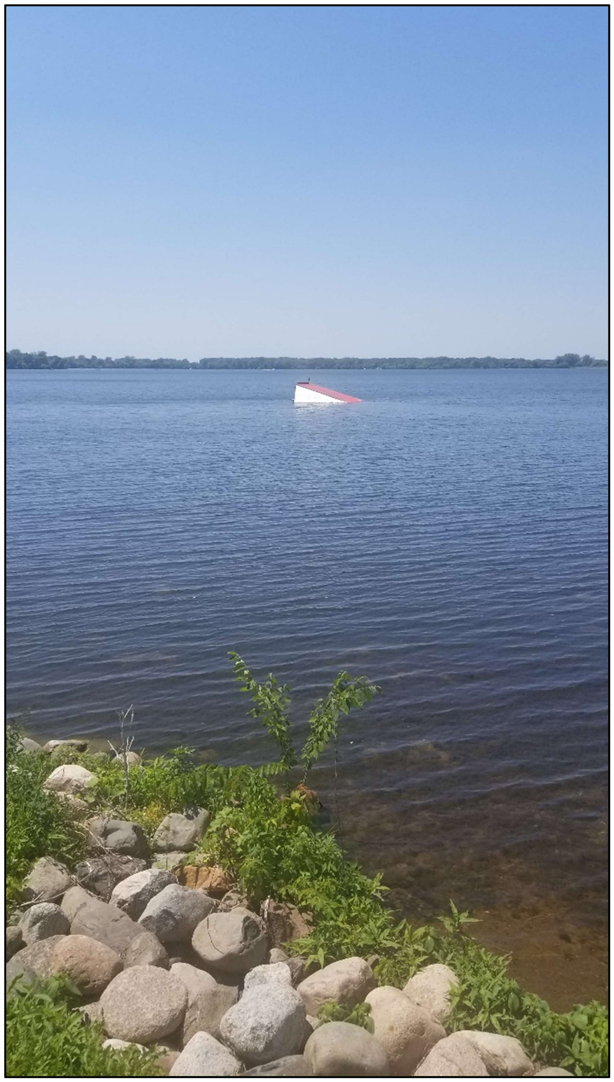

Centerville Lake
Stormwater Retrofit Analysis

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

RICE CREEK WATERSHED DISTRICT

Centerville Lake Stormwater Retrofit Analysis: 2023

Prepared for the Rice Creek Watershed District (RCWD) by:
Anoka Conservation District

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Disclaimer: At the time of printing, this report identifies and ranks potential BMPs for selected subwatersheds in the cities of Centerville and Lino Lakes that drain to Centerville Lake. This list of practices is not all-inclusive and does not preclude adding additional priority BMPs in the future. An updated copy of the report shall be housed at either Anoka Conservation District or the Rice Creek Watershed District.

Abstract

Anoka Conservation District completed this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects throughout areas draining to Centerville Lake. The target area consists of portions of the cities of Centerville and Lino Lakes within the Rice Creek Watershed District.

This analysis is primarily intended to identify potential projects within the target areas to improve water quality in Centerville Lake through stormwater retrofits. In this SRA, both costs and pollutant reductions were estimated and used to calculate cost-effectiveness for each potential retrofit identified. Water quality benefits associated with the installation of each identified project were individually modeled using the Source Loading and Management Model for Windows (WinSLAMM). The volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. The costs associated with project design, administration, promotion, land acquisition, opportunity costs, construction oversight, installation, and maintenance were estimated. The total costs over the assumed effective life of each project were then divided by the modeled benefits over the same time period to enable ranking by cost-effectiveness.

The 418-acre study area was divided into nine catchments. Eight catchments were created for well-defined, unique outfalls to Centerville Lake, and one catchment represents direct discharge from adjacent shoreline areas. A WinSLAMM model was created for each catchment. Details of the volume and pollutant loading within each catchment are provided in the Catchment Profile pages. A variety of stormwater retrofit approaches was identified and potential projects are organized from most cost-effective to least based on pollutants removed. That said, cost-effective opportunities are limited due to the prevalence of existing treatment, primarily stormwater ponds, throughout the study area.

Table of Contents

List of Figures

List of Tables

Executive Summary

Anoka Conservation District (ACD) completed this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects in the Centerville Lake subwatershed. The subwatershed is located in the cities of Centerville and Lino Lakes and consist primarily of residential, commercial, and institutional land uses. Total phosphorus (TP) and total suspended solids (TSS) were the target parameters analyzed. Volume was also documented as a model output.

This analysis is primarily intended to identify potential projects within the target areas to improve water quality in Centerville Lake through stormwater retrofits. Stormwater retrofits refer to best management practices (BMPs) that are added to an already developed landscape where little open space exists. The process is investigative and creative. Stormwater retrofits can be improperly judged by comparing the total number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this report, both costs and pollutant reductions were estimated and used to calculate cost-effectiveness for each potential retrofit identified.

Water quality benefits associated with the installation of each identified project were individually modeled using the Source Loading and Management Model for Windows (WinSLAMM). WinSLAMM uses an abundance of stormwater data from the Upper-Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses and allows the user to build a model “landscape”. WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user’s model for each storm.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Specific model inputs (e.g. pollutant probability distribution, runoff coefficient, particulate solids concentration, particle residue delivery, and street delivery files) are detailed in Appendix A – Modeling Methods.

The costs associated with project design, administration, promotion, land acquisition, opportunity costs, construction oversight, installation, and maintenance were estimated. The total costs over the assumed effective life of each project were then divided by the modeled benefits over the same time period to enable ranking by cost-effectiveness.

A variety of stormwater retrofit approaches was identified. They included bioretention (biofiltration), enhanced street sweeping, hydrodynamic devices, and lakeshore stabilizations. Funding limitations and landowner interest will ultimately determine how many retrofits are installed. It is recommended that projects be installed in order of cost-effectiveness (pounds of pollution reduced per dollar spent). Other factors, including a project’s educational value/visibility, construction timing, total cost, or non-target pollutant reduction also affect project installation decisions and should be considered by resource managers when pursuing projects.

For each type of recommended retrofit, conceptual siting is provided in the project profiles section. The intent of these figures is to provide an understanding of the approach. If a project is selected, site-specific designs must be prepared. In addition, some of the proposed retrofits (e.g. hydrodynamic devices) will require a more detailed feasibility analysis and engineered plan sets if selected. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners, both public and private.

The 418-acre target study areas was divided into nine catchments. Eight catchments were created for well-defined, unique outfalls to Centerville Lake, and one catchment represents direct discharge from adjacent shoreline areas. The tables in the Project Ranking and Selection section summarize potential projects ranked by cost-effectiveness with respect to both TP and TSS. Potential projects are organized from most cost-effective to least based on pollutants removed.

In summary, 17 projects were identified throughout the nine catchments. Project types included bioretention (4, 23% of total), hydrodynamic devices (2, 12% of total), lakeshore stabilizations (10, 59% of total), and optimization of an existing water reuse system (1, 6% of total). The prevalence of existing stormwater ponds throughout most of the study area limited the opportunities for large, regional practices. Few areas discharge directly to the lake without some form of existing water quality treatment.

Overall, cost-effectiveness for TP removal ranged from ~$0/lb-TP to ~$27,000/lb-TP. The most cost-effective projects for TP removal are optimization of the existing water reuse system to make full use of the design capacity and lakeshore stabilizations. Cost-effectiveness for TSS removal ranged from ~$0/1,000 lbs-TSS to ~$51,000/1,000 lbs-TSS. Similar to TP, the most cost-effective projects for TSS removal are optimization of the existing water reuse system and lakeshore stabilizations.

Installation of projects in series will result in lower total treatment than the simple sum of treatment achieved by the individual projects due to treatment train effects. Reported treatment levels are dependent upon optimal site selection and sizing. More detail about each project is available in the catchment profile pages of this report. Projects deemed infeasible due to prohibitive size, number, or expense were not included in this report.

Document Organization

This document is organized into five sections, plus references and appendices. Each section is briefly discussed below.

Background

The background section provides a brief description of the landscape characteristics within the study area.

Analytical Process and Elements

The analytical process and elements section overviews the procedures that were followed when analyzing the subwatershed. It explains the processes of retrofit scoping, desktop analysis, field investigation, modeling, cost/treatment analysis, project ranking, and project selection. Refer to Appendix A – Modeling Methods for a detailed description of the modeling methods.

Project Ranking and Selection

The project ranking and selection section describes the methods and rationale for how projects were ranked. Local resource management professionals will be responsible to select and pursue projects, taking into consideration the many possible ways to prioritize projects. Several considerations in addition to project cost-effectiveness for prioritizing installation are included. Project funding opportunities may play a large role in project selection, design, and installation.

This section also ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by the amount of pollutant removed by each project over 30 years. The final cost per pound treatment value includes installation and maintenance costs over the estimated life of the project. If a practice's effective life was expected to be less than 30 years, rehabilitation or reinstallation costs were included in the cost estimate. There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point.

BMP Descriptions

For each type of project included in this report, there is a description of the rationale for including that type of project, the modeling method employed, and the cost calculations used to estimate associated installation and maintenance expenses.

Catchment Profiles

The drainage area for this analysis was divided into nine catchments and assigned unique identification numbers. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads under existing conditions. Existing conditions included notable stormwater treatment practices for which information was available from either RCWD or the City of Centerville. Small, site-specific practices (e.g. rain-leader disconnect rain gardens) were not included in the existing conditions model. A brief description of the land cover, stormwater infrastructure, and any other important general information is also described in this section. Notable existing stormwater practices are explained and their estimated effectiveness presented.

Retrofit Opportunities

Retrofit opportunities are presented for each catchment and include a description of the proposed BMP, cost-effectiveness table including modeled volume and pollutant reductions, and an overview map showing the contributing drainage area for each BMP.

References

This section identifies various sources of information synthesized to produce the protocol used in this analysis.

Appendices

This section provides supplemental information and/or data used during the analysis.

Background

Many factors are considered when choosing which subwatersheds to analyze for stormwater retrofits. Water quality monitoring data, non-degradation report modeling, and TMDL studies are just a few of the resources available to help determine which water bodies are a priority. Stormwater retrofit analyses supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the process also rank highly. For some communities a stormwater retrofit analysis complements their MS4 stormwater permit. The focus is always on a high priority waterbody.

The target area studied for this analysis is located in the cities of Centerville and Lino Lakes within the RCWD and drains to Centerville Lake via a variety of outfalls. The area analyzed was divided into nine catchments and consists of 418 acres. The Centerville Lake subwatershed is largely developed, with the exception of Catchment 9 that includes Anoka County's Rice Creek Chain of Lakes Park Reserve along the south and southwest shore of the lake. Development throughout the cities of Centerville and Lino Lakes has resulted in the installation of subsurface drainage systems (i.e. stormwater infrastructure) to convey stormwater runoff, which increased due to the coverage of impervious surfaces throughout the catchments.

The runoff generated within the subwatershed is still conveyed to Centerville Lake, as it was historically. However, the runoff is now captured by catch basins and directed underground before being discharged via stormwater pipes. This along with the impervious surfaces has caused increased volume and pollutant loading to Centerville Lake relative to natural, historical conditions.

Stormwater runoff from impervious surfaces can carry a variety of pollutants. Stormwater treatment to remove these pollutants is prevalent throughout most of the subwatershed, primarily in the form of stormwater ponds. This SRA is intended to review the subwatershed and identify potential projects that will benefit Centerville Lake water quality.

ACD completed this SRA for the purpose of identifying and analyzing projects to improve the quality of stormwater runoff from contributing drainage areas to Centerville Lake. Overall subwatershed loading of TP, TSS, and stormwater volume were estimated for catchments throughout the subwatershed. Proposed retrofits were modeled to estimate each practice's capability for removing pollutants and reducing volume. Finally, each project was ranked based on the estimated cost-effectiveness of the project to reduce pollutants.

Analytical Process and Elements

This stormwater retrofit analysis is a watershed management tool to identify and prioritize potential stormwater retrofit projects by performance and cost-effectiveness. This process helps maximize the value of each dollar spent. The process used for this analysis is outlined in the following pages and was modified from the Center for Watershed Protection's Urban Stormwater Retrofit Practices, Manuals 2 and 3 (Schueler & Kitchell, 2005 and Schueler et al. 2007). Locally relevant design considerations were also incorporated into the process (Technical Documents, Minnesota Stormwater Manual, 2023).

Scoping includes determining the objectives of the retrofits (volume reduction, target pollutant, etc.) and the level of treatment desired. It involves meeting with local stormwater managers, city staff, and watershed management organization members to determine the issues in the subwatershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria. In order to create a manageable area to analyze in large subwatersheds, a focus area may be determined.

In this analysis, the focus areas were the contributing drainage areas to storm sewer outfalls that discharge directly into the target water body (i.e. Centerville Lake). Included are areas of residential, commercial, industrial, and institutional land uses. The focus area was divided into nine catchments using a combination of existing subwatershed mapping data, stormwater infrastructure maps, and observed topography.

The targeted pollutants for this study were TP and TSS, though volume was also estimated and reported. Volume of stormwater was tracked throughout this study because it is necessary for pollutant loading calculations and potential retrofit project considerations. Table 1 describes the target pollutants and their role in water quality degradation. Projects that effectively reduce loading of multiple target pollutants can provide greater immediate and long-term benefits.

Table 1: Target Pollutants

Target Pollutant	Description
Total Suspended Solids (TSS)	Very small mineral and organic particles that can be dispersed into the water column due to turbulent mixing. TSS loading can create turbid and cloudy water conditions and carry particulate phosphorus (PP). As such, reductions in TSS will also result in TP reductions.
Total Phosphorus (TP)	Phosphorus is a nutrient essential to plant growth and is commonly the factor that limits the growth of plants in surface water bodies. TP is a combination of PP, which is bound to sediment and organic debris, and dissolved phosphorus (DP), which is in solution and readily available for plant growth (active).
Volume	Higher runoff volumes and velocities can carry greater amounts of TSS to receiving water bodies. It can also exacerbate in-stream erosion, thereby increasing TSS loading. As such, reductions in volume may reduce TSS loading and, by extension, TP loading.

Desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that do not need to be analyzed because of existing stormwater treatment or disconnection from the target water body. Accurate GIS data are extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include 2-foot or finer topography (Light Detection and Ranging [LiDAR] was used for this analysis), surface hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography, and the stormwater drainage infrastructure (with invert elevations).

Field investigation is conducted after potential retrofits are identified in the desktop analysis to evaluate each site and identify additional opportunities. During the investigation, the drainage area and surface stormwater infrastructure mapping data were verified in areas where the available GIS data were insufficient. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search.

Modeling involves assessing multiple scenarios to estimate pollutant loading and potential reductions by proposed retrofits. WinSLAMM (version 10.5.0), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis. This is important for estimating treatment train effects associated with multiple BMPs in series. Furthermore, it allows for estimation of volume and pollutant loading at the outfall point to the waterbody, which is the primary point of interest in this type of study.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Specific model inputs (e.g. pollutant probability distribution, runoff coefficient, particulate solids concentration, particle residue delivery, and street delivery files) are detailed in Appendix A – Modeling Methods.

The initial step was to create a “base” model, which estimates pollutant loading from each catchment in its present-day state without taking into consideration any existing stormwater treatment. Drainage area delineations were used to model the land uses in each catchment. The drainage areas were consolidated into catchments using geographic information systems (specifically, ArcMap). Land use data (based on 2020 Metropolitan Council land use file) were used to calculate acreages of each land use type within each catchment. Each land use polygon classification was compared with high-resolution 2022 aerial photography, the most recent available at the time of this analysis, as well as ground truthing, and corrected if land use had changed since 2020. This process addressed recent development throughout the study area by reclassifying land use types accordingly. Soil types throughout the study area were predominantly silt based on information available in the Anoka County soil survey and associated assumptions made for soils listed as ‘cut and fill.’ Entering the acreages, land use, and soil data into WinSLAMM ultimately resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment.

Once the “base” model was established, an “existing conditions” model was created by incorporating notable existing stormwater treatment practices in the catchment for which data were available from the City of Centerville and the Rice Creek Watershed District (Figure 2). For example, street cleaning, stormwater treatment ponds, hydrodynamic devices, and others were included in the “existing conditions” model if information was available.

Finally, each proposed stormwater retrofit practice was added individually to the “existing conditions” model and pollutant reductions were estimated. Because neither a detailed design of each practice nor in-depth site investigation was completed, a generalized design for each practice was used. Whenever possible, site-specific parameters were included. Design parameters were modified to obtain various levels of treatment. It is worth noting that each practice was modeled individually, and the benefits of projects may not be additive, especially if serving the same area (i.e. treatment train effects). Reported treatment levels are dependent upon optimal site selection and sizing. Additional information on the WinSLAMM models can be found in Appendix A – Modeling Methods.

Cost estimating is essential for the comparison and ranking of projects, development of work plans, and pursuit of grants and other funds. All estimates were developed using 2023 dollars. Costs throughout this report were estimated using a multitude of sources. Costs were derived from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals (Schueler & Kitchell, 2005 and Schueler et al. 2007) and recent installation costs and cost estimates provided to the ACD by personal contacts. Cost estimates were annualized costs that incorporated the elements listed below over a 30-year period.

> **Project promotion and administration** includes local staff efforts to reach out to landowners, administer related grants, and complete necessary administrative tasks.
>
> **Design** includes site surveying, engineering, and construction oversight.
>
> **Land or easement acquisition** covers the cost of purchasing property or the cost of obtaining necessary utility and access easements from landowners.
>
> **Construction** calculations are project specific and may include all or some of the following: grading, erosion control, vegetation management, structures, mobilization, traffic control, equipment, soil disposal, and rock or other materials.
>
> **Maintenance** includes annual inspections and minor site remediation such as vegetation management, structural outlet repair and cleaning, and washout repair.

In cases where promotion to landowners is important, such as rain gardens, those costs were included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs were estimated using a non-linear relationship that accounted for savings with scale. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. It should be understood that no site-specific construction investigations were done as part of this stormwater retrofit analysis, and therefore cost estimates account for only general site considerations. Detailed feasibility analyses may be necessary for some projects.

Project ranking is essential to identify which projects could be pursued to achieve water quality goals. Project ranking tables are presented based on cost per 1,000 pounds of TSS and cost per pound of TP removed.

Project selection involves considerations other than project ranking, including but not limited to total cost, treatment train effects, social acceptability, and political feasibility.

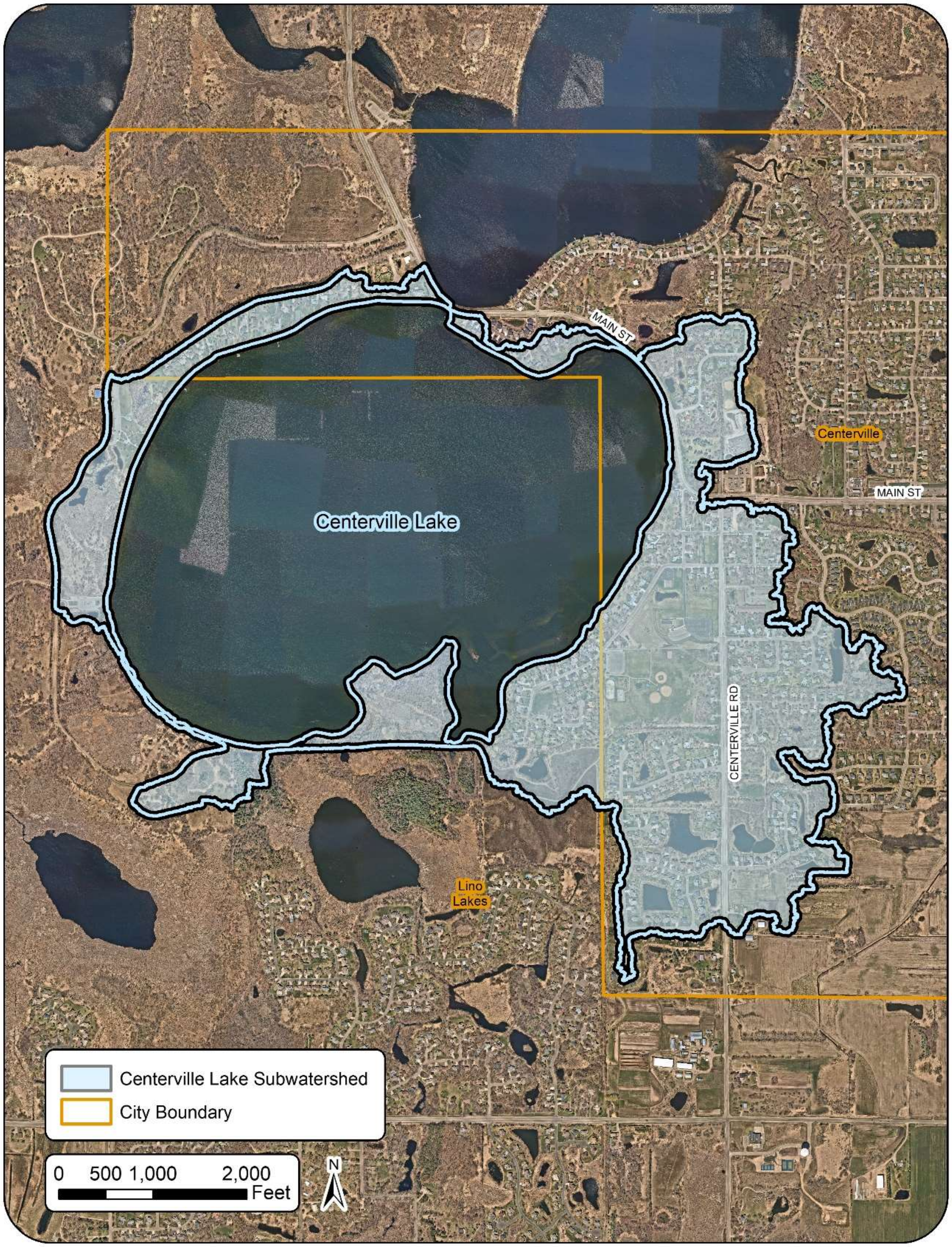


Figure 1: Centerville Lake subwatershed (418 acres).

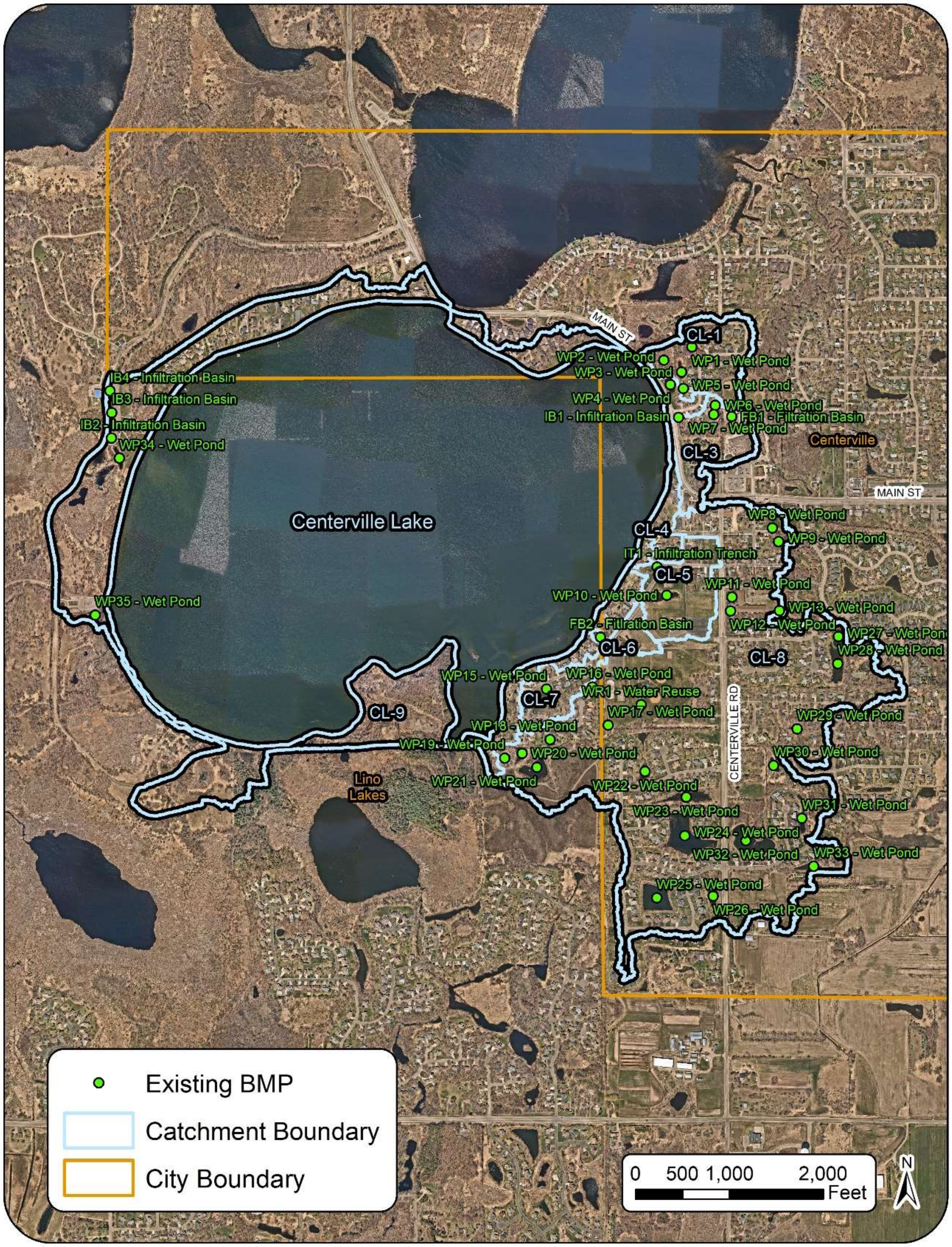


Figure 2: Centerville Lake subwatershed existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the study area.

Table 2: Centerville Lake subwatershed existing BMPs included in the WinSLAMM model. Street sweeping is not shown in the table but was included throughout the study area.

EXISTING BMP ID	DESCRIPTION	CATCHMENT	SUBCATCHMENT
WP1	Wet Pond	CL-1	CL-1-1
WP5	Wet Pond	CL-1	CL-1-2
WP3	Wet Pond	CL-1	CL-1-3
WP2	Wet Pond	CL-1	CL-1-4
WP4	Wet Pond	CL-2	CL-2-3
WP6	Wet Pond	CL-3	CL-3-1
WP7	Wet Pond	CL-3	CL-3-2
FB1	Filtration Basin	CL-3	CL-3-3
IB1	Infiltration Basin	CL-3	CL-3-5
WP10	Wet Pond	CL-5	CL-5-1
IT1	Infiltration Trench	CL-5	CL-5-2
FB2	Fitlration Basin	CL-6	CL-6-1
WP15	Wet Pond	CL-7	CL-7-2
WP28	Wet Pond	CL-8	CL-8-10
WP29	Wet Pond	CL-8	CL-8-14
WP33	Wet Pond	CL-8	CL-8-16
WP32	Wet Pond	CL-8	CL-8-17
WP31	Wet Pond	CL-8	CL-8-18
WP30	Wet Pond	CL-8	CL-8-19
WP25	Wet Pond	CL-8	CL-8-21
WP26	Wet Pond	CL-8	CL-8-22
WP24	Wet Pond	CL-8	CL-8-23
WP23	Wet Pond	CL-8	CL-8-24
WP22	Wet Pond	CL-8	CL-8-25
WP17	Wet Pond	CL-8	CL-8-26
WR1	Water Reuse	CL-8	CL-8-26
WP16	Wet Pond	CL-8	CL-8-27
WP18	Wet Pond	CL-8	CL-8-29
WP8	Wet Pond	CL-8	CL-8-3
WP21	Wet Pond	CL-8	CL-8-30
WP20	Wet Pond	CL-8	CL-8-31
WP19	Wet Pond	CL-8	CL-8-32
WP9	Wet Pond	CL-8	CL-8-4
WP13	Wet Pond	CL-8	CL-8-5
WP12	Wet Pond	CL-8	CL-8-6
WP11	Wet Pond	CL-8	CL-8-7
WP27	Wet Pond	CL-8	CL-8-9
IB2	Infiltration Basin	CL-9	CL-9
IB3	Infiltration Basin	CL-9	CL-9
IB4	Infiltration Basin	CL-9	CL-9
WP34	Wet Pond	CL-9	CL-9
WP35	Wet Pond	CL-9	CL-9

Project Ranking and Selection

The intent of this analysis is to provide the information necessary to enable local natural resource managers to secure funding for the most cost-effective projects to achieve water quality goals. This analysis ranks potential projects by cost-effectiveness to facilitate project selection. There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Local resource management professionals will be responsible to select projects to pursue. Several considerations in addition to project cost-effectiveness for prioritizing installation are included.

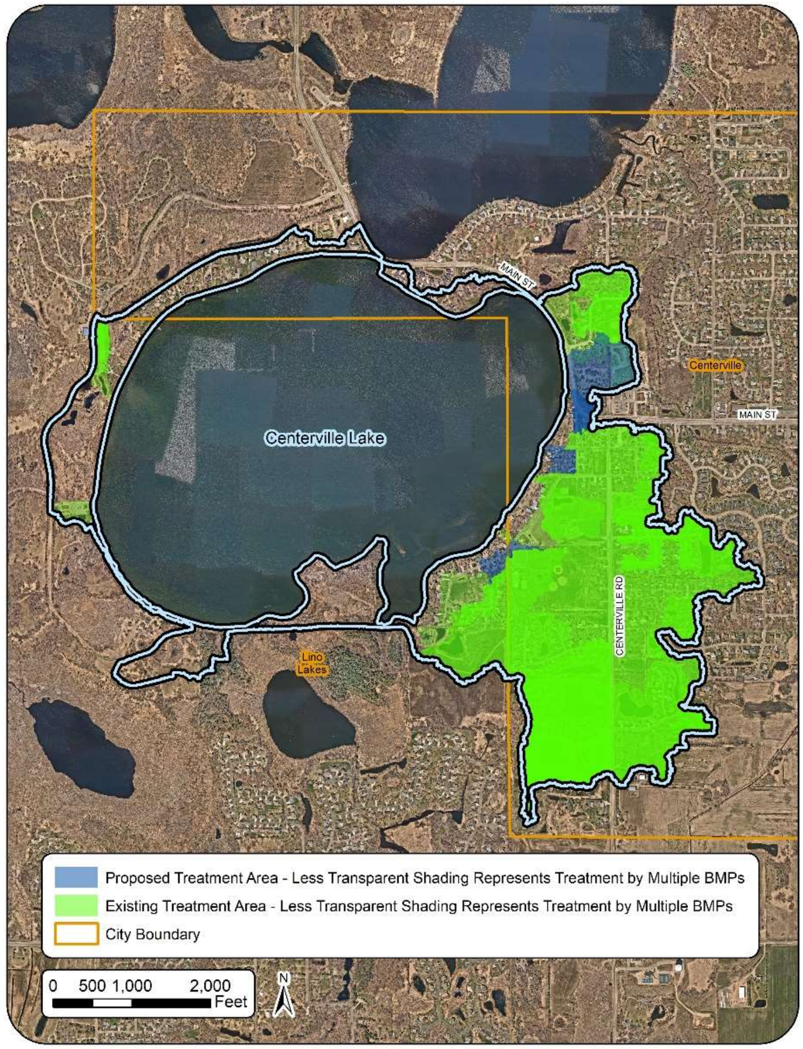


Figure 3: Areas with water quality treatment from existing and proposed BMPs.

Figure 3 shows portions of the drainage area that are currently treated by existing BMPs as well as the areas that could be treated with the retrofit opportunities identified in this report. Areas not covered by either existing or proposed BMPs are generally located adjacent to the lake and primarily represent direct drainage from lakeshore properties.

Project Ranking

The tables on the following pages rank all modeled projects by cost-effectiveness.

Projects were ranked in two ways:

1) Cost per pound of total phosphorus removed.
2) Cost per 1,000 pounds of total suspended solids removed and

Table 3: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1-17 are shown on this table. TSS and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ lb-TP/year (30-year)[1]
1	CL-8 WR-1	58	Water Reuse Optimization	CL-8	6.62	747	10.63	$0	$0	$0.00
2	CL-9 LS-9-10[2]	71	Lakeshore Stabilization	CL-9	3.15	6295	N/A	$47,209	$75	$523.81
3	CL-9 LS-9-8[2]	69	Lakeshore Stabilization	CL-9	2.58	5168	N/A	$39,474	$75	$538.20
4	CL-9 LS-9-7[2]	68	Lakeshore Stabilization	CL-9	0.99	1988	N/A	$17,634	$75	$666.86
5	CL-9 LS-9-4[2]	65	Lakeshore Stabilization	CL-9	1.45	2902	N/A	$89,309	$75	$2,103.32
6	CL-9 LS-9-9[2]	70	Lakeshore Stabilization	CL-9	1.08	2154	N/A	$67,309	$75	$2,153.08
7	CL-9 LS-9-2[2]	63	Lakeshore Stabilization	CL-9	0.94	1876	N/A	$59,134	$75	$2,181.68
8	CL-9 LS-9-1[2]	62	Lakeshore Stabilization	CL-9	0.86	1712	N/A	$54,309	$75	$2,202.92
9	CL-9 LS-9-3[2]	64	Lakeshore Stabilization	CL-9	0.57	1141	N/A	$37,534	$75	$2,324.33
10	CL-9 LS-9-6[2]	67	Lakeshore Stabilization	CL-9	0.42	845	N/A	$28,834	$75	$2,451.84
11	CL-9 LS-9-5[2]	66	Lakeshore Stabilization	CL-9	0.30	592	N/A	$21,384	$75	$2,662.38
12	CL-7 BF-7-1-2	53	Biofiltration Basin	CL-7	0.29	108	0.15	$23,984	$295	$3,813.47
13	CL-3 BF-3-6-1	38	Biofiltration Basin	CL-3	0.25	86	0.07	$23,984	$295	$4,343.12
14	CL-7 BF-7-1-1	52	Biofiltration Basin	CL-7	0.17	59	0.14	$23,984	$295	$6,476.13
15	CL-4 HD-4-1-1	42	Hydrodynamic Device	CL-4	0.24	89	N/A	$41,250	$630	$8,251.03
16	CL-3 HD-3-6-1	36	Hydrodynamic Device	CL-3	0.68	264	N/A	$153,750	$630	$8,475.70
17	CL-3 BB-3-6-1	37	Boulevard Bioretention	CL-3	0.03	13	0.01	$11,184	$295	$26,712.00

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]
[2] Lakeshore stabilization loading and reductions are not included in the catchment WinSLAMM loading estimates.

Table 4: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 17 are shown on this table. TP and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	CL-8 WR-1	58	Water Reuse Optimization	CL-8	6.62	747	10.63	$0	$0	$0.00
2	CL-9 LS-9-10[2]	71	Lakeshore Stabilization	CL-9	3.15	6295	N/A	$47,209	$75	$261.90
3	CL-9 LS-9-8[2]	69	Lakeshore Stabilization	CL-9	2.58	5168	N/A	$39,474	$75	$269.10
4	CL-9 LS-9-7[2]	68	Lakeshore Stabilization	CL-9	0.99	1988	N/A	$17,634	$75	$333.43
5	CL-9 LS-9-4[2]	65	Lakeshore Stabilization	CL-9	1.45	2902	N/A	$89,309	$75	$1,051.66
6	CL-9 LS-9-9[2]	70	Lakeshore Stabilization	CL-9	1.08	2154	N/A	$67,309	$75	$1,076.54
7	CL-9 LS-9-2[2]	63	Lakeshore Stabilization	CL-9	0.94	1876	N/A	$59,134	$75	$1,090.84
8	CL-9 LS-9-1[2]	62	Lakeshore Stabilization	CL-9	0.86	1712	N/A	$54,309	$75	$1,101.46
9	CL-9 LS-9-3[2]	64	Lakeshore Stabilization	CL-9	0.57	1141	N/A	$37,534	$75	$1,162.16
10	CL-9 LS-9-6[2]	67	Lakeshore Stabilization	CL-9	0.42	845	N/A	$28,834	$75	$1,225.92
11	CL-9 LS-9-5[2]	66	Lakeshore Stabilization	CL-9	0.30	592	N/A	$21,384	$75	$1,331.19
12	CL-7 BF-7-1-2	53	Biofiltration Basin	CL-7	0.29	108	0.15	$23,984	$295	$10,133.95
13	CL-3 BF-3-6-1	38	Biofiltration Basin	CL-3	0.25	86	0.07	$23,984	$295	$12,726.36
14	CL-7 BF-7-1-1	52	Biofiltration Basin	CL-7	0.17	59	0.14	$23,984	$295	$18,550.28
15	CL-3 HD-3-6-1	36	Hydrodynamic Device	CL-3	0.68	264	N/A	$153,750	$630	$21,799.24
16	CL-4 HD-4-1-1	42	Hydrodynamic Device	CL-4	0.24	89	N/A	$41,250	$630	$22,553.43
17	CL-3 BB-3-6-1	37	Boulevard Bioretention	CL-3	0.03	13	0.01	$11,184	$295	$51,369.23

[1][(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

[2]Lakeshore stabilization loading and reductions are not included in the catchment WinSLAMM loading estimates.

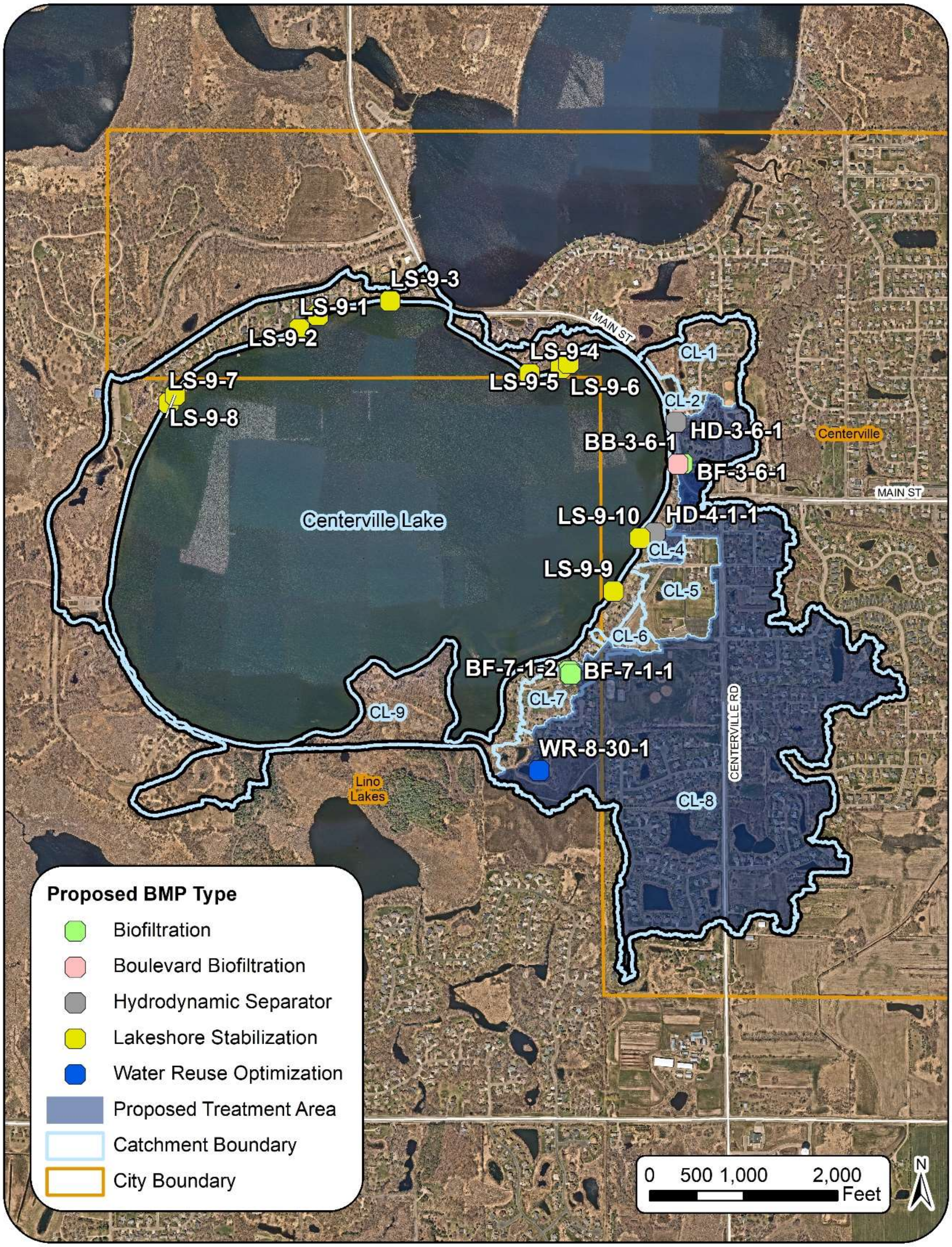


Figure 4: Study area map showing the proposed retrofits in the Centerville Lake subwatershed included in this report.

Project Selection

The combination of projects selected for pursuit could strive to achieve TP and TSS reductions in the most cost-effective manner possible. Several other factors affecting project installation decisions could be weighed by resource managers when selecting projects to pursue. These factors include but are not limited to the following:

- Total project costs
- Cumulative treatment
- Availability of funding
- Economies of scale
- Landowner willingness
- Project combinations with treatment train effects
- Non-target pollutant reductions
- Timing coordination with other projects to achieve cost savings
- Stakeholder input
- Number of parcels (landowners) involved
- Project visibility
- Educational value
- Long-term impacts on property values and public infrastructure

BMP Descriptions

BMP types proposed throughout the target areas are detailed in this section. This was done to reduce duplicative reporting. For each BMP type, the method of modeling, assumptions made, and cost estimate considerations are described.

BMPs were proposed for a specific site within the research area. Each of these projects, including site location, size, and estimated cost and pollutant reduction potential are noted in detail in the Catchment Profiles section. Project types included in the following sections are:

- Bioretention
    - Curb-cut Rain Gardens (Biofiltration)
    - Boulevard Biofiltration
- Enhanced Street Sweeping
- Hydrodynamic Device
- Lakeshore Stabilization

Bioretention

Bioretention BMPs utilize soil and vegetation to treat stormwater runoff from roads, driveways, rooftops, and other impervious surfaces. Differing levels of volume and/or pollutant reductions can be achieved depending on the type of bioretention selected.

Bioretention can function as either filtration (biofiltration) or infiltration (bioinfiltration). Biofiltration BMPs are designed with a buried perforated drain tile that allows water in the basin to discharge to the stormwater drainage system after having been filtered through the soil. Bioinfiltration BMPs have no underdrain, ensuring that all water that enters the basins will either infiltrate into the soil or be evapotranspired into the air. Bioinfiltration provides 100% retention and treatment of captured stormwater, whereas biofiltration basins provide excellent removal of particulate contaminants but limited removal of dissolved contaminants, such as DP.

Table 5 conveys the general efficacy of the two types of bioretention (biofiltration and bioinfiltration) in terms of the three most common pollutants, total suspended solids (TSS), particular phosphorus (PP), dissolved phosphorus (DP), and stormwater volume.

Table 5: Matrix describing curb-cut rain garden efficacy for pollutant removal based on type.

Curb-cut Rain Garden Type	TSS Removal	PP Removal	DP Removal	Volume Reduction	Size of Area Treated	Site Selection and Design Notes
Bioinfiltration	High	High	High	High	High	Optimal sites are low enough in the landscape to capture most of the watershed but high enough to ensure adequate separation from the water table for treatment purposes. Higher soil infiltration rates allow for deeper basins and may eliminate the need for underdrains.
Biofiltration	High	Moderate	Low	Low	High	

The treatment efficacy of a particular bioretention project depends on many factors, including but not limited to the pollutant of concern, the quality of water entering the project, the intensity and duration of storm events, project size, position of the project in the landscape, existing downstream treatment, soil and vegetation characteristics, and project type (i.e. bioinfiltration or biofiltration). Optimally, new bioretention will capture water that would otherwise discharge into a priority waterbody untreated.

