Watershed Restoration and Protection Plan for Budd Lake

Mount Olive Township, New Jersey

Draft 3 – April 1, 2023

Photo of Budd Lake by Lauren Theis, RHA

Developed by

Raritan Headwaters & Rutgers Cooperative Extension Water Resources Program

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ACKNOWLEDGEMENTS

This project was a collaborative effort of Raritan Headwaters, Rutgers Cooperative Extension Water Resources Program, and Mount Olive Township, resulting in the Watershed Restoration and Protection Plan for Budd Lake (WRPP). Project leads were Christopher Obropta, Ph.D., P.E., Associate Extension Specialist, Rutgers Cooperative Extension Water Resource Program (WRP) and Kristi MacDonald, Ph.D., Director of Science, Raritan Headwaters (RHA). Additional key staff on the project were Lisa Galloway Evrard, Senior Program Coordinator, WRP, Tracy Gordon, Budd Lake Coordinator and Science Program Assistant, RHA, and Emily Mayer, Watershed Scientist, RHA.

WRP compiled all data on land use land cover, loadings and load reductions. In addition, they provided the summary of target projects to reduce and treat stormwater runoff to Budd Lake. All mapping was done by WRP. In addition, staff from WRP conducted site visits to Budd Lake and attended online and in person meetings of the Budd Lake Advisory Committee. They also participated in a public outreach presentation at the Mount Olive Library.

RHA was the lead on the 319h grant application and provided project management and administration of the grant including final drafts, invoicing, and grant reporting. In addition, RHA developed the Budd Lake Advisory Committee and organized regular meetings with this group. RHA also developed relationships with property owners at the targeted sites for projects through meetings and as presenters at the public outreach event at the Mount Olive Library. Furthermore, RHA expanded its existing monitoring (benthic marcroinvertebrates, visual habitat and chemical) on the South Branch Raritan River just below Budd Lake (view data for RHA monitoring site SB21) to include a new Mayfly Enviro-DIY climate station. The climate station collects temperature, depth and conductivity readings every 15 minutes and transmits the data via cell service and can be viewed here. RHA developed the proposed monitoring plan for Budd Lake as part of the Budd Lake WRPP.

The Budd Lake Advisory Committee members provided their time in reviewing project plans, attending meetings, and providing feedback on an earlier draft of the plan. The Budd Lake Advisory Committee consisted of both municipal and agency personnel as well as unaffiliated local residents with knowledge of the environmental issues there. Members of the Committee were Kristi MacDonald, Ph.D., Director of Science RHA, Cindy Ehrenclou, Executive Director RHA, Emily Mayer, Watershed Scientist, Surface Water, Mara Tippet, Associate Director RHA, Tracy Gordon, Budd Lake Coordinator RHA, Christopher Obropta, Ph.D., Rutgers Cooperative Extension Water Resources Program, Lisa Galloway Evrard, Senior Program Coordinator, Rutgers Cooperative Extension Water Resources Program, Andrew Tatarenko, Mount Olive Township Business Administrator, Timothy Quinn, Mount Olive Township Director of Public

Works, Michael Vreeland, Mount Olive Township Engineer (Van Cleef Engineering Assoc.), Joseph Vuich, Mount Olive Township Engineer (Van Cleef Engineering Assoc.), Kathy Murphy, Mount Olive Township Vice-Chair Open Space & Chair Environmental Committee, Robert Delpizzo, Mount Olive Township Chair Open Space & Member Environmental Committee, Irene Sergonis, Mount Olive Township Vice-Chair Environmental Committee, Jim Sweet, NJ Department of Transportation, Jason Nowak, NJ Department of Transportation, Scott Collenburg, New Jersey Department of Environmental Protection, Division of Fish & Wildlife, Kelley Curran, Science Manager Highlands Council, Kathy Hale, NJ Water Supply Authority, and Sandy Williams, President Eco Islands.

Aileen Drum, Student at Rutgers University, reviewed a draft of the WRPP as part of her Watershed Internship and provided feedback on areas for improvement.

Funding for this project was provided by the New Jersey Department of Environmental Protection (NJDEP) through the 319(h) Grants for Nonpoint Source Pollution Control.

EXECUTVE SUMMARY

- Raritan Headwaters (RHA), Rutgers Cooperative Extension Water Resources Program (WRP), and Mount Olive Township were the main partners on New Jersey Department of Environmental Protection (NJDEP) 319h grant to develop a Watershed Restoration and Protection Plan for Budd Lake (WRPP). The aim of the project is to reduce pollutant loadings to Budd Lake, the headwaters of the South Branch Raritan, through stormwater runoff management.
- Budd Lake is a 374-acre glacial lake located in Mount Olive Township, Morris County, New Jersey and is contained in HUC14 02030105010030, Raritan River South Branch (above Rt 46). The Lake is located in the Highlands Preservation Area. It is the largest naturally formed lake in New Jersey and is the headwaters of the South Branch Raritan River. Budd Lake is a Category 1 (C1) waterbody. A Total Maximum Daily Load (TMDL) has been developed to identify and characterize potential pathogen sources and the load reductions necessary to meet Surface Water Quality Standards (SWQS). In addition, Budd Lake has experienced Harmful Algal Blooms (HABs) over the past several years, which has impacted recreational uses of the lake.
- Urban development and climate change are resulting in large volumes of polluted stormwater runoff into the Lake. This Plan mainly addresses capturing runoff before it reaches the Lake.
- The WRPP includes the 9 points stipulated by the United States Environmental Protection Agency.
- WRPP development mainly took place between January 2022 and March 2023.
- RHA was the lead on developing the Budd Lake Advisory Committee. A 20-person Budd Lake Advisory Committee was initiated in January 2022 to provide a forum for exchange of information about potential projects, engagement of government agencies, and a conduit for outreach to local decision-makers and the public on the project. The committee met 7 times in total; 5 remote and 2 in person field meetings.
- The Rutgers WRP was the lead on developing preliminary data on land use land cover, pollutant loadings and load reduction targets, as well as maps and initial drafts of the Plan. They also developed concept plans and budgets for individual projects that are included in the WRPP.
- Important BMPs recommended in the WRPP is for Mount Olive to increase their leaf collection and catch basin cleaning and street cleaning programs, especially during fall. In addition, investment in more advanced street sweeping equipment is recommended.
- Projects identified by Rutgers included both immediate and longterm goals. The immediate goals included 21 manufactured treatment devices (MTDs; one at each of the stormwater outfalls to the Lake); green infrastructure retrofits at 10 developed sites including rain gardens, bioswales, and porous pavement; installation of 10 floating islands in the Lake; and conversion of 5 stormwater detention basins to bioretention

basins. These projects would reduce total phosphorous loadings to Budd Lake by about 714 lbs/year.

- Enlisting the help of the community in addressing stormwater pollution is another important recommendation of the WEPP. Implementation of outreach programs including rain garden design and rain garden rebate programs as well as River Friendly resident, business, and school programs are recommended. A goal of rain gardens at 25% of the homes within the 1,000 foot buffer of the Lake is proposed.
- In addition, forest preservation, riparian forest restoration, and systematic placement of bioswales along 25% of the roadways in the Budd Lake watershed are recommended as ongoing, longterm activities for Mount Olive.
- RHA was the lead on the monitoring plan. RHA has a long-term stream monitoring site on the South Branch Raritan River just downstream of Budd Lake, which will be helpful in assessing the impacts of future project implementation on water quality. As part of this project, a Mayfly Enviro-DIY climate monitoring station was also installed to collect data on temperature, depth and conductivity every 15 minutes, which will also provide useful data on the success of future implementation. RHA also proposed a Budd Lake Characterization project and in-lake as well as tributaries to the Lake and downstream on the South Branch Raritan monitoring pre- and post- project implementation.
- RHA and WRP presented the project to the Environmental Commission on 6/1/2022. RHA and WRP presented the project to a broad array of community members at the Mount Olive Library on March 11, 1-3pm.
- The next step is to work to seek funding to implement the identified projects.

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[1] Theriault, Amelie and Sophie Duchesne, 2015. Quantifying the Fecal Coliform Loads in Urban Watersheds by Hydrologic/Hydraulic Modeling: Case Study of the Beauport River Watershed in Quebec, Water, 7, 615-633; doi: 10.3390/w7020615

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Embedded URL Citations

[1] Raritan Headwaters- Site Description SB21, Mount Olive Township, Morris County

https://www.raritanheadwaters.org/sb21/

[2] Monitor My Watershed-South Branch Raritan (RHA03)

https://monitormywatershed.org/sites/RHA03/

[3] Raritan Headwaters-How Healthy is Our Watershed, 2020 Water Quality Report Card

https://www.raritanheadwaters.org/watershed-report/

[4] Raritan Headwaters- Stream Health in the North and South Branch Raritan Watershed (WMA8), New Jersey, USA, 1992-2017

https://www.raritanheadwaters.org/wp-content/uploads/2022/10/Stream-Trend-Report_Draft-_2019.pdf

[5] New Jersey Department of Environmental Protection, 2023- New Jersey Extreme Precipitation Projection Tool
https://njprojectedprecipitationchanges.com/

Introduction

Budd Lake is a 374-acre glacial lake located in Mount Olive Township, Morris County, New Jersey and is contained in HUC14 02030105010030, Raritan River South Branch (above Rt 46). The Lake is located in the Highlands Preservation Area. It is the largest naturally formed lake in New Jersey and is the headwaters of the South Branch Raritan River. Budd Lake is a Category 1 (C1) waterbody, and while this designation applies primarily to point sources of pollution, the New Jersey Stormwater Management Rules establish a 300-foot special water resource protection area (SWRPA) around C1 waterbodies and their intermittent and perennial tributaries within the HUC 14 subwatershed. In the SWRPA, new development is typically limited to existing disturbed areas to maintain the integrity of the C1 waterbody. C1 waters receive the highest form of water quality protection in the state, which prohibits any measurable deterioration of the existing water quality. There are several tributaries to Budd Lake, including Black Brook and several small streams mainly named on topographic maps as South Branch Raritan River tributaries. Budd Lake is an impaired waterbody with respect to pathogens. Fish kills are a fairly common occurrence in the lake.

Budd Lake's water quality is likely influenced by surrounding groundwater entering the lake from springs and groundwater-surface water exchange. Residents in the densely populated area around the lake along Sand Shore Road rely on private wells for drinking water. Recent testing of both public water supply and private wells in the Budd Lake watershed have indicated the presence of coliform bacteria and E. *coli* indicators of the presence of other pathogens. Elevated levels of radionuclides and per-and polyfluoroalkyl substances (PFAS) have also been detected in residents' drinking water supplies. In addition, NJGeoweb indicates there is a major groundwater contamination area in the watershed associated with the North Combe Landfill site (contaminant listed is 1,4 Dioxane). A watershed includes surface water, as well as the water entering and exiting a waterbody through groundwater; it is likely the surrounding aquifers and the lake are exchanging pollutants.

Widely used by the public for fishing, swimming, and boating, Budd Lake is also the home of the Budd Lake Bog Preserve and Budd Lake Wildlife Management Area, an ancient Spruce-Tamarack bog of floating plant mass that has existed and developed over thousands of years. Roughly half of the shoreline of the lake is and will remain undeveloped as it is part of the bog and is under the purview of NJ Fish and Wildlife. The presence of forests and wetlands in the Budd Lake watershed are critical for maintaining good water quality in the lake. The other half of the area immediately surrounding the lake is categorized as urban.

Urban land uses generally have high unit areal loading rates for pollutants that lead to degraded water quality and can contribute to pathogen loading due to high volumes of stormwater runoff. Mount Olive is a Tier A municipality and is regulated under the New Jersey Pollutant Discharge Elimination System (NJPDES) municipal stormwater permitting program. Tier A municipalities are generally located within the more densely populated regions of the state or along the coast. These municipalities meet the population size requirements of the US Environmental Protection Agency's (EPA's) Municipal Separate Storm Sewer System (MS4) program for regulating urban stormwater discharges. Stormwater point sources, like stormwater nonpoint sources, derive their pollutant loads from runoff from land surfaces, and load reduction is accomplished through the use of best management practices (BMPs).

Water quality leaving Budd Lake (site SB21) is monitored annually as part of a large-scale stream monitoring program throughout the North and South Branch Raritan Watershed Region/Upper Raritan (WMA8) by Raritan Headwaters Association (RHA), a non-profit conservation organization based in Bedminster, NJ as well as by NJDEP every 5 years as part of their AMNET stream monitoring program. RHA's chemical, biological and habitat data can be found here. [1] In addition, RHA installed a Mayfly Enviro-DIY climate station below the confluence (RHA03) in April 2022 to collect and transmit time-series data every 15 minutes on temperature, conductivity and depth. This station is providing important baseline and long-term data on climate change and the impacts of stormwater project implementation on water quality. Data for the RHA climate station can be viewed here. [2] The RHA annual report card for the Budd Lake subwatershed (HUC14) can be viewed here. [3] Overall, the subwatershed receives a "D-." The subwatershed fails to meet NJ Surface Water Quality Standards (SWQS) for visual habitat and phosphates. Specific conductance, a measure of ions such as dissolved salt in the water, is present at concentrations known to harm aquatic organisms but there is currently no SWQS for this parameter. The High Gradient Macroinvertebrate Index (HGMI), temperature, dissolved oxygen, pH, and nitrates were all meeting SWQS. Data collected at site SB21 below Budd Lake on the South Branch Raritan exhibited a positive trend in High Gradient Macroinvertebrate Index (HGMI), improving between 2010 and 2017 based on a longterm trend analysis conducted by RHA. [4] Budd Lake and SB21 just downstream are classified as FW2-TP(C1), as are most stretches of the South Branch Raritan within the Highlands Region. Native brook trout populations are present in several tributaries of the South Branch Raritan in Mount Olive Township downstream of Budd Lake.

The Budd Lake Watershed Restoration and Protection Plan (hereafter referred to as the Watershed Plan) leverages all the past work completed to protect and restore Budd Lake and its watershed. The New Jersey Department of Environmental Protection (NJDEP) has prepared a TMDL for pathogens for Budd Lake that requires a 98.94% reduction in pathogen loading from internal and external sources. This plan will be a blueprint for how to achieve reductions in pollutant loading to Budd Lake. The plan follows the US Environmental Protection Agency's (EPA's) criteria and contains the nine components of a watershed restoration and protection plan. There is a strong educational and outreach component to engage the community to help with the lake protection and restoration. RHA worked closely with the Rutgers Cooperative Extension (RCE) Water Resources Program and Mount Olive Township to complete the Watershed Plan and engage the local community for their input. The 24-member Budd Lake Advisory Committee consisted of representatives from Raritan Headwaters, Rutgers Water Resources Program, Mount Olive Township (municipal officials, volunteers, and residents), NJDEP, Highlands Council, and NJ Water Supply Authority. Local knowledge and input has been invaluable in the development of this Watershed Plan.

Criteria #1: Identification of the Causes and Sources of Nutrient Loading to the Lake

The causes and sources of nutrient and pollutant loading to the lake have been identified. Pollutant loading from the land use within the Budd Lake watershed was calculated in the 2007 TMDL that was completed by NJDEP using 2002 land use cover data. These calculations were updated to address this criterion.

The Budd Lake watershed is presented in Figure 1. The total planning area for the Budd Lake watershed restoration and protection plan is 5.1 square miles. The breakdown of land use categories is provided in Table 1. The watershed is dominated by urban land uses, which has high unit areal loads for phosphorus (See Figure 2). Figure 3 provides an illustration of the land use in a pie chart format.

Nonpoint source pollutant loading coefficients were assigned to each land use. Table 2 was taken from Chapter 3 (*Page 3-11*) of the NJDEP Stormwater Best Management Practices Manual (February 2004)[2]. These pollutant loading coefficients were assigned to the unique land uses contained within the study area (See Table 3). The values in Table 3 were then used to calculate pollutant loads for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS). These pollutant loads are shown in Table 4. Figures 4 - 6 provide pie charts of the pollutant loading by general land use category.

Technical Release 55 (TR-55) was used to calculate runoff volumes for the New Jersey Water Quality Storm, 2-year design storm, 10-year design storm, and 100-year design storm. TR-55 presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds, especially urbanizing watersheds, in the United States. First issued by the Soil Conservation Service (SCS) in January 1975, TR-55 incorporates current SCS procedures. The first step in this process is to assign a curve number (CN) to each land use classification based upon soil type. These are presented in Appendix A. Table 5 shows the stormwater runoff volumes for each design storm.

Because data from the Budd Lake subwatershed was not available, data from the nearby Mulhockaway Creek at the Van Syckel (RA126) gauge for 2021 was downloaded to use for fecal coliform loading calculations (See Table 6). Only daily total rainfall totals greater than or equal to 0.1 inches were used in the analysis, which resulted in a rainfall total of 53.72 inches for 2021. Event mean concentration (EMC) values taken from literature were used to determine annual fecal coliform loads. These values are shown in Table 7. For storms where runoff was greater than one-inch, the runoff was set to one-inch for the fecal coliform loading calculation to represent the first flush of runoff. Table 8 shows the annual runoff volume and fecal coliform loading by land use for the HUC14. Appendix B contains the fecal coliform loads for the HUC14 by land use and hydrologic soil group.

2 https://www.njstormwater.org/bmp_manual2.htm

Two studies conducted by the Northeast Regional Climate Center in partnership with the NJDEP looked at, (1) current rainfall data in New Jersey from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 by incorporating 19 additional years of climate data, and (2) long-term rainfall intensity projections developed from climate model simulations under moderate and high future emissions scenarios (https://njprojectedprecipitationchanges.com/). [5] Results from these studies show higher precipitation depths from the longer and more complete dataset (1950-2019) compared to those reported in the NOAA Atlas 14 (1950-2000) and include updated ranges of possible rainfall outcomes for the state through this century. This information was used to develop an interactive tool for users to identify regional and local estimates of projected changes in extreme rainfall amounts within a 24-hour duration for various return periods between current estimates and a future time period under either of two future emission scenarios. Users can select their choice of rainfall return period (i.e., the 2-year, 10-year, 100-year storm, etc.), the future greenhouse gas emission scenario determined by Representative Concentration Pathway (RCP) 4.5 or RCP 8.5, and future time period. Projections can be summarized by county, municipality, 0.1 degree grid cell, or for a custom area by drawing a polygon on the map area or uploading a geographic information system (GIS) shapefile saved as a zip file. Projections for municipalities and custom areas are calculated based on the weighted average of projected change factors within the area that intersect 0.1 degree grid cells applied to the rainfall data from the current NOAA Atlas 14 dataset. This tool was used to determine rainfall totals for the 2, 10, and 100-year storms for the RCP 4.5 scenario for the years of 2020 to 2069. Table 9 shows the existing rainfall totals and the new totals taken from the extreme precipitation tool.

At >10% impervious cover water quality and aquatic life show signs of impairment. NJDEP developed a very detailed impervious cover GIS data layer for the 2015 condition. Table 10 illustrates the impervious cover based upon these data for the watershed; 16% of the Budd Lake watershed is impervious cover. To further understand the impact of existing development in the immediate vicinity of Budd Lake on water quality, an analysis was completed for a 1,000-foot buffer around Budd Lake (See Figure 7). The 1,000-foot buffer encompasses 477.5 acres of land, which has approximately 24.5% impervious cover (See Figure 8 and Figure 9). Table 11 illustrates the impervious cover broken down by three classes: buildings, roads, and other.

Within this 477.5 acres, there are 791 parcels, which contain 672 buildings. Of this 477.5 acres, there are 14.8 acres of park or open space. Table 12 presents the breakdown of the land use within the 1,000-foot buffer. At 50% of the land cover, the predominant land use is urban. Because wetlands and forests are natural areas, the focus of installing stormwater management throughout the watershed will be in the urban areas. The same aerial loading calculations were completed for the land use in the 1,000-foot buffer. The results are shown in Table 13. EMC values taken from literature were used to determine annual fecal coliform loads for the 1,000-foot buffer area (See Table 7). For storms where runoff was greater than one-inch, the runoff was set to one-inch for the fecal coliform loading calculation to represent the first flush of runoff. Table 14 shows the annual runoff volume and fecal coliform loading by land use for the 1,000-foot buffer area.

In addition to stormwater runoff, septic systems can contribute to fecal coliform loading. Since sanitary sewers have been installed around Budd Lake, there is no longer a septic load to Budd Lake. Other sources of fecal coliform loading are pet waste and wildlife, including waterfowl.

Canada geese likely contribute significantly to fecal coliform loading to the lake. Systems may continue to leach nutrients into groundwater for decades.

Criteria #2: Estimation of the Load Reductions Expected for the Management Measures

On January 5, 2011, New Jersey passed a fertilizer law that prohibits phosphorus from being applied from November 15th to March 1st. While this should have reduced nutrient loading to Budd Lake, it is difficult to estimate the quantity of this load reduction. In January 2004, Mount Olive received a general permit for the municipal separate storm sewer system (MS4) that required several management practices be implemented in the watershed such as street sweeping, catch basin cleaning, and leaf removal. Mount Olive Township conducts street sweeping of all municipally owned or operated roads at a minimum in two stages during the spring and fall season months. Additionally, street sweeping is conducted during the summer in response to major storm events. County roads are swept by the county, and state highways are swept by the New Jersey Department of Transportation (NJDOT).

Several studies have been completed to define removal rates for street and storm drain cleaning and for leaf removal. The Chesapeake Bay Program Partnership assembled an expert panel to review removal rates for street sweeping and storm drain cleaning. A final report was released on May 19, 2016.[3] Additionally, Tetra Tech prepared a memorandum to the Minnesota Pollution Control Agency that summarized a survey of crediting approaches for street sweeping.[4]
These reports contain estimates of nutrient loading in roadway sediments. For example, the Chesapeake Bay Program uses 2.0 lbs/impervious acres/year TP, 15.4 lbs/impervious acre/year TN, and 0.65 tons/acre/year TSS. The Florida Department of Environmental Protection assumes that sediment cleaned from catch basins contains 679 mg/kg TN and 417 mg/kg TP, and sediment removed from BMPs contains 899 mg/kg TN and 364 mg/kg TP.

Based upon these studies, TSS, TP and TN removal by street sweeping is a function of the type of street sweeper and the number of times a street is swept per year. Also, credit is only given for curb and gutter roadways. The Chesapeake Bay Program provides removal rates for 11 different practices which include two different types of sweepers: 1) Advanced Sweeping Technology and 2) Mechanical Broom Technology and frequency ranging from two passes per week to one pass per 12 weeks. The maximum removal rates for TSS, TN, and TP are 21%, 4%, and 10%, respectively, for streets that are swept twice a week with Advanced Sweeping Technology. The Chesapeake Bay Program does not give any nutrient removal credit for Mechanical Broom Technology. US EPA Region 1 has a credit program that is similar to the Chesapeake Bay Program. EPA Region 1 also has a catch basin cleaning credit that is available based on multiplying the impervious drainage area by the same nutrient load export rates for impervious land uses used for street sweeping by the catch basin cleaning reduction factors of 0.02 for phosphorus and 0.06 for nitrogen, which yields a reduction in pounds per year.

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[3] Donner, Sebastian, Bill Frost, Norm Goulet, Mary Hurd, Neely Law, Thomas Maguire, Bill Selbig, Justin Shafer, Steve Steward and Jenny Tribo, 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Final Report.
[4] Molloy, Aileen and Jennifer Olson, 2019. Final Street Sweeping: Survey of Crediting Approaches. Memorandum to Minnesota Pollution Control Agency.

The Wisconsin Department of Natural Resources (WDNR) has recognized research that estimated that on average 43% of the annual phosphorus load is discharged during the fall. WDNR went on to approve a 17% total phosphorus annual load reduction from leaf collection efforts. This credit only applies to residential land use with a high level of tree canopy. To receive this credit, municipalities must collect leaves three to four times spaced throughout late September, October, and November. Also, within 24 hours of leaf collection, the roadway must be swept.

Mount Olive Township currently owns and operates 2,200 catch basins. The township's Department of Public Works (DPW) performs catch basin and storm drain inlet inspections, cleaning, maintenance, and repairs annually to maintain its functionality and efficiency. During inspections, if no sediment, trash, or debris are observed in the catch basins, then those catch basins are not cleaned. All catch basins are inspected annually, even if they were found to be "clean" the previous year. In 2019, Mount Olive Township spent $4,000 on street sweeping. In 2020, Mount Olive Township spent $3,000 on street sweeping.

Mount Olive Township has identified 21 stormwater outfalls to Budd Lake. All are located along the east side of the lake along US Route 46 and Sand Shore Road. The outfall map is attached in Appendix C.

Table 15 compares nutrient loading from roadways in the watershed to the entire nutrient load from all land uses in the watershed. The roadway loads were calculated using values taken from the Chesapeake Bay Program (i.e., 2.0 lbs/impervious acres/year TP and 15.4 lbs/impervious acres/year TN). Table 16 illustrates the maximum nutrient load reduction that street sweeping can yield based upon the Chesapeake Bay Program data for advanced sweeping technologies at two passes per week.

WDNR has identified that leaf collection coupled with street sweeping in the fall can have a larger impact than simply street sweeping twice a week. The reduction for leaf collection with street sweeping from late September through November can yield a 17% reduction in phosphorus loading as compared to a high frequency (i.e., twice a week) street sweeping, with an advanced sweeper technology, only reduced total phosphorus loads by 10%. Table 17 below shows the potential reduction for the leaf collection combined with street sweeping.

The New Jersey Hydrologic Modeling Database was searched for existing detention basins in the Budd Lake watershed. Five detention basins were identified. Three provide stormwater management for residential developments: 1) Hidden Meadows, 2) Hunters Ridge Estates, and 3) Lakeview Estates. One basin is for a small doctor's office on Route 46 (Lot 3, Block 3207). The fifth basin is associated with Turkey Brook Park. The database provides drainage areas for all of these basins except the one at Turkey Brook Park. The four remaining basins provide stormwater management for 43.22 acres of medium density residential land use. According to the NJDEP Stormwater Best Management Practices Manual, these detention basins can reduce total phosphorus loads by 20%. This yields a reduction of 12.1 lbs/year of total phosphorus. By converting these detention basins into bioretention basins that infiltrate runoff from the New Jersey Water Quality Storm, these basins would increase the reduction of total phosphorus load to 54.5 lbs/year.

Criteria #3: Recommendation of NPS Management Measures to Address the Causes and Sources

While source reduction through leaf collection, street sweeping, and catch basin cleaning can help reduce phosphorus loads to Budd Lake, stormwater management practices will have to be installed to capture and treat stormwater runoff from existing developed areas. Several stormwater management strategies are discussed below for reducing total phosphorus loads and other pollutants to Budd Lake. Table 21 lists the strategies and the TP reduction for each strategy.

- The 21 outfalls to Budd Lake can be retrofitted with manufactured treatment devices (MTDs) to help reduce sediment and phosphorus inputs to Budd Lake. The Minnesota Pollution Control Agency's Stormwater Manual recognizes the total phosphorus removal efficiency of 50% for various MTDs. Table 18 shows the potential reduction in phosphorus load if MTDs were installed on the 21 outfalls along the east side of Budd Lake to capture and treat stormwater runoff from the urban land uses within the 1,000-foot buffer.

- Another option is to retrofit existing development with green infrastructure. Green infrastructure is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure projects capture, filter, absorb, and reuse stormwater to maintain or mimic natural systems and to treat runoff as a resource. Green infrastructure practices use soil and vegetation to recycle stormwater runoff through infiltration and evapotranspiration. These practices are very scalable and can be incorporated into almost any existing landscape to intercept stormwater at its source. Green infrastructure practices such as bioretention, green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.

- Fourteen sites in the Budd Lake Watershed were identified as possible locations that could be retrofitted with green infrastructure. On Friday, September 23, 2022, a small group from the Budd Lake Watershed Restoration and Protection Plan Advisory Committee toured these sites. A subsequent field visit was held on September 30, 2022 and additional sites identified. The goal was to confirm that green infrastructure could be used at these sites to capture and treat stormwater runoff from impervious surfaces to reduce pollutant loads to Budd Lake. Of the 14 sites, 10 have opportunities for retrofitting with green infrastructure. Each site is discussed below, and concept plans are contained in Appendix D.

BUDD LAKE: POTENTIAL GREEN INFRASTRUCTURE SITES

(See Appendix D for Concept Plans)

Peace Abiding Lutheran Church, 305 US-46 East, Mount Olive, NJ 07828

There are multiple opportunities at this site. A rain garden can be used to capture and treat stormwater runoff from the main parking lot. The overflow parking lot could be retrofitted with porous asphalt. A rain garden can be installed in front of the church along Route 46 to capture roof runoff. A rainwater harvesting system/cistern can be installed to collect roof runoff for the existing community garden. Additionally, a roadside rain garden/bioswale could be installed to capture road runoff from Cleacene Avenue.

BJ Sandwich Shop, 329 US-46 East, Mount Olive, NJ 07828

A rain garden can be installed in front of the sandwich shop to collect roof runoff. The parking lot could be replaced with porous asphalt.

Budd Lake Diner, 120 US-46 West, Mount Olive, NJ 07828

There are ***no opportunities*** to capture and treat stormwater runoff from this site. However, a roadside rain garden/bioswale could be installed in the right-of-way along Elizabeth Lane next to the diner's parking lot.

Budd Lake Union Chapel, 54 Sand Shore Road, Mount Olive, NJ 07828

There is an opportunity to install a rain garden in front of the chapel to capture and treat rooftop runoff, but gutters would have to be installed on the building. There is a great deal of traditional pavement associated with this site, and it would be difficult to capture stormwater runoff from these surfaces. The best option would be to convert these parking lots to porous asphalt, but they do not appear to be in disrepair, so this project may have to wait several years.

Eagle Rock Village, 36 Anthony Court, Mount Olive, NJ 07828

There are multiple opportunities in this apartment complex. Roadside rain gardens/bioswales could be installed along Eagle Rock Village Road. Rain gardens can be installed at numerous downspouts. Even though Eagle Rock Village is on the edge of the HUC14 with a portion of the development outside the watershed, it appears that the stormwater infrastructure is conveying all the stormwater from this development to Budd Lake. This site could serve as an example for other apartment complexes in the watershed.

I.C. Machine Inc., 199 US-46 East, Mount Olive, NJ 07828

There are ***no opportunities*** at this site. The building and rear parking lot drain to the wooded area behind the facility, which is serving as a natural stormwater management treatment system.

Lou Nelson Park, Sand Shore Road/Warren Drive, Mount Olive, NJ 07828

The stormwater runoff from the parking lot near the basketball court can be captured and treated by twin rain gardens, one on each side of the parking lot entrance. A trench drain across the parking lot entrance will be needed to intercept the runoff.

Mount Olive Chiropractic Center & Jessica Megaro PT, 197 US-46 East, Mount Olive, NJ 07828

Although there is a large amount of pavement at this site, currently there are ***no opportunities***.

NatiCycle, 111 US-46 East, Mount Olive, NJ 07828

There are ***no opportunities*** at this site.

Pax Amicus Castle Theatre, 23 Lake Shore Road, Mount Olive, NJ 07828

A rain garden could be installed to capture and treat stormwater runoff from the roof of the theater. There are two downspouts, one from each side of the castle. A medieval style rain garden could be designed for each of them to compliment the architecture of the theatre and serve as a demonstration garden for the public.

Special Technical Services & Atlantis Aerial Survey, 295 US-46 East, Mount Olive, NJ 07828

The parking lot at this site is in disrepair, but all the stormwater runoff drains to the center of the parking lot. Either the entire parking lot could be replaced with porous asphalt, or the parking lot could be regraded, and only the parking spaces can be designed to contain porous asphalt. There is a better opportunity along Cleacene Avenue to install roadside rain garden/bioswales to capture and treat roadway stormwater runoff.

The Pavilion Lounge, 44 Sand Shore Road, Mount Olive, NJ 07828

The overflow parking lot at the lounge poses the best opportunity. This parking lot could be replaced with porous asphalt, or the parking lot could be repaved and pitched away from the lake to a rain garden that could be designed to capture and treat runoff from the parking lot.

Turkey Brook Park, 120 US-46 West, Mount Olive, NJ 07828

There are numerous opportunities at this park for rain gardens, bioswales, and possibly porous asphalt parking lots. Even though Turkey Brook Park is on the edge of the HUC14 with a portion of the park outside the watershed, it appears that the stormwater infrastructure is conveying all the stormwater from this site to Budd Lake.

St. Jude Thaddeus Roman Catholic Church, 17 Mt Olive Rd, Mount Olive, NJ 07828

There are numerous opportunities at this church for rain gardens and porous asphalt parking lots. Rain gardens can be used to manage stormwater runoff from rooftops. Porous asphalt could be used to replace existing parking spaces to manage runoff from the site.

For the sites listed above, three main green infrastructure practices are recommended: bioretention (rain gardens), bioswales, and permeable pavement. Each of these practices can reduce total phosphorus concentrations by 60%. These practices can reduce total phosphorus loads by 90% if designed to capture, treat, and infiltrate the 2-year design storm. Table 19 shows the drainage area proposed to be managed for each site and the site of the green infrastructure practices.

Table 20 shows phosphorus load reductions that can be achieved for each retrofitted site. Load reductions assume a reduction in TP, TN, and TSS of 60, 30, and 80%, respectively, with an underdrain and 90, 90, and 90%, respectively, without an underdrain (i.e., complete infiltration of runoff from the water quality storm).

- According to the 2015 NJDEP impervious cover GIS layer, there are 2,687 buildings in the Budd Lake watershed, which total 1,057 acres of rooftop. If 25% of the building owners construct rain gardens to manage 25% of their rooftops, a significant reduction in total phosphorus load can be obtained. This would manage 66 acres of rooftop and provide a total phosphorus reduction of 99.9 lbs/yr. To accomplish this level of implementation, a robust educational and outreach program would need to be developed and delivered. Additionally, incentives may need to be provided to encourage property owners to participate.

- According to the 2015 NJDEP impervious cover GIS layer, there are 192.4 acres of roadways in the Budd Lake watershed. The roadways in the 1,000-ft buffer total 46.4 acres. If bioswales are used to treat road runoff for the roadways outside of the 1,000-ft buffer, 146 acres of roadway are available for treatment. Assuming 25% of these roads can be captured, 36.5 acres can be treated. Using the Chesapeake Bay Program TP loading of 2 lb/acre/yr and a 90% reduction of TP by using a bioswale that infiltrates the New Jersey Water Quality Storm, a TP reduction of 78.8 lb/yr can be achieved.

- Another best management practice for eutrophic (highly productive) lakes and ponds with limited watershed space is the installation of Floating Wetland Islands (FWIs). FWIs can serve as an effective means of assimilating nutrients, such as nitrogen and phosphorus, that otherwise would fuel the growth of nuisance algae and certain aquatic plants. FWI are structures composed of woven, recycled, plastic material. Vegetation is planted directly in the plastic material of the FWI with some peat and mulch and then launched into a water body. Once in position, the FWI is secured in place with a set of lines and anchors. The vegetation grows on the FWI, with roots growing through the plastic material, creating excellent habitat for a variety of microorganisms. This is achieved primarily through the creation of a large amount of surface area that harbors a large amount of diverse microbial growth. It is estimated that a 250-square foot FWI has the surface area equal to approximately one acre of natural wetland. Ten FWIs totaling 2,500 square feet is a reasonable goal for Budd Lake. A number of studies have estimated that the amount of phosphorus removed through the use of one 250-square foot FWI is approximately 10 lbs of total phosphorus per year (100 lbs of phosporus per year from 10 islands).

- Protection of forests, especially along riparian corridors, should be a priority within the Budd Lake watershed. One target is the Black Brook, a tributary of Budd Lake, which has extensive remaining riparian forