70
98
115
125
138
140
147
Water/Sediment Depths (ft)
Distance (ft)
Original Depth (ft)
Water Depth (ft)


Cross Section 3+00G
Water/Sediment Depths (ft)
0.0
-5.0
-10.0
-15.0
-20.0
0
8
17
50
77
103
118
125
Distance (ft)
Original Depth (ft)
Water Depth (ft)


Cross Section 6+14G
Water/Sediment Depths (ft)
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
0
19
27
36
74
150
215
243
268
278
286
Distance (ft)
Original Depth (ft)
Water Depth (ft)


Cross Section 1+96H
Water/Sediment Depths (ft)
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0
18
86
164
251
293
324
Distance (ft)
Original Depth (ft)
Water Depth (ft)

# Laboratory Analyses of Sediment Core Samples

An Analytical
Testing Laboratory

Prairie Analytical Systems, INCORPORATED

1210 Capital Airport Drive
Springfield, Illinois 62707
Phone: 217-753-1148
Fax: 217-753-1152
www.prairieanalytical.com

June 04, 2007

Mr. Peter Berrini
HDR/Cochran & Wilken, Inc.
5201 South Sixth Street
Springfield, IL 62703

RE: Lake Hillsboro

PAS Order No.: 0705207

Dear Mr. Peter Berrini:

Prairie Analytical Systems, Inc. received 2 samples on 5/21/2007 5:00:00 PM for the analyses presented in the following report.

All applicable quality control procedures met method specific acceptance criteria.

This report shall not be reproduced, except in full, without the prior written consent of Prairie Analytical Systems, Inc.

If you have any questions, please feel free to call me at (217) 753-1148.

Sincerely,

Michael D. Brophy
Project Manager

# Prairie Analytical Systems, Inc.

**Date:** *04-Jun-07*

| | | | |
|---|---|---|---|
| **CLIENT:** | HDR/Cochran & Wilken, Inc. | **Client Sample ID:** | #1 |
| **Lab Order:** | 0705207 | **Tag Number:** | |
| **Project:** | Lake Hillsboro | **Collection Date:** | 5/17/2007 2:30:00 PM |
| **Lab ID:** | 0705207-001A | **Matrix:** | SOLID |

| Analyses | Result | Limit | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **PARTICLE SIZE ANALYSIS** | | **D422** | | | | Analyst: **SUB** |
| Gravel | 0 | 0.01 | | % | 1 | 6/2/2007 |
| Sand | 8.2 | 0.01 | | % | 1 | 6/2/2007 |
| Silt | 40.7 | 0.01 | | % | 1 | 6/2/2007 |
| Clay | 51.1 | 0.01 | | % | 1 | 6/2/2007 |

# Prairie Analytical Systems, Inc.

**Date:** *04-Jun-07*

| | | | |
|---|---|---|---|
| **CLIENT:** | HDR/Cochran & Wilken, Inc. | **Client Sample ID:** | 4 Hour Supernatant |
| **Lab Order:** | 0705207 | **Tag Number:** | |
| **Project:** | Lake Hillsboro | **Collection Date:** | 5/17/2007 2:30:00 PM |
| **Lab ID:** | 0705207-001C | **Matrix:** | AQUEOUS |

| Analyses | Result | Limit | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **METALS ANALYSIS** | | **E200.8** | | **(SW3005A)** | | Analyst: **MCL** |
| Lead | 0.0719 | 0.00200 | | mg/L | 1 | 5/30/2007 7:35:00 PM |
| Zinc | 3.46 | 0.100 | | mg/L | 10 | 5/31/2007 11:05:00 AM |
| **TOTAL SUSPENDED SOLIDS ANALYSIS** | | **M2540 D** | | | | Analyst: **RMN** |
| Total Suspended Solids | 1150 | 16.0 | | mg/L | 1 | 5/31/2007 8:00:00 PM |
| **VOLATILE SOLIDS ANALYSIS** | | **M2540 E** | | | | Analyst: **AJD** |
| Total Volatile Solids | 124 | 50.0 | | mg/L | 1 | 6/1/2007 |
| **AMMONIA ANALYSIS** | | **M4500-NH3 F** | | | | Analyst: **AJD** |
| Ammonia (as N) | 3.70 | 0.100 | | mg/L | 1 | 5/30/2007 4:12:00 PM |