The volume and pollutant removal potential of each bioretention practice was estimated using WinSLAMM. In order to calculate cost-benefit, the cost of each project had to be estimated. To estimate the total cost of project installation, labor costs for project outreach and promotion, project design, project administration, and project maintenance over the anticipated life of the practice were considered in addition to actual construction costs. If multiple projects were installed, cost savings could be achieved on the administration and promotion costs (and possibly the construction costs for a large and competitive bid).

Curb-cut Rain Gardens (Biofiltration)

Curb-cut rain gardens capture stormwater that is in roadside gutters and redirects it into shallow roadside basins. These curb-cut rain gardens can provide treatment for impervious surface runoff from one-to-many properties and can be located anywhere sufficient space is available. Because curb-cut rain gardens capture water that is already part of the stormwater drainage system, they are more likely to provide higher benefits. Generally, curb-cut rain gardens were proposed in areas without sufficient existing stormwater treatment and located immediately upgradient of a catch basin serving a large drainage area.

Figure 5: Rain garden before/after and during a rainfall event

All curb-cut rain gardens were presumed to have pretreatment, mulch, and perennial ornamental and native plants. The useful life of the project was assumed to be 30 years and so all costs are amortized over that time period. Additional costs were included for rehabilitation of the gardens at years 10 and 20. Rehabilitation includes removal of accumulated sediment and supplemental planting. Annual maintenance was assumed to be completed by the landowner of the property at which the rain garden could be installed.

Boulevard Biofiltration

Similar to curb-cut rain gardens, stormwater runoff could be directed to a boulevard area via a curb-cut. The limited space available within most boulevards restricts the storage volume available for water quality treatment.

Enhanced Street Sweeping

Street sweeping is a cost-effective way to reduce nutrient and sediment loads entering lakes, streams and wetlands from storm sewers. Sweeping is typically completed in the spring to remove accumulated sediment from winter road treatment, and again in the fall to reduce leaf litter. However, trees adjacent to roadways can be a significant contributor of nutrient loading throughout the year as they drop seeds, pollen, leaves, and other organic debris. Similarly, large gaps in traditional fall and spring sweeping schedules give these materials time to re-accumulate and flush into storm drains before they can be removed.

Enhanced street sweeping is the incorporation of additional sweeping protocols, the timing and location of which are targeted to maximize water quality protection. One way to prioritize locations for enhanced sweeping is to quantify tree canopy cover overhanging and immediately adjacent to roadways; this is because tree canopy cover is highly correlated with the amount of recoverable organic materials on roadways (Kalinosky, 2015) and average total phosphorus concentrations in stormwater runoff (Janke et al. 2017). Tree canopy data can then be combined with stormwater infrastructure information to identify roadways likely contributing most to nutrient inputs derived from fallen tree materials.

Tree canopy cover within the study areas was analyzed following methodology in the *Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization*, produced by Emmons and Oliver Resources Inc. (EOR) for the Lower St. Croix Watershed Partnership (LSCWP).

First, centerline data was compiled for all paved roadways within or immediately adjacent to the targeted subwatershed boundaries. Next, each roadway was assigned a right-of-way width corresponding with its MNDOT functional classification. Right-of-way values were then referenced to generate a buffer around each roadway, and deciduous tree canopy abundance within these buffers (total % coverage) was quantified by intersecting them with the *Twin Cities Metro Area (TCMA) Urban Tree Canopy Classification* dataset. Altogether, these processes allowed for canopy cover comparisons within the study areas, and correspondingly the prioritization of roadways most likely to contribute nutrient-rich stormwater derived from tree materials.

The streets are currently swept once annually. Enhanced sweeping schedules were modeled for each catchment, and page 24 summarizes the modeling results. Maps are provided of road tree canopy cover percentage in the Catchment Profiles.

Hydrodynamic Devices

In heavily urbanized settings, stormwater is immediately intercepted with roadway catch basins and conveyed rapidly via storm sewer pipes to its destination. Once stormwater is intercepted by catch basins, it can be very difficult to supply treatment without large end-of-pipe projects such as regional ponds. One option is a hydrodynamic device (Figure 6). Hydrodynamic devices are installed in line with the existing storm sewer network and can provide treatment for up to 10-15 acres of upland drainage area. This practice applies some form of filtration, settling, or hydrodynamic separation to remove coarse sediment, litter, oil, and grease. These devices are particularly useful in small but highly urbanized drainage areas and can be used as pretreatment for other downstream stormwater BMPs.

Each device's pollutant removal potential was estimated using WinSLAMM. Devices were sized based on upstream drainage area to ensure peak flow does not exceed each device's design guidelines. For this analysis, Downstream Defender devices were modeled based on available information and to maintain continuity across other SRAs. Devices were proposed along particular storm sewer lines and often just upstream of intersections with another, larger line. Model results assume the device is receiving input from all nearby catch basins noted.

In order to calculate cost-effectiveness, the cost of each project had to be estimated. Cost estimation included labor costs for project outreach, promotion, design, administration, and maintenance over the anticipated life of the practice were considered in addition to actual material and construction costs. Load reduction estimates for these projects are noted in the Catchment Profiles section.

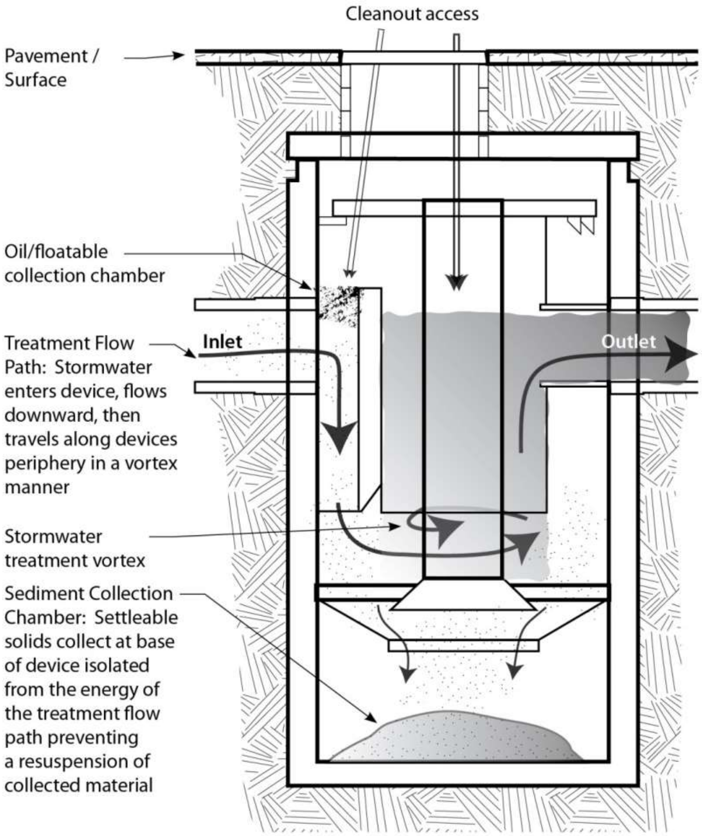


Figure 6: Schematic of a typical hydrodynamic device

Lakeshore Stabilization

ACD completed a Centerville Lake shoreline erosion inventory in 2021. Centerville Lake has approximately 20,400 feet of shoreline, and the entire area was inventoried. Photos of the shoreline were collected using a 360° GPS camera mounted within a boat. The pictures are available for viewing on Google Maps (see example screen capture to right).

The picture inventory was used in conjunction with GIS resources to estimate the size and severity of erosion. Only 1% of the shoreline was categorized as severely eroding and only 7% was categorized as moderately eroding. Stretches of severe and moderate erosion primarily align with mowed turf grass areas, clearly highlighting the value and importance of shoreline buffers for shoreline stabilization. The remainder of the shoreline was either stable (71%) or slightly eroding (21%).

Annual soil loss metrics were calculated using estimates of shoreline length, height, and erosion severity. Assumptions for moderately eroding sites included a 1’ vertical face and 0.1’ annual lateral recession rate. Whereas assumptions for severely eroding sites included a 2’ vertical face and 0.3’ annual lateral recession rate. The WI NRCS Direct Volume method was paired with the Board of Water and Soil Resources (BWSR) ‘BWSR Water Erosion Pollution Reduction Estimator 2.0’ spreadsheet to estimate erosion volumes and associated TSS and TP reductions. Specifically, the ‘Stream&Ditch’ tab assuming silt soils was utilized.

Cost estimates for each stretch of erosion were calculated using equations informed by previous ACD-led stabilization projects. Cost: benefit values derived from project cost estimates and lakeshore sediment losses were then determined, providing a metric for gauging the cost effectiveness of each potential project.

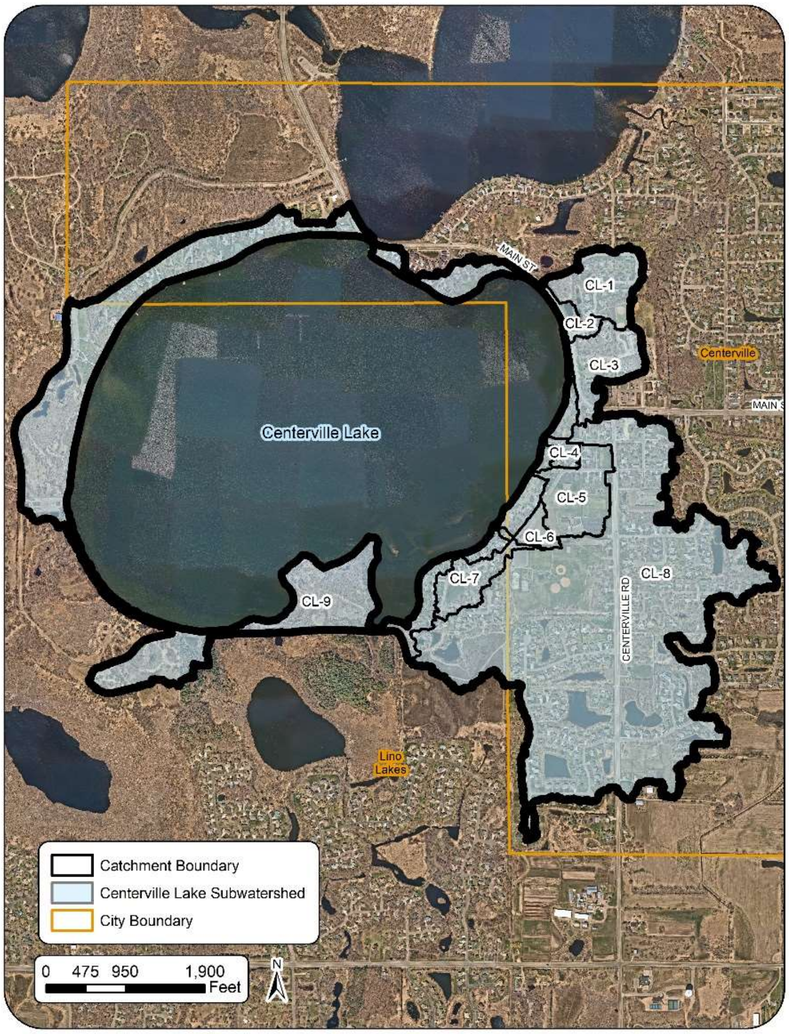
Profile pages with site-specific information for each eroded lakeshore are included in this report. Collectively, the erosion inventory provided herein facilitates the strategic pursuit of lakeshore stabilization projects that protect water quality and enhance lakeshore habitat at Centerville Lake.

Note that loadings and reductions associated with shoreline erosion are not included in the catchment WinSLAMM loading estimates. The shoreline erosion load estimates are independent of the catchment TSS and TP load estimates in this analysis. Nevertheless, lakeshore erosion is the most direct source of loading to Centerville Lake (i.e. 100% of the TSS and TP reaches the lake).

Centerville Lake Subwatershed

Catchment Profiles

Catchment ID	Page
CL-1	29
CL-2	32
CL-3	35
CL-4	41
CL-5	45
CL-6	48
CL-7	51
CL-8	56
CL-9	61



Existing Conditions Summary	
Acres	417.7
Dominant Land Cover	Residential
Volume (ac-ft/yr)	147.81
TP (lb/yr)	167.88
TSS (lb/yr)	30,984

SUBWATERSHED SUMMARY

The 418-acre Centerville Lake subwatershed was divided into nine catchments for this analysis. Catchment profiles on the following pages provide additional information, including details on existing and proposed stormwater treatment.

EXISTING STORMWATER TREATMENT

Substantial stormwater treatment exists throughout the Centerville Lake subwatershed. Of particular note are the abundant stormwater ponds and a large water reuse system. The City of Centerville also conducts street cleaning once annually throughout the subwatershed. Table X provides a summary of catchment volume, TSS, and TP loading under base and existing conditions. Reductions associated with exiting BMPs are also included. Additional detail is provided in the Catchment Profiles.

Table 6: Catchment volume, TSS, and TP loading under base and existing conditions. Reductions associated with existing BMPs are also shown.

			BASE CONDITION			EXISTING CONDITION			REDUCTIONS DUE TO EXISTING BMPS		
Catchment	Acres	Dominant Land Cover	Volume (ac-ft/yr)	TSS (lb/yr)	TP (lb/yr)	Volume (ac-ft/yr)	TSS (lb/yr)	TP (lb/yr)	Volume (ac-ft/yr)	TSS (lb/yr)	TP (lb/yr)
CL-1	16.7	Medium Density Residential	8.12	3563	12.94	8.12	985	6.25	0.00	2578	6.69
CL-2	3.5	Medium Density Residential	2.41	469	2.34	2.41	102	1.34	0.00	367	0.99
CL-3	14.8	Medium Density Residential	9.56	4036	13.52	7.98	2304	9.07	1.58	1732	4.45
CL-4	2.5	Medium Density Residential	1.44	578	2.16	1.44	528	2.05	0.00	50	0.12
CL-5	16.7	Open Space	10.71	4263	13.35	9.41	1687	7.66	1.30	2576	5.69
CL-6	3.8	Open Space	1.36	556	2.00	1.02	167	1.10	0.34	389	0.90
CL-7	9.7	Medium Density Residential	4.20	1913	7.88	4.20	1129	5.56	0.00	784	2.32
CL-8	221.9	Medium Density Residential	98.48	42231	171.70	83.40	11500	80.50	15.08	30731	91.20
CL-9	128.1	Park	30.62	14429	60.05	29.82	12581	54.35	0.80	1848	5.70
CL TOTAL	417.7		166.91	72038	285.93	147.81	30984	167.88	19.10	41055	118.05

RETROFITS CONSIDERED

STORMWATER PONDS

New ponds and retrofits to existing stormwater ponds were considered. However, plan sets were available for most ponds included in the analysis, and no obvious deficiencies were noted. An extensive field inventory of current pond condition was not completed, nor was any water quality monitoring conducted. The City of Centerville has an active pond inspection program that has documented minimal sedimentation within existing ponds to date. Current pond sedimentation estimates from the City of Centerville indicated pond dredging will be required every 75 years.

Because most of the pollutant reductions from existing BMPs throughout the subwatershed are due to stormwater ponds, continued pond condition inventories will be valuable. Maintenance needs could be identified in the future to ensure all ponds are functioning as originally designed, which is how the ponds were modeled in this analysis. Furthermore, water quality monitoring could identify any hot spots that may warrant the consideration of pond retrofits (e.g. increasing storage volume through either increasing ponding depth or pond footprint or installation of either passive or pump-controlled iron-enhanced sand filters).

ENHANCED STREET SWEEPING

Enhanced street sweeping was also considered throughout the subwatershed. Methodology for the analysis is detailed in the 'Enhanced Street Sweeping' profile in the 'BMP Descriptions' section of this report. Road tree canopy cover maps are also included in each of the Catchment Profiles if targeted street sweeping is pursued. However, increasing street sweeping frequency in the WinSLAMM models resulted in marginal additional reductions of TP and TSS. This is due to the prevalence of existing BMPs, primarily the stormwater ponds.

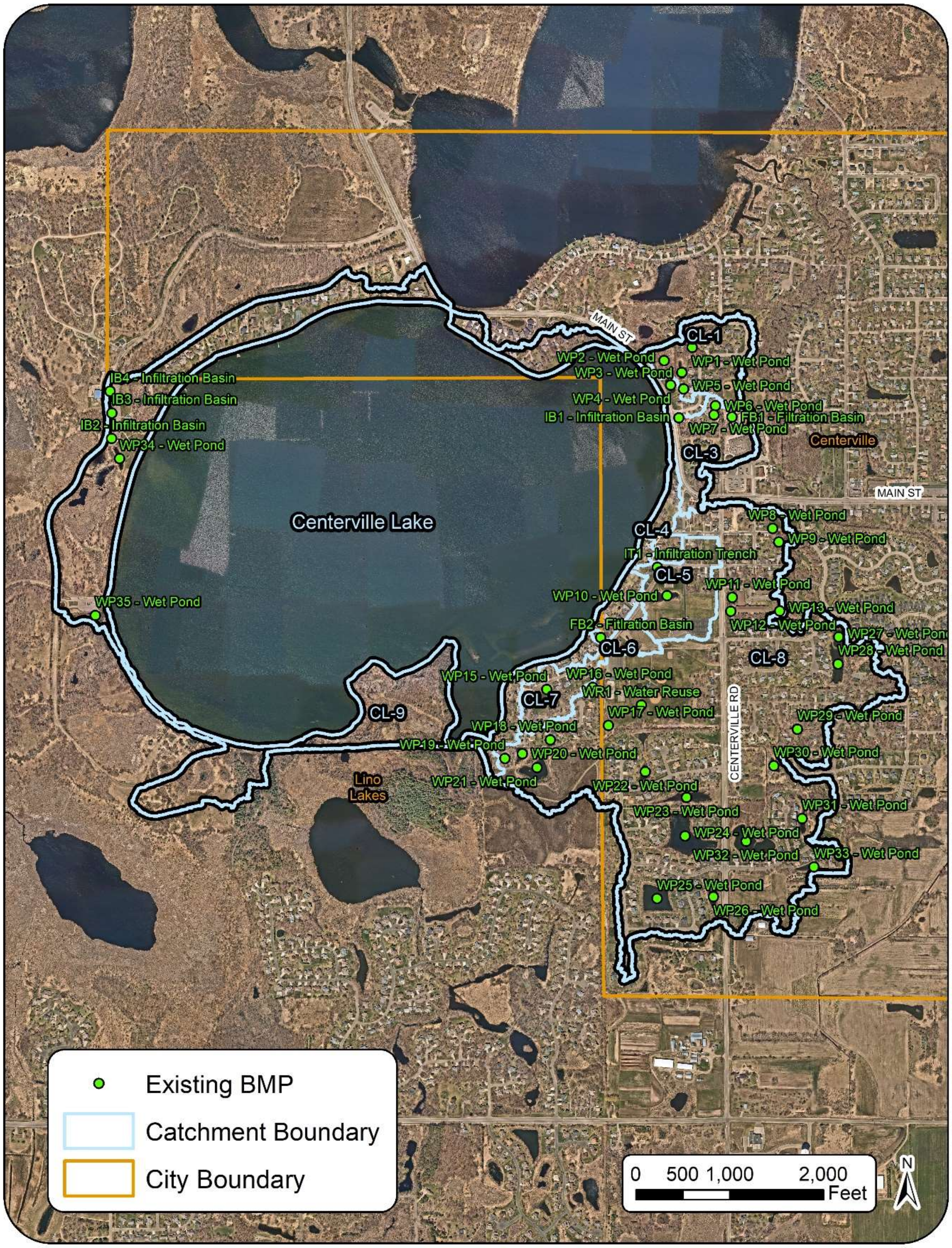
The largest catchment, CL-8 (222 acres with many roads and primarily residential land use), can be used as an example. Street cleaning frequency was increased to once every eight weeks (i.e. 5 times per year) in the WinSLAMM model, which resulted in the additional removal of 52 lbs-TSS/yr and 0.04 lbs-TP/yr. Considering the increased frequency results in four additional sweepings per year, the additional pollutant reductions are arguably insignificant (i.e. 13 lbs-TSS/yr and 0.01 lbs-TP/yr per additional sweeping event).

The highest frequency sweeping available in WinSLAMM is daily sweeping, which would be infeasible. Daily sweeping was modeled only to compare potential pollutant reductions. Sweeping 217 times per year in CL-8 only resulted in the additional removal of 1,649 lbs-TSS/yr and 2.98 lbs-TP/yr. From a TP perspective that represents a 3.7% reduction, and the associated cost would most likely be infeasible. Therefore, based solely on the estimates from WinSLAMM, street cleaning was not deemed a cost-effective retrofit.

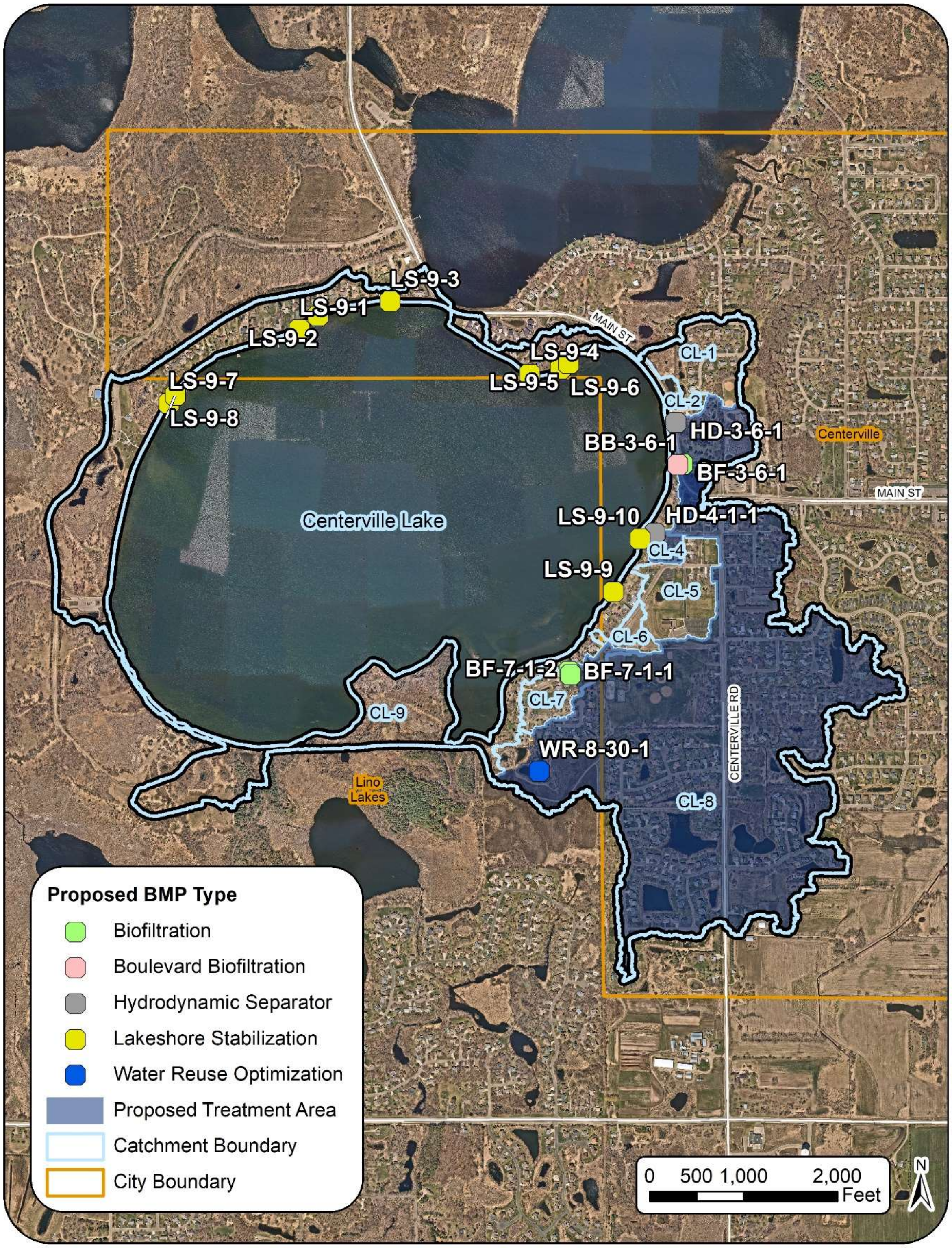
Street cleaning could result in reduced stormwater pond maintenance and extended longevity/functionality by limiting sediment and organic matter accumulation within the ponds. That said, as previously mentioned, the City of Centerville has an active pond inspection program that has documented minimal sedimentation to date. Current pond sedimentation estimates from the City of Centerville indicated pond dredging will be required every 75 years.

Because the ponds were modeled based on as-built conditions using the best available information (i.e. original plan sets in most cases), they were assumed to be functioning as originally designed. Continued stormwater pond inspections documenting current depths paired with water quality monitoring data at pond outlets may identify future pond maintenance and/or retrofit opportunities.

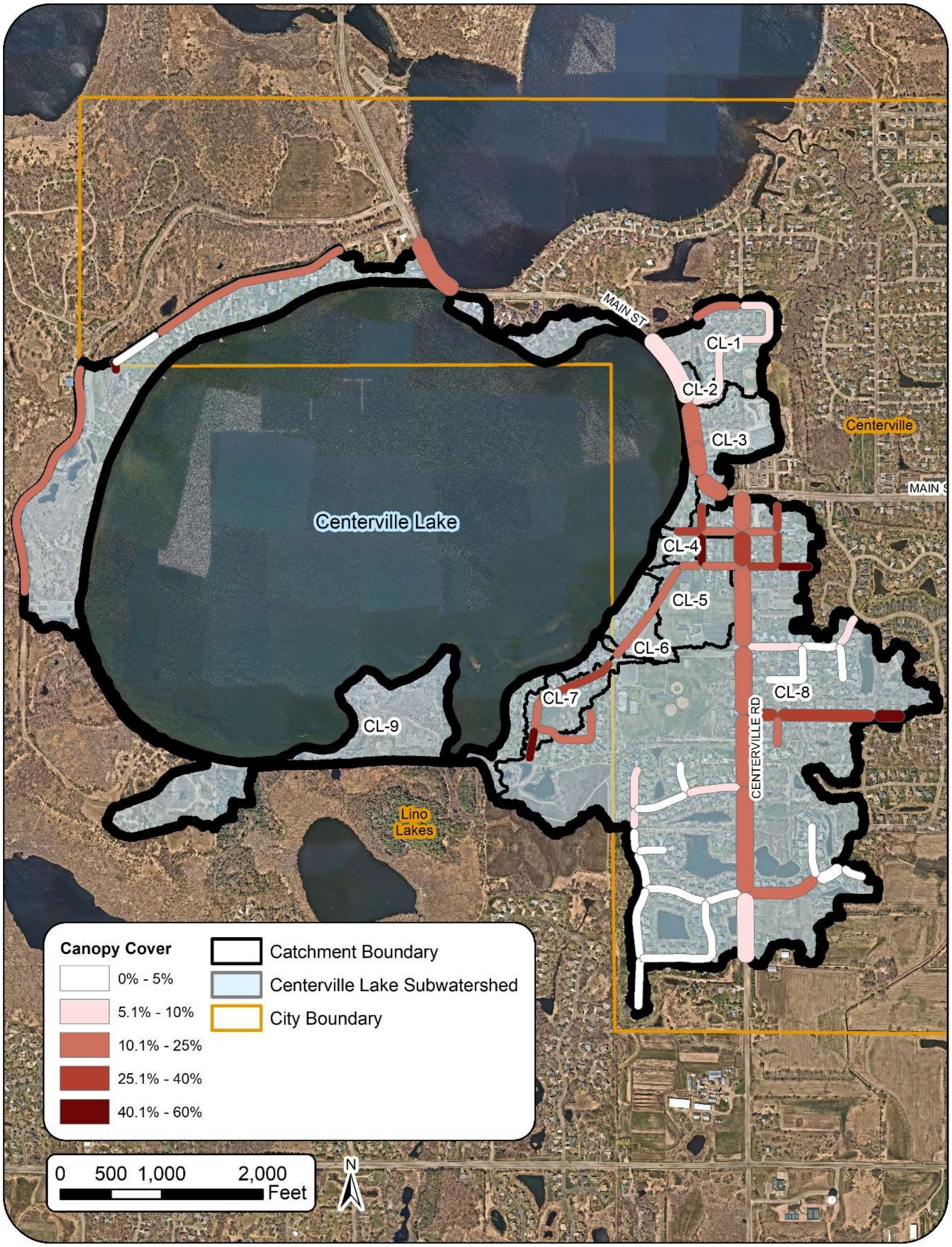
EXISTING STORMWATER TREATMENT OVERVIEW



RETROFIT OPPORTUNITIES OVERVIEW

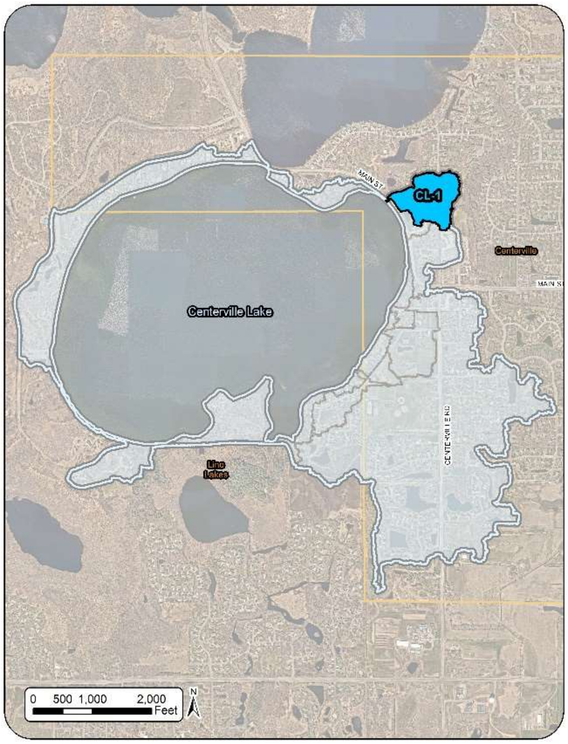


ROAD TREE CANOPY COVER



Catchment CL-1

Existing Catchment Summary	
Acres	16.7
Parcels	37
Land Cover	76.7% Residential 12.4% Open Space 10.9% Institutional



CATCHMENT DESCRIPTION

This catchment is located in Centerville on the northeast side of the lake and includes the northern portion of the Lakeland Hills residential development. Stormwater runoff is routed through a series of stormwater ponds and a wetland prior to discharging into Centerville Lake.

EXISTING STORMWATER TREATMENT

There are three wet ponds and a large wetland that provide stormwater treatment within this catchment. In addition, street cleaning is conducted in the spring of each year by the City of Centerville. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	5			
	BMP Types	Street Cleaning, 4 Wet Ponds (WP1, WP2, WP3, WP5)			
	TP (lb/yr)	12.94	6.69	52%	**6.25**
	TSS (lb/yr)	3,563	2,578	72%	**985**
	Volume (acre-feet/yr)	8.1	0.0	0%	**8.1**

RETROFIT OPPORTUNITIES OVERVIEW

No retrofits were modeled in this catchment because of the existing treatment train provided by the stormwater ponds and wetland.

RETROFITS CONSIDERED

Because the catchment is primarily comprised of residential land use, curb-cut rain gardens were considered at locations that would maximize contributing drainage areas. However, the multiple wet ponds and large wetland were deemed sufficient for water quality treatment. Furthermore, a high water table was indicated in the underlying soils data that would likely restrict infiltration.

A wetland enhancement was considered, but monitoring data collected at the outlet of the wetland is recommended prior to pursuing a project. Wetland export of TP can be variable based on wetland type and hydrologic conditions that have been modified as a result of development. The wetland in its current state likely provides effective TSS removal.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER

Catchment CL-2

Existing Catchment Summary	
Acres	3.5
Parcels	9
Land Cover	55.0% Residential 45.0% Open Space

CATCHMENT DESCRIPTION

This catchment is also located on the northeast side of Centerville Lake. It includes a section of Main Street and a southern portion of the Lakeland Hills residential development. Stormwater runoff is routed to a stormwater pond then discharges into Centerville Lake.

EXISTING STORMWATER TREATMENT

All stormwater runoff is routed to a stormwater pond located on the east side of Main Street. In addition, street cleaning is conducted in the spring of each year by the City of Centerville. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Wet Pond (WP4)			
	TP (lb/yr)	2.34	0.99	43%	**1.34**
	TSS (lb/yr)	469	367	78%	**102**
	Volume (acre-feet/yr)	2.4	0.0	0%	**2.4**

RETROFIT OPPORTUNITIES OVERVIEW

No stormwater retrofits are recommended for this catchment because of the existing treatment provided by the stormwater pond.

RETROFITS CONSIDERED

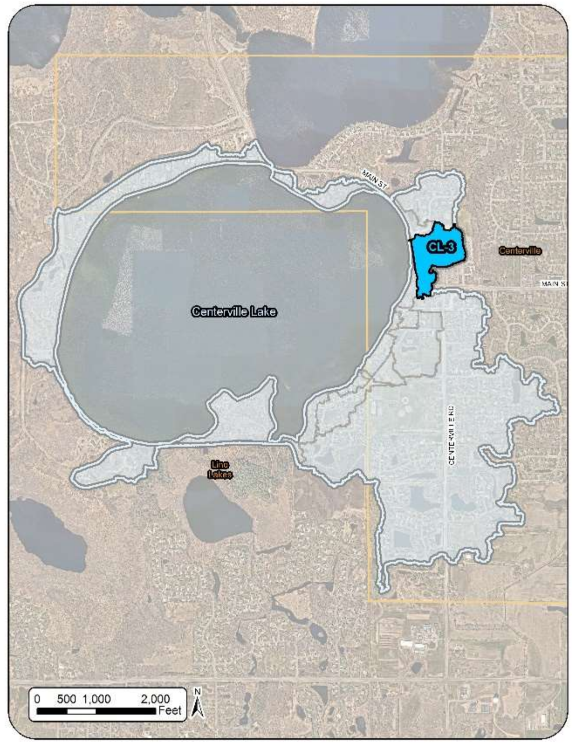
Curb-cut rain gardens were considered at locations that would maximize contributing drainage areas. However, the wet pond was deemed sufficient for water quality treatment. A pond modification and iron enhanced sand filter were also considered for the existing pond, but the small contributing drainage area (3.8 acres) does not likely warrant substantial retrofits.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER

Catchment CL-3

Existing Catchment Summary	
Acres	14.8
Parcels	19
Land Cover	55.8% Residential 39.7% Institutional 4.5% Open Space



CATCHMENT DESCRIPTION

This catchment is located on the northeast side of Centerville Lake. It includes the northern portion of the Centerville Elementary School campus, a section of Main Street, and the southernmost backyards of the Lakeland Hills residential development. Stormwater runoff is routed from east to west and south to north prior to discharging into Centerville Lake. Land use in the catchment is comprised of residential and institutional.

EXISTING STORMWATER TREATMENT

Subsets of the catchment are treated by two stormwater ponds, a filtration basin, and an infiltration basin. In addition, street cleaning is conducted in the spring of each year by the City of Centerville. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	5			
	BMP Types	Street Cleaning, 2 Wet Ponds (WP6, WP7), Filtration Basin (FB1), Infiltration Basin (IB1)			
	TP (lb/yr)	13.52	4.45	33%	**9.07**
	TSS (lb/yr)	4,036	1,732	43%	**2,304**
	Volume (acre-feet/yr)	9.6	1.58	17%	**8.0**

RETROFIT OPPORTUNITIES OVERVIEW

Three BMPs are proposed within this catchment. They include one hydrodynamic separator, one biofiltration basin, and one boulevard biofiltration basin.

Much of the catchment is either landscaped area (i.e. pervious) or already treated by a BMP. Therefore, the proposed BMPs are positioned in order to provide treatment for the areas of Main Street that are currently discharging directly to Centerville Lake. The hydrodynamic separator is positioned near the outfall to the lake in order to provide treatment for the entire 14.5 acre catchment. The biofiltration basin is positioned on the east side of Main Street adjacent to a catch basin for an underdrain connection. The boulevard biofiltration basin is positioned on the west side of Main Street where a walking trail creates a boulevard and limits available space for a larger biofiltration basin. Similar to the biofiltration basin on the east side, the boulevard biofiltration basin is adjacent to a catch basin in order to accommodate an underdrain connection.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER

Project ID: CL-3 HD-3-6-1

Main St. and Lakeland Circle
Hydrodynamic Device

Drainage Area – 14.8 acres
Location – Intersection of Main St. and Lakeland Circle
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Main St. A device at this location would provide treatment to runoff from the entire catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	10	ft diameter
	TP (lb/yr)	0.68	7.5%
	TSS (lb/yr)	264	11.5%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***	$3,750	
	Design & Construction Costs**	$150,000	
	Total Estimated Project Cost (2021)	**$153,750**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$8,476**	
	30-yr Average Cost/1,000lb-TSS	**$21,799**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($100,000 for materials) + ($50,000 for labor and installation costs)

***Per BMP: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: CL-3 BB-3-6-1

Main St.
Boulevard Biofiltration Basin

Drainage Area – 1.5 acres
Location – West side of Main St. just east of Trail Side Park
Property Ownership – Public
Site Specific Information – An opportunity for a boulevard biofiltration basin exists at this location. A boulevard biofiltration basin was modeled at the optimal location adjacent to the catch basin due to the limited infiltration capacity of the underlying soils. The proposed basin is in close proximity to the existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Boulevard Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	90	sq-ft
	TP (lb/yr)	0.03	0.3%
	TSS (lb/yr)	13	0.6%
	Volume (acre-feet/yr)	0.01	0.1%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$10,520
	Total Estimated Project Cost (2023)		**$11,184**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$26,712**	
	30-yr Average Cost/1,000lb-TSS	**$51,369**	
	30-yr Average Cost/ac-ft Vol.	**$64,500**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($80/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: CL-3 BF-3-6-1

Main St.
Biofiltration Basin

Drainage Area – 1.34 acres
Location – East side of Main St. just east of Trail Side Park
Property Ownership – Private
Site Specific Information – An opportunity for a biofiltration basin exists at this location. A biofiltration basin was modeled at the optimal location adjacent to the catch basin due to the limited infiltration capacity of the underlying soils. The proposed basin is in close proximity to the existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.25	2.8%
	TSS (lb/yr)	86	3.7%
	Volume (acre-feet/yr)	0.07	0.8%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$23,320
	Total Estimated Project Cost (2023)		**$23,984**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$4,343**	
	30-yr Average Cost/1,000lb-TSS	**$12,726**	
	30-yr Average Cost/ac-ft Vol.	**$16,577**	

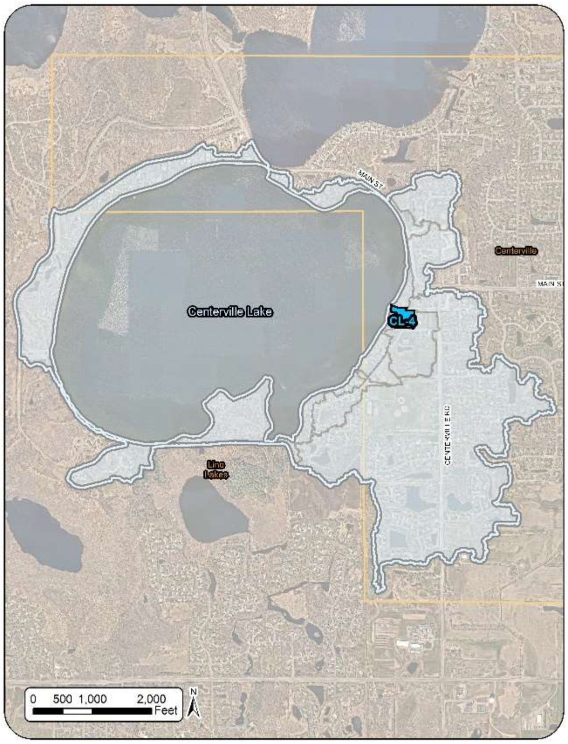
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($80/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment CL-4

Existing Catchment Summary	
Acres	2.5
Parcels	8
Land Cover	98.1% Residential 0.9% Water 0.6% Open Space 0.4% Institutional



CATCHMENT DESCRIPTION

Catchment CL-4 is located on the east side of Centerville Lake and is comprised primarily of residential land use. The contributing drainage area is small and is largely pervious (i.e. residential backyard areas) with a small section of Sorel St. Stormwater runoff is routed from the southeast to northwest via overland flow where it enters a catch basin on Sorel St. that discharges directly to Centerville Lake.

