CEDAR LAKE AQUATIC ECOSYSTEM FEASIBILITY STUDY

CEDAR LAKE, INDIANA

APPENDIX L
MONITORING PLAN

U.S. Army Corps of Engineers
Chicago District

July 2016

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Amieurus nebulosus - brown bullhead found in Cedar Lake.

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TABLE OF CONTENTS

Introduction

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure, that when conducting a feasibility study for a project (or component of a project) under the Corps ecosystem restoration mission, that the recommended project includes a monitoring plan to measure the success of the ecosystem restoration and to dictate the direction adaptive management should proceed, if needed. This monitoring and adaptive management plan shall include a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring as well as specify that monitoring will continue until such time as the Secretary determines that the success criteria have been met.

Section 2039 of WRDA 2007 also directs the Corps to develop an adaptive management plan for all ecosystem restoration projects. The adaptive management plan must be appropriately scoped to the scale of the project. The information generated by the monitoring plan will be used by the District in consultation with the Federal and State resources agencies and the MSC to guide decisions on operational or structural changes that may be needed to ensure that the ecosystem restoration project meets the success criteria.

An effective monitoring program is necessary to assess the status and trends of ecological health and biota richness and abundance on a per project basis, as well as to report on regional program success within the United States. Assessing status and trends includes both spatial and temporal variations. Gathered information under this monitoring plan will provide insights into the effectiveness of current restoration projects and adaptive management strategies, and indicate where goals have been met, if actions should continue, and/or whether more aggressive management is warranted.

Monitoring the changes at a project site is not always a simple task. Ecosystems, by their very nature, are dynamic systems where populations of macroinvertebrates, fish, birds, and other organisms fluctuate with natural cycles. Water quality also varies, particularly as seasonal and annual weather patterns change. The task of tracking environmental changes can be difficult, and distinguishing the changes caused by human actions from natural variations can be even more difficult. This is why a focused monitoring protocol tied directly to the planning objectives needs to be followed.

This Monitoring and Adaptive Management Plan describes the existing habitats and monitoring methods that could be utilized to assess projects. By reporting on environmental changes, the results from this monitoring effort will be able to evaluate whether measurable results have been achieved and whether the intent of the Cedar Lake Ecosystem Restoration are being met.

Guidance

The following documents provide distinct Corps policy and guidance that are pertinent to developing this monitoring and adaptive management plan:

Section 2039 of WRDA 2007 Monitoring Ecosystem Restoration

(a) In General - In conducting a feasibility study for a project (or a component of a project) for ecosystem restoration, the Secretary shall ensure that the recommended project includes, as an integral part of the project, a plan for monitoring the success of the ecosystem restoration.

(b) Monitoring Plan - The monitoring plan shall--

(1) include a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, and the estimated cost and duration of the monitoring; and

(2) specify that the monitoring shall continue until such time as the Secretary determines that the criteria for ecosystem restoration success will be met.
(c) Cost Share - For a period of 10 years from completion of construction of a project (or a component of a project) for ecosystem restoration, the Secretary shall consider the cost of carrying out the monitoring as a project cost. If the monitoring plan under subsection (b) requires monitoring beyond the 10-year period, the cost of monitoring shall be a non-Federal responsibility.

USACE. 2009. Planning Memorandum. Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) - Monitoring Ecosystem Restoration

USACE. 2000. ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. Washington D.C.

USACE. 2003a. ER 1105-2-404. Planning Civil Work Projects under the Environmental Operating Principles. Washington, D.C.

General Monitoring Objectives

As presented in "Guidance on Monitoring Ecosystem Restoration Project" on 12 January 2010, the following are general project monitoring objectives:

- To determine and prioritize needs for ecosystem restoration
- To support adaptive management of implemented projects
- To assess and justify adaptive management expenditures
- To minimize costs and maximize benefits of future restoration projects
- To determine "ecological success", document, and communicate it
- To advance the state of ecosystem restoration practice

Project Area Description

Cedar Lake is a 781-acre, glacially formed lake located in the Town of Cedar Lake in Lake County, Indiana. The study area is located in west central Lake County, T34N, R9W, Sections 22, 23, 26, 27, 34 and 35. It lays 4.5-miles southwest of Crown Point and forty miles southeast of Chicago. US Route 41 (Wicker Street), Lake Shore Drive, Parrish Street, Lauerman Street, 133rd Avenue, 141st Avenue and Morse Street are the main streets surrounding the lake.