## Prairie Analytical Systems, Inc.

**Date:** *04-Jun-07*

| | | | |
|---|---|---|---|
| **CLIENT:** | HDR/Cochran & Wilken, Inc. | **Client Sample ID:** | 24 Hour Supernatant |
| **Lab Order:** | 0705207 | **Tag Number:** | |
| **Project:** | Lake Hillsboro | **Collection Date:** | 5/17/2007 2:30:00 PM |
| **Lab ID:** | 0705207-001D | **Matrix:** | AQUEOUS |

| Analyses | Result | Limit | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **TOTAL SUSPENDED SOLIDS ANALYSIS** | | **M2540 D** | | | | Analyst: **RMN** |
| Total Suspended Solids | 107 | 8.00 | | mg/L | 1 | 5/31/2007 8:00:00 PM |

## Prairie Analytical Systems, Inc.

**Date:** *04-Jun-07*

| | | | |
|---|---|---|---|
| **CLIENT:** | HDR/Cochran & Wilken, Inc. | **Client Sample ID:** | #2 |
| **Lab Order:** | 0705207 | **Tag Number:** | |
| **Project:** | Lake Hillsboro | **Collection Date:** | 5/17/2007 2:30:00 PM |
| **Lab ID:** | 0705207-002A | **Matrix:** | SOLID |

| Analyses | Result | Limit | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **PARTICLE SIZE ANALYSIS** | | **D422** | | | | Analyst: **SUB** |
| Gravel | 0 | 0.01 | | % | 1 | 6/2/2007 |
| Sand | 17.1 | 0.01 | | % | 1 | 6/2/2007 |
| Silt | 35.2 | 0.01 | | % | 1 | 6/2/2007 |
| Clay | 47.7 | 0.01 | | % | 1 | 6/2/2007 |

# Prairie Analytical Systems, Inc.

**Date:** *04-Jun-07*

| | | | |
|---|---|---|---|
| **CLIENT:** | HDR/Cochran & Wilken, Inc. | **Client Sample ID:** | 4 Hour Supernatant |
| **Lab Order:** | 0705207 | **Tag Number:** | |
| **Project:** | Lake Hillsboro | **Collection Date:** | 5/17/2007 2:30:00 PM |
| **Lab ID:** | 0705207-002C | **Matrix:** | AQUEOUS |

| Analyses | Result | Limit | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **METALS ANALYSIS** | | **E200.8** | | **(SW3005A)** | | Analyst: **MCL** |
| Lead | 0.0325 | 0.00200 | | mg/L | 1 | 5/30/2007 7:41:00 PM |
| Zinc | 0.712 | 0.0100 | | mg/L | 1 | 5/30/2007 7:41:00 PM |
| **TOTAL SUSPENDED SOLIDS ANALYSIS** | | **M2540 D** | | | | Analyst: **RMN** |
| Total Suspended Solids | 624 | 16.0 | | mg/L | 1 | 5/31/2007 8:00:00 PM |
| **VOLATILE SOLIDS ANALYSIS** | | **M2540 E** | | | | Analyst: **AJD** |
| Total Volatile Solids | 90.0 | 50.0 | | mg/L | 1 | 6/1/2007 |
| **AMMONIA ANALYSIS** | | **M4500-NH3 F** | | | | Analyst: **AJD** |
| Ammonia (as N) | 0.925 | 0.100 | | mg/L | 1 | 5/30/2007 4:19:00 PM |

**Prairie Analytical Systems, Inc.**

**Date:** *04-Jun-07*

| | | | |
|---|---|---|---|
| **CLIENT:** | HDR/Cochran & Wilken, Inc. | **Client Sample ID:** | 24 Hour Supernatant |
| **Lab Order:** | 0705207 | **Tag Number:** | |
| **Project:** | Lake Hillsboro | **Collection Date:** | 5/17/2007 2:30:00 PM |
| **Lab ID:** | 0705207-002D | **Matrix:** | AQUEOUS |

| Analyses | Result | Limit | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **TOTAL SUSPENDED SOLIDS ANALYSIS** | | **M2540 D** | | | | Analyst: **RMN** |
| Total Suspended Solids | 55.0 | 8.00 | | mg/L | 1 | 5/31/2007 8:00:00 PM |

**Qualifiers :**

B - Analyte detected in the associated method blank.

E - Value above quantitation range.

H - Analysis performed past holding time.

HT - Sample received past holding time.

J - Analyte detected between RL and MDL.

R - RPD outside acceptance limits.

S - Spike recovery outside acceptance limits.

U - Analyte not detected (i.e. less than RL or MDL).

# Representative Photographs

















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