EXISTING STORMWATER TREATMENT

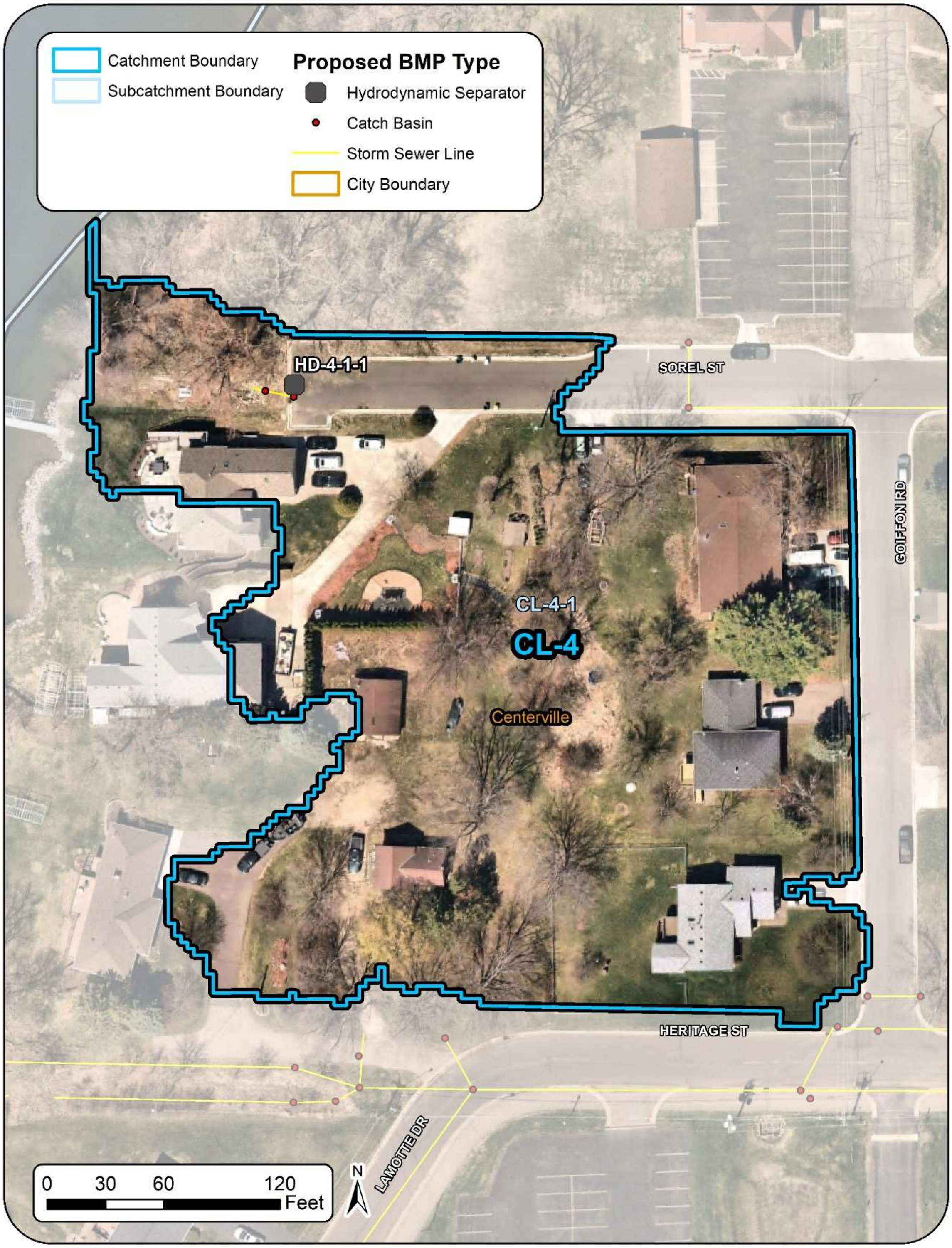
Street cleaning is conducted in the spring of each year by the City of Centerville. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	2.16	0.12	5%	**2.05**
	TSS (lb/yr)	578	50	9%	**528**
	Volume (acre-feet/yr)	1.4	0.0	0%	**1.4**

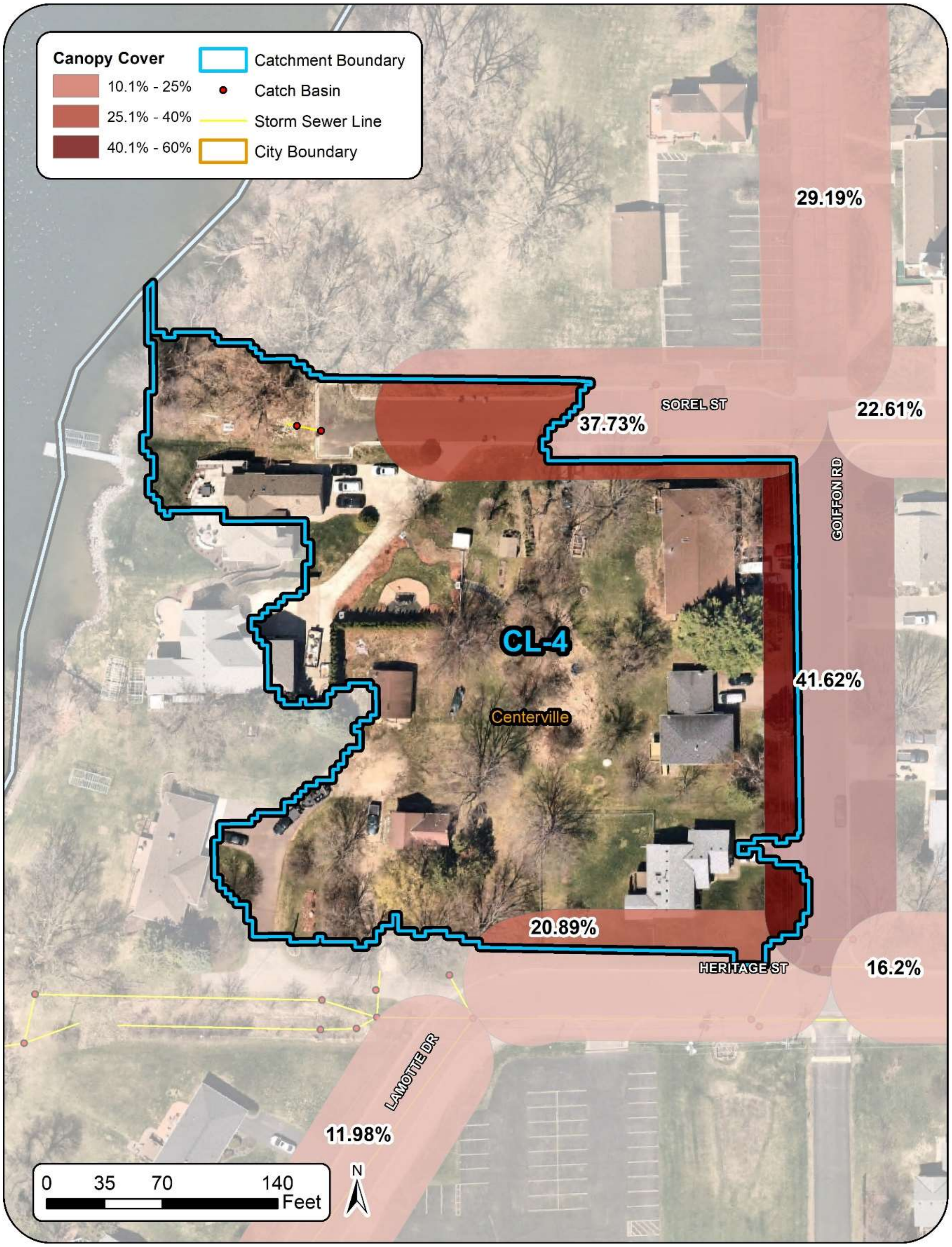
RETROFIT OPPORTUNITIES OVERVIEW

A hydrodynamic separator is proposed at the western most extent of Sorel St. The structure would provide treatment for the entire catchment. Given the limited space available and steep slope adjacent to the lake, an underground structure was deemed appropriate.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER



Project ID: CL-4 HD-4-1-1

West End of Sorel St.
Hydrodynamic Device

Drainage Area – 2.5 acres
Location – Western end of Sorel St. just east of Centerville Lake
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed in line with the storm sewer line on Sorel St. just east of Centerville Lake. A device at this location would provide treatment to runoff from the entire catchment. The table below provides pollutant removals and estimated costs.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMP	6	ft diameter
	TP (lb/yr)	0.24	11.9%
	TSS (lb/yr)	89	16.8%
	Volume (acre-feet/yr)	n/a	n/a
Cost	Administration & Promotion Costs*	$3,750	
	Design & Construction Costs**	$37,500	
	Total Estimated Project Cost (2021)	**$41,250**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$8,251**	
	30-yr Average Cost/1,000lb-TSS	**$22,553**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

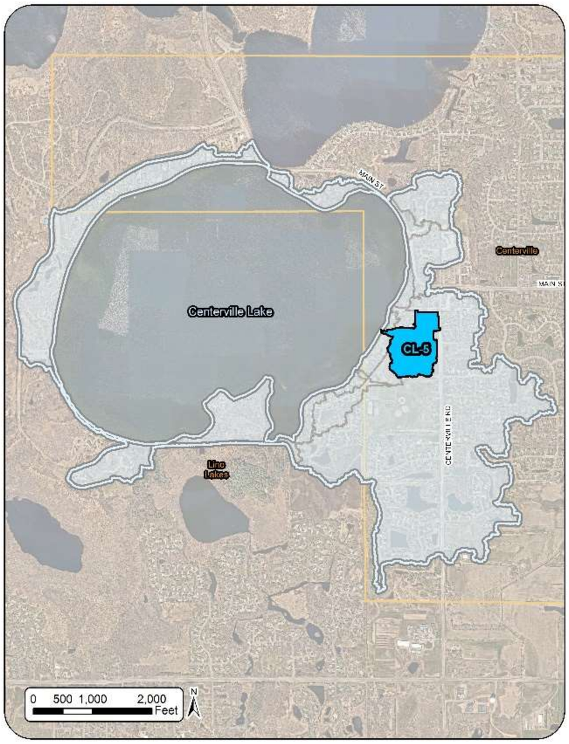
*Indirect Cost: (25 hours at $150/hour)

**Direct Cost: ($25,000 for materials) + ($12,500 for labor and installation costs)

***Per BMP: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

Catchment CL-5

Existing Catchment Summary	
Acres	16.7
Parcels	23
Land Cover	37.8% Open Space 36.2% Institutional 26.0% Residential



CATCHMENT DESCRIPTION

This catchment is located on the east side of Centerville Lake and includes residential and institutional land uses. The primary stormwater conveyance is from east to west along Heritage Street where it ultimately discharges into Centerville Lake.

EXISTING STORMWATER TREATMENT

One stormwater pond, a hydrodynamic separator, and an infiltration trench exist in the catchment. St. Genevieve Church has a large stormwater pond that provides water treatment for the campus. The hydrodynamic separator serves as pretreatment for the infiltration trench that receives runoff from the entire catchment prior to discharging to Centerville Lake. In addition, street cleaning is conducted in the spring of each year by the City of Centerville. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	4			
	BMP Types	Street Cleaning, Wet Pond (WP10), Hydrodynamic Separator (HD1), Iniltration Trench (IT1)			
	TP (lb/yr)	13.35	5.69	43%	**7.66**
	TSS (lb/yr)	4,263	2,576	60%	**1,687**
	Volume (acre-feet/yr)	10.7	1.3	12%	**9.4**

RETROFIT OPPORTUNITIES OVERVIEW

No stormwater retrofits are recommended for this catchment because of the existing treatment present.

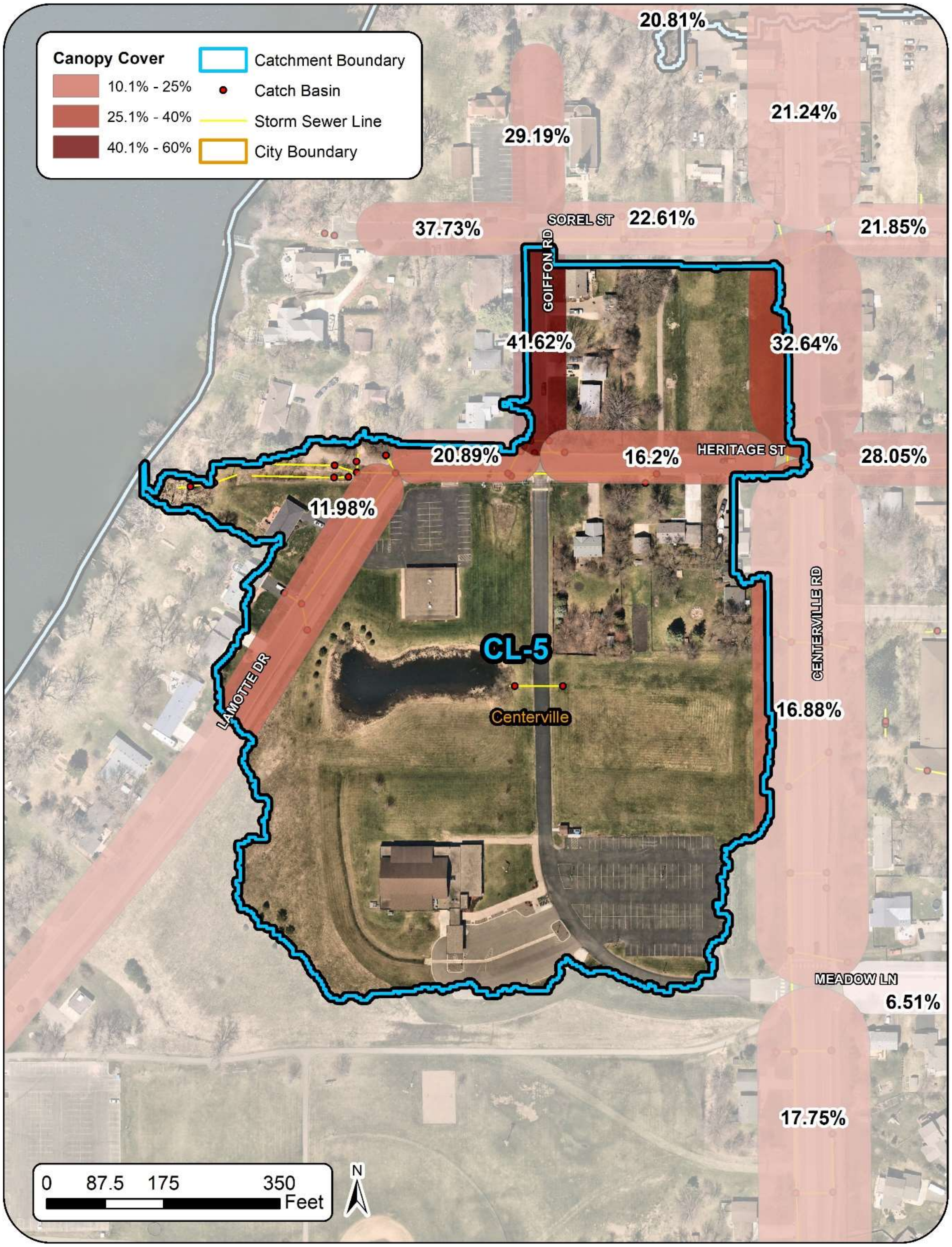
RETROFITS CONSIDERED

Curb-cut rain gardens were considered at locations that would maximize contributing drainage areas. However, the existing treatment was deemed sufficient for water quality treatment.

A retrofit to the existing pond was considered, but based on the available plan set, the pond was determined to be providing sufficient treatment for the contributing drainage area at St. Genevieve Church.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Catchment CL-6

Existing Catchment Summary	
Acres	3.8
Parcels	10
Land Cover	58.0% Open Space 23.7% Park 12.1% Industrial 4.0% Residential 2.1% Institutional 0.1% Water

CATCHMENT DESCRIPTION

Catchment CL-6 is on the east side of the lake and encompasses a small drainage area primarily comprised of open space within Laurie LaMotte Memorial Park on the east side of LaMotte Drive. Stormwater runoff is routed to a filtration basin on the west side of LaMotte Drive prior to discharging to Centerville Lake.

EXISTING STORMWATER TREATMENT

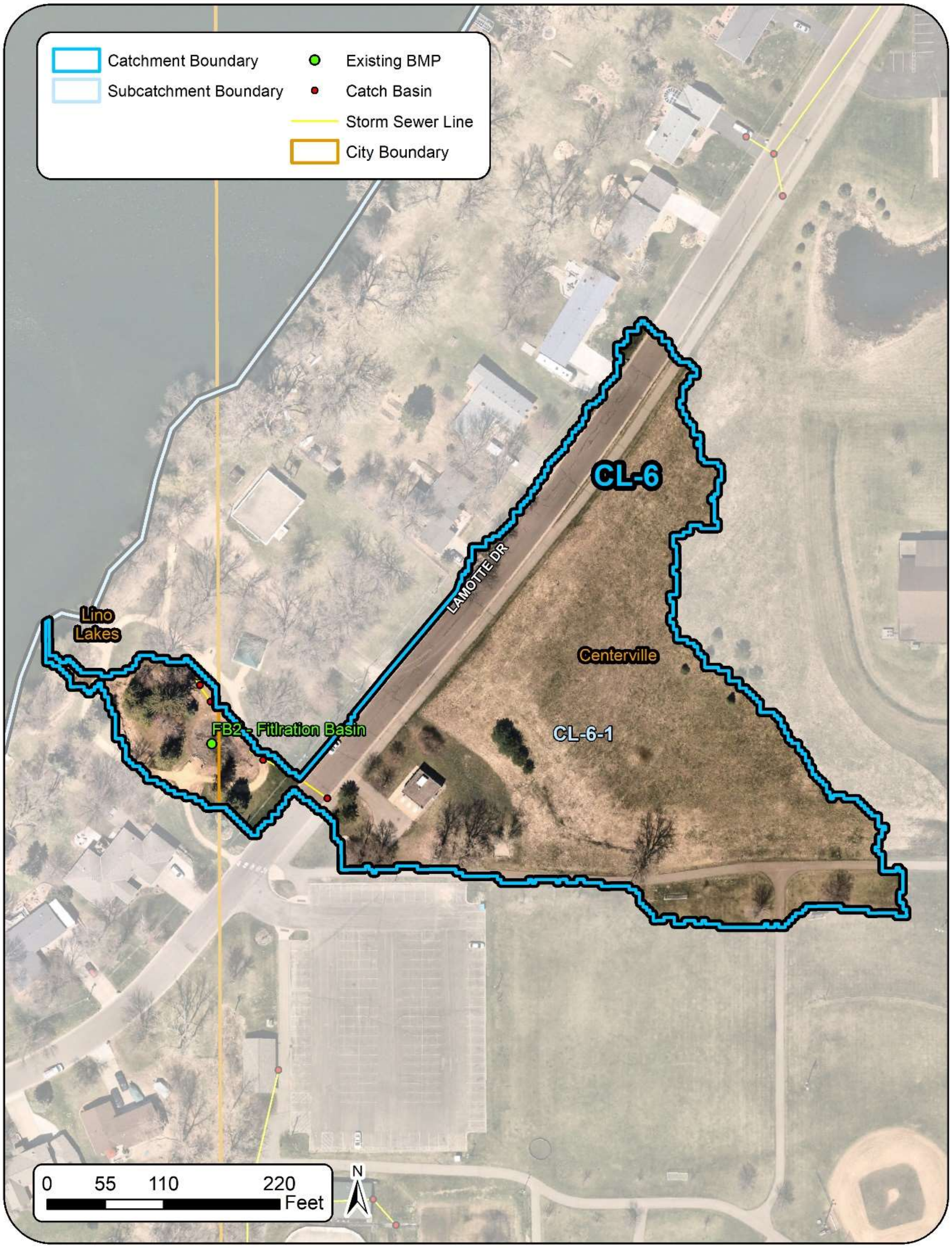
There is one filtration basin through which all stormwater runoff passes prior to discharging into Centerville Lake. In addition, street cleaning is conducted in the spring of each year by the City of Centerville. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**Number of BMPs**	2			
	BMP Types	Street Cleaning, Filtration Basin (FB2)			
	TP (lb/yr)	2.00	0.90	45%	**1.10**
	TSS (lb/yr)	556	389	70%	**167**
	Volume (acre-feet/yr)	1.4	0.34	25%	**1.0**

RETROFIT OPPORTUNITIES OVERVIEW

No retrofits were modeled in this catchment because of the existing treatment provided by the filtration basin.

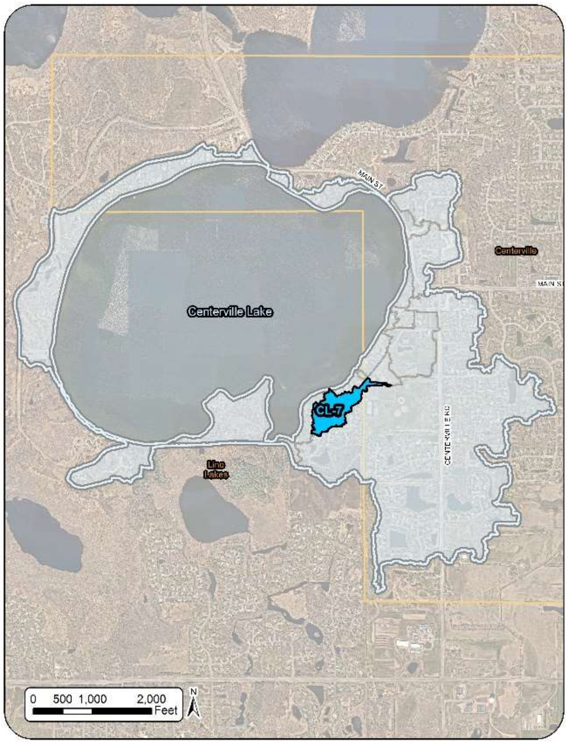
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER

Catchment CL-7

Existing Catchment Summary	
Acres	9.7
Parcels	36
Land Cover	68.5% Residential 31% Park 0.5% Industrial



CATCHMENT DESCRIPTION

Catchment CL-7 is primarily located in Lino Lakes on the southeast side of Centerville Lake. With the exception of the northeastern most extent that includes a small portion of Laurie LaMotte Memorial Park, land use throughout the catchment is residential. Primary roads include LaMotte Drive and the western extent of LaMotte Circle. Stormwater runoff is routed to Centerville Lake via a single outfall.

EXISTING STORMWATER TREATMENT

The southern portion of the catchment drains to a large filtration basin located within a neighborhood park. In addition, street cleaning is conducted in the spring of each year by the City of Lino Lakes. Present day stormwater pollutant loading and treatment is summarized in the table below.

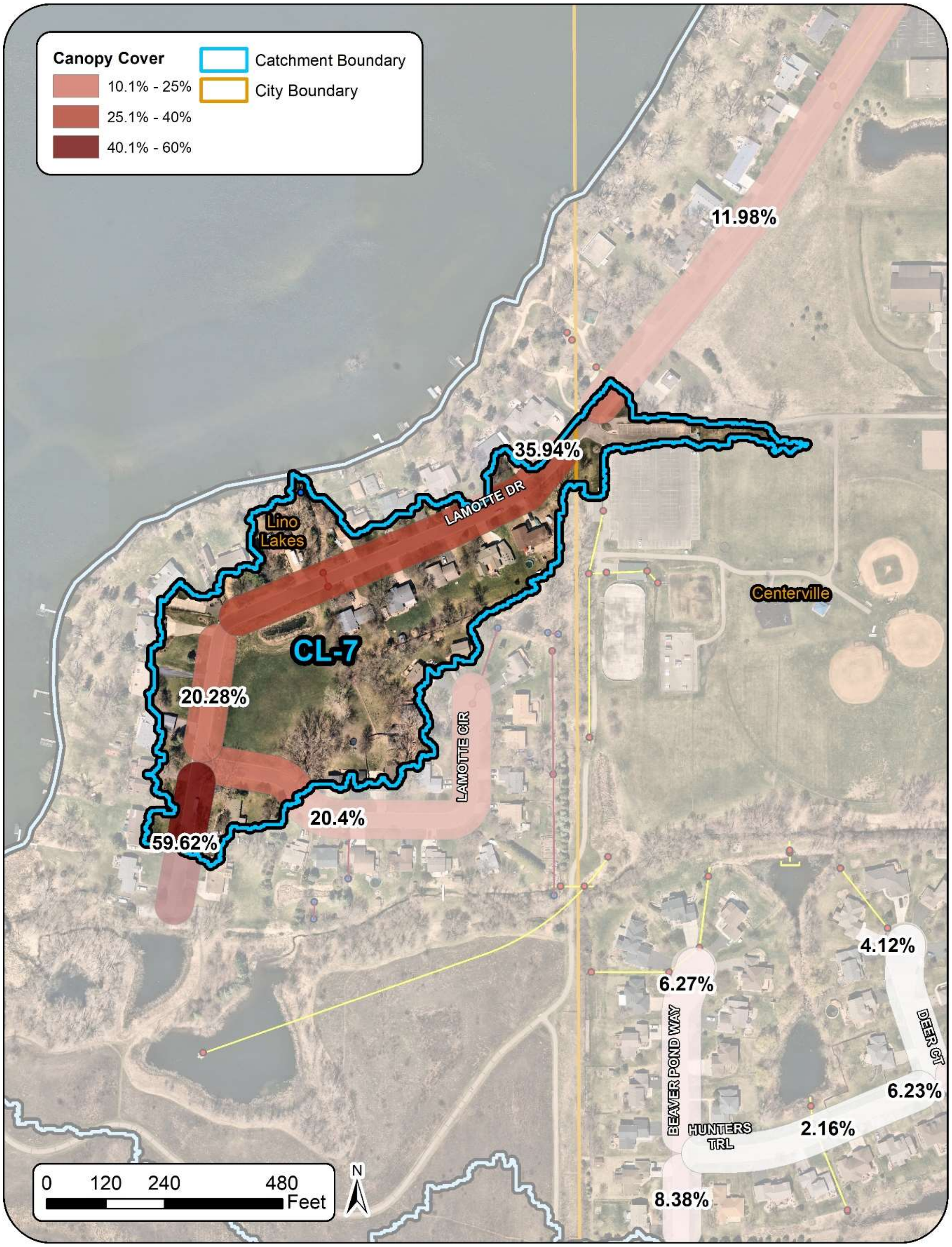
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Street Cleaning, Wet Pond (WP15)			
	TP (lb/yr)	7.88	2.32	29%	**5.56**
	TSS (lb/yr)	1,913	784	41%	**1,129**
	Volume (acre-feet/yr)	4.2	0.00	0%	**4.2**

RETROFIT OPPORTUNITIES OVERVIEW

Two biofiltration basins are proposed in this catchment. The biofiltration basins are positioned on LaMotte Drive adjacent to catch basins for underdrain connections. Stormwater runoff from the contributing drainage areas is currently discharged directly to Centerville Lake without any stormwater treatment.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Project ID: CL-7 BF-7-1-1

Lamotte Dr.
Biofiltration Basin

Drainage Area – 0.52 acres
Location – North side of Lamotte Dr. west of Laurie LaMotte Memorial Park
Property Ownership – Private
Site Specific Information – An opportunity for a biofiltration basin exists at this location. A biofiltration basin was modeled at the optimal location adjacent to the catch basin due to the limited infiltration capacity of the underlying soils. The proposed basin is in close proximity to the existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

Curb-Cut Biofiltration

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.17	3.0%
	TSS (lb/yr)	59	5.2%
	Volume (acre-feet/yr)	0.14	3.4%
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$23,320
	Total Estimated Project Cost (2023)		**$23,984**
	Annual O&M***		$295
Efficiency	**30-yr Average Cost/lb-TP**	**$6,476**	
	30-yr Average Cost/1,000lb-TSS	**$18,550**	
	30-yr Average Cost/ac-ft Vol.	**$7,588**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($80/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: CL-7 BF-7-1-2

Lamotte Dr.
Biofiltration Basin

Drainage Area – 2.01 acres
Location – South side of Lamotte Dr. west of Laurie LaMotte Memorial Park
Property Ownership – Private
Site Specific Information – An opportunity for a biofiltration basin exists at this location. A biofiltration basin was modeled at the optimal location adjacent to the catch basin due to the limited infiltration capacity of the underlying soils. The proposed basin is in close proximity to the existing catch basin, which could serve as the connection point for the underdrain outlet. The table below provides pollutant removals and estimated costs.

	Curb-Cut Biofiltration		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	250	sq-ft
	TP (lb/yr)	0.29	5.2%
	TSS (lb/yr)	108	9.6%
	Volume (acre-feet/yr)	0.15	3.6%
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$23,320	
	Total Estimated Project Cost (2023)	**$23,984**	
	Annual O&M***	$295	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,813**	
	30-yr Average Cost/1,000lb-TSS	**$10,134**	
	30-yr Average Cost/ac-ft Vol.	**$7,329**	

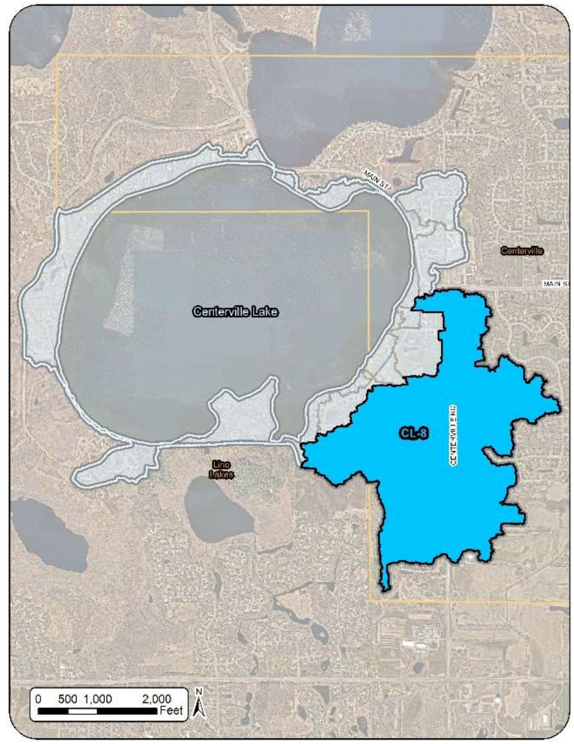
*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($80/sq-ft for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($220/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment CL-8

Existing Catchment Summary	
Acres	221.9
Parcels	377
Land Cover	66.1% Residential 18.5% Park 11.5% Open 1.8% Water 1.7% Institutional 0.4% Shopping



CATCHMENT DESCRIPTION

Catchment CL-8 is the largest and represents 53% of the total Centerville Lake watershed. The majority of the catchment is within the City of Centerville, with the exception of the western most portion, which is located in the City of Lino Lakes. The catchment is primarily comprised of residential land use but also includes Laurie LaMotte Memorial Park. Drainage throughout the catchment is largely from south to north and then from east to west where it discharges into the southeastern corner of Centerville Lake.

EXISTING STORMWATER TREATMENT

There are 23 stormwater ponds throughout the catchment. Most of the ponds provide treatment to stormwater runoff from residential areas. There is also a water reuse system for irrigation located within Laurie LaMotte Memorial Park. In addition, street cleaning is conducted in the spring of each year by the City of Centerville and the City of Lino Lakes. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	25			
	BMP Types	Street Cleaning, 23 Wet Ponds (WP8-WP9, WP11-WP13, WP16-WP33), Water Reuse (WR1)			
	TP (lb/yr)	171.70	91.20	53%	**80.50**
	TSS (lb/yr)	42,231	30,731	73%	**11,500**
	Volume (acre-feet/yr)	98.5	15.08	15%	**83.4**

RETROFIT OPPORTUNITIES OVERVIEW

While technically not a retrofit because the LaMotte water reuse system is already in place, maximizing use of the system to the design capacity of 26 ac-ft/yr (8,472,126 gal/yr) could provide substantial additional volume and pollutant reductions from CL-8. The system is currently assumed to be using approximately 15.34 ac-ft/yr (5,000,000 gal/yr), so adjusting capacity to meet the design volume represents a 70% increase in use. The corresponding volume and pollutant reductions are shown in the Project ID page below.

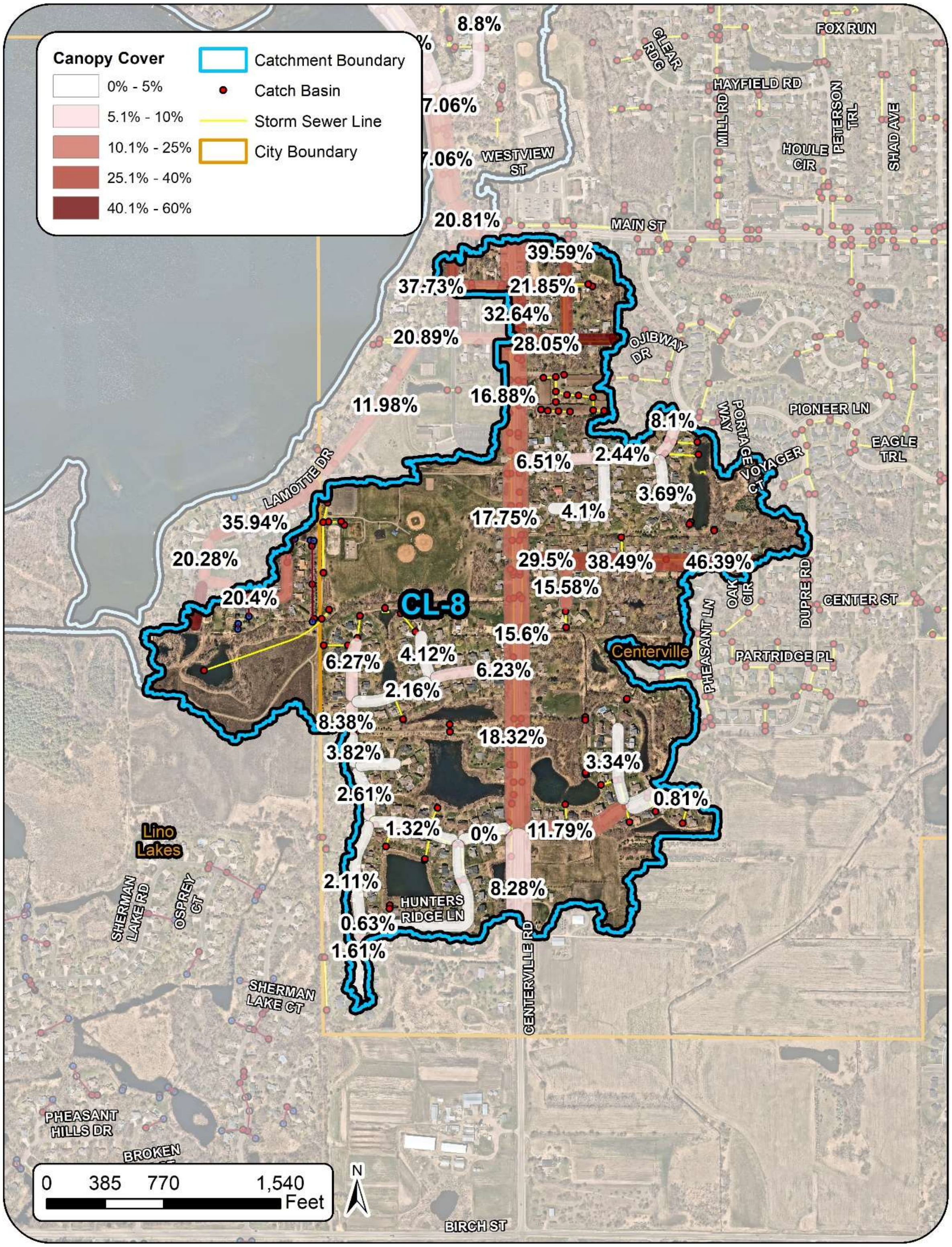
Please note the City of Centerville is currently actively working to maximize use of the water reuse system. Recent modificaitons include installation of a flow meter for tracking accurate, detailed irrigation volumes, the expansion of irrigated areas, and a revised irrigation schedule to achieve 1”of irrigation per week in the tight soil conditions while still maintaining accetable moisture levels on the ball fields. Barring limitations due to drought, these modifications are anticipated to achieve full system use based on design capacity.

RETROFITS CONSIDERED

Because the catchment is primarily comprised of residential land use, curb-cut rain gardens were considered at locations that would maximize contributing drainage areas. However, the many wet ponds throughout CL-8 were deemed sufficient for water quality treatment. Furthermore, a high water table was indicated in the underlying soils data throughout much of the catchment that would likely restrict infiltration.

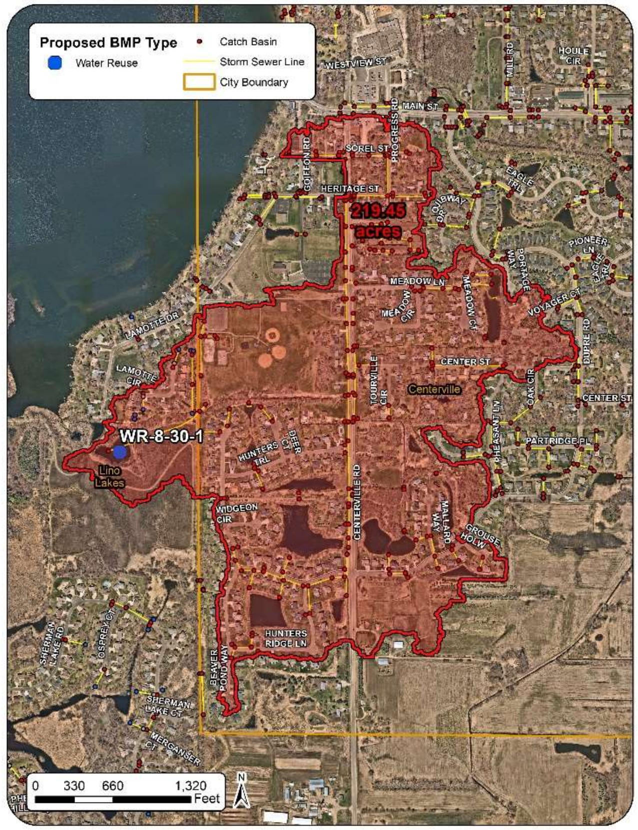
EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES

ROAD TREE CANOPY COVER



Project ID: CL-8 WR-8-30-1

LaMotte Park
Water Reuse Optimization



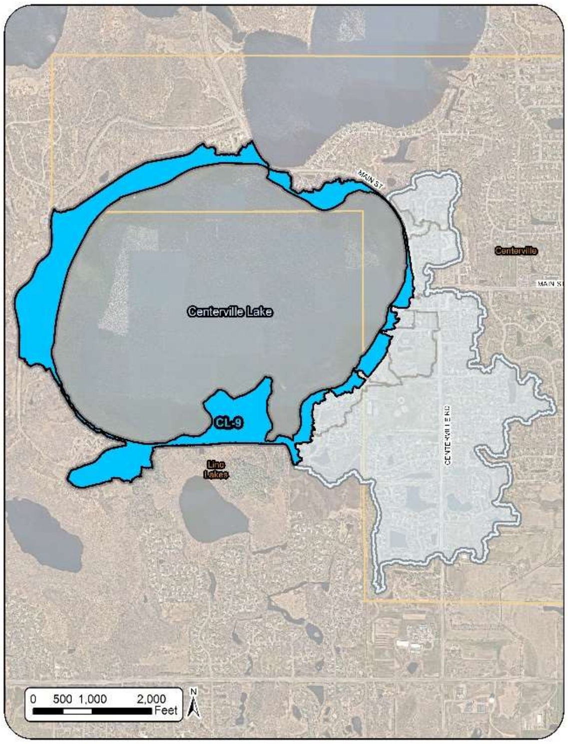
Drainage Area – 219.45 acres
Location – Laurie LaMotte Memorial Park
Property Ownership – Public
Site Specific Information – Optimization of the existing water reuse system within LaMotte Park could result in the volume and pollutant removals shown in the table below. The system was originally designed for the use of 26 acre-feet annually. Current use is estimated to be approximately 15.34 acre-feet. Therefore, an additional 10.63 acre-feet could be used for irrigation annually.

Please note the City of Centerville is currently actively working to maximize use of the water reuse system. Recent modificaitons include installation of a flow meter for tracking accurate, detailed irrigation volumes, the expansion of irrigated areas, and a revised irrigation schedule to achieve 1"of irrigation per week in the tight soil conditions while still maintaining accetable moisture levels on the ball fields. Barring limitations due to drought, these modifications are anticipated to achieve full system use based on design capacity.

	Water Reuse Optimization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMP**	N/A	
	TP (lb/yr)	6.62	8.2%
	TSS (lb/yr)	747	6.5%
	Volume (acre-feet/yr)	10.63	12.7%
Cost	**Administration & Promotion Costs***		$0
	Design & Construction Costs**		$0
	Total Estimated Project Cost (2023)		**$0**
	Annual O&M***		$0
Efficiency	**30-yr Average Cost/lb-TP**	**$0**	
	30-yr Average Cost/1,000lb-TSS	**$0**	
	30-yr Average Cost/ac-ft Vol.	**$0**	

Catchment CL-9

Existing Catchment Summary	
Acres	128.1
Parcels	137
Land Cover	57.5% Park 33.6% Residential 4.8% Water 3.1% Open 0.6% Industrial 0.4% Institutional



CATCHMENT DESCRIPTION

Catchment CL-9 is the second largest catchment and represents 31% of the Centerville Lake watershed. This catchment contains all of the direct drainage areas to the lake, which are shoreline areas or those areas that are lacking stormwater infrastructure yet still discharge to the lake. The west side of the catchment includes the Centerville Lake beach and boat launch. Land use throughout the catchment is residential, park, and open space.

EXISTING STORMWATER TREATMENT

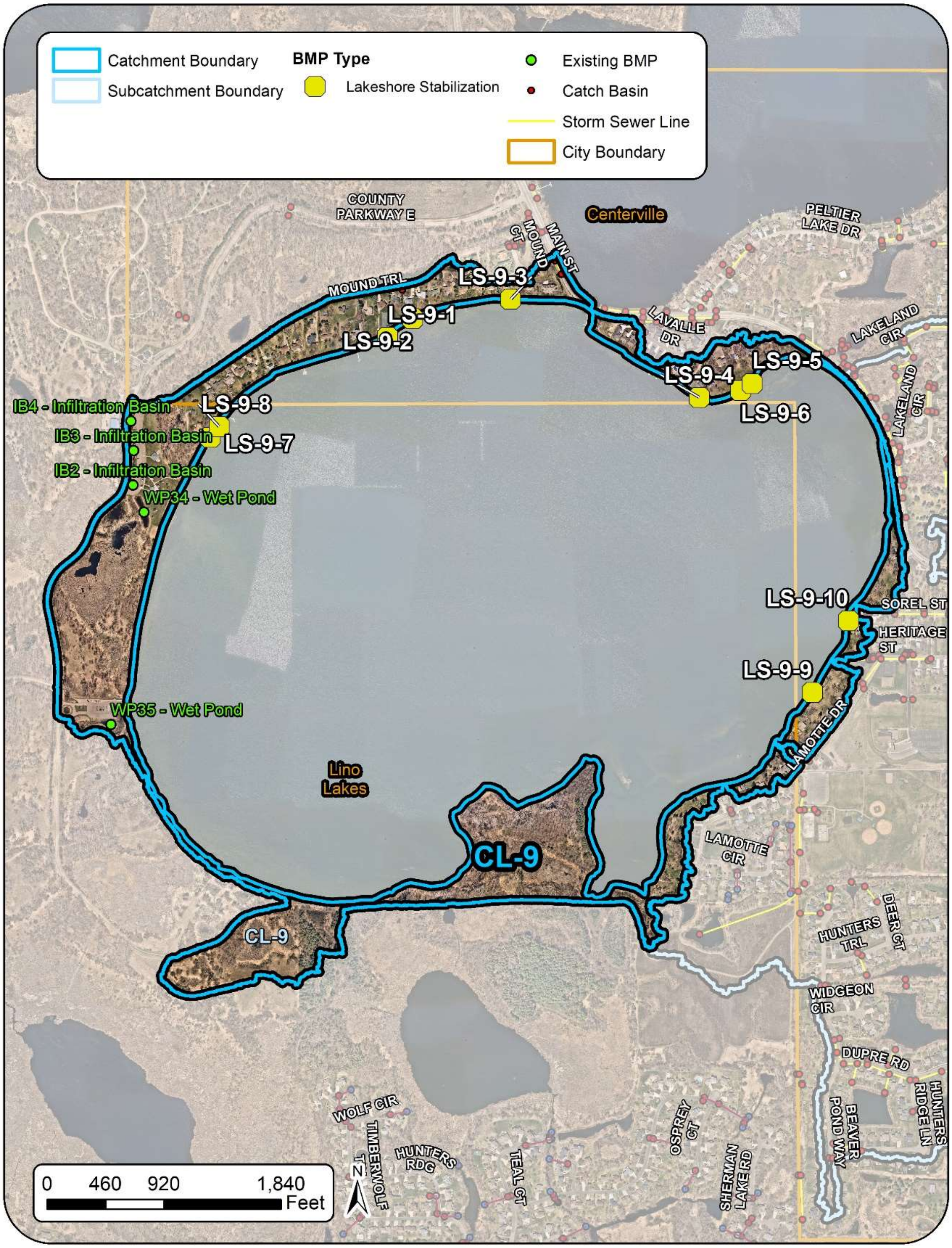
The boat launch and beach areas each have a stormwater pond that provides water quality treatment to runoff from most of the paved areas. Similarly, multiple curb-cuts direct stormwater runoff from impervious surfaces near the beach area into bioretention areas. In addition, street cleaning is conducted in the spring of each year by the City of Centerville or Lino Lakes. Present day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	6			
	BMP Types	Street Cleaning, 2 Wet Ponds (WP34, WP35), 3 Infiltration Basins (IB2, IB3, IB4)			
	TP (lb/yr)	60.05	5.70	9%	**54.35**
	TSS (lb/yr)	14,429	1,848	13%	**12,581**
	Volume (acre-feet/yr)	30.6	0.80	3%	**29.8**

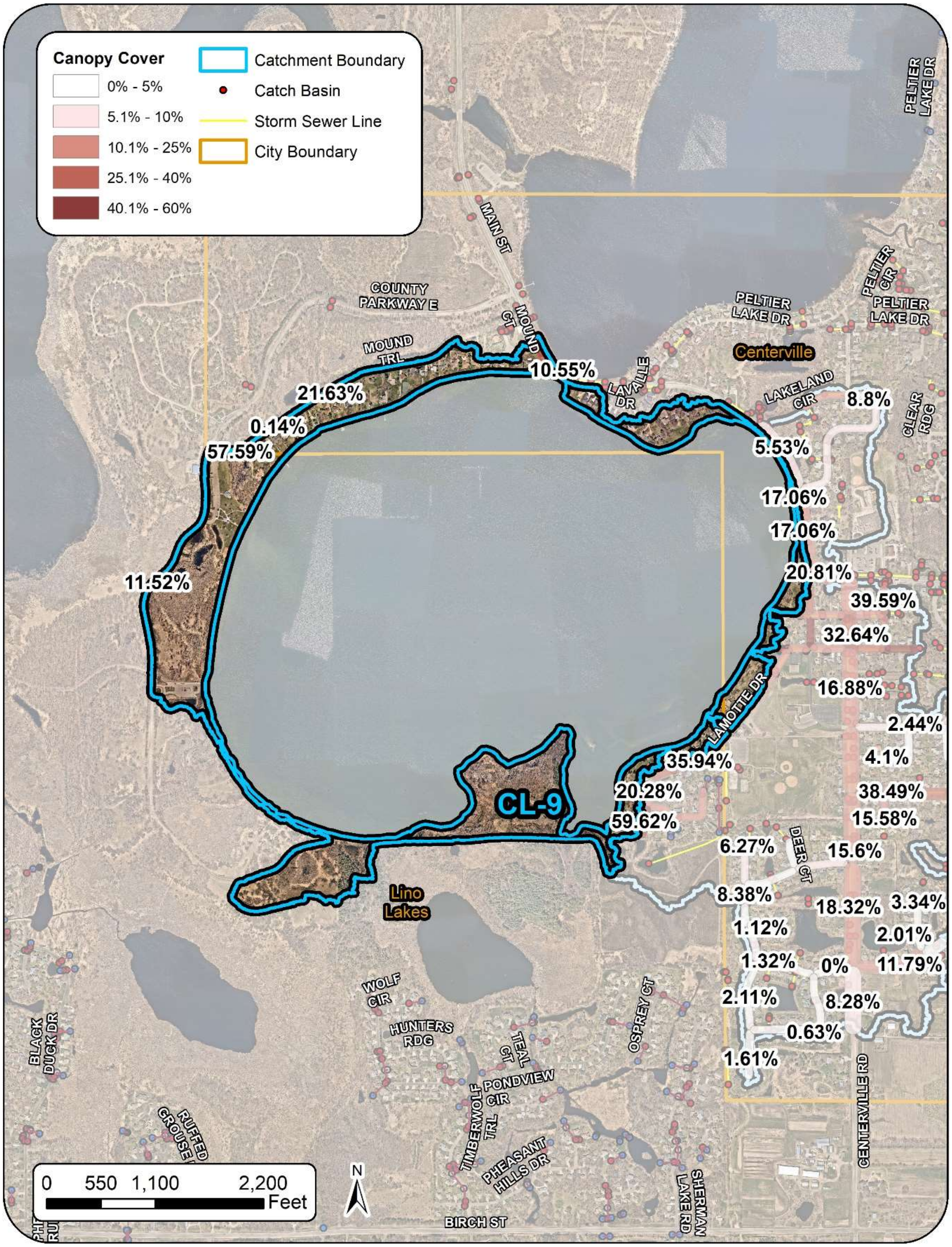
RETROFIT OPPORTUNITIES OVERVIEW

Lakeshore stabilizations are proposed based on a Centerville Lake shoreline erosion inventory completed in 2021. More details are available in the 'Lakeshore Stabilization' profile of the 'BMP Descriptions' section of this report.

EXISTING STORMWATER TREATMENT AND RETROFIT OPPORTUNITIES



ROAD TREE CANOPY COVER



Project ID: CL-9 LS-9-1

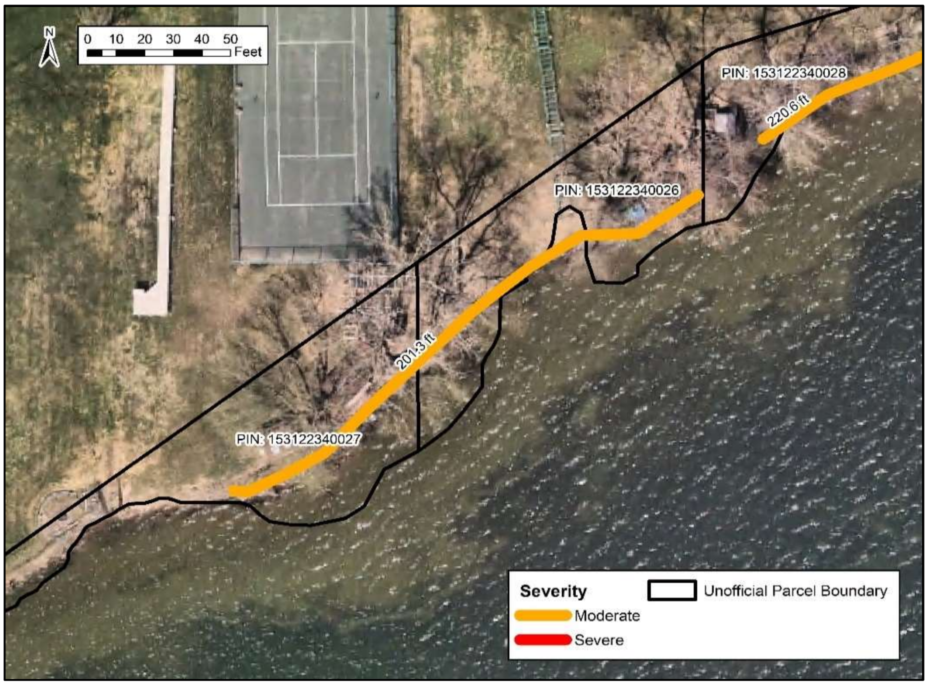
Centerville Lake
Lakeshore Stabilization

Length – 201.3 feet

Location – PIN: 153122340027 and PIN: 153122340026

Property Ownership – Private

Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.



	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	201.3	feet
	TP (lb/yr)	0.86	100.0%
	TSS (lb/yr)	1,712	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$53,645	
	Total Estimated Project Cost (2023)	**$54,309**	
	Annual O&M***	$75	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,203**	
	30-yr Average Cost/1,000lb-TSS	**$1,101**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

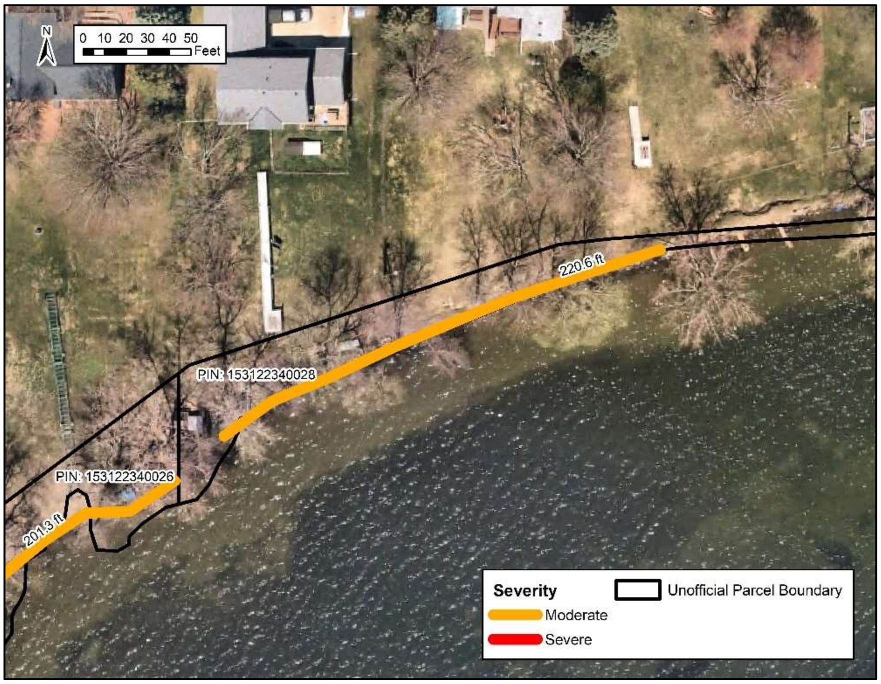
**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-2

Centerville Lake
Lakeshore Stabilization

Length – 220.6 feet
Location – PIN: 153122340028
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.



	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	220.6	feet
	TP (lb/yr)	0.94	100.0%
	TSS (lb/yr)	1,876	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$58,470	
	Total Estimated Project Cost (2023)	**$59,134**	
	Annual O&M***	$75	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,182**	
	30-yr Average Cost/1,000lb-TSS	**$1,091**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID:
CL-9 LS-9-3
Centerville Lake
Lakeshore Stabilization

Length – 134.2 feet
Location – PIN: 153122430026
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	134.2	feet
	TP (lb/yr)	0.57	100.0%
	TSS (lb/yr)	1,141	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$36,870	
	Total Estimated Project Cost (2023)	**$37,534**	
	Annual O&M***	$75	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,324**	
	30-yr Average Cost/1,000lb-TSS	**$1,162**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-4

Centerville Lake
Lakeshore Stabilization

Length – 341.3 feet
Location – PIN: 153122440012
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	341.3	feet
	TP (lb/yr)	1.45	100.0%
	TSS (lb/yr)	2,902	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$88,645	
	Total Estimated Project Cost (2023)	**$89,309**	
	Annual O&M***	$75	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,103**	
	30-yr Average Cost/1,000lb-TSS	**$1,052**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-5

Centerville Lake
Lakeshore Stabilization

Length – 69.6 feet
Location – PIN: 153122440044
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

Lakeshore Stabilization			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMPs	69.6	feet
	TP (lb/yr)	0.30	100.0%
	TSS (lb/yr)	592	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	Administration & Promotion Costs*		$664
	Design & Construction Costs**		$20,720
	Total Estimated Project Cost (2023)		**$21,384**
	Annual O&M***		$75
Efficiency	30-yr Average Cost/lb-TP	**$2,662**	
	30-yr Average Cost/1,000lb-TSS	**$1,331**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-6

Centerville Lake
Lakeshore Stabilization

Length – 99.4 feet
Location – PIN: 153122440045
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

Lakeshore Stabilization			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	99.4	feet
	TP (lb/yr)	0.42	100.0%
	TSS (lb/yr)	845	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$28,170
	Total Estimated Project Cost (2023)		**$28,834**
	Annual O&M***		$75
Efficiency	**30-yr Average Cost/lb-TP**	**$2,452**	
	30-yr Average Cost/1,000lb-TSS	**$1,226**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-7

Centerville Lake
Lakeshore Stabilization

Length – 39.0 feet
Location – PIN: 22312220008
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	39.0	feet
	TP (lb/yr)	0.99	100.0%
	TSS (lb/yr)	1,988	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***	$664	
	Design & Construction Costs**	$16,970	
	Total Estimated Project Cost (2023)	**$17,634**	
	Annual O&M***	$75	
Efficiency	**30-yr Average Cost/lb-TP**	**$667**	
	30-yr Average Cost/1,000lb-TSS	**$333**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($350/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-8

Centerville Lake
Lakeshore Stabilization

Length – 101.4 feet
Location – PIN: 22312222013
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Total Size of BMPs	101.4	feet
	TP (lb/yr)	2.58	100.0%
	TSS (lb/yr)	5,168	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	Administration & Promotion Costs*	$664	
	Design & Construction Costs**	$38,810	
	Total Estimated Project Cost (2023)	**$39,474**	
	Annual O&M***	$75	
Efficiency	30-yr Average Cost/lb-TP	**$538**	
	30-yr Average Cost/1,000lb-TSS	**$269**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

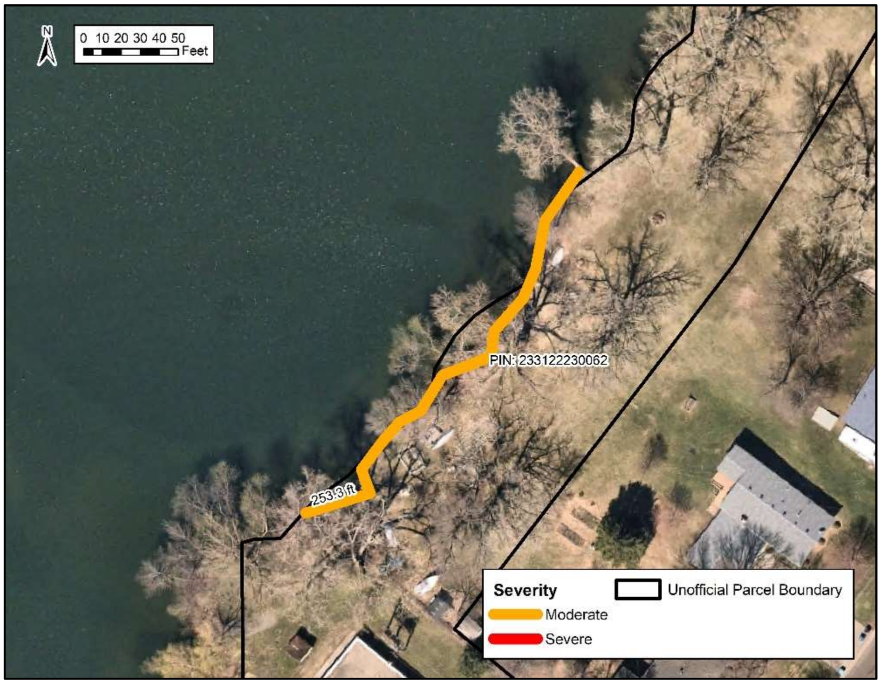
**Direct Cost: ($350/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-9

Centerville Lake
Lakeshore Stabilization

Length – 253.3 feet
Location – PIN: 233122230062
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.



Lakeshore Stabilization			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	253.3	feet
	TP (lb/yr)	1.08	100.0%
	TSS (lb/yr)	2,154	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$66,645
	Total Estimated Project Cost (2023)		**$67,309**
	Annual O&M***		$75
Efficiency	**30-yr Average Cost/lb-TP**	**$2,153**	
	30-yr Average Cost/1,000lb-TSS	**$1,077**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($250/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

Project ID: CL-9 LS-9-10

Centerville Lake
Lakeshore Stabilization

Length – 123.5 feet
Location – PIN: 233122230071
Property Ownership – Private
Site Specific Information – A lakeshore stabilization project is proposed based on a 2021 photographic inventory of shoreline condition. The table below provides pollutant removals and estimated costs. Note that lakeshore loading and reductions are not included in the catchment WinSLAMM loading estimates.

	Lakeshore Stabilization		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Total Size of BMPs**	123.5	feet
	TP (lb/yr)	3.15	100.0%
	TSS (lb/yr)	6,295	100.0%
	Volume (acre-feet/yr)	n/a	n/a
Cost	**Administration & Promotion Costs***		$664
	Design & Construction Costs**		$46,545
	Total Estimated Project Cost (2023)		**$47,209**
	Annual O&M***		$75
Efficiency	**30-yr Average Cost/lb-TP**	**$524**	
	30-yr Average Cost/1,000lb-TSS	**$262**	
	30-yr Average Cost/ac-ft Vol.	**n/a**	

*Indirect Cost: (8 hours at $83/hour base cost)

**Direct Cost: ($350/linear foot for materials and labor) + (40 hours at $83/hour for design)

***Per BMP: ($75/year for routine maintenance)

References

Janke, Benjamin D., Jacques C. Finlay, and Sarah E. Hobbie. 2017. Trees and Streets as Drivers of Urban Stormwater Nutrient Pollution. Sci. Technol. DOI: 10.1021/acs.est.7b02225 Environ.

Kalinosky, P.M. 2015. Quantifying Solids and Nutrient Recovered Through Street Sweeping in a Suburban Watershed. A Thesis Submitted to the Faculty of University of Minnesota. Minneapolis, MN.

Lower St. Croix Watershed Partnership (LSCWP) and Emmons and Oliver Resources Inc. (EOR). Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization. 2022.

Schueler, T. and A. Kitchell. 2005. *Methods to Develop Restoration Plans for Small Urban Watersheds. Manual 2, Urban Subwatershed Restoration Manual Series*. Center for Watershed Protection. Ellicott City, MD.

Schueler, T., D. Hirschman, M. Novotney, and J. Zielinski. 2007. *Urban Stormwater Retrofit Practices. Manual 3, Urban Subwatershed Restoration Manual Series. Center for Watershed Protection*. Ellicott City, MD.

Technical documents. (2023). *Minnesota Stormwater Manual*.

Appendix A – Modeling Methods

The following sections include WinSLAMM model details for each type of best management practice modeled for this analysis.

WinSLAMM

Pollutant and volume reductions were estimated using the stormwater model Source Load and Management Model for Windows (WinSLAMM). WinSLAMM uses an abundance of stormwater data from the Upper-Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses, and allows the user to build a model "landscape". WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user's model for each storm. WinSLAMM version 10.5.0 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 7.

Table 7: General WinSLAMM Model Inputs (i.e. Current File Data)

Parameter	File/Method
Land use acreage	ArcMap; Metropolitan Council 2020 Land Use, corrected using 2022 aerial photography
Precipitation/Temperature Data	Minneapolis 1959 – best approximation of a typical year
Winter season	Included in model. Winter dates are 11-4 to 3-13.
Pollutant probability distribution	WI_GEO01.ppd
Runoff coefficient file	WI_SL06 Dec06.rsv
Particulate solids concentration file	WI_AVG01.psc
Particle residue delivery file	WI_DLV01.prr
Street delivery files	WI files for each land use

Existing Conditions

Existing stormwater BMPs were included in the WinSLAMM model for which information was available. The practices listed below were included in the existing conditions models.

Filtration Basins

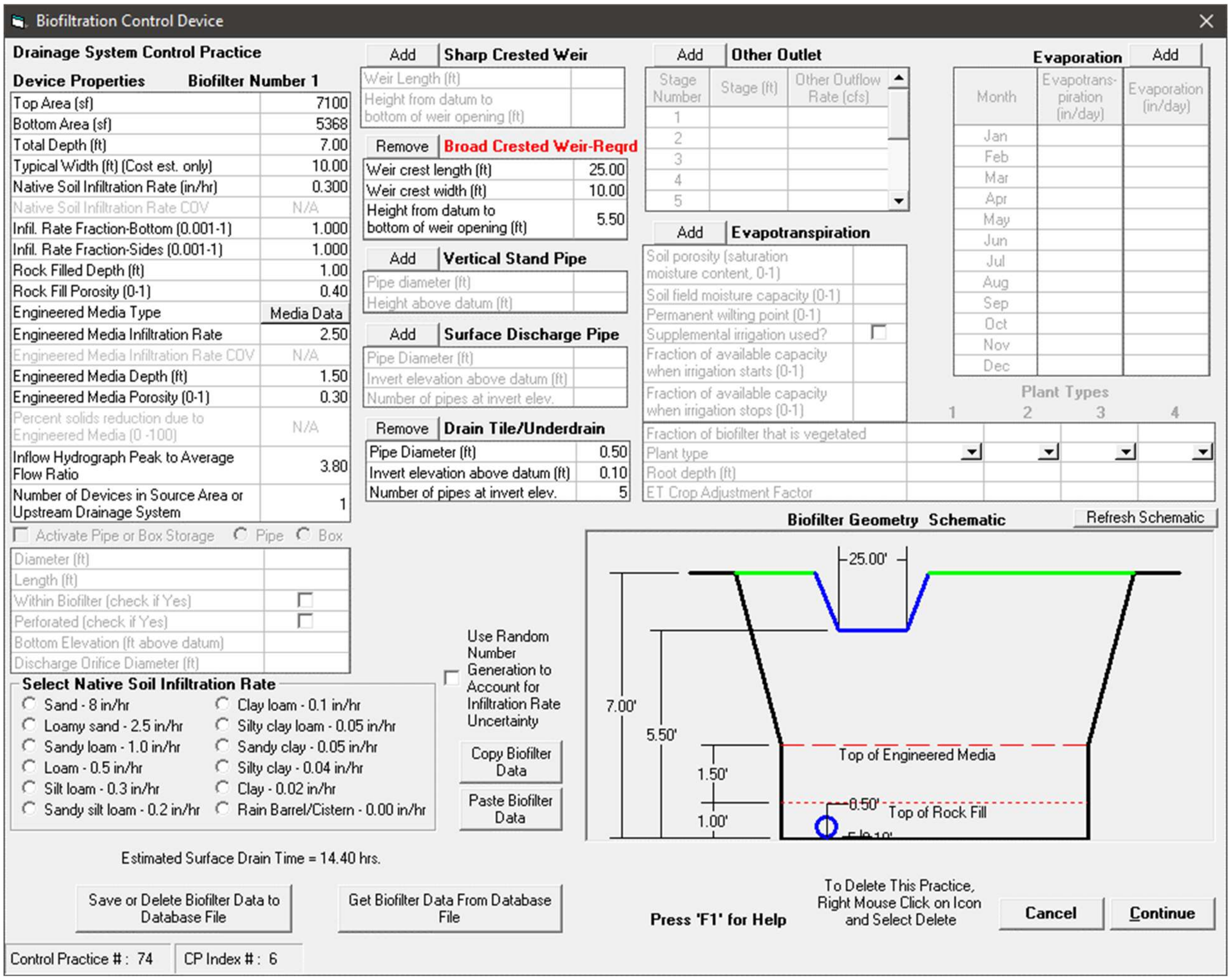


Figure 7: CL-3 FB1.

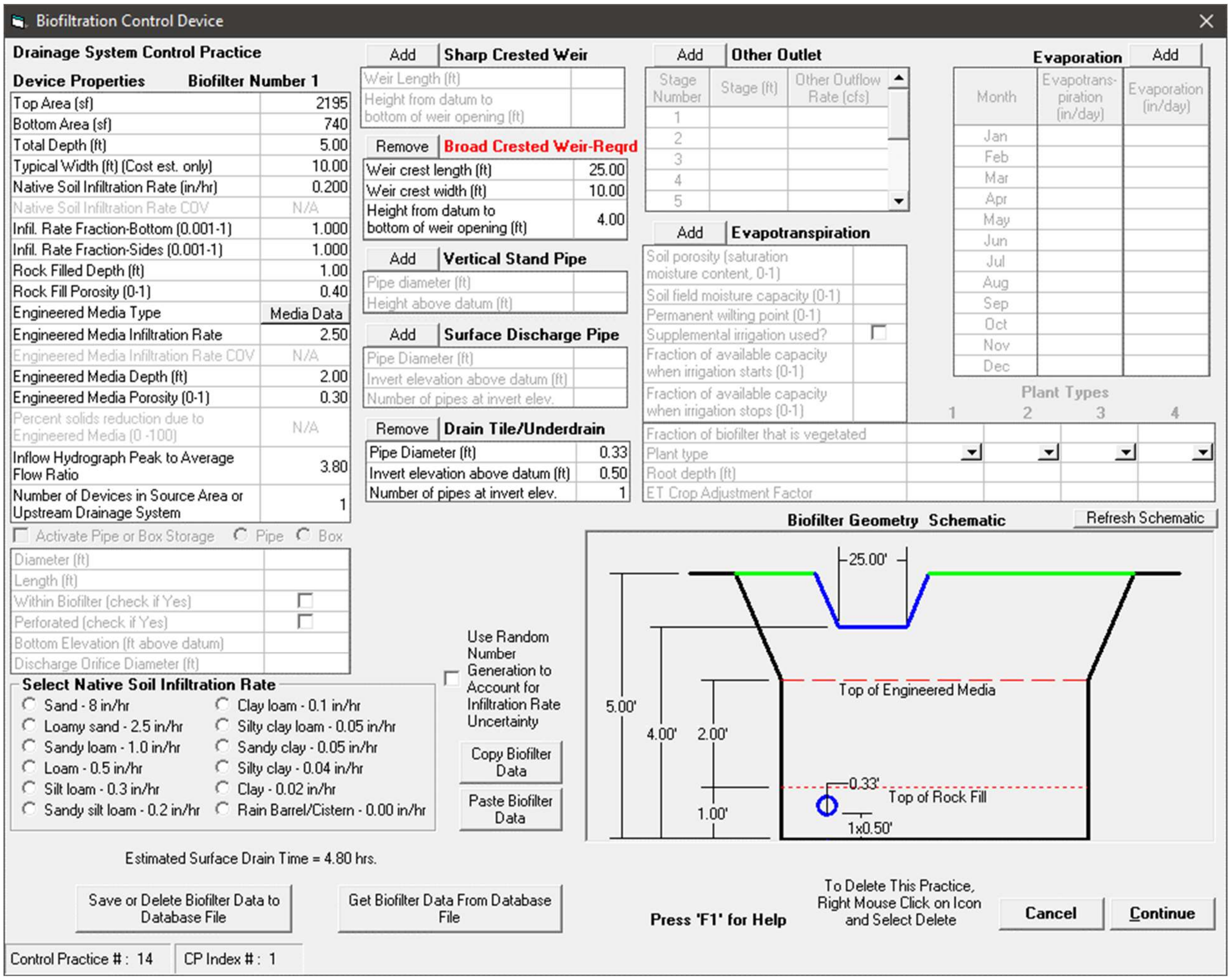
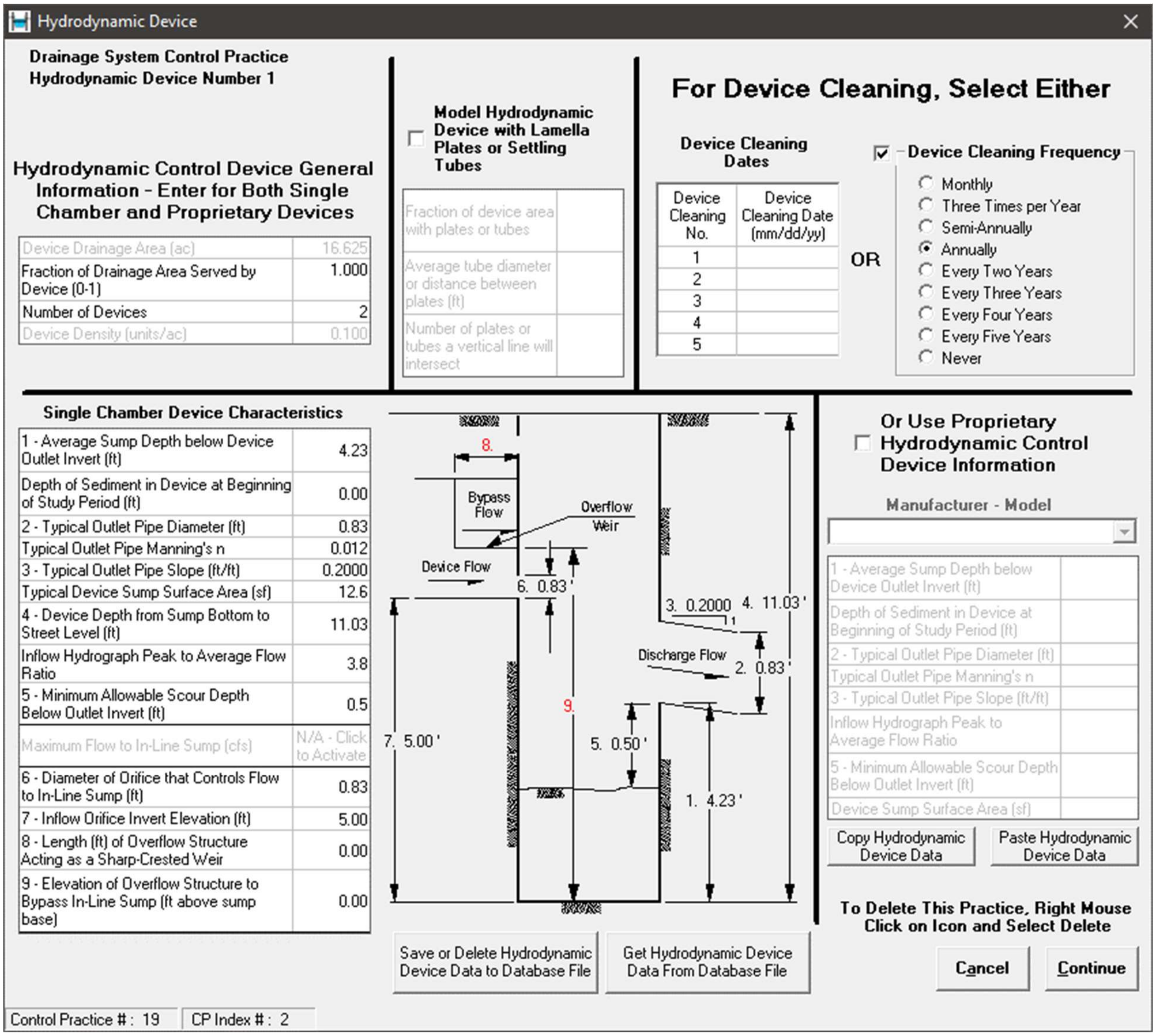


Figure 8: CL-6 FB2.

Hydrodynamic Device



Hydrodynamic Device

Drainage System Control Practice
Hydrodynamic Device Number 1

Hydrodynamic Control Device General Information - Enter for Both Single Chamber and Proprietary Devices

Device Drainage Area (ac)	16.625
Fraction of Drainage Area Served by Device (0-1)	1.000
Number of Devices	2
Device Density (units/ac)	0.100

Model Hydrodynamic Device with Lamella Plates or Settling Tubes

Fraction of device area with plates or tubes	
Average tube diameter or distance between plates (ft)	
Number of plates or tubes a vertical line will intersect	

For Device Cleaning, Select Either

Device Cleaning Dates

Device Cleaning No.	Device Cleaning Date (mm/dd/yy)
1	
2	
3	
4	
5	

OR

Device Cleaning Frequency
Monthly
Three Times per Year
Semi-Annually
Annually
Every Two Years
Every Three Years
Every Four Years
Every Five Years
Never

Single Chamber Device Characteristics

1 - Average Sump Depth below Device Outlet Invert (ft)	4.23
Depth of Sediment in Device at Beginning of Study Period (ft)	0.00
2 - Typical Outlet Pipe Diameter (ft)	0.83
Typical Outlet Pipe Manning's n	0.012
3 - Typical Outlet Pipe Slope (ft/ft)	0.2000
Typical Device Sump Surface Area (sf)	12.6
4 - Device Depth from Sump Bottom to Street Level (ft)	11.03
Inflow Hydrograph Peak to Average Flow Ratio	3.8
5 - Minimum Allowable Scour Depth Below Outlet Invert (ft)	0.5
Maximum Flow to In-Line Sump (cfs)	N/A - Click to Activate
6 - Diameter of Orifice that Controls Flow to In-Line Sump (ft)	0.83
7 - Inflow Orifice Invert Elevation (ft)	5.00
8 - Length (ft) of Overflow Structure Acting as a Sharp-Crested Weir	0.00
9 - Elevation of Overflow Structure to Bypass In-Line Sump (ft above sump base)	0.00

Or Use Proprietary Hydrodynamic Control Device Information

Manufacturer - Model

1 - Average Sump Depth below Device Outlet Invert (ft)	
Depth of Sediment in Device at Beginning of Study Period (ft)	
2 - Typical Outlet Pipe Diameter (ft)	
Typical Outlet Pipe Manning's n	
3 - Typical Outlet Pipe Slope (ft/ft)	
Inflow Hydrograph Peak to Average Flow Ratio	
5 - Minimum Allowable Scour Depth Below Outlet Invert (ft)	
Device Sump Surface Area (sf)	

Copy Hydrodynamic Device Data
Paste Hydrodynamic Device Data

To Delete This Practice, Right Mouse Click on Icon and Select Delete

Save or Delete Hydrodynamic Device Data to Database File
Get Hydrodynamic Device Data From Database File
Cancel
Continue

Control Practice # : 19
CP Index # : 2

Figure 9: CL-5 HD1.

Infiltration Basins

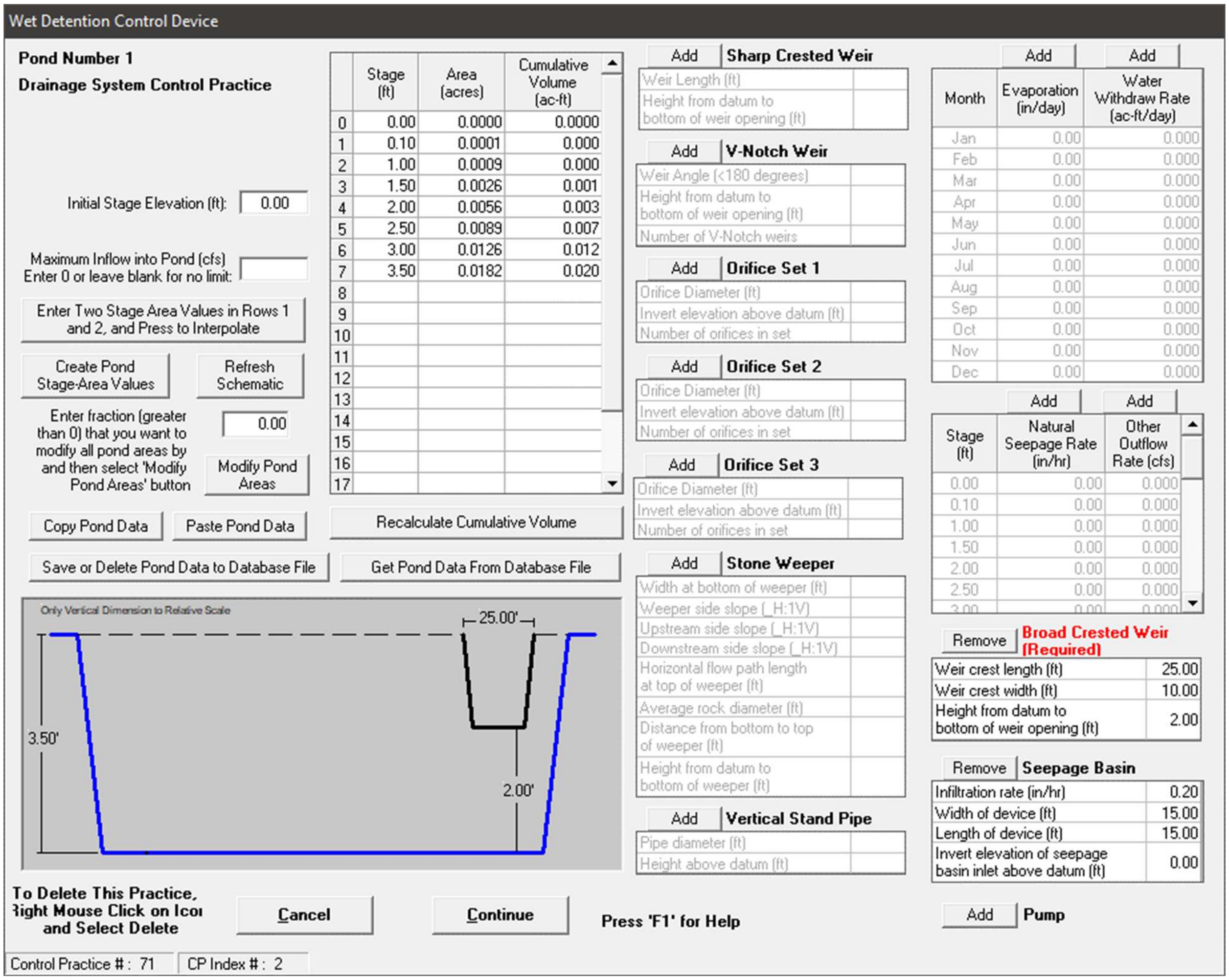


Figure 10: CL-3 IB1.

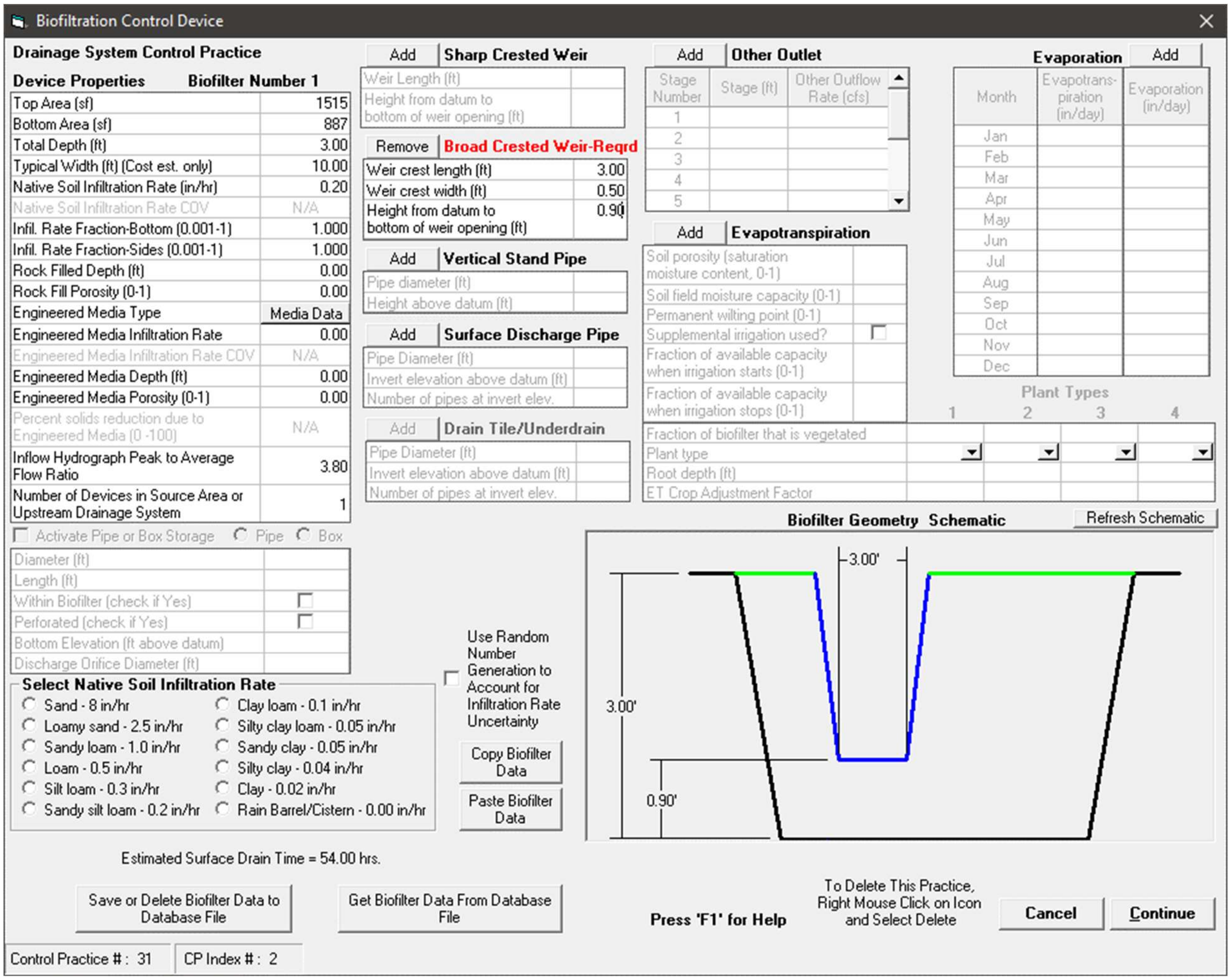


Figure 11: CL-9 IB2.

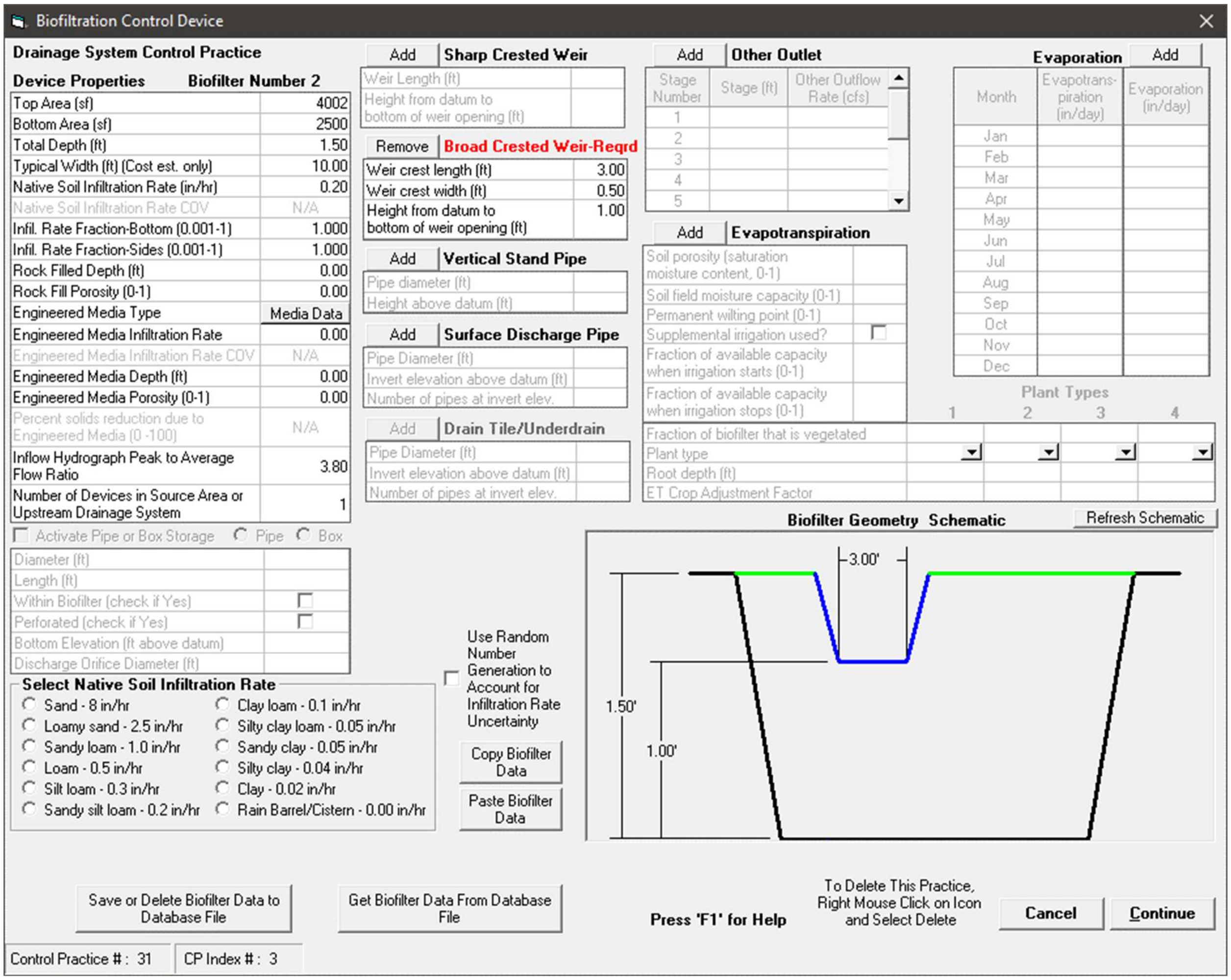


Figure 12: CL-9 IB3.

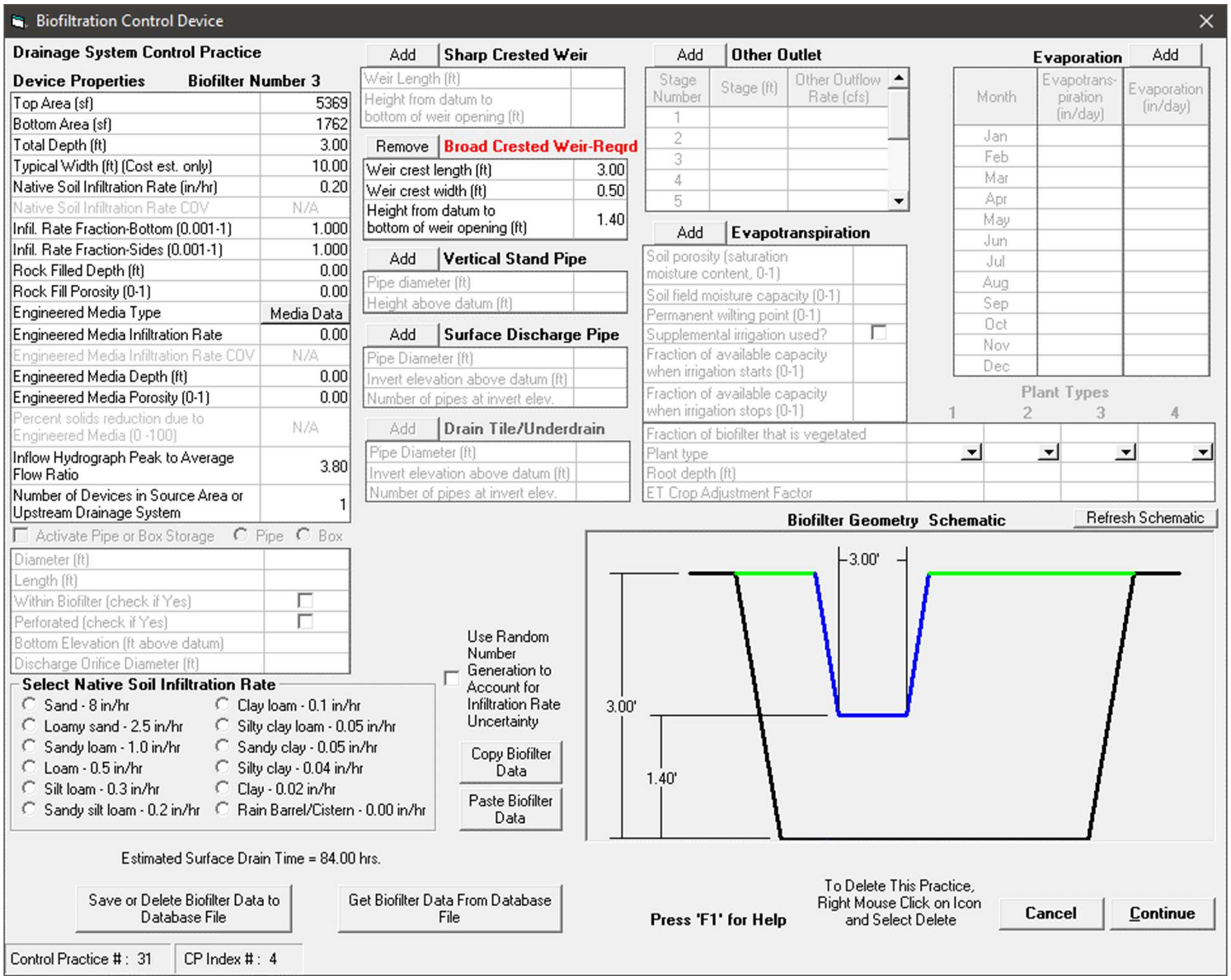


Figure 13: CL-9 IB4.

Infiltration Trench

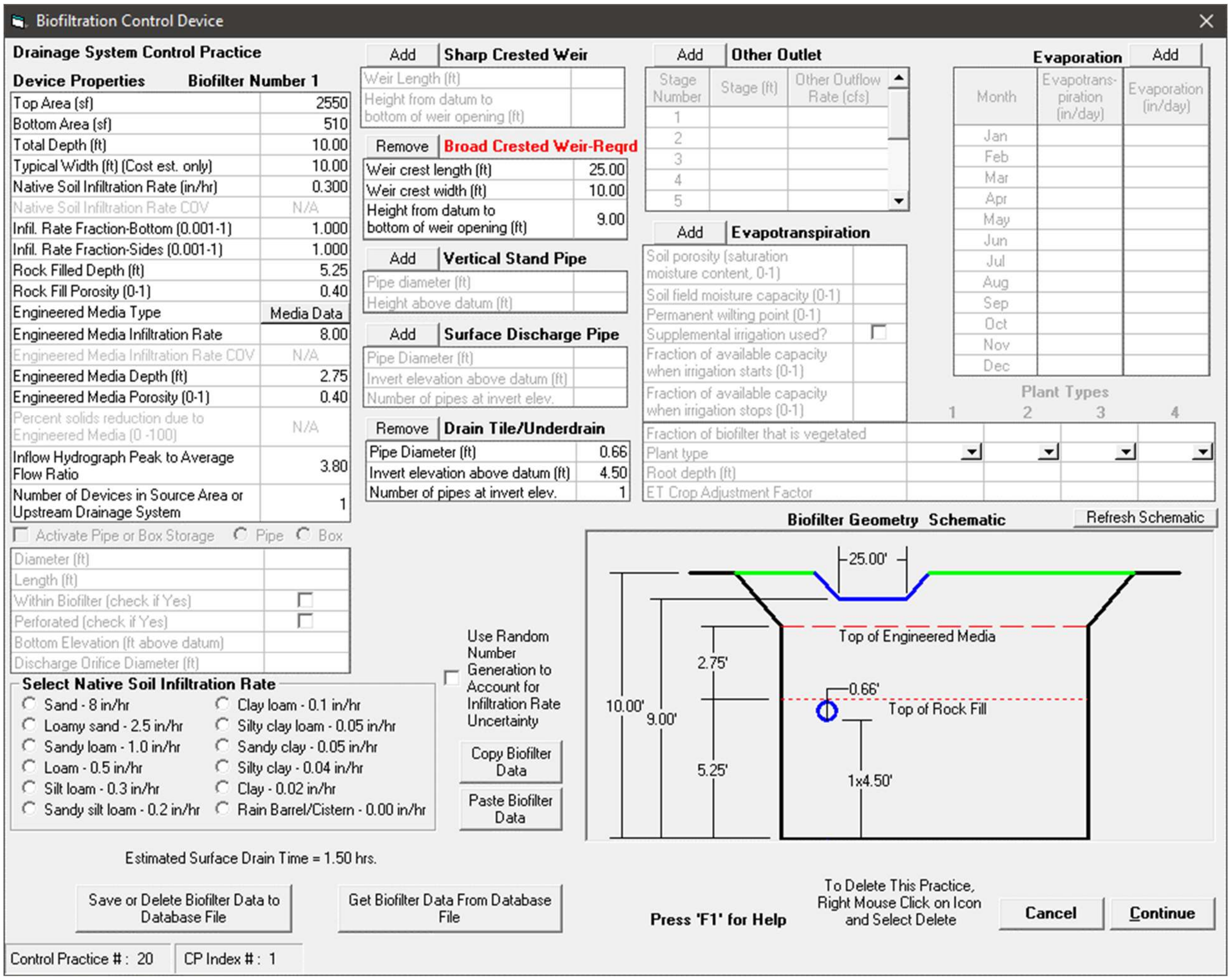


Figure 14: CL-5 IT1.

Street Cleaning

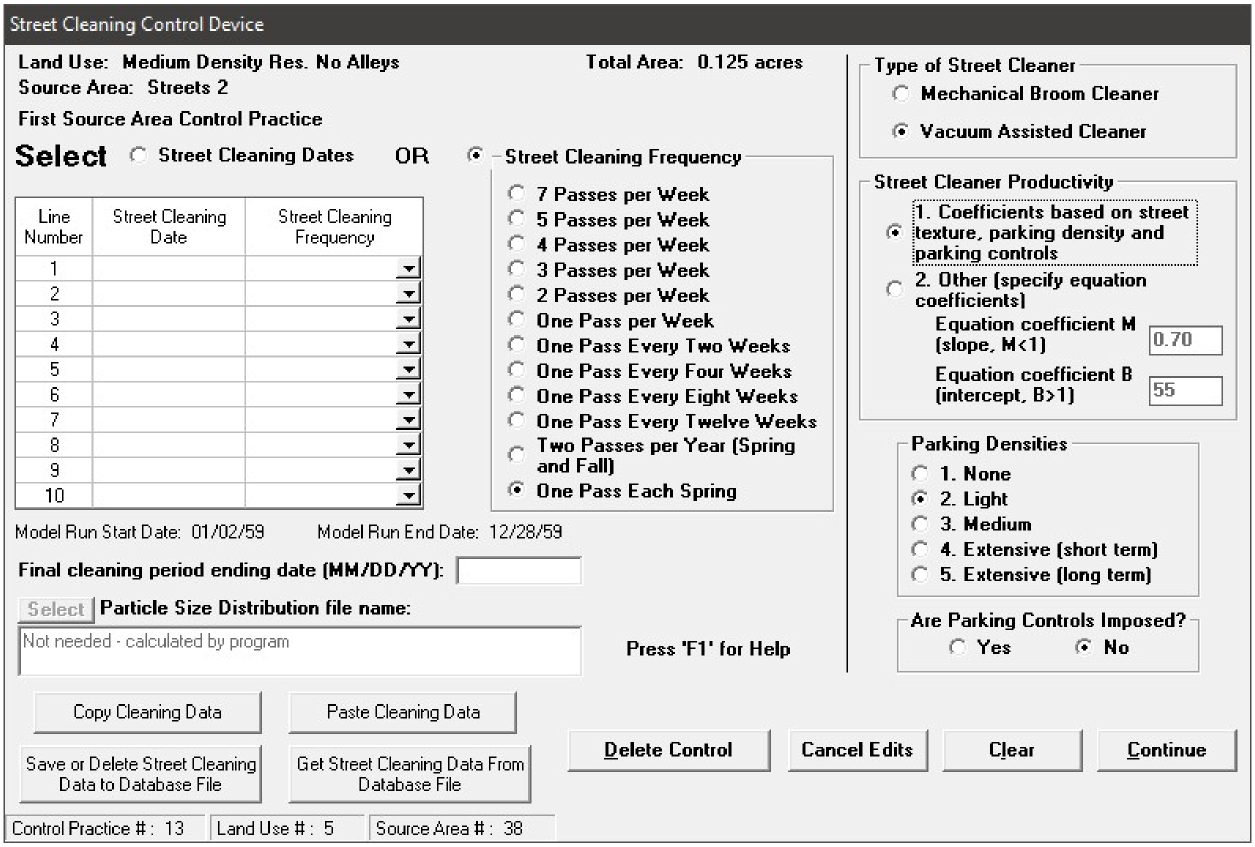
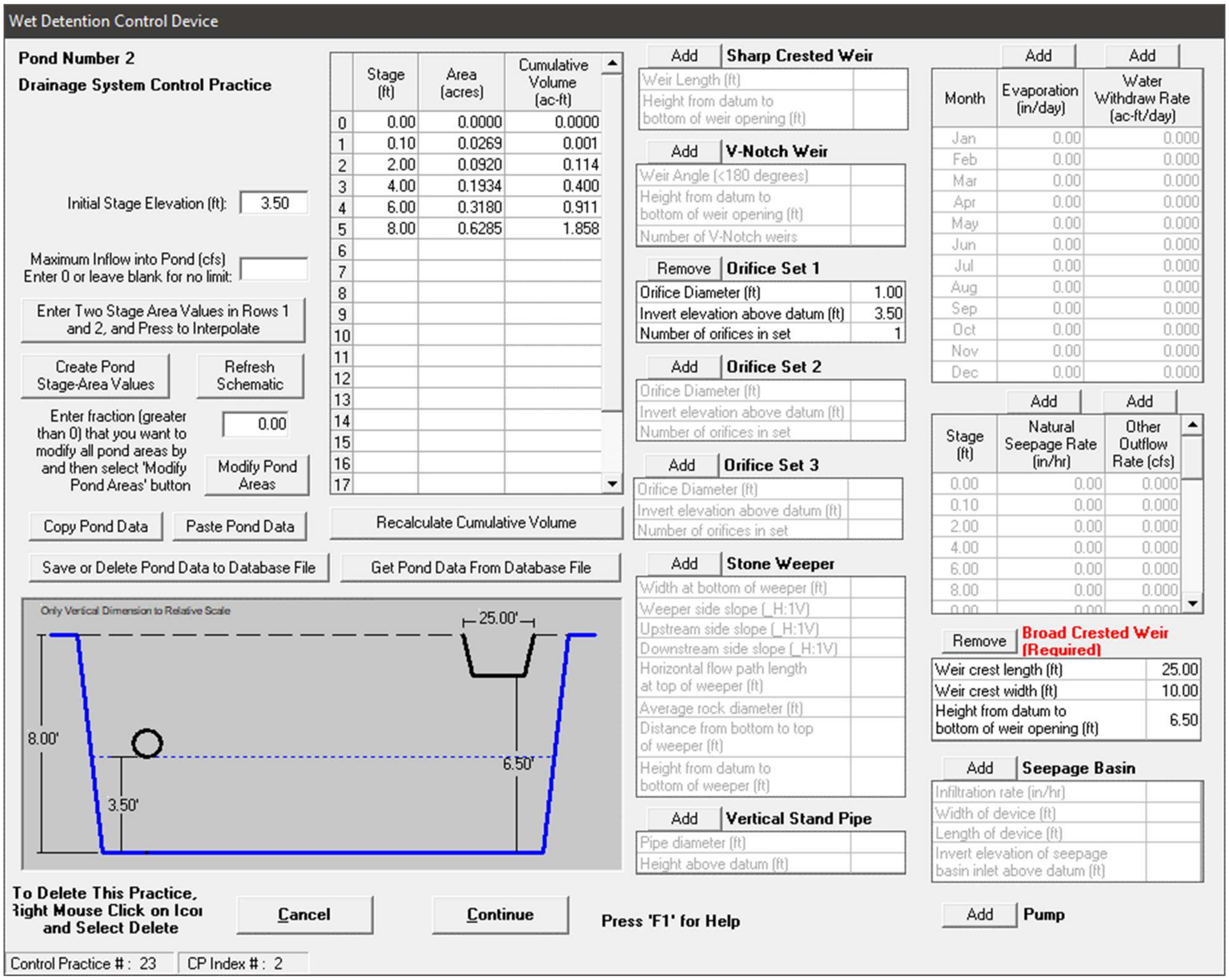


Figure 15: Street cleaning parameters for the City of Centerville. Street cleaning occurs once annually in the spring.

Wet Ponds


Wet Detention Control Device

Pond Number 2

Drainage System Control Practice

Initial Stage Elevation (ft): 3.50

Maximum Inflow into Pond (cfs) Enter 0 or leave blank for no limit:

Enter Two Stage Area Values in Rows 1 and 2, and Press to Interpolate

Create Pond Stage-Area Values | Refresh Schematic

Enter fraction (greater than 0) that you want to modify all pond areas by and then select 'Modify Pond Areas' button: 0.00 | Modify Pond Areas

	Stage (ft)	Area (acres)	Cumulative Volume (ac-ft)
0	0.00	0.0000	0.0000
1	0.10	0.0269	0.001
2	2.00	0.0920	0.114
3	4.00	0.1934	0.400
4	6.00	0.3180	0.911
5	8.00	0.6285	1.858
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

Copy Pond Data | Paste Pond Data | Recalculate Cumulative Volume

Save or Delete Pond Data to Database File | Get Pond Data From Database File

Add **Sharp Crested Weir**: Weir Length (ft); Height from datum to bottom of weir opening (ft)

Add **V-Notch Weir**: Weir Angle (<180 degrees); Height from datum to bottom of weir opening (ft); Number of V-Notch weirs

Remove **Orifice Set 1**

Orifice Diameter (ft)	1.00
Invert elevation above datum (ft)	3.50
Number of orifices in set	1

Add **Orifice Set 2**: Orifice Diameter (ft); Invert elevation above datum (ft); Number of orifices in set

Add **Orifice Set 3**: Orifice Diameter (ft); Invert elevation above datum (ft); Number of orifices in set

Add **Stone Weeper**: Width at bottom of weeper (ft); Weeper side slope (_H:1V); Upstream side slope (_H:1V); Downstream side slope (_H:1V); Horizontal flow path length at top of weeper (ft); Average rock diameter (ft); Distance from bottom to top of weeper (ft); Height from datum to bottom of weeper (ft)

Add **Vertical Stand Pipe**: Pipe diameter (ft); Height above datum (ft)

Month	Evaporation (in/day)	Water Withdraw Rate (ac-ft/day)
Jan	0.00	0.000
Feb	0.00	0.000
Mar	0.00	0.000
Apr	0.00	0.000
May	0.00	0.000
Jun	0.00	0.000
Jul	0.00	0.000
Aug	0.00	0.000
Sep	0.00	0.000
Oct	0.00	0.000
Nov	0.00	0.000
Dec	0.00	0.000

Stage (ft)	Natural Seepage Rate (in/hr)	Other Outflow Rate (cfs)
0.00	0.00	0.000
0.10	0.00	0.000
2.00	0.00	0.000
4.00	0.00	0.000
6.00	0.00	0.000
8.00	0.00	0.000

Remove **Broad Crested Weir (Required)**

Weir crest length (ft)	25.00
Weir crest width (ft)	10.00
Height from datum to bottom of weir opening (ft)	6.50

Add **Seepage Basin**: Infiltration rate (in/hr); Width of device (ft); Length of device (ft); Invert elevation of seepage basin inlet above datum (ft)

Add **Pump**

To Delete This Practice, Right Mouse Click on Icon and Select Delete | Cancel | Continue | **Press 'F1' for Help**

Control Practice # : 23 | CP Index # : 2

Figure 16: CL-1 WP1.

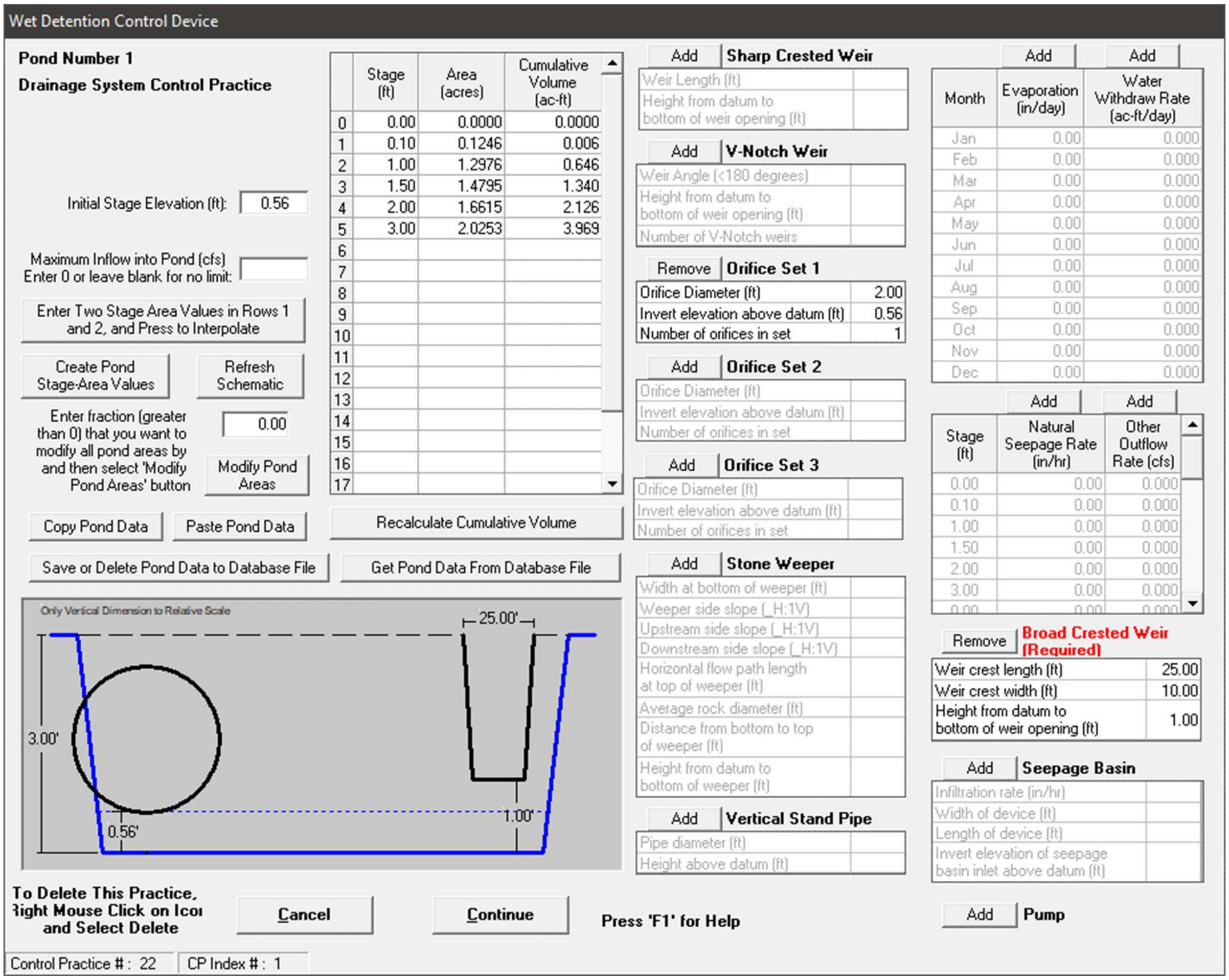


Figure 17: CL-1 WP2.

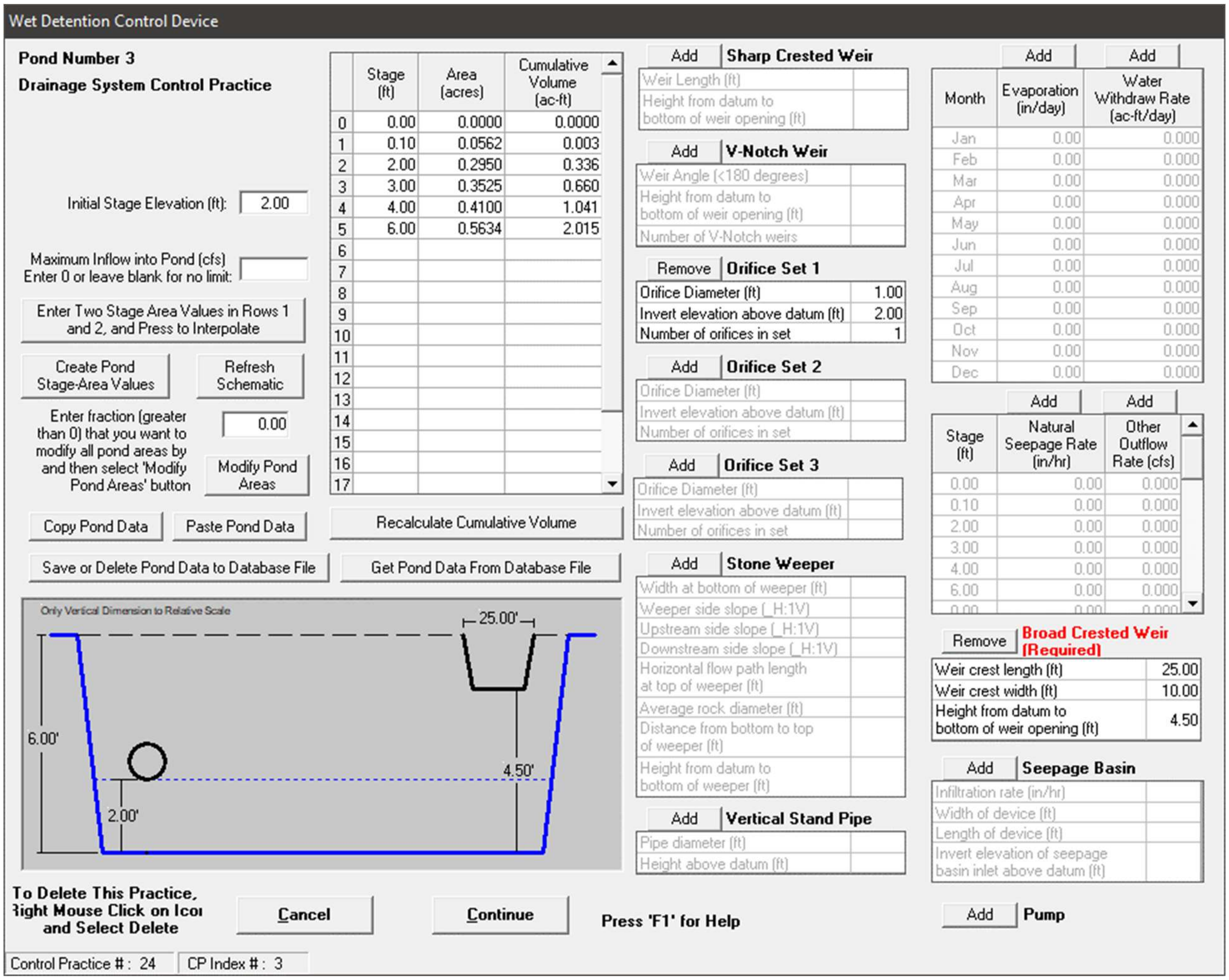


Figure 18: CL-1 WP3.

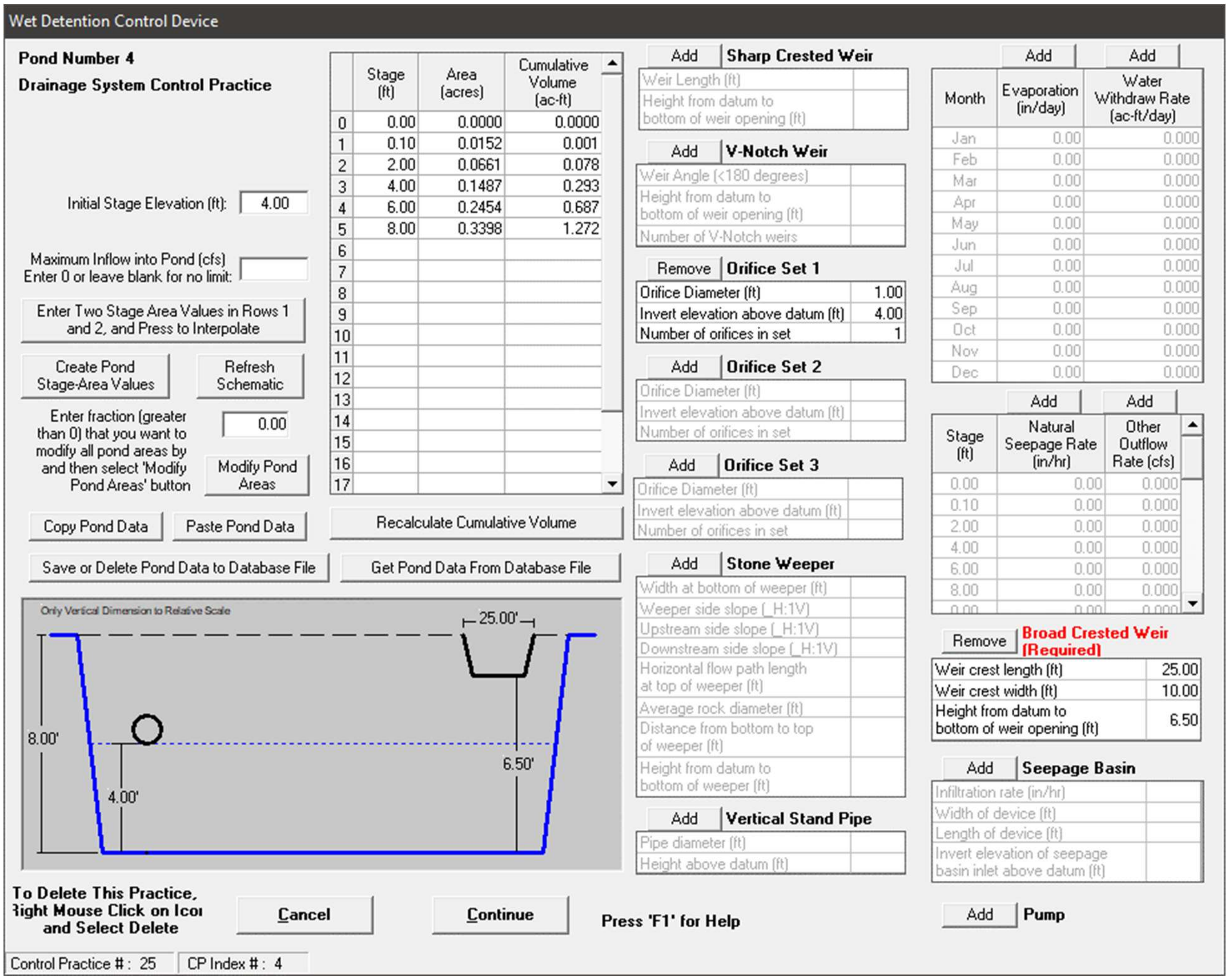


Figure 19: CL-1 WP5.

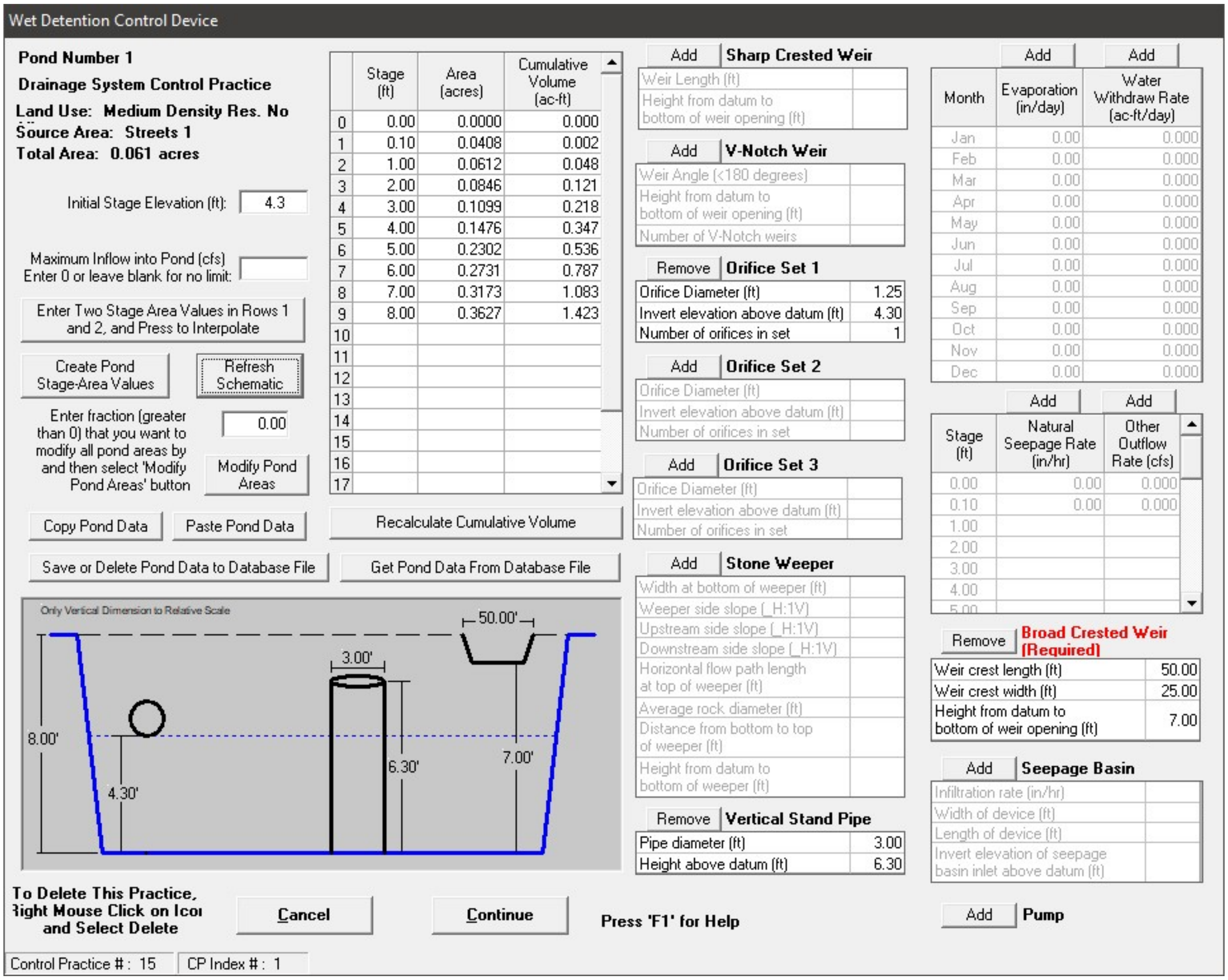


Figure 20: CL-2 WP4.

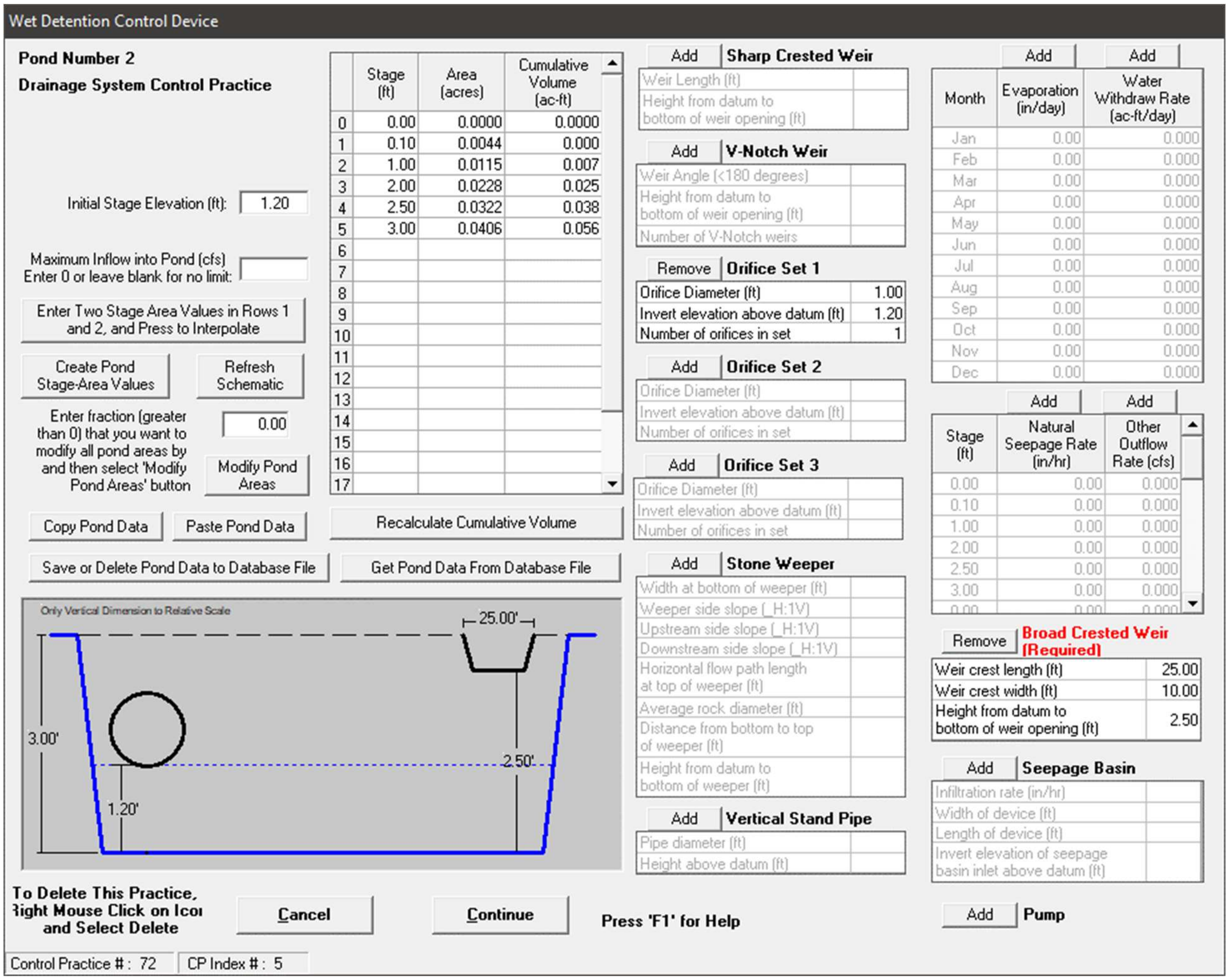


Figure 21: CL-3 WP6.

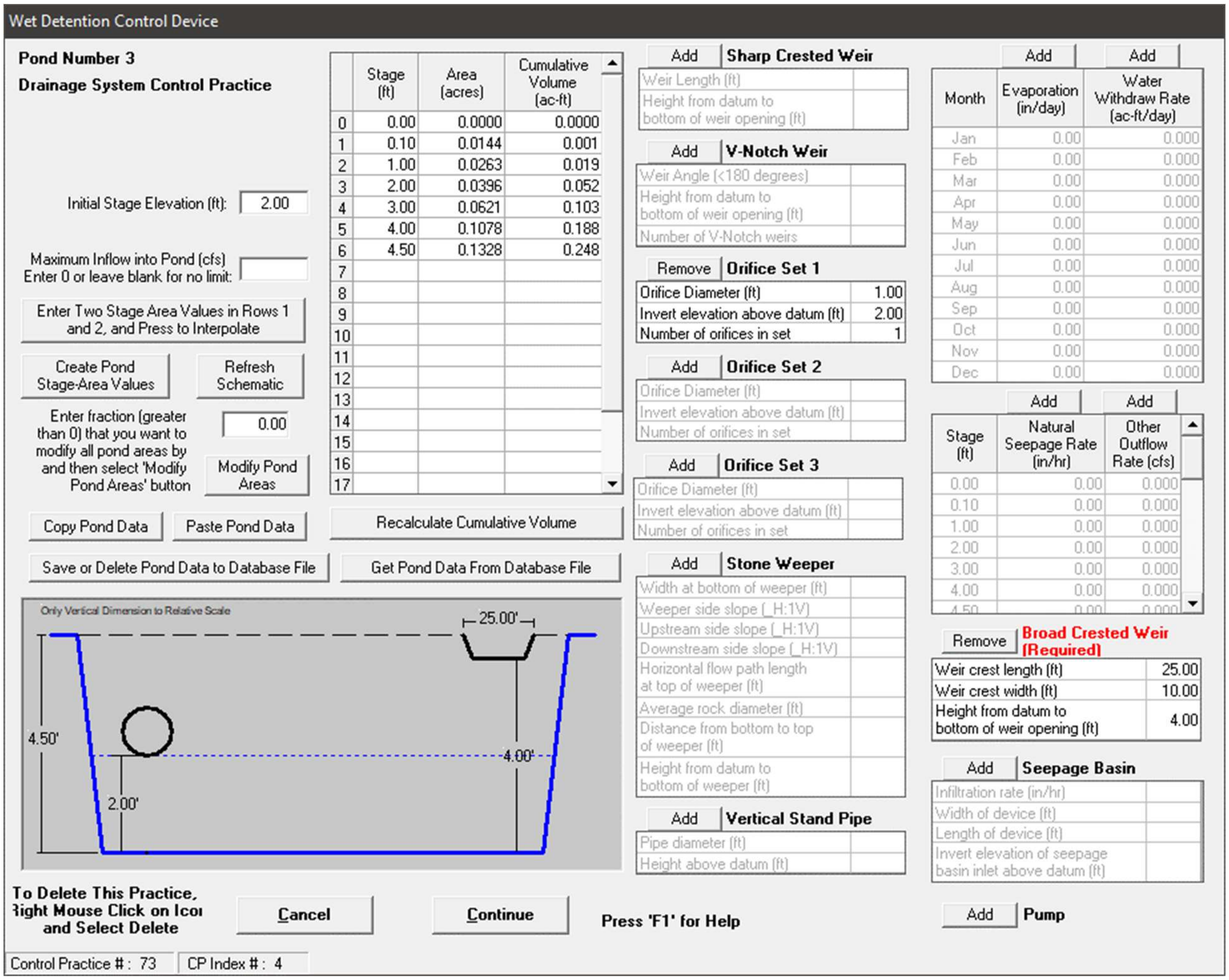


Figure 22: CL-3 WP7.

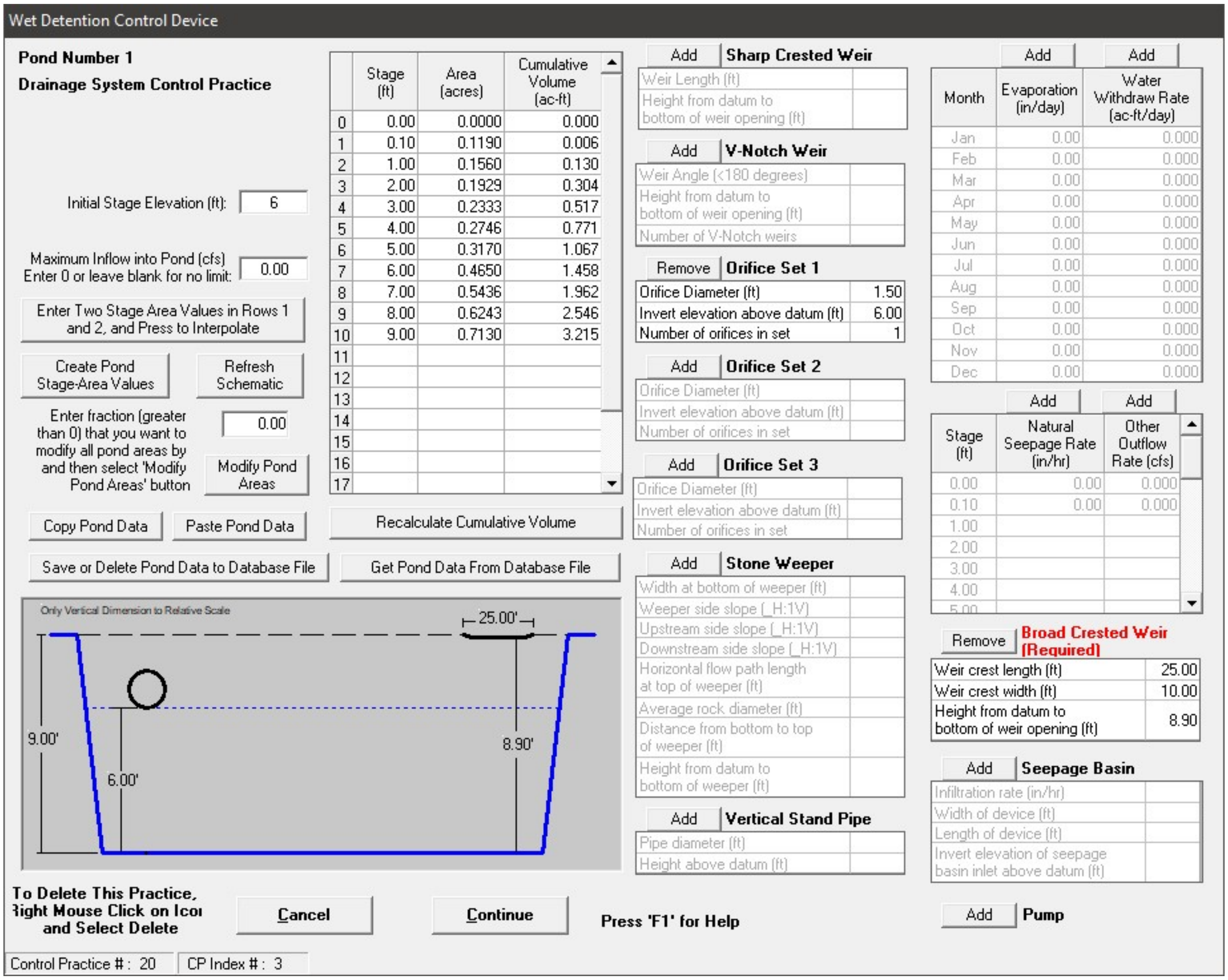


Figure 23: CL-5 WP10.

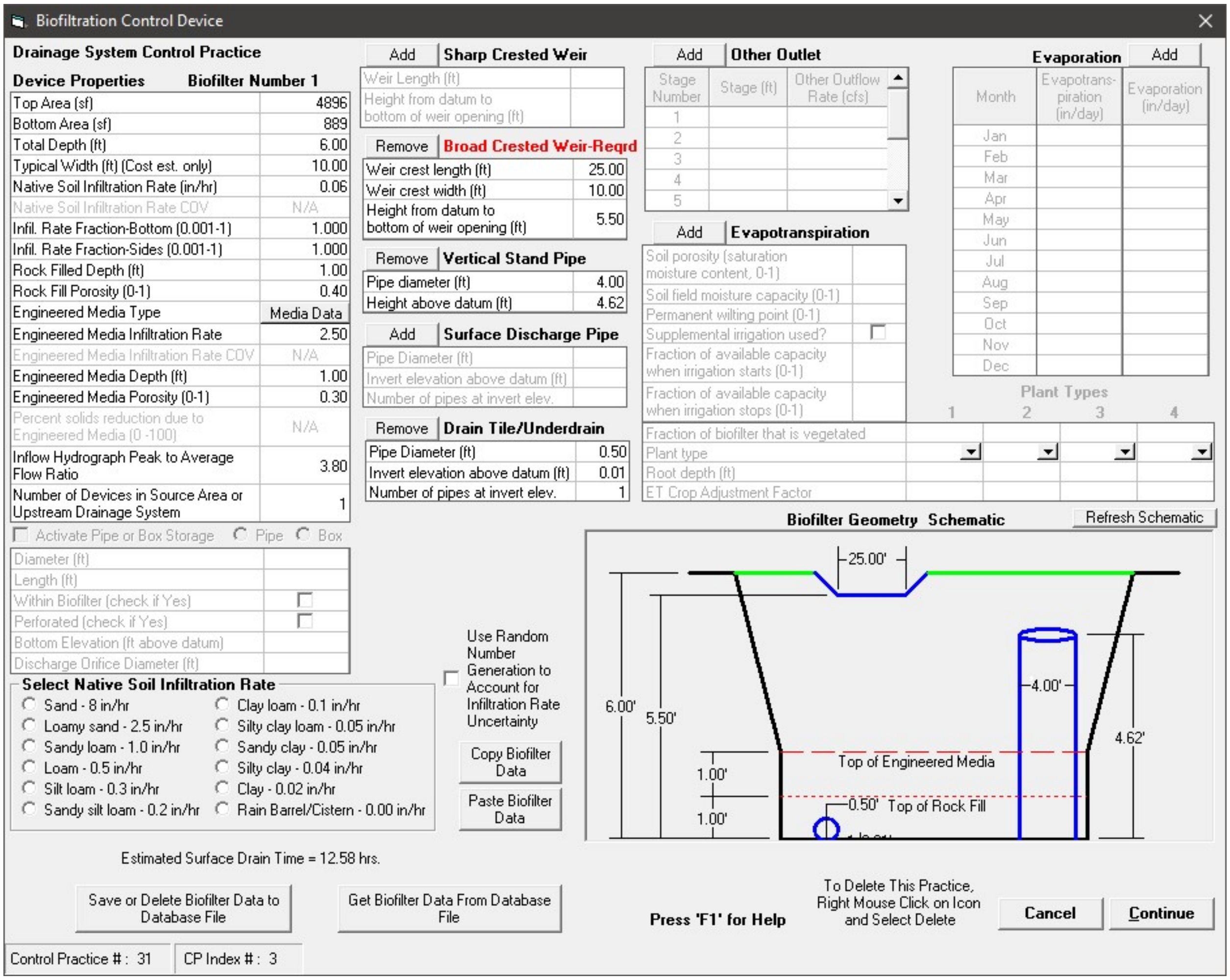


Figure 24: CL-7 WP15. Modeled as a biofiltration control device because of the underdrain.

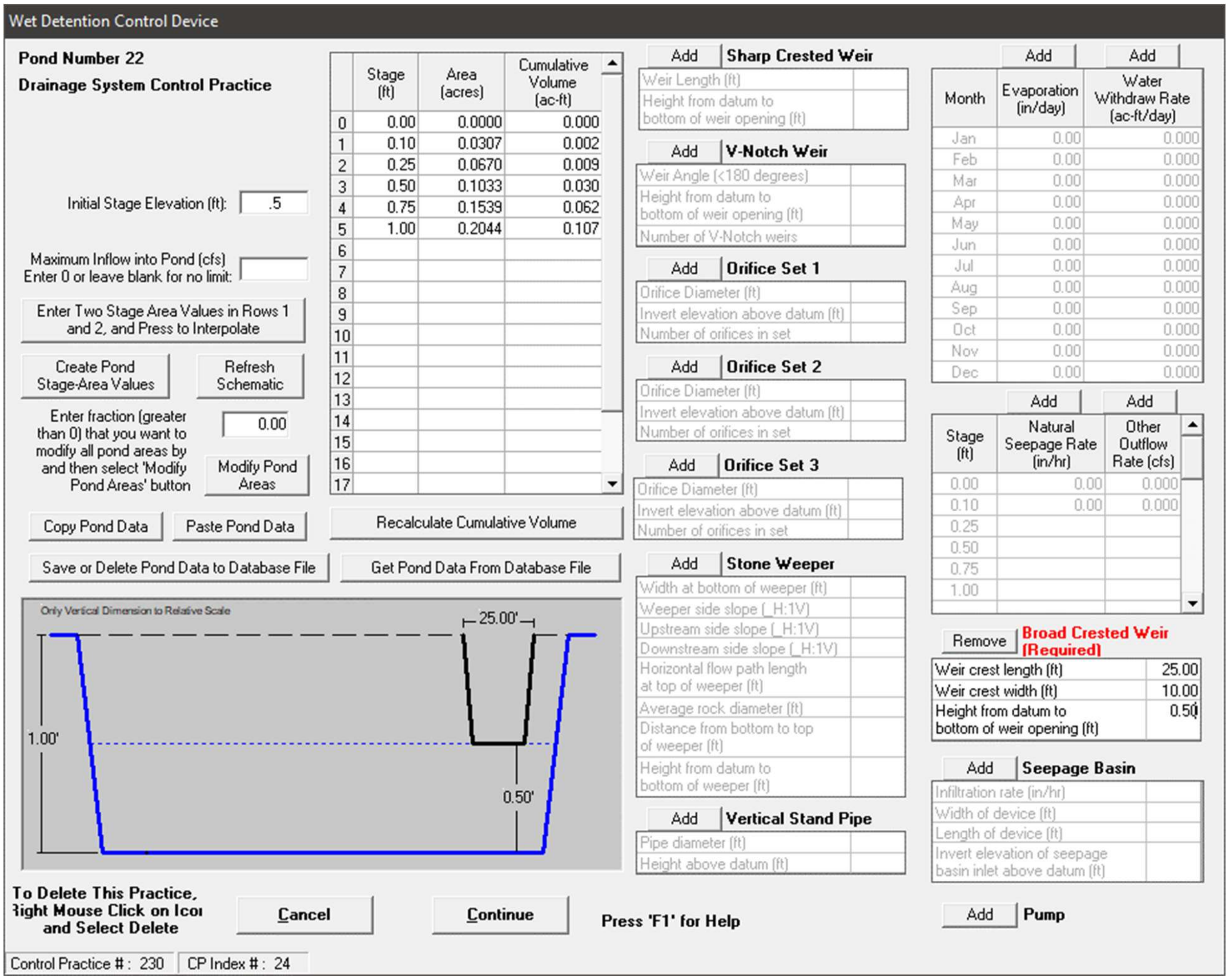


Figure 25: CL-8 WP8.

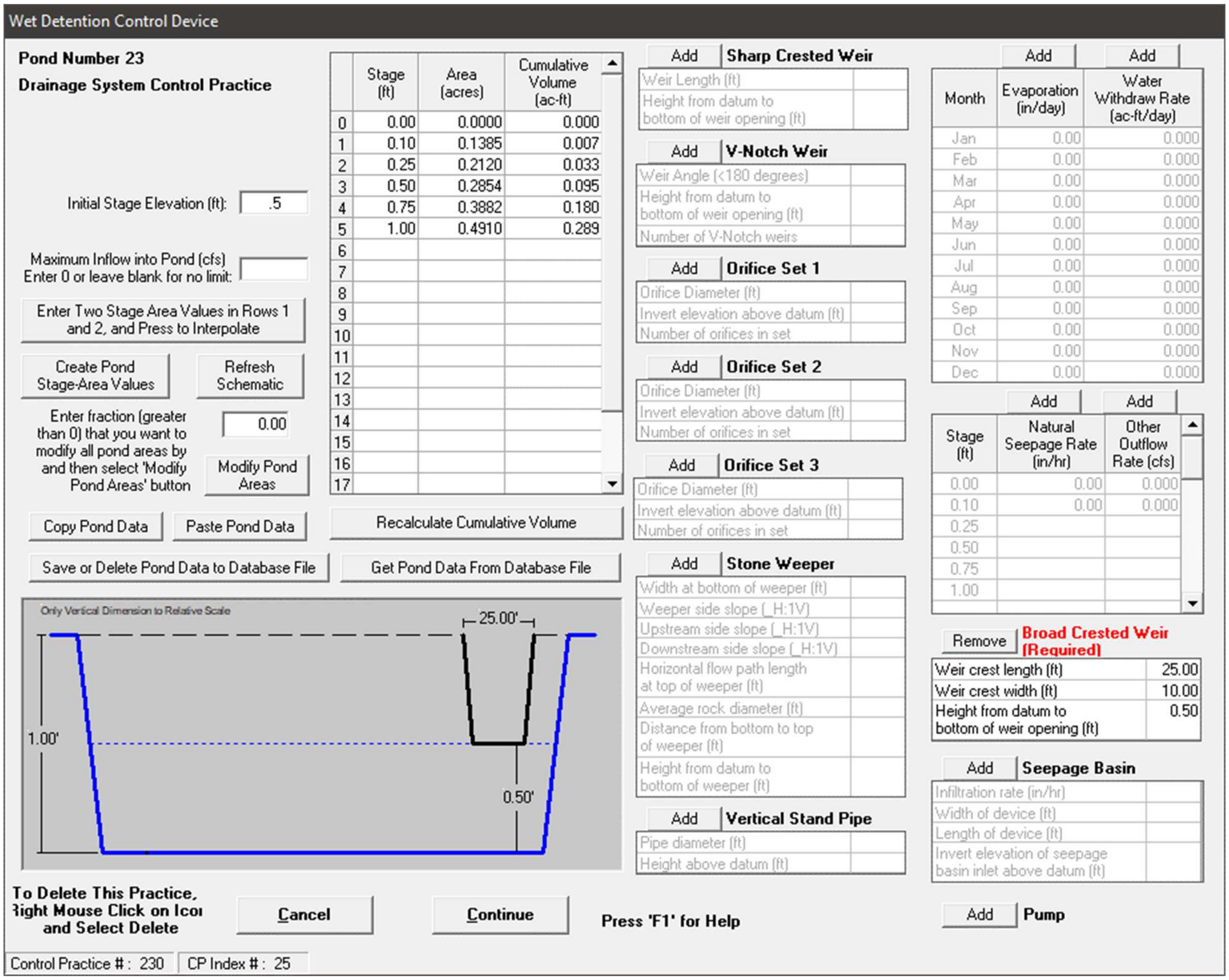


Figure 26: CL-8 WP9.

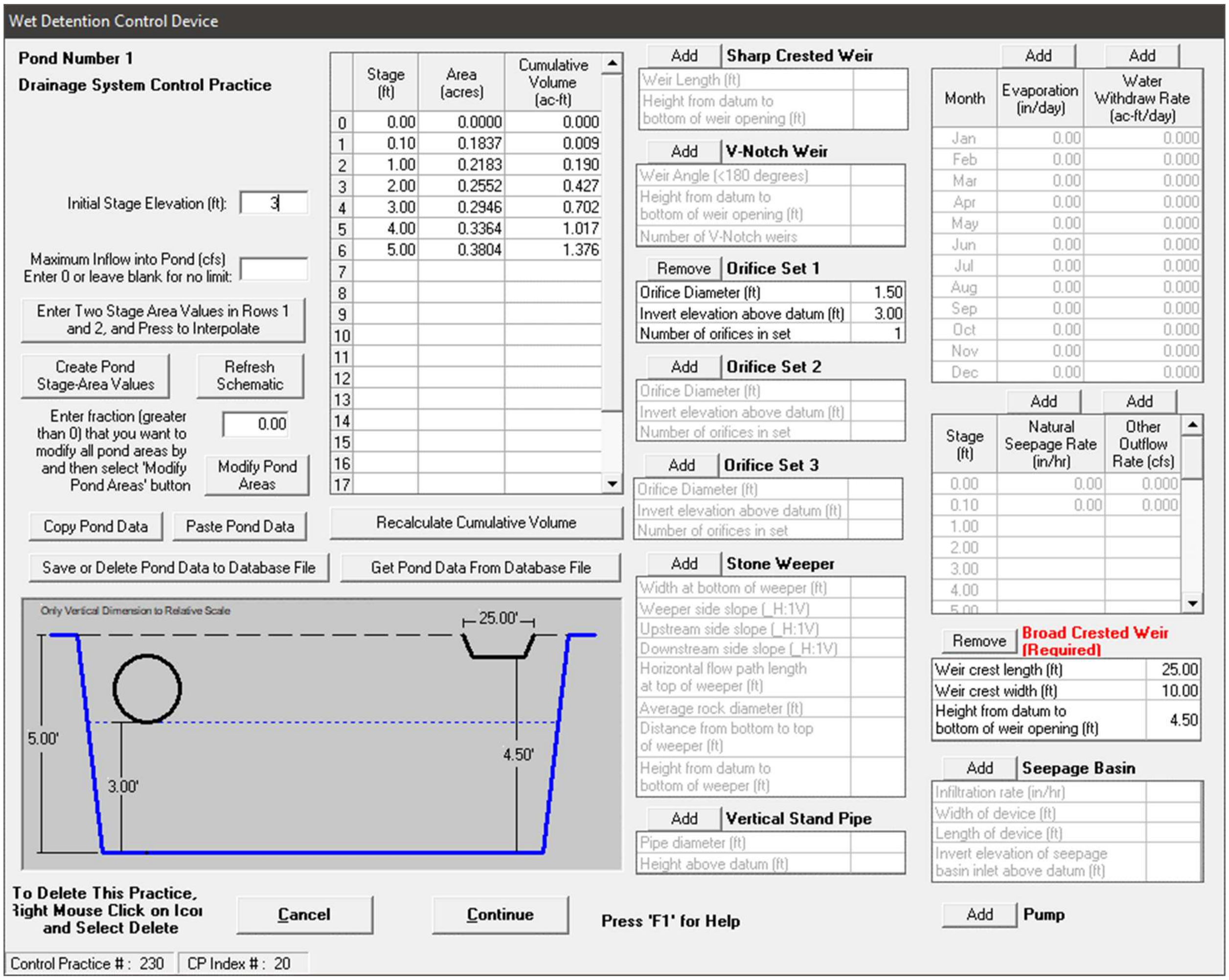


Figure 27: CL-8 WP11.

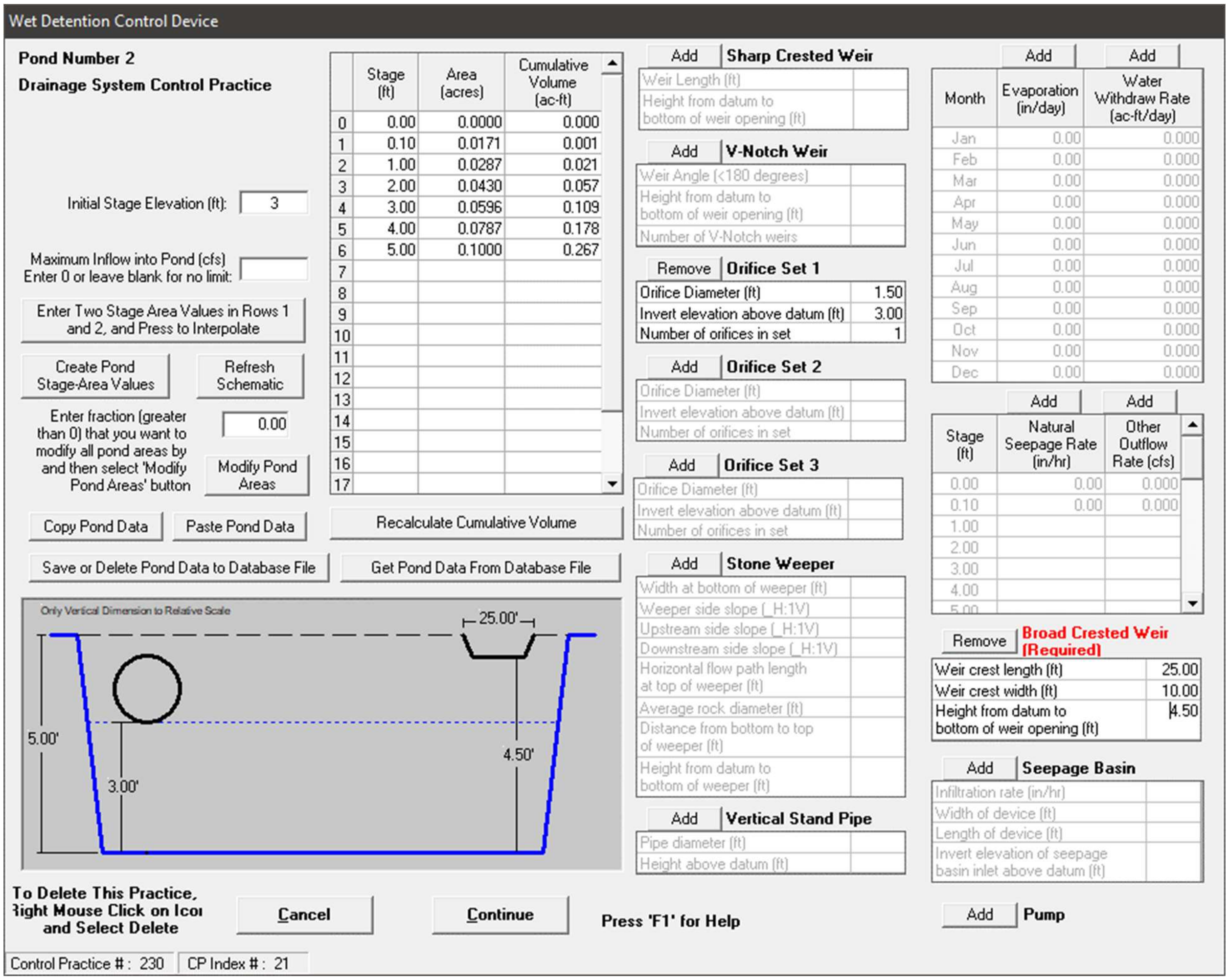


Figure 28: CL-8 WP12.

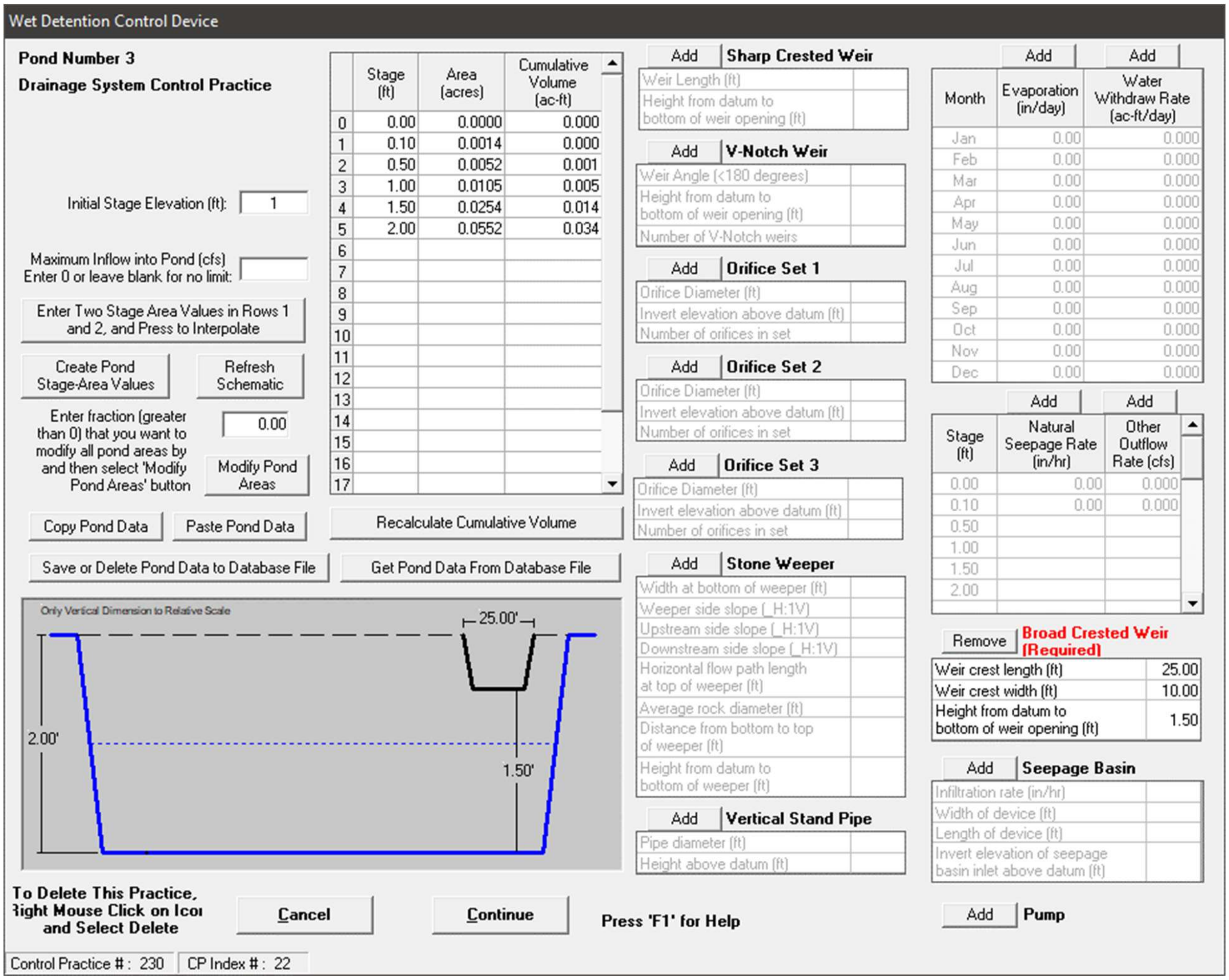


Figure 29: CL-8 WP13.

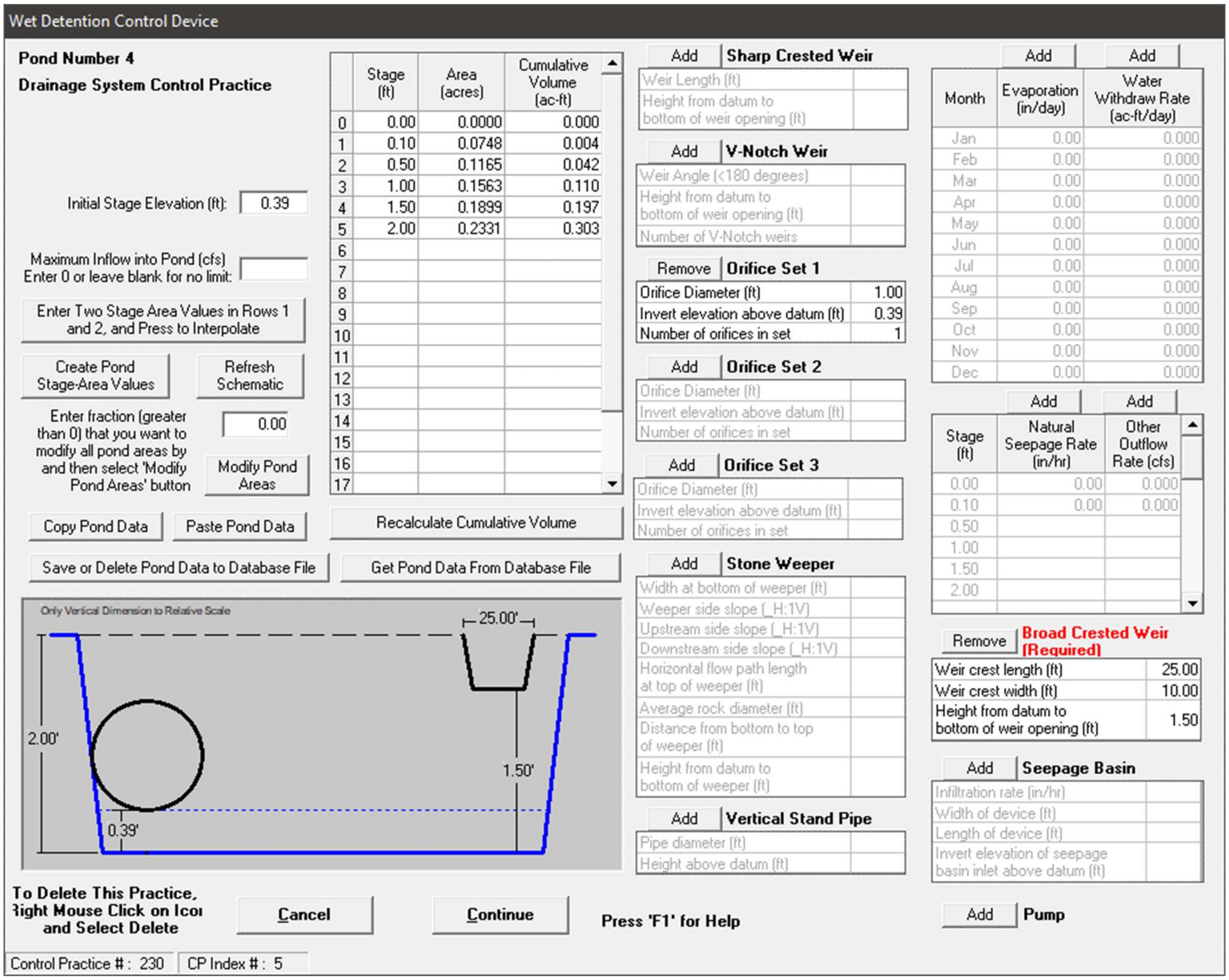


Figure 30: CL-8 WP16.

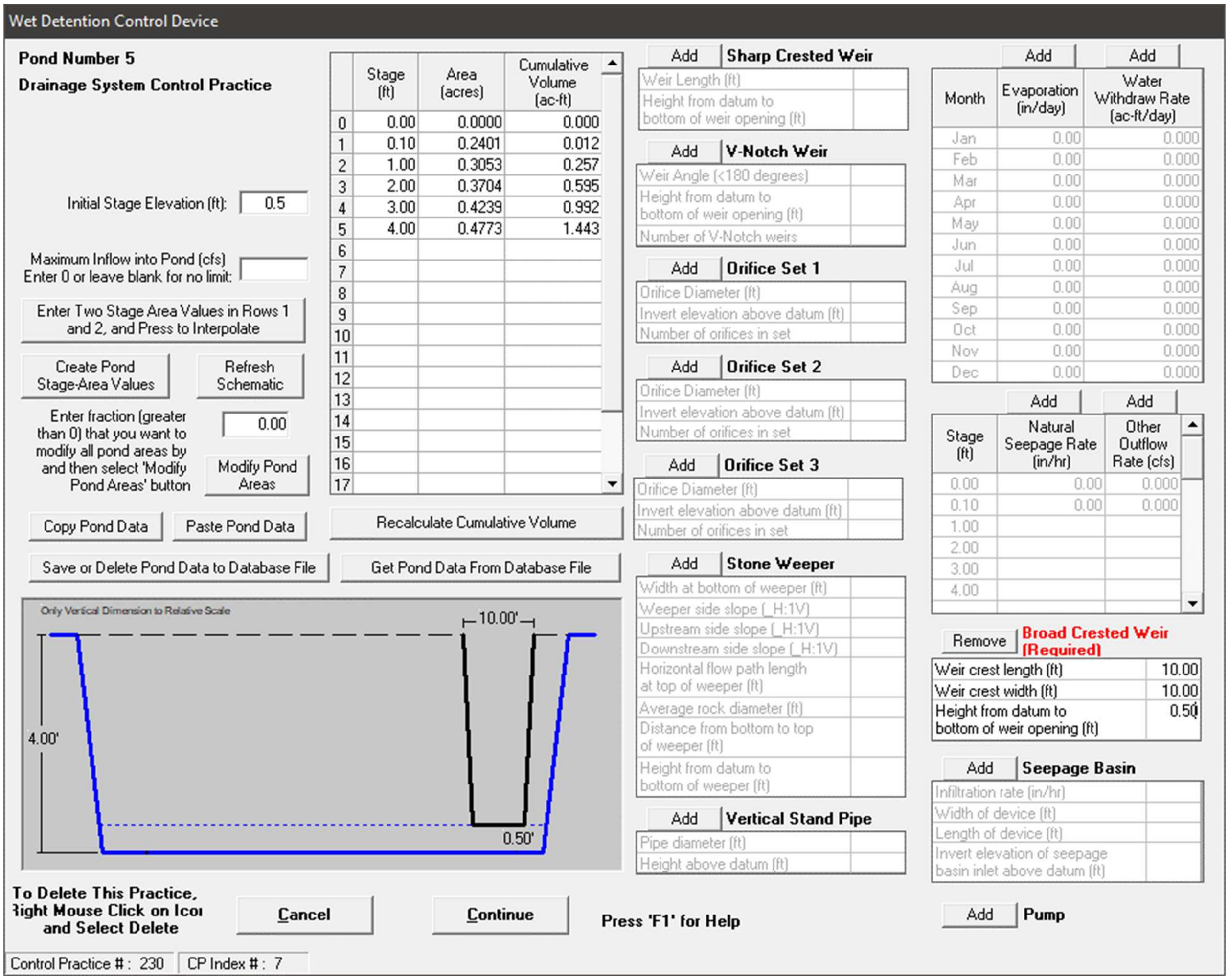


Figure 31: CL-8 WP17.

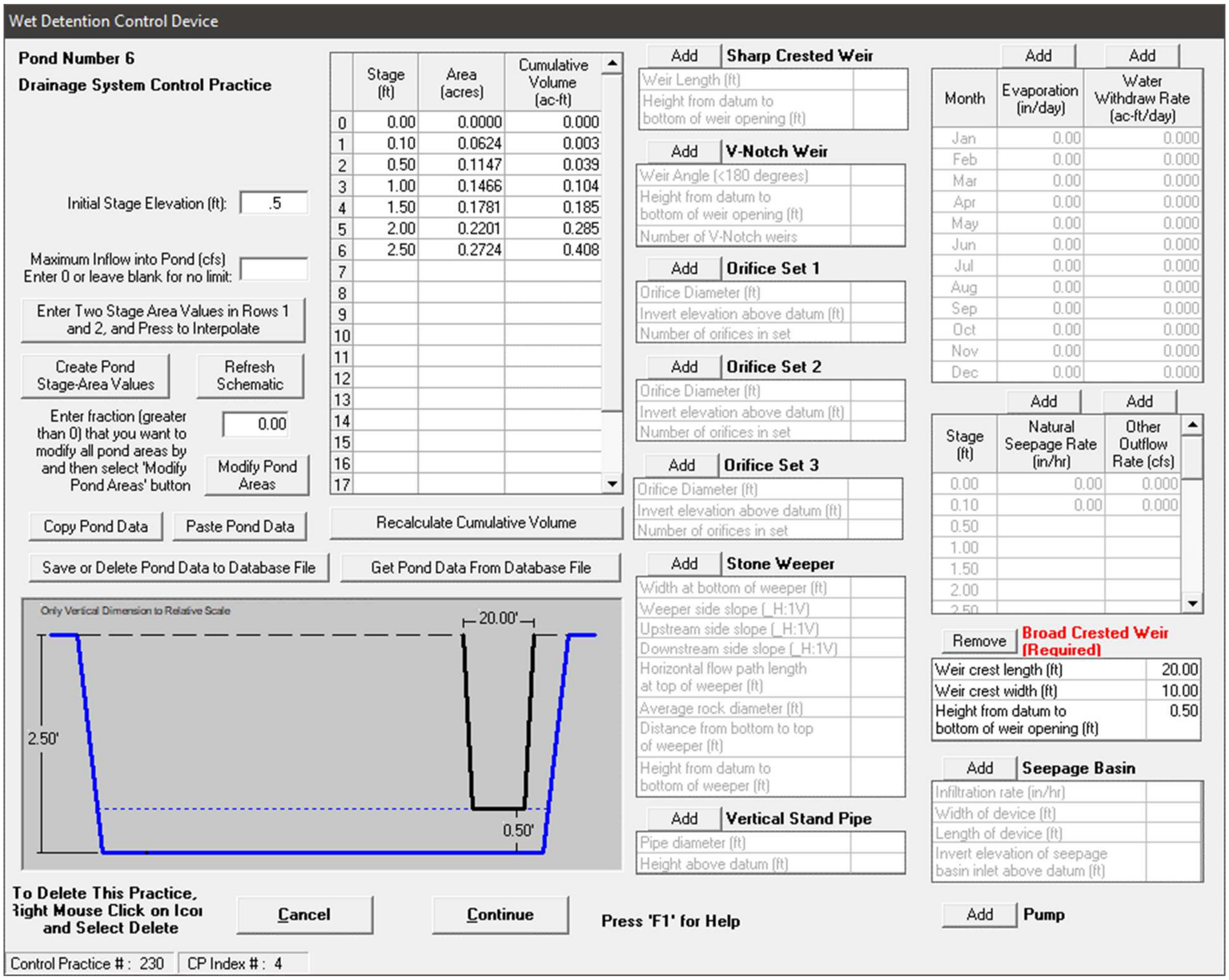


Figure 32: CL-8 WP18.

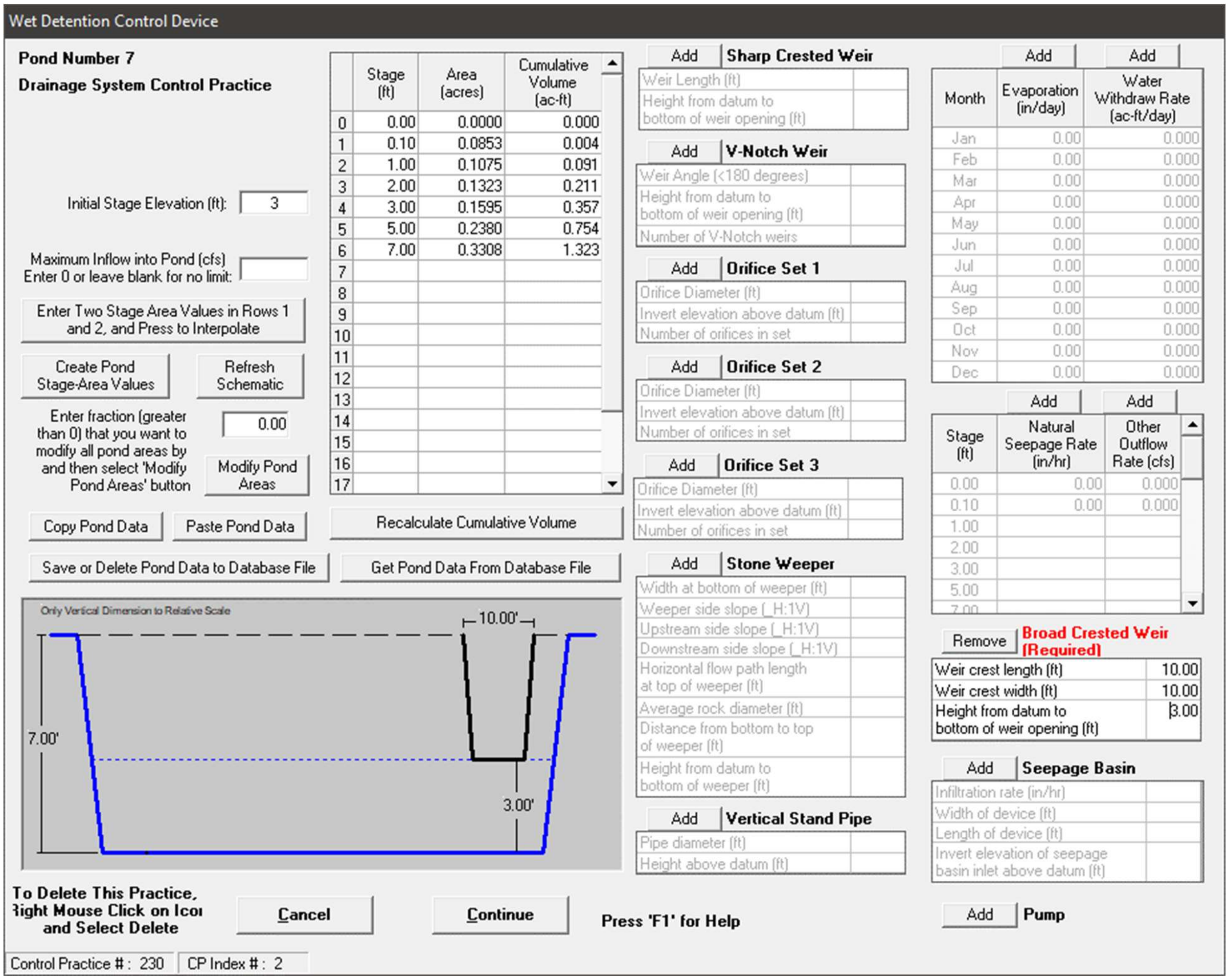


Figure 33: CL-8 WP19.

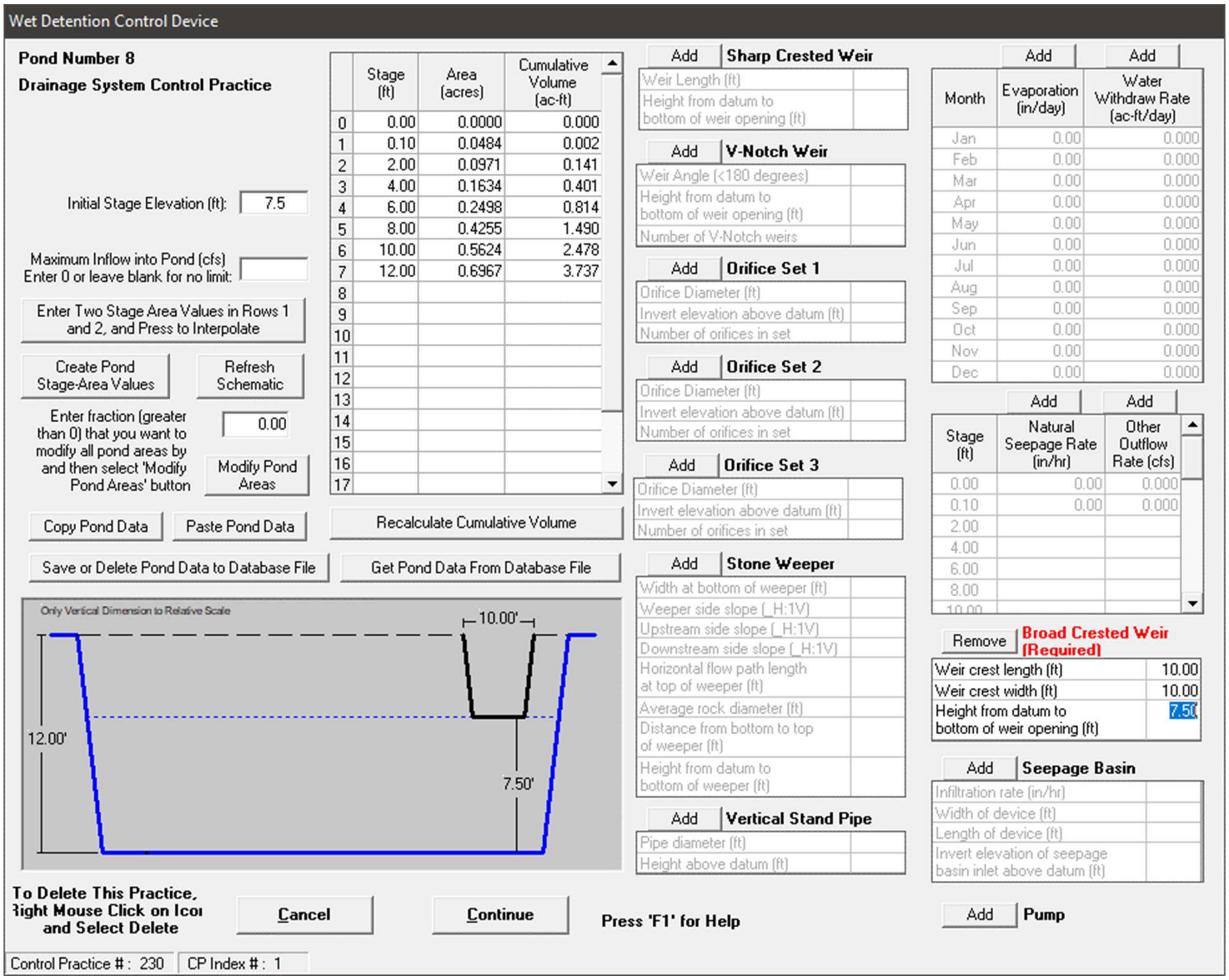


Figure 34: CL-8 WP20.

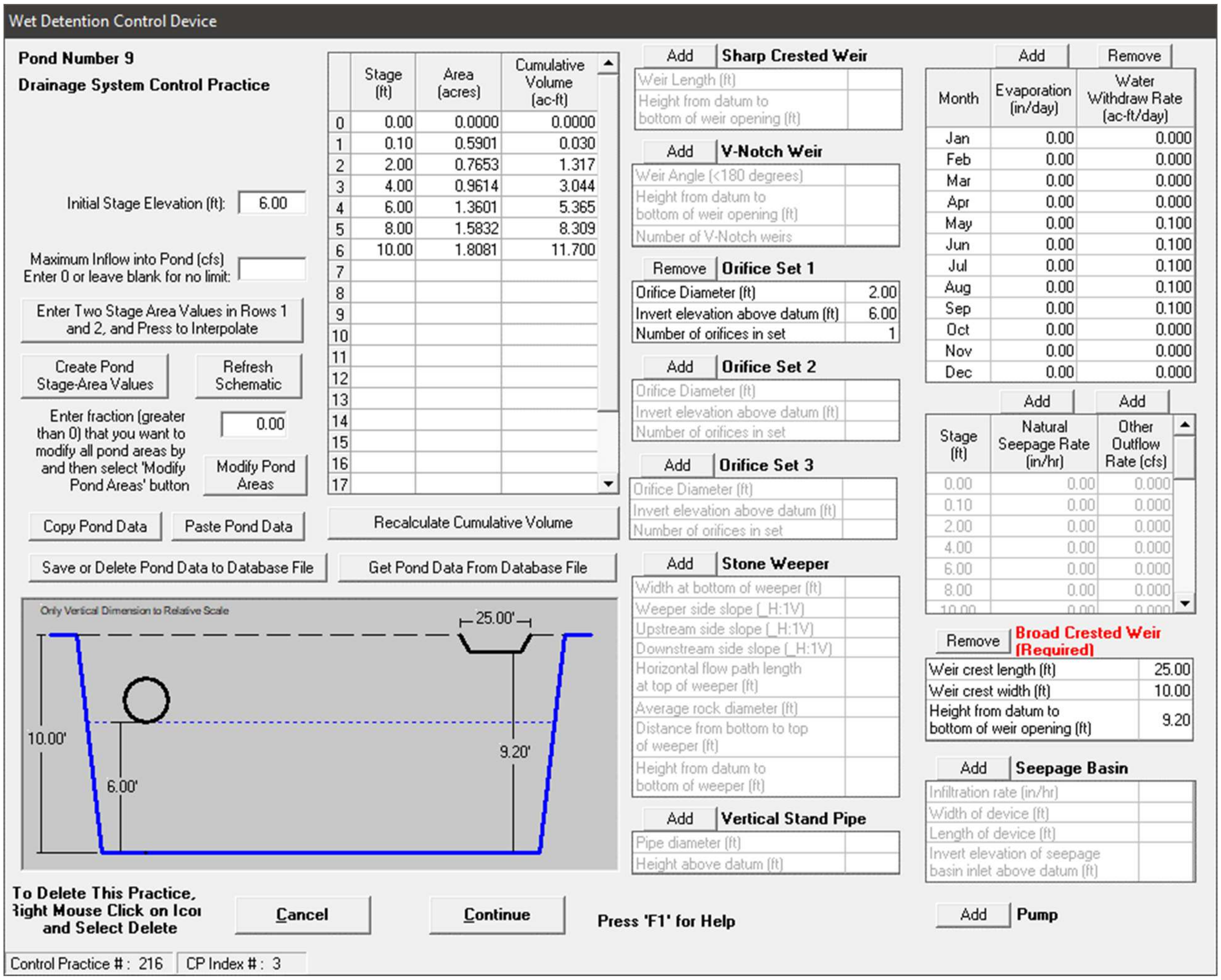


Figure 35: CL-8 WP21. WP21 includes the LaMotte reuse system.

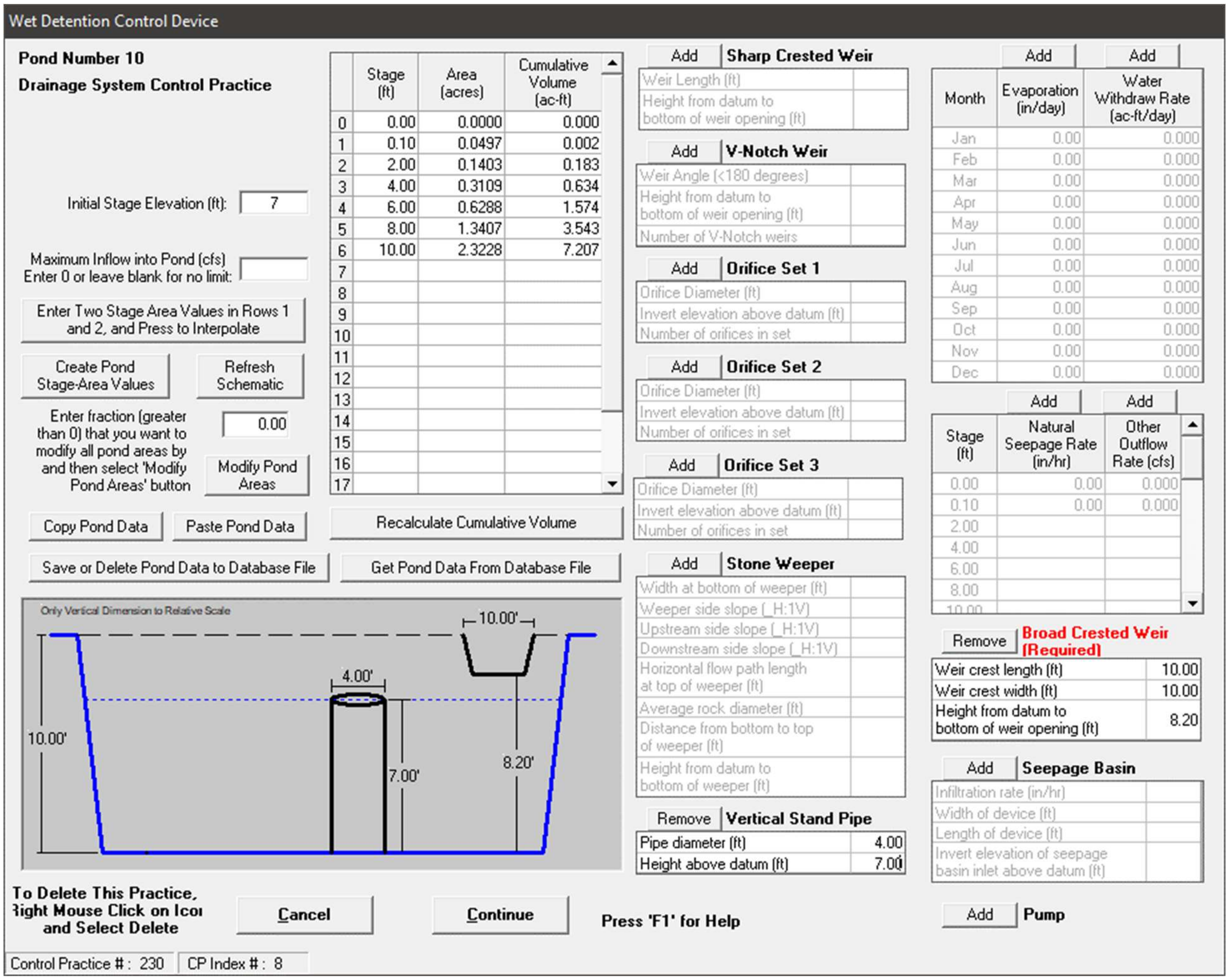


Figure 36: CL-8 WP22.

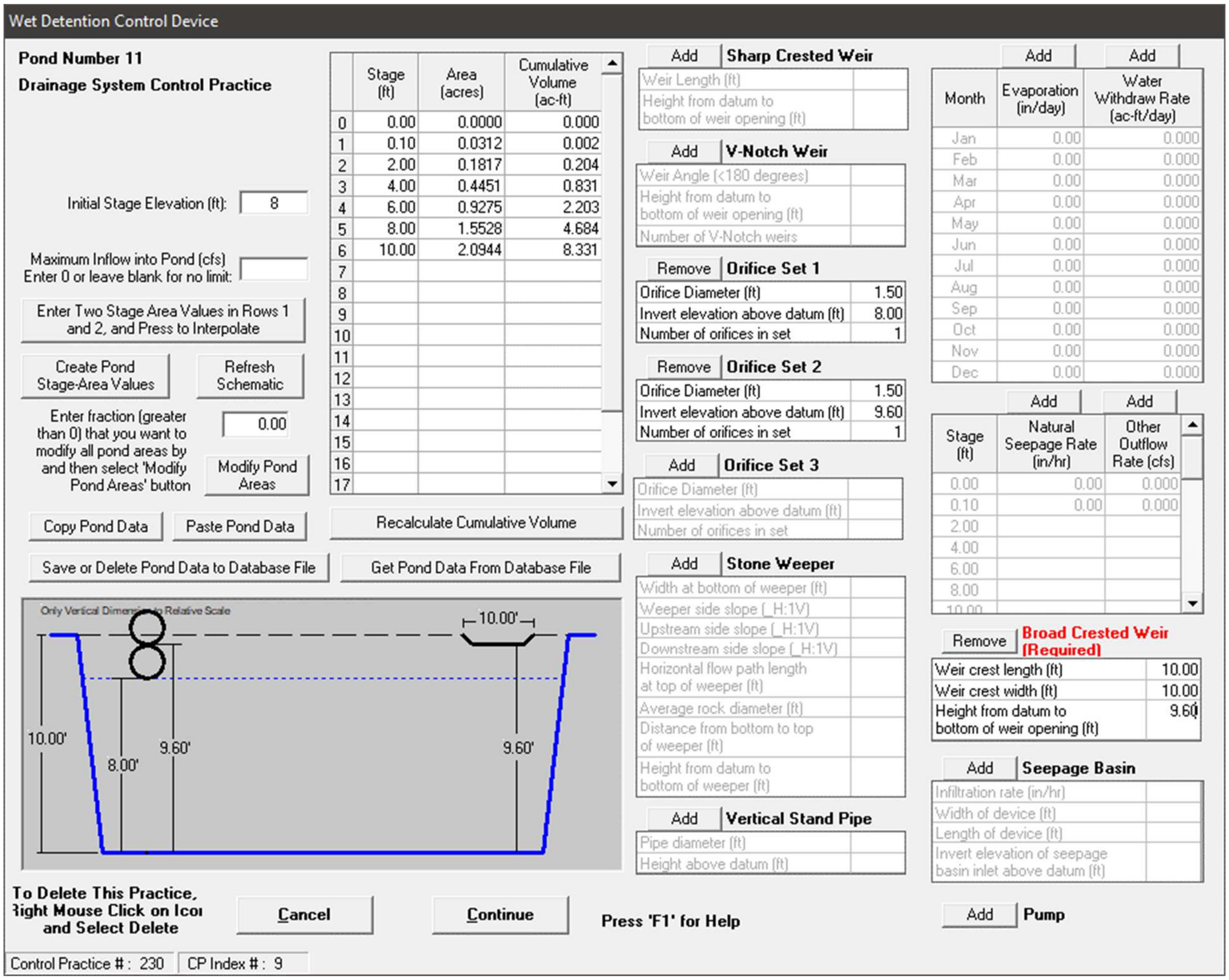


Figure 37: CL-8 WP23.

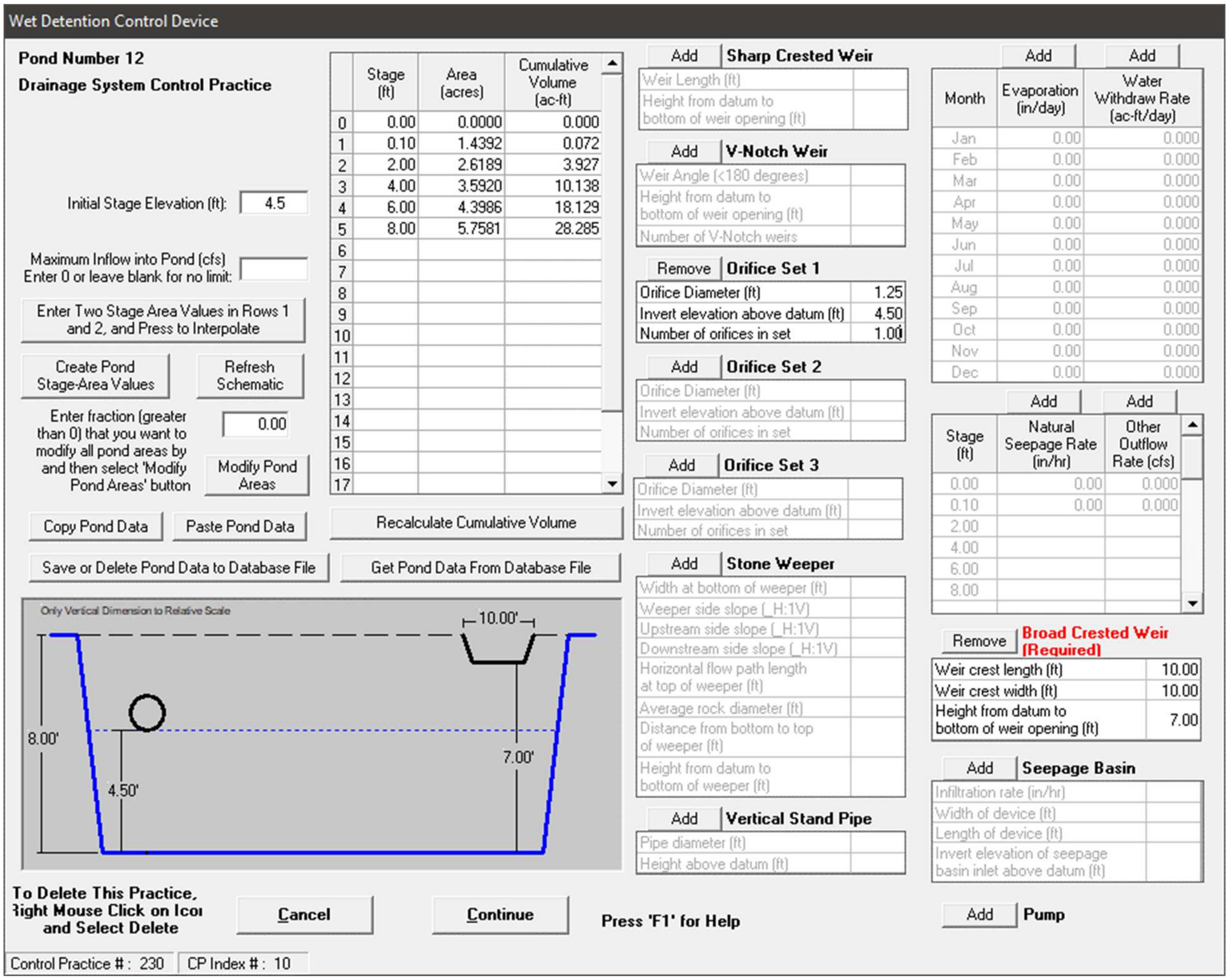


Figure 38: CL-8 WP24.

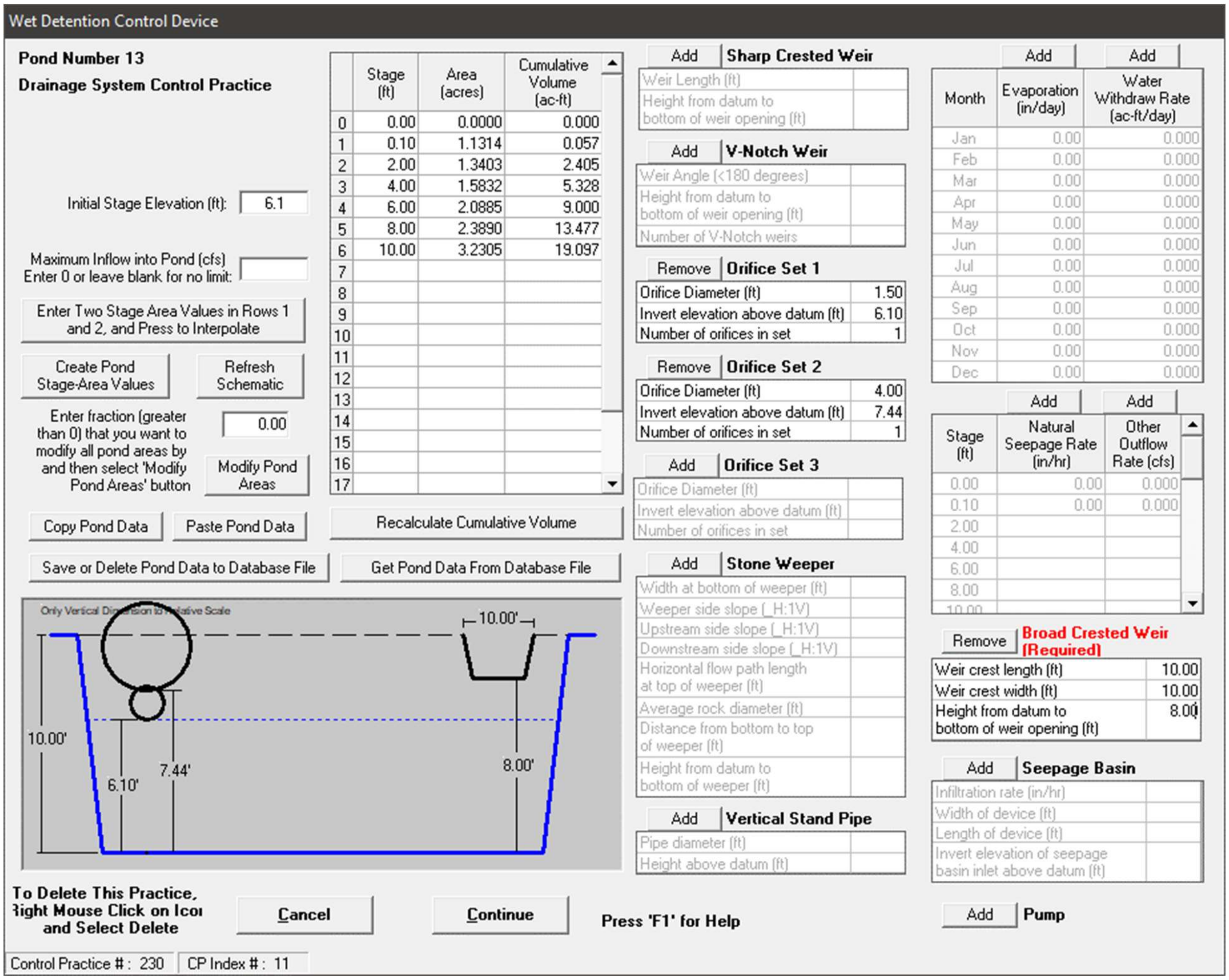


Figure 39: CL-8 WP25.

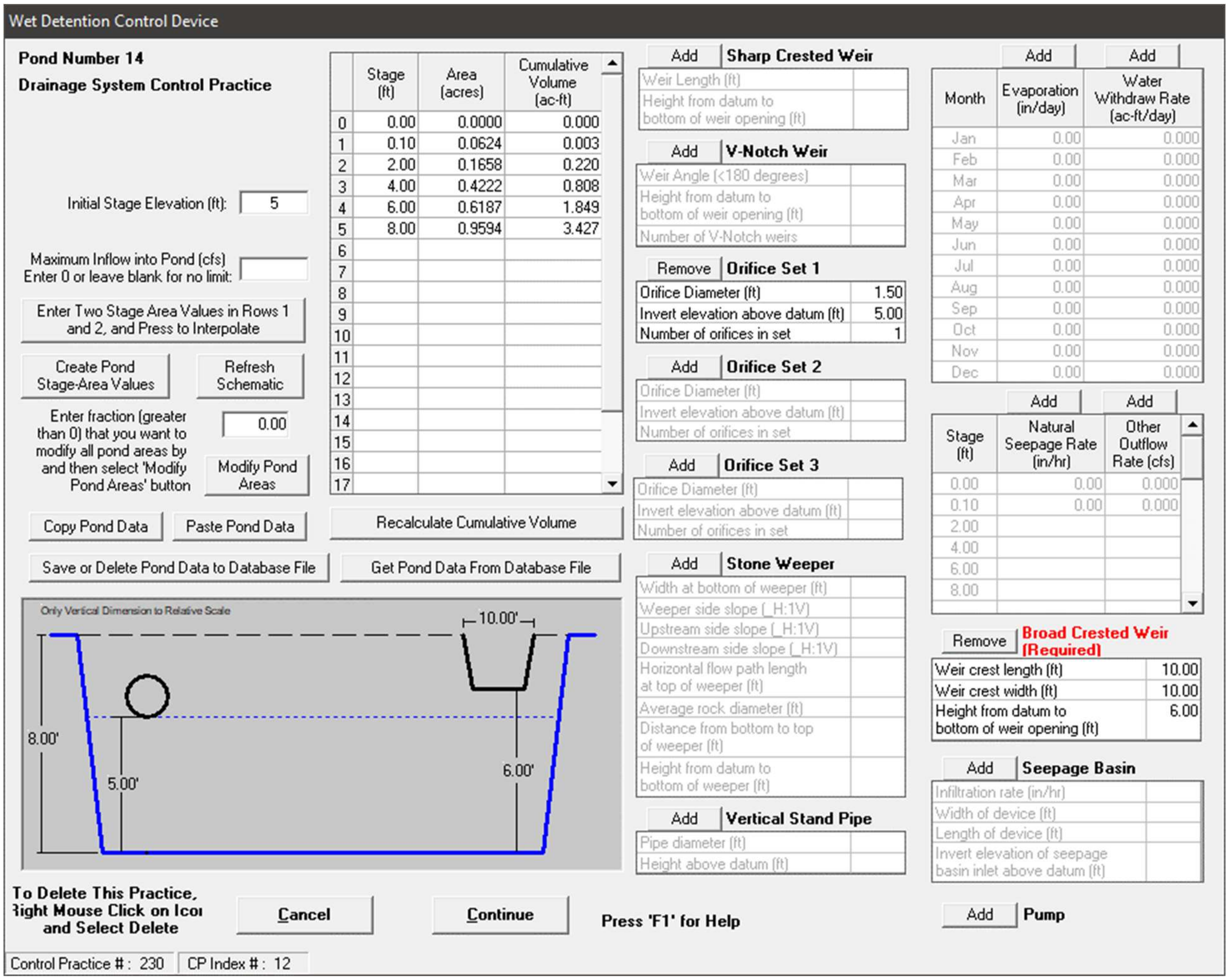


Figure 40: CL-8 WP26.

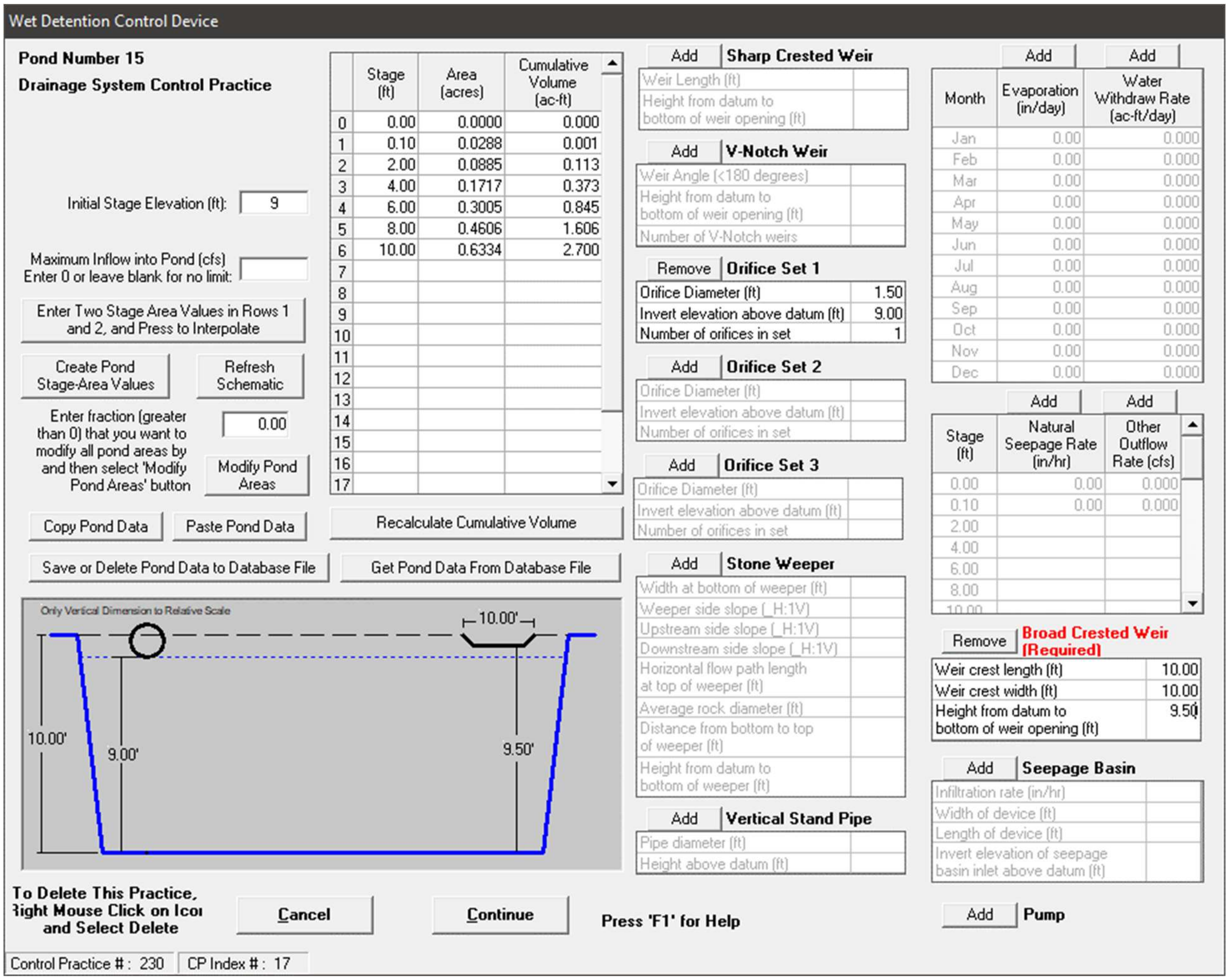


Figure 41: CL-8 WP27.

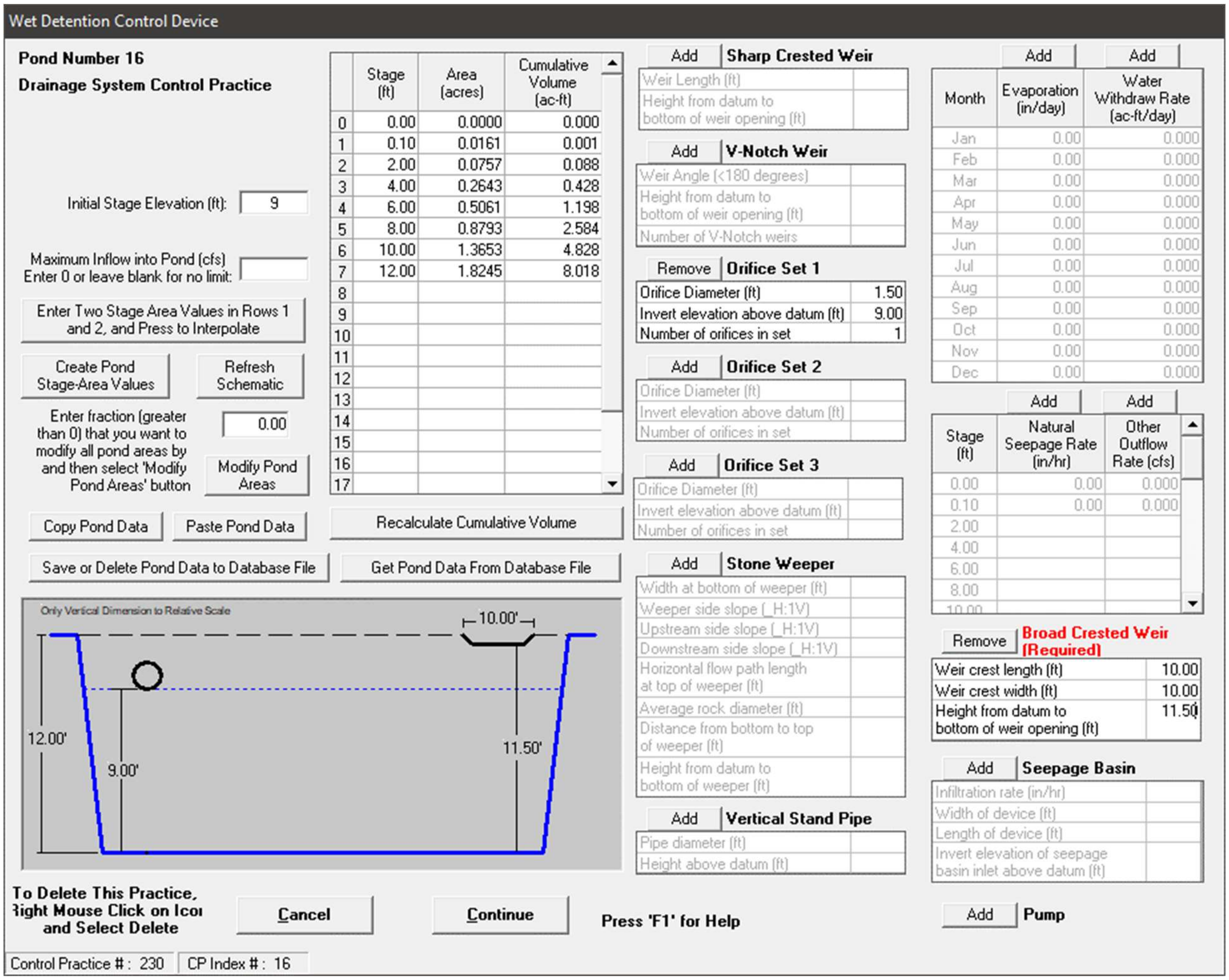


Figure 42: CL-8 WP28.

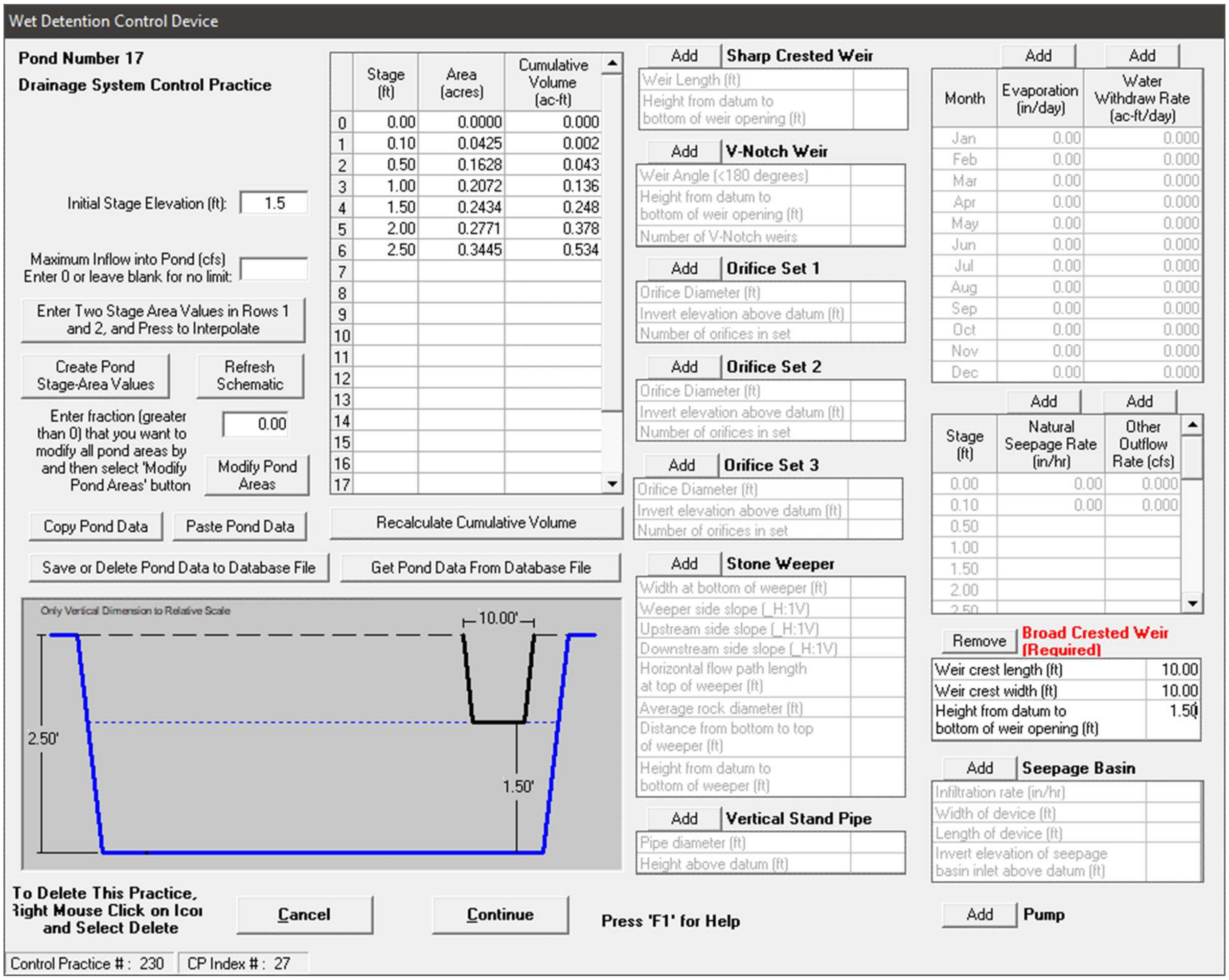


Figure 43: CL-8 WP29.

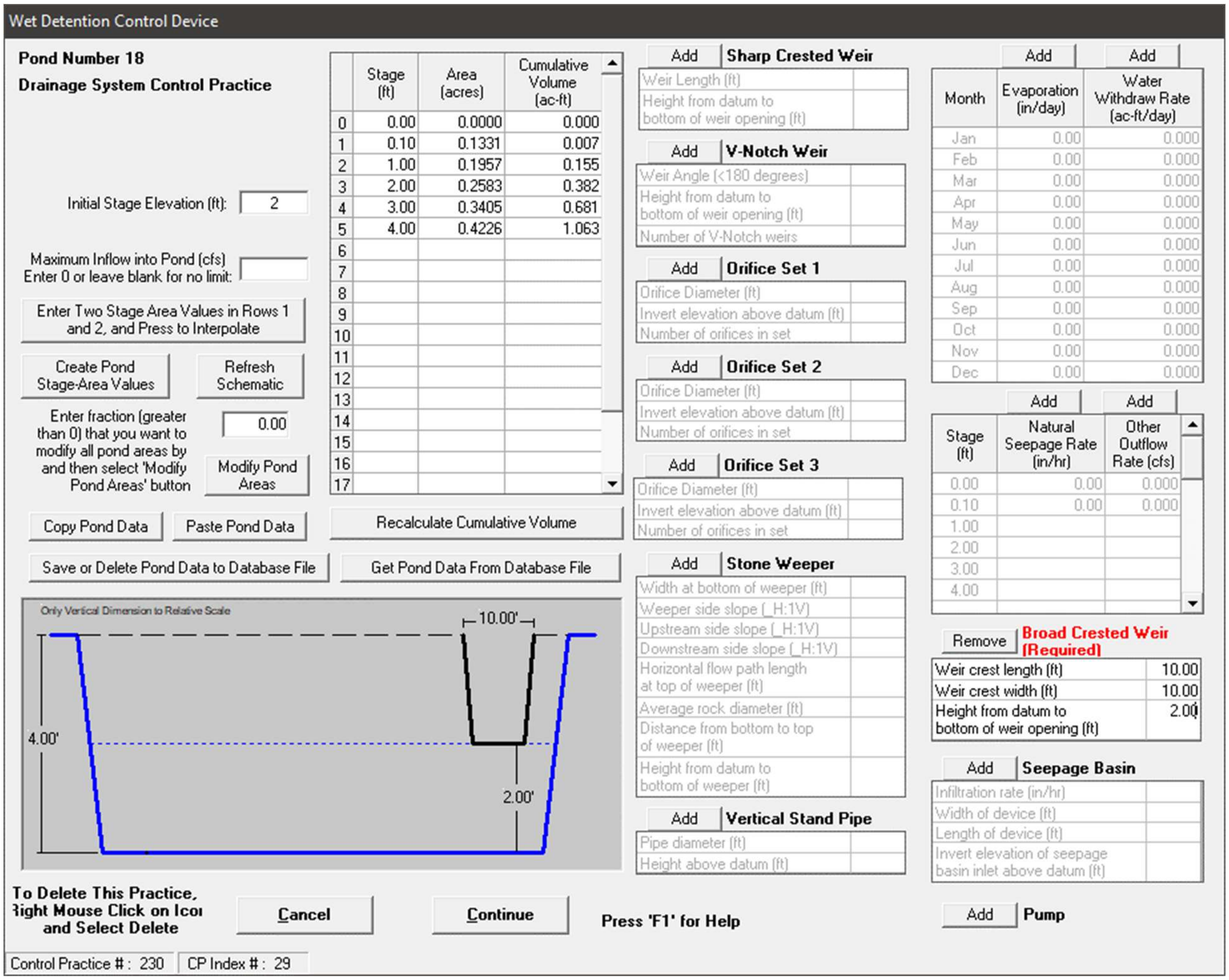


Figure 44: CL-8 WP30.

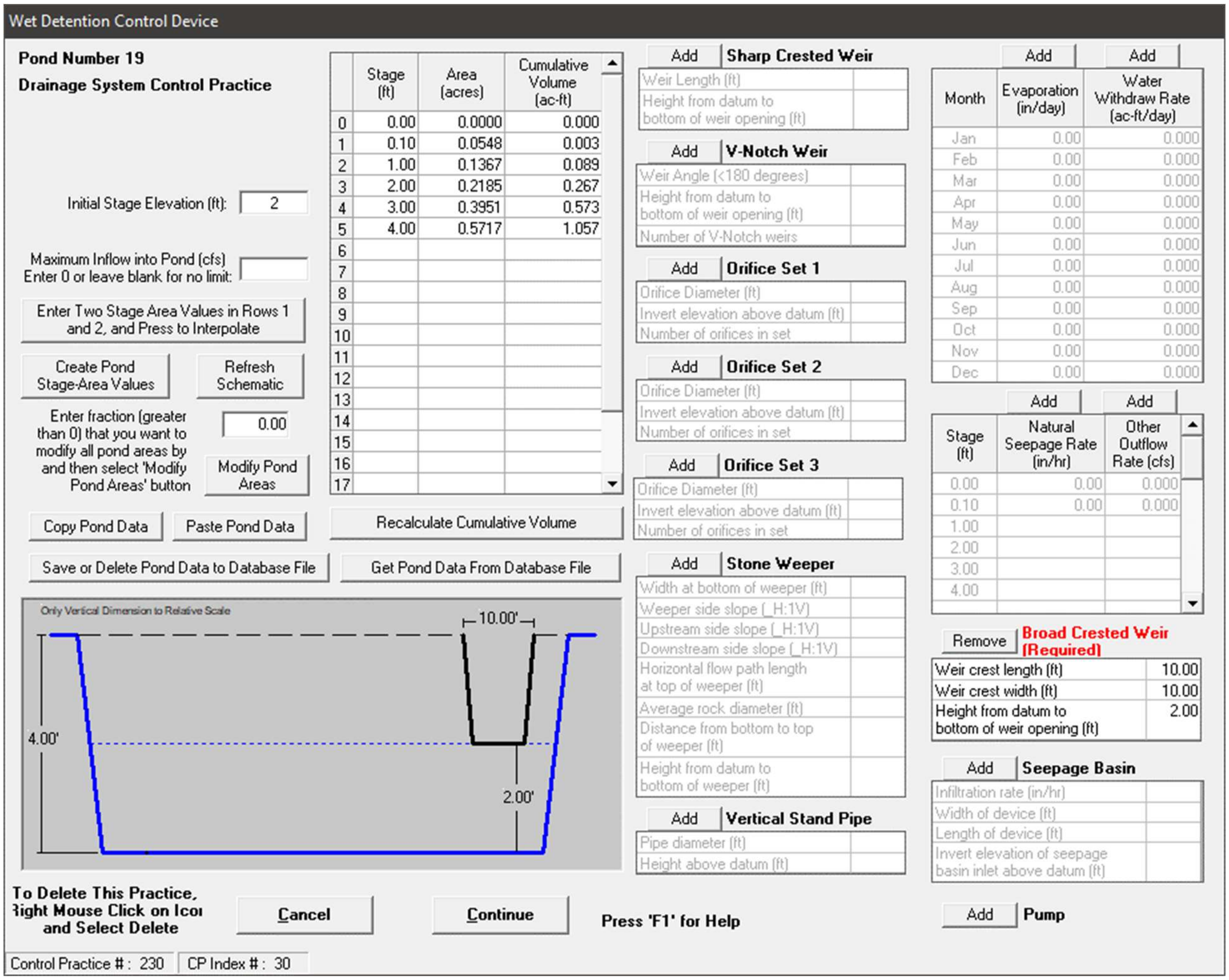


Figure 45: CL-8 WP31.

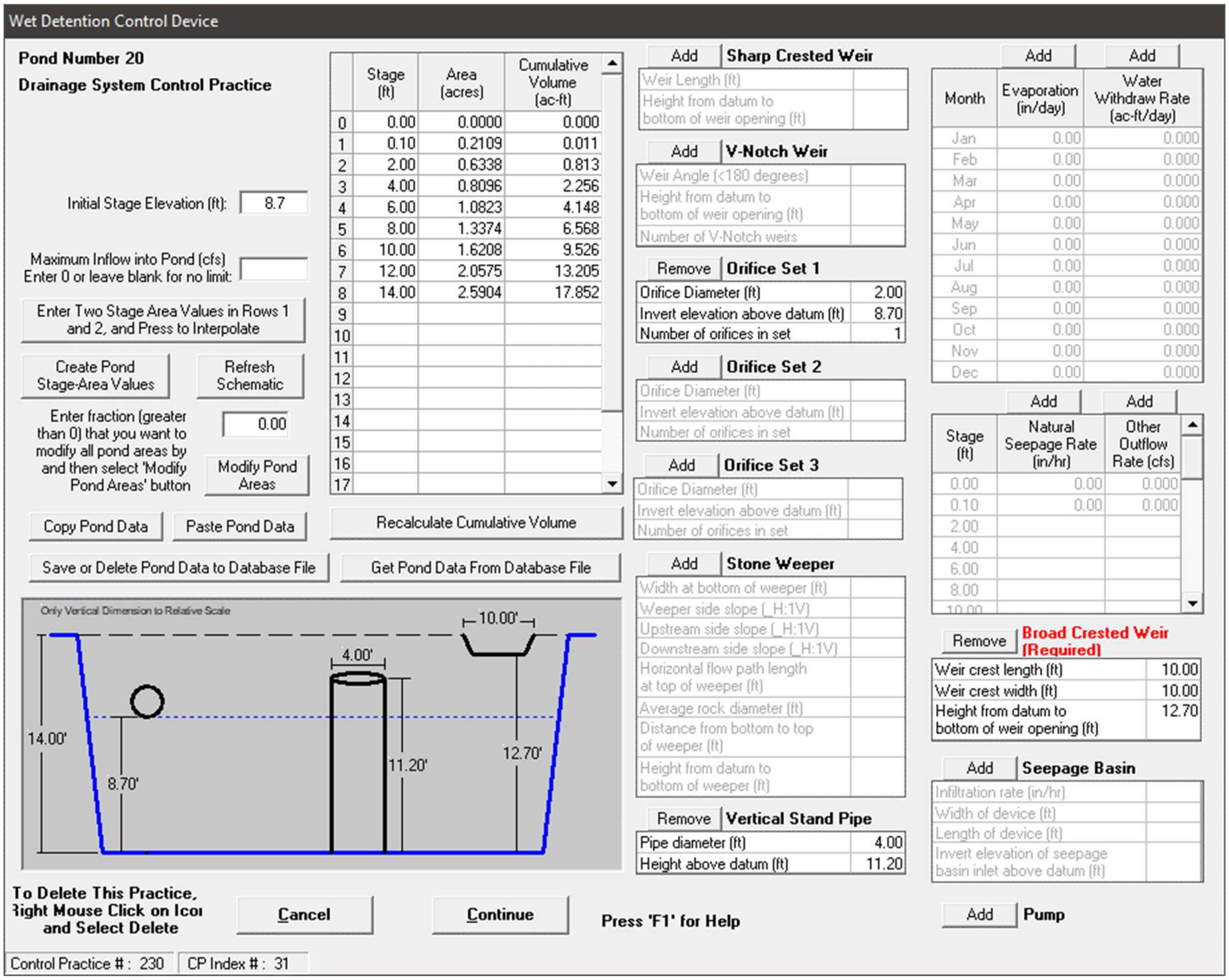


Figure 46: CL-8 WP32.

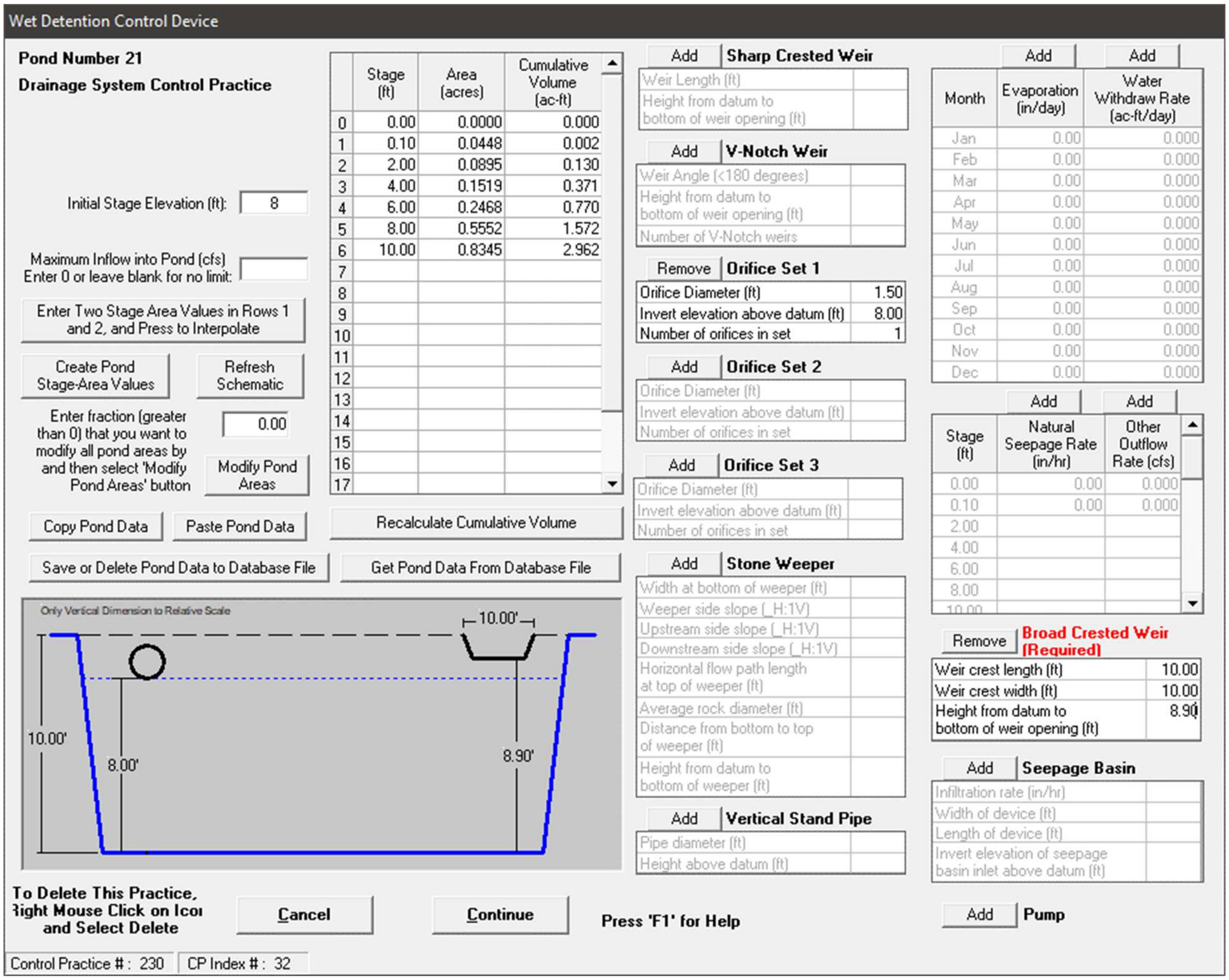


Figure 47: CL-8 WP33.

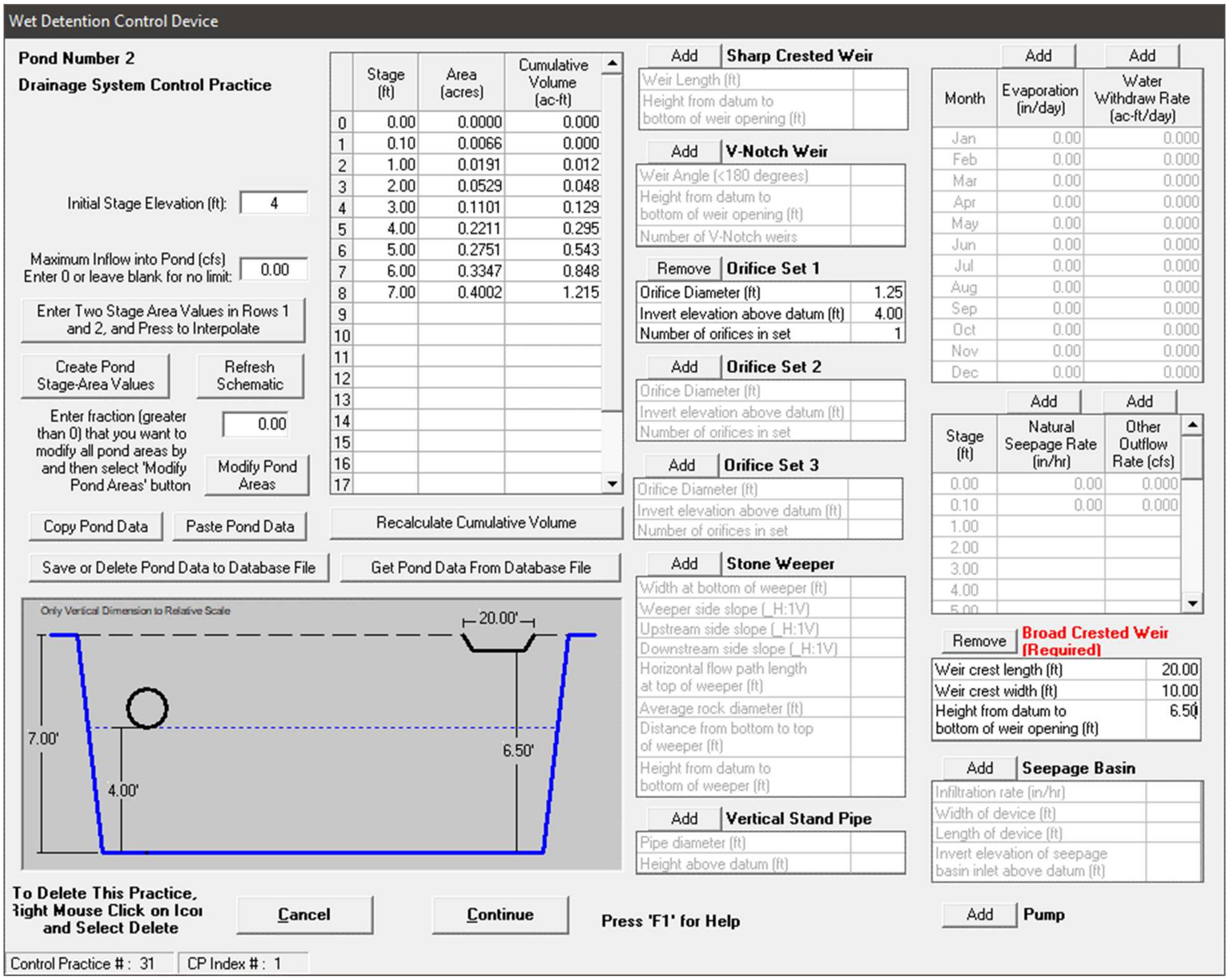


Figure 48: CL-9 WP34.

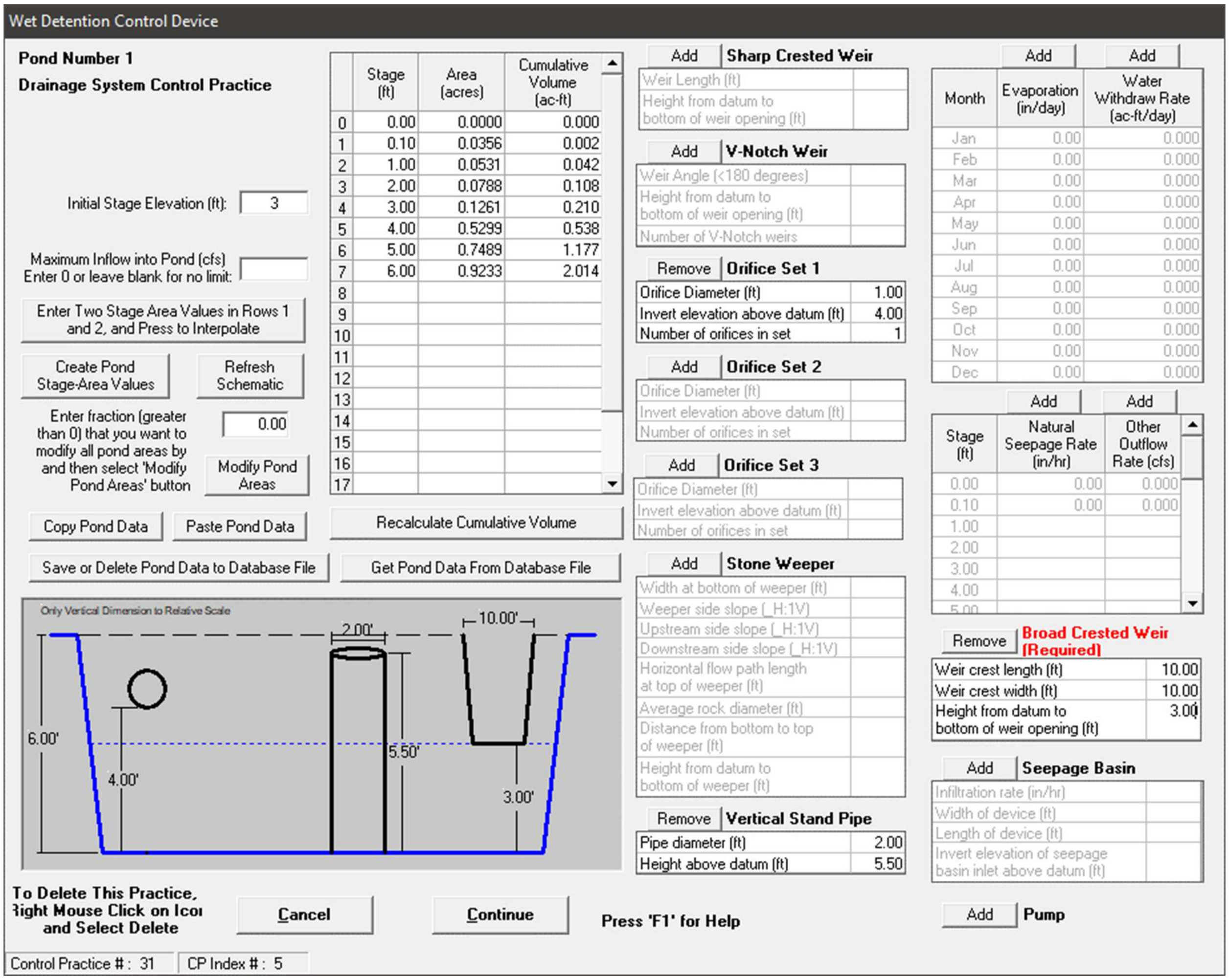


Figure 49: CL-9 WP35.

Proposed Conditions

The practices listed below were included in the proposed conditions WinSLAMM models.

Biofiltration Basins

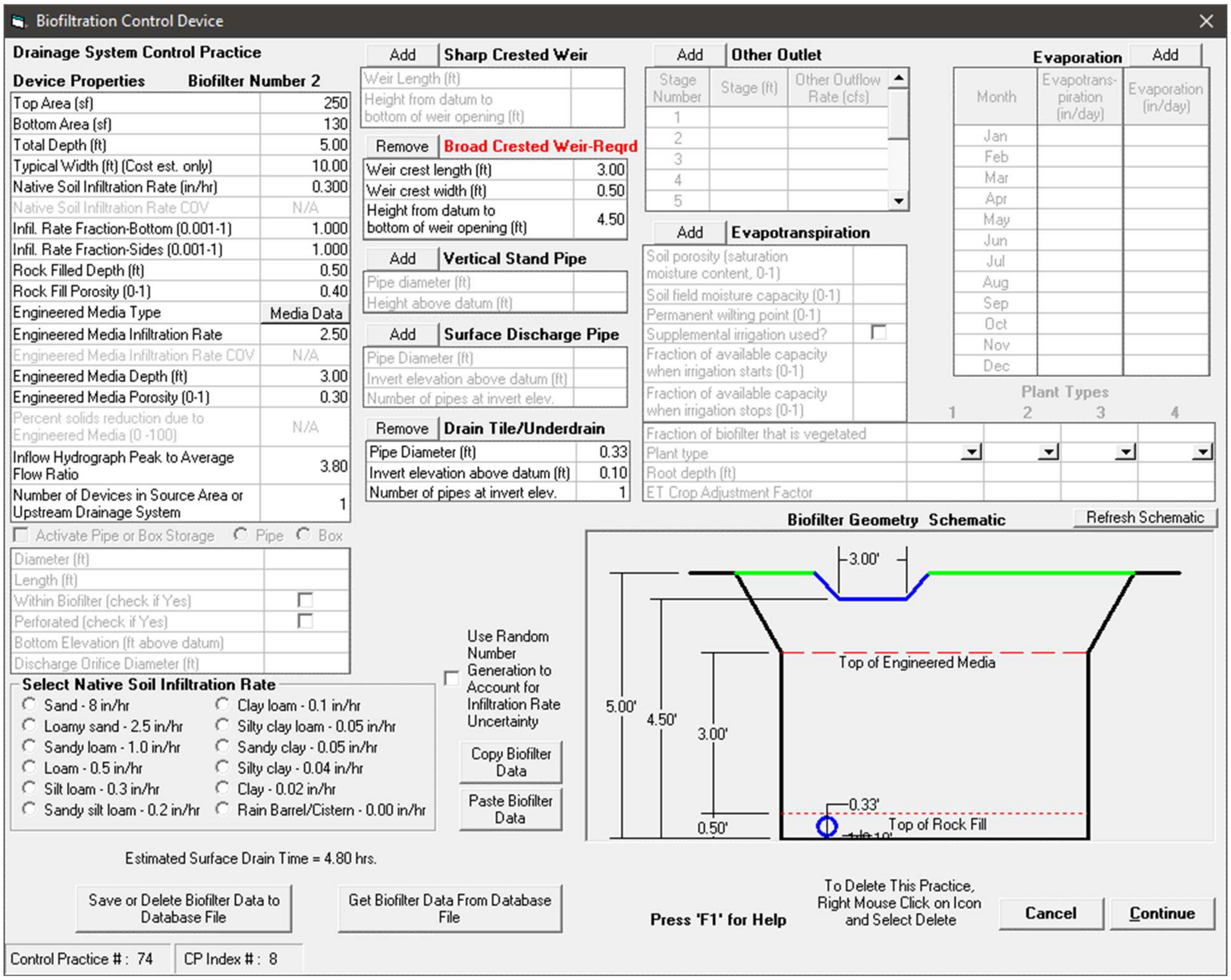


Figure 50: CL-3 BF-3-6-1.

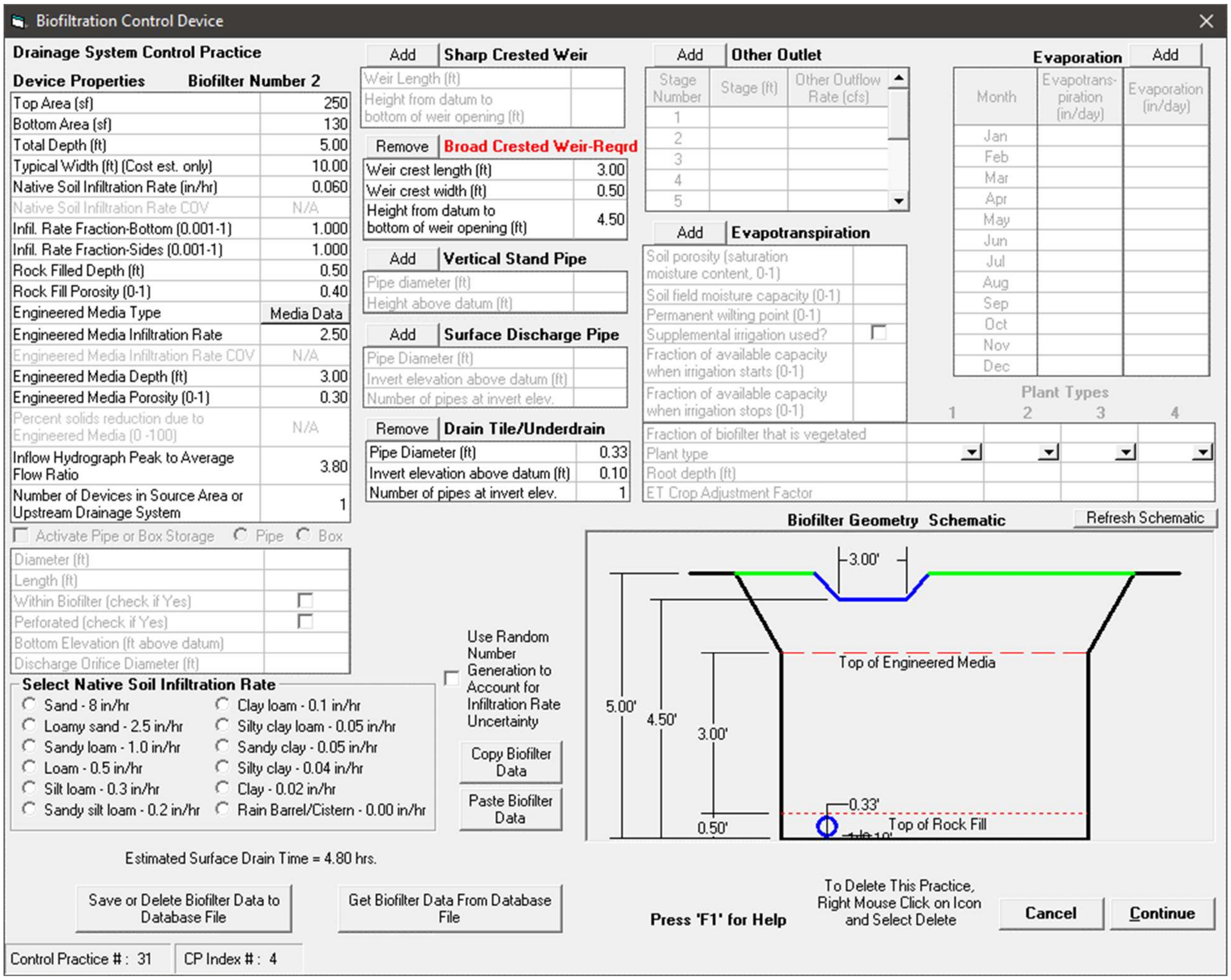


Figure 51: CL-7 BF-7-1-1.

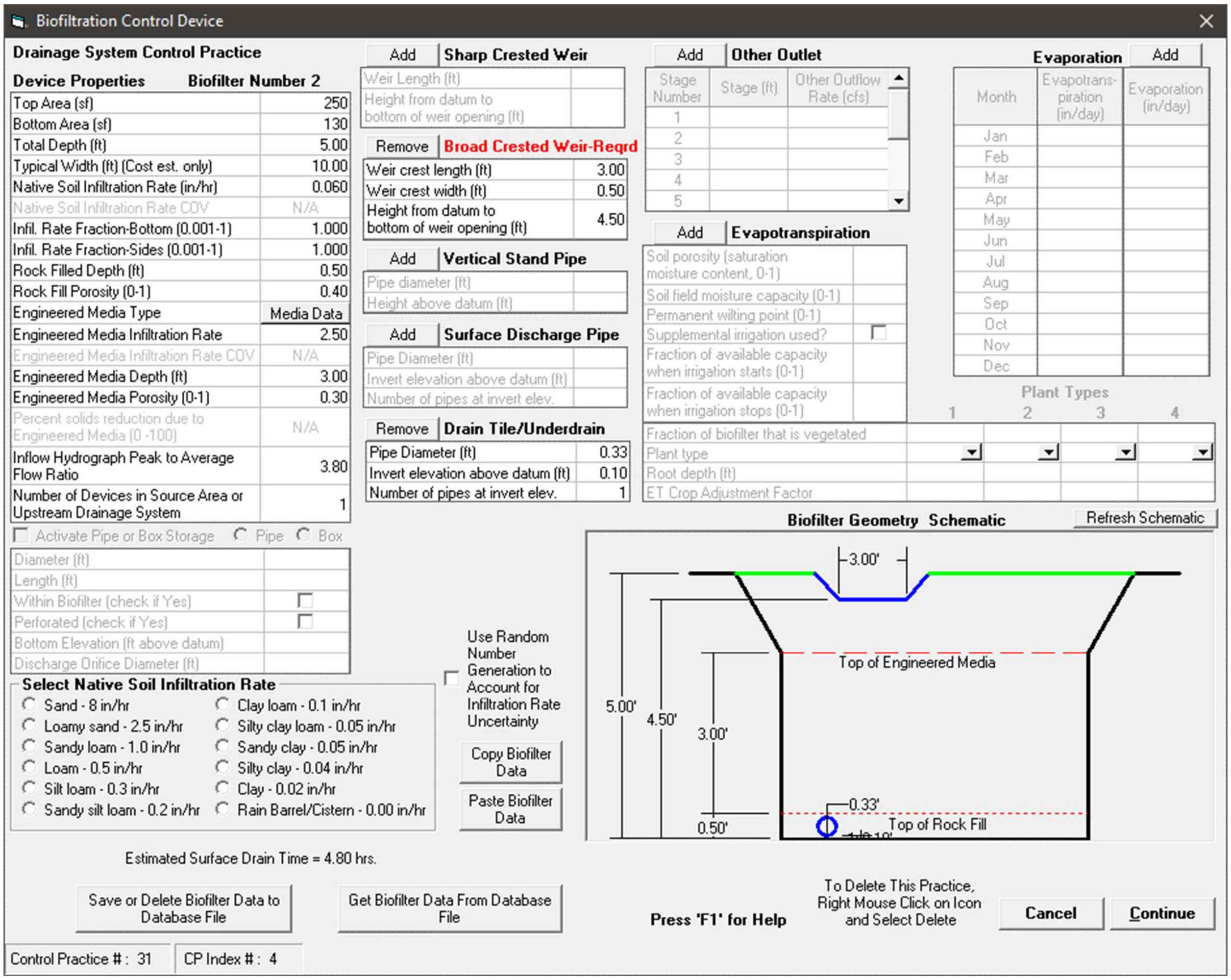


Figure 52: CL-7 BF-7-1-2.

Boulevard Biofiltration Basin

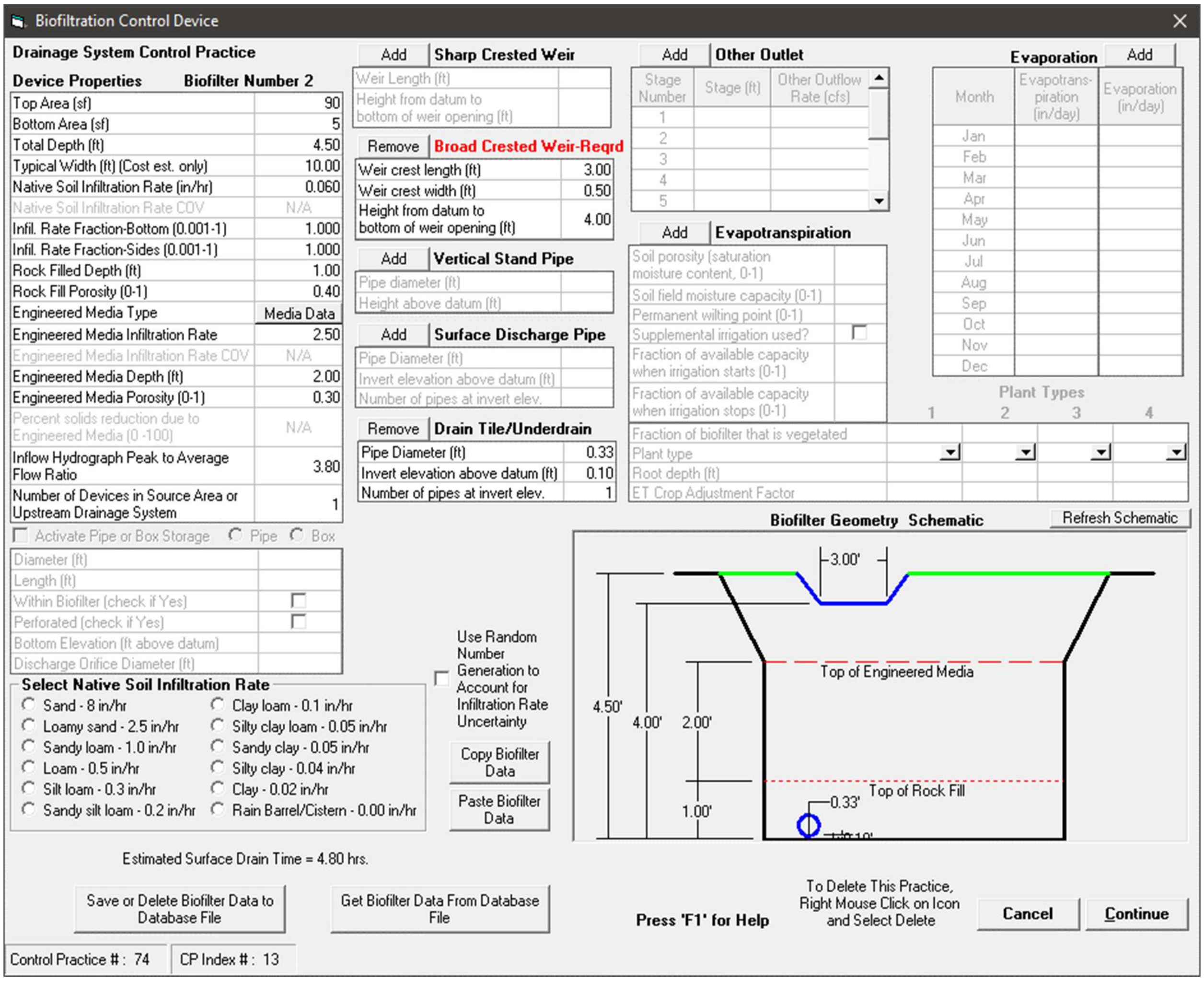


Figure 53: CL-3 BB-3-6-1.

Hydrodynamic Devices

Table 8: Hydrodynamic Device Sizing Criteria

Drainage Area (acres)	Peak Q (cfs)	Hydrodynamic Device Diameter (ft)
1	1.97	4
2	3.90	6
3	5.83	6
4	7.77	6
5	9.72	8
6	11.68	8
7	13.65	8
≥8	15.63	10

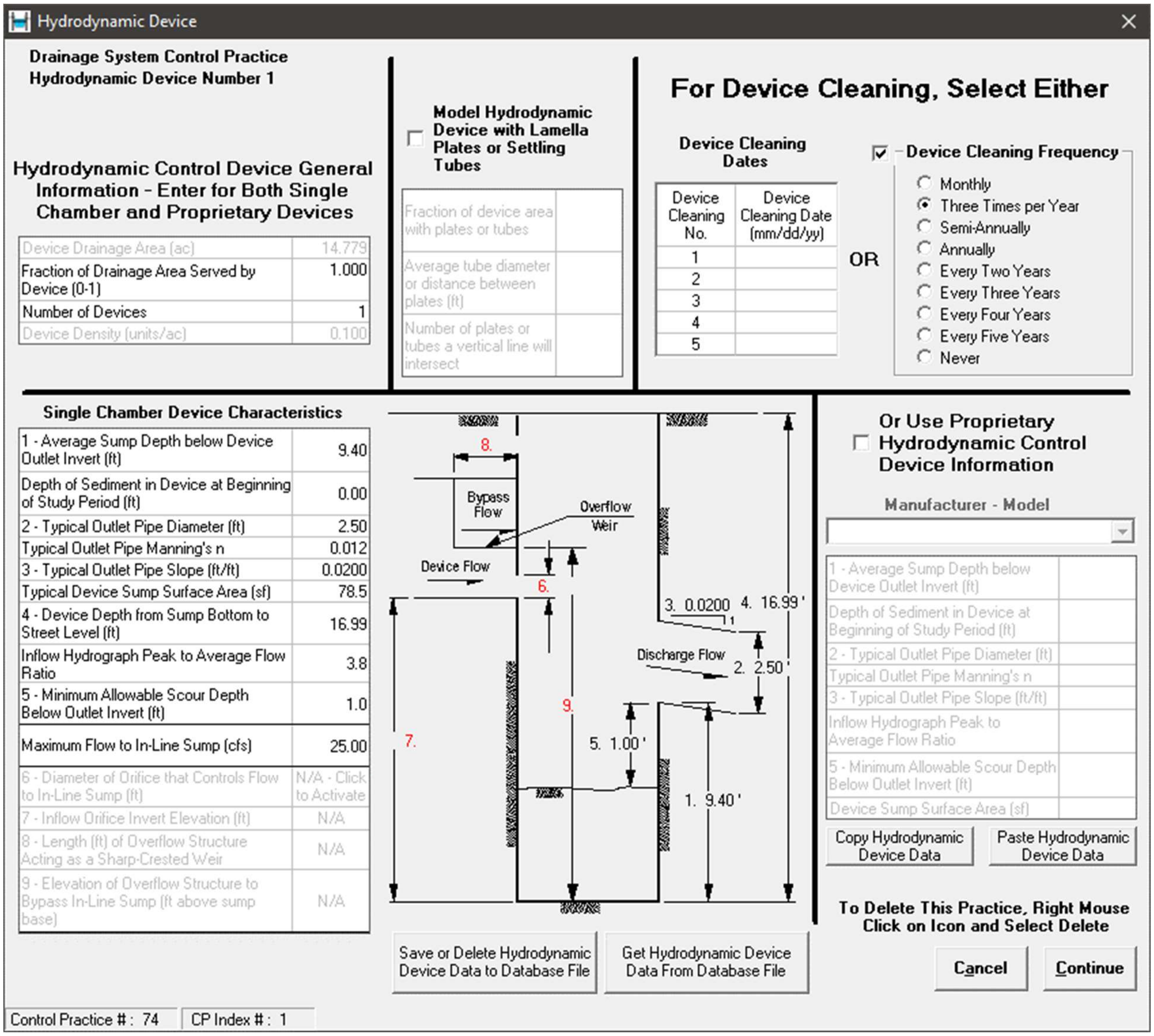


Figure 54: CL-3 HD-3-6-1.

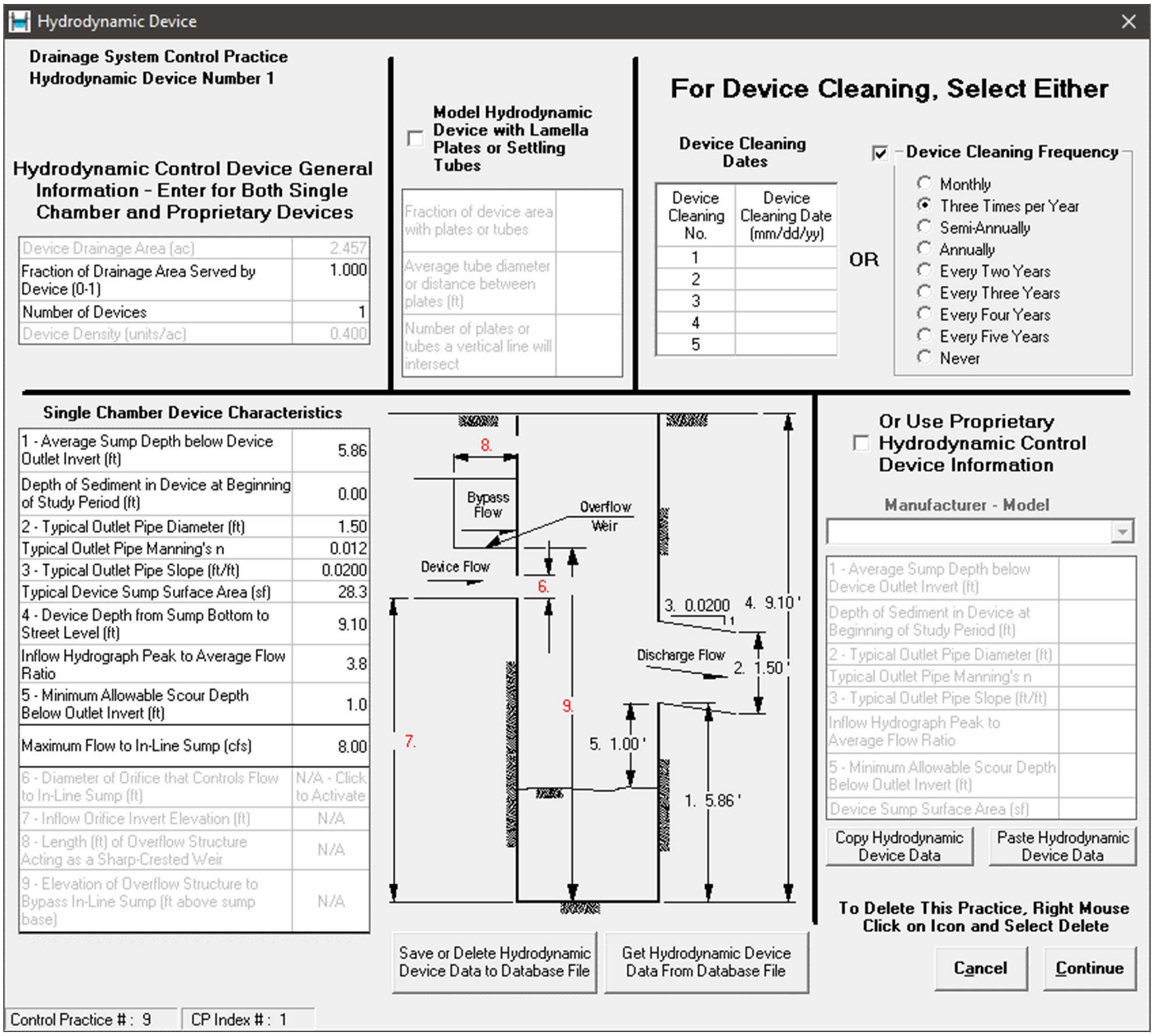


Figure 55: CL-4 HD-4-1-1.

Water Reuse Optimization

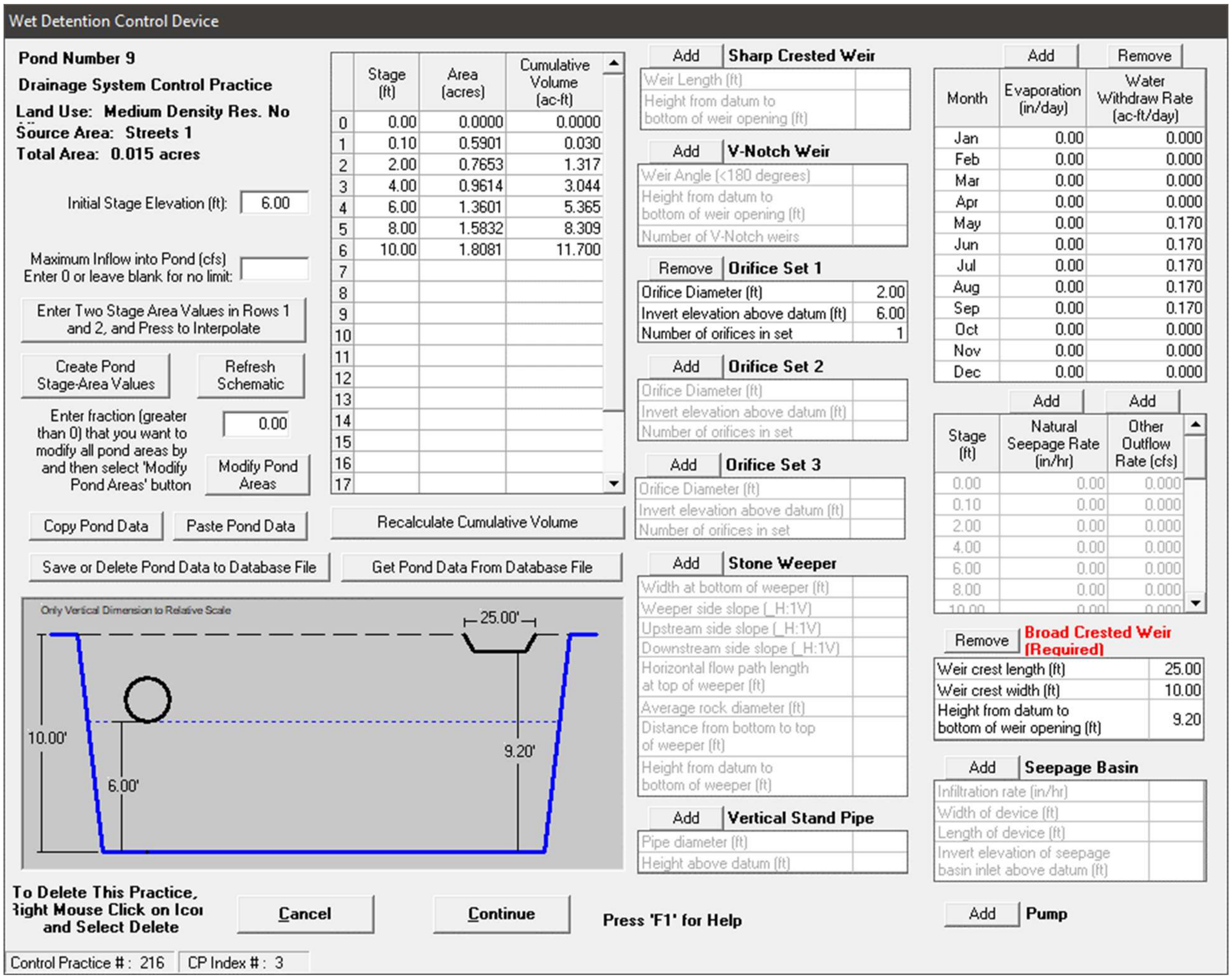


Figure 56: CL-8 WR-8-30-1.

Appendix B – Soil Information

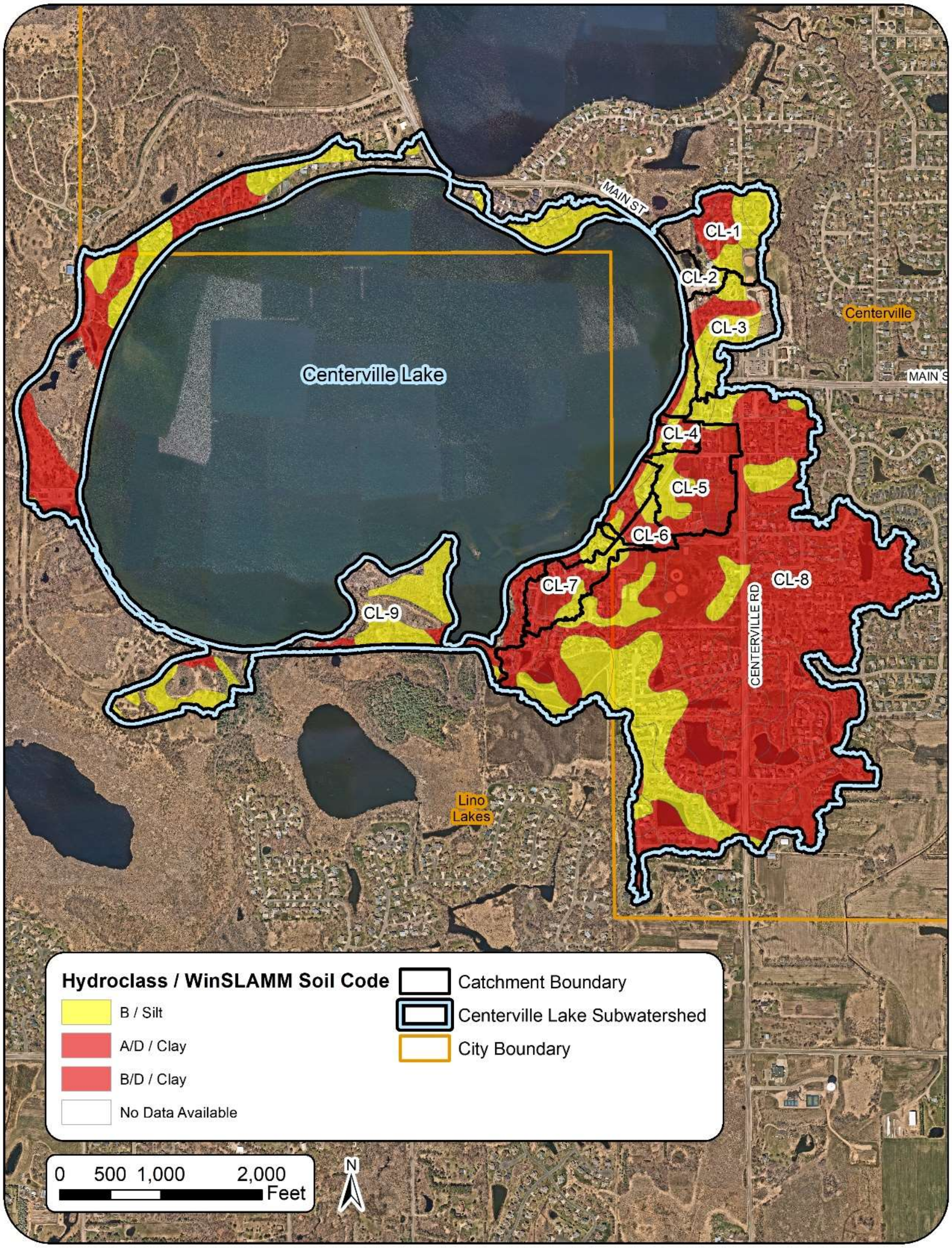


Figure 57: Soil hydroclass and texture used for WinSLAMM model.

Appendix C –Wellhead Protection Areas

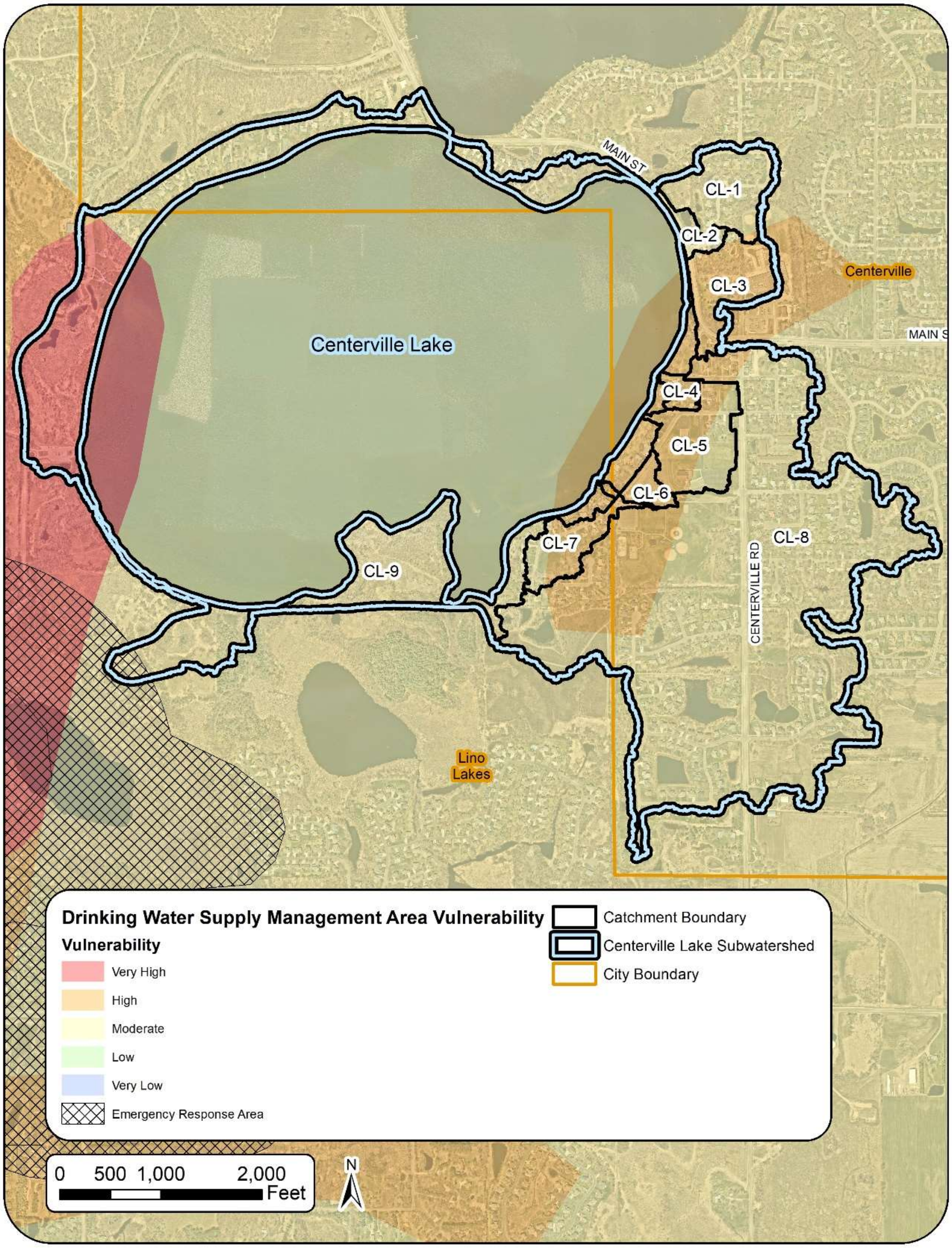


Figure 58: Drinking Water Supply Management Area (DWSMA) Vulnerability and Emergency Response Areas