The Cedar Lake watershed is located atop the Valparaiso Moraine and is characterized by distinct glacial topography. Since the 1800s, Cedar Lake has been described in numerous accounts, including reports of early surveyors, settlers, and explorers for natural resources (Large

1897, Indiana Academy of Science 1896, Blatchey 1900). Early accounts indicate that Cedar Lake was formed when the melt-water of retreating glaciers collected on clay deposits in a narrow valley. Processes that formed the lake created a relatively small and limited watershed covering about 7.6 square miles or 4,864 acres, with all but the southern portions of the lake confined by steep slopes. One significant exception to the steep slopes of the surrounding basin is the 400-acre Cedar Lake Marsh on the south end of the lake, which was formed when the lake was drained and lowered by 12-feet. Nearly half of the entire Cedar Lake watershed drains into this marsh before reaching the lake (SPEA 1984). In addition to the marsh, two small riparian wetlands are associated with intermittent tributaries on the north end of the lake.

Habitat Trends Triggering Restoration

This project aims to remedy adverse trends of:

- increased nuisance algae blooms
- reduced water clarity
- reduced native aquatic vegetation
- oversaturation of dissolved oxygen
- increased instances of fish kills
- loss of native and desirable fish species
- decreased social value
- decreased aesthetic value

Restoration Design Overview

It was determined that the implementation of the recommended plan will improve lacustrine conditions by removing legacy phosphorus pollution, decreasing algal blooms, increasing aquatic macrophytes, and reestablishing fish community structure that are integral to any natural glacial lake. Alternative 6, the Locally Preferred Plan (LPP), was selected for implementation by the Feasibility Study. Specific elements of the proposed action are:

- Removal of a significant portion of legacy phosphorus through substrate restoration
- Neutralization of remaining phosphorus through alum treatment
- Eradicating non-native invasive fish species
- Reestablishing pockets of aquatic macrophytes
- Reestablishing the native glacial lake fish assemblage
- Restricting recreational boating to prevent adverse littoral zone effects and sediment resuspension

Monitoring Components

Monitoring Plan Goals & Objectives

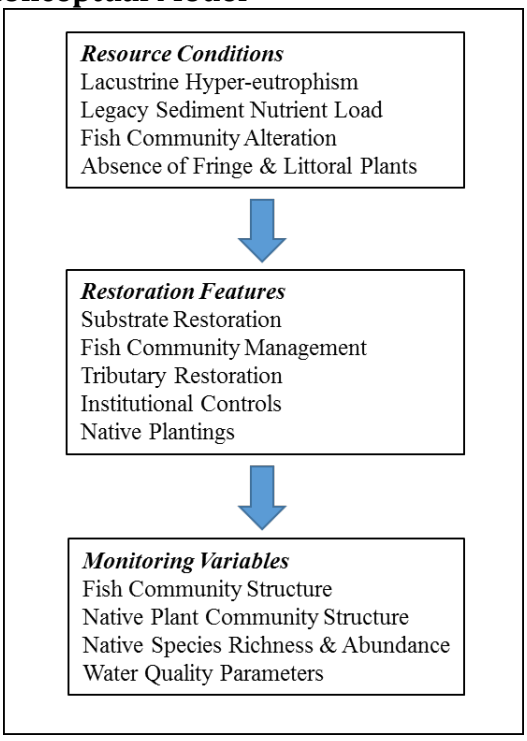
Restoring the abiotic and biotic lacustrine structure is the primary goal of the Cedar Lake ecosystem restoration project. Site inventories documenting and establishing baseline ecological conditions are detailed

in the Feasibility Study for this project. Based on these studies and other available information, the following specific objectives were established for monitoring the effectiveness of this project:

- Restore abiotic habitat as measured by Water Quality Indicators:
  - Target Total Phosphorus = **≤70µg/L**
  - Target Secchi Depth = **≥4-feet**
  - Target Dissolved Oxygen = **~7mg/L**
- Rectify Native Fish Assemblage:
  - Target Richness = **≥25**
  - Target Abundance = **Observational**
  - Target Invasive Species Reduction = **<5% Abundance of Total Sample**
- Increase Aquatic Macrophyte Richness & Coverage:
  - Target Emergent Species Richness = **≥6**
  - Target Emergent Aerial Coverage = **35-acres**
  - Target Submergent Species Richness = **≥10**
  - Target Submergent Aerial Coverage = **95-acres**

In order to evaluate the overall effectiveness of the project and to determine if the specific objectives are met, the following Monitoring Plan is proposed, and includes several basic monitoring components of water quality parameters, native species richness and abundance and presence of invasive species. All components with be monitored as specified below, once prior to the project and one time per year for five years following completion of the project.

Conceptual Model



Fish Assemblage Richness & Abundance

Monitoring of fish communities is a well-established approach for evaluating overall aquatic ecosystem health and will be quantified through the use of native fish species richness and abundance. Fish species richness can be explained as a total count of species present within the site and abundance is the total number of individuals. Fish are not only a highly visible part of the aquatic resource, but they are quite sensitive to the surrounding water and habitat quality. Because Cedar Lake is a closed system, species richness will not increase without anthropological assistance. The Cedar Lake restoration project includes the active reintroduction of 16 native glacial lake fish species from the surrounding native populations. Although species richness will be known at the completion of the project, fish species assemblage will be assessed throughout the monitoring period with electrofishing and fyke net surveys to ensure reintroduced species become established and non-native species remain as a small percentage of the total.

Aquatic Macrophyte Richness & Abundance

The plant community will be sampled qualitatively and quantitatively. The qualitative method will consist of performing a meander survey to record an inventory of all plant species present within each habitat type of each restoration plot. The quantitative method will involve selecting transect lines by a stratified random sampling design. Along these transects quadrats will be placed that will be 0.25 to 0.5 meters squared in size. Placement of the quadrats along the transects will depend on the amount of area within each habitat type. Each habitat type will have at least three transects sampled. Percent coverage of native plants and invasive species will be recorded from each quadrat along with the identification of all plant species present within the quadrat (a measure of native plant richness). Quantitative monitoring will be performed by the same person throughout the year and from year to year to maintain a consistent sampling bias.

Sampling means for each variable for each habitat type and the FQA mean conservatism (C) score will be calculated for each habitat type.

Water Quality Parameters

The trophic state of a lake refers to its overall level of nutrition or biological productivity. The most widely used and accepted tropic state index (TSI) in the United States was developed by Bob Carlson. Carlson analyzed summertime total phosphorus, chlorophyll a, and Secchi disk transparency data for numerous lakes and found statistically significant relationships among the three parameters. Mathematical equations for these relationships were developed and these are used as the basis for the Carlson TSI. Quantitative and qualitative water quality monitoring of chemical and biological parameters will define the trophic state and key chemical stressors or impairments impacting the water quality of Cedar Lake during the monitoring period. In addition the water quality parameters included below, conditions of the lakeshore (such as level of human disturbance) and conditions of water quality (using temperature, pH, secchi depth, and dissolved oxygen) at the inlets will be documented during water quality monitoring period.

Additional water quality parameters are proposed beyond Total P, secchi disk, DO, and chlorophyll-a to monitor the general water quality of Cedar Lake after implementation of the project. Results from monitoring nutrient and suspended solid concentrations, and other general water quality parameters, will be used to evaluate whether measurable results have been achieved, whether the intent of the Cedar Lake Ecosystem Restoration are being met, and if changes are causing adverse conditions that may impact the

ecological health and biota richness and abundance.

Parameter	Method(s)	Reporting Limit (mg/L)
Total Phosphorus	SM 365.2	0.05
Total Orthophosphorous	SM 365.2	0.05
Ammonia Nitrogen (NH_3-N)	SM 350.2	0.20
Nitrate Nitrogen (NO_3-N)	SM 353.2	0.10
Nitrite Nitrogen (NO_2-N)	SM 354.1	0.02
Total Kjeldahl Nitrogen	SM 351.3	0.40
Total Dissolved Solids	SM 160.1	10
Total Suspended Solids	SM 160.2	5
pH (field)	Membrane electrode (field)	NA
Temperature (field)	Electronic thermometer (field)	NA
Dissolve Oxygen (field)	Membrane electrode (field)	NA
Water Transparency	Secchi Disk (field)	NA
Chlorophyll-a	SM 445.0	0.11 µg/L

Sampling Stations

Sampling stations will be determined after plans and specifications are complete to ensure the appropriate areas are surveyed for success.

Reference Site Discussion

No reference site is deemed necessary; improvements will be judged from site current conditions.

Sampling/Survey Frequency

Fish Assemblage

Fish assemblage monitoring would occur twice a year, once in the late spring and once in the late summer. The total monitoring period would be for 5-years after a greater percentage of the native fishes have been reintroduced.

Plant Communities

Plant monitoring would occur between June and August of each year of monitoring activities. Sampling would occur once a year. The total monitoring period will be 5-years.

Water Quality

Water quality monitoring would occur between June and August of each year of monitoring activities. Sampling would occur once a year. The total monitoring period will be 5-years.

Data Analysis

Fish Community

The information generated through monitoring the fish communities would be used to indicate the trend in overall condition of the area. Fish species richness and abundance is expected to increase dramatically during the restoration as reintroduction measures are implemented and should maintain this elevated level throughout the monitoring period. If the trends in the data indicate a decrease in species richness, adaptive management actions may be taken.

Plant Communities

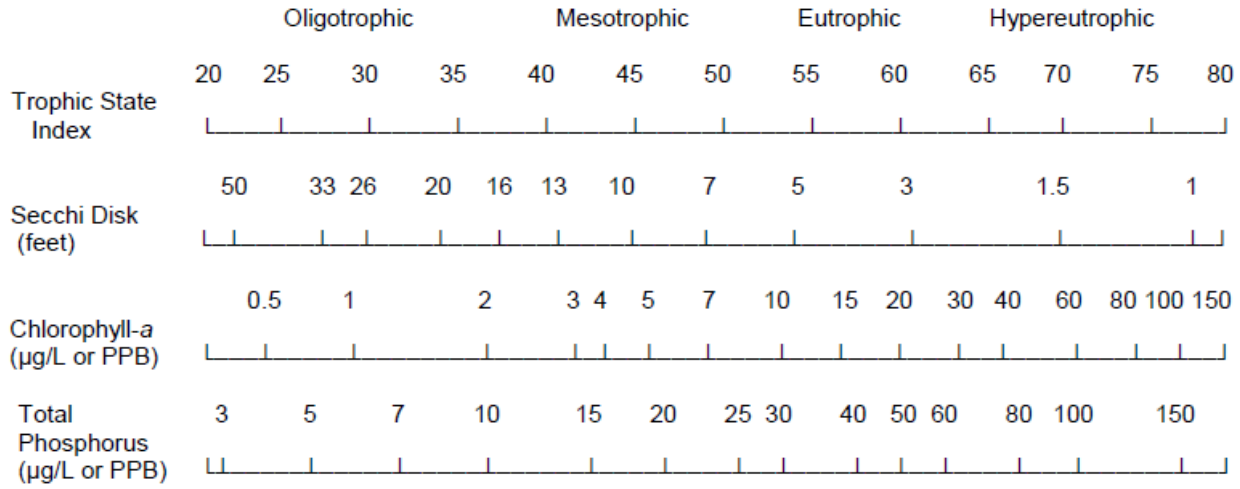
The information generated through sampling the plant community would be used to indicate the trend in overall condition of the area. The FQA mean coefficient of conservatism is expected to increase each year. If the FQA analysis indicates a decrease in condition, adaptive management actions may be taken to increase the score for the following sampling year. Soil analysis will compare test results to baseline data procured during the feasibility phase, and will help guide adaptive management decisions.

Water Quality

The information generated through water quality monitoring would be used to indicate the overall water quality and productivity of Cedar Lake. Data collected from water quality monitoring will be compared to the State of Indiana water quality standards and will be used to establish the tropic state of Cedar Lake during the monitoring period using the TSI. Carlson's scale is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive); eutrophic (very productive) and hypereutrophic (extremely productive). Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass.

The TSI is expected to decrease over time after the restoration measures and additional water quality improvements are implemented in the watershed.

Carlson's Trophic State Index



Monitoring Responsibilities

The USACE will be responsible for monitoring water quality, fish and macrophytes.

Monitoring Costs & Funding Schedule

Tasks	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Fish Assemblage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Aquatic Macrophytes	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Water Quality Parameters	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Final Report	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Reporting Results

A yearly monitoring summary report would be drafted by the USACE that briefly summarizes the data collected and determines if adaptive management is needed. A final monitoring report would be drafted that details the outcomes of the restoration project.

Contact Information

Fish Assemblage & Aquatic Macrophytes

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Adaptive Management

Potential adaptive management needs are primarily of concern for invasive species resurgence and fish species richness. Additional reintroductions of native fish species may be required to attain a breeding population within the ponds. Invasive species control with the use of spot herbiciding and/or mechanical removal may also be warranted in areas of high public use or disturbance to contain potential spreading of nuisance plant species. The degree to which a particular monitoring trend deviates from its intended course will be discussed with local managers, sponsors, and USACE personnel to determine the appropriate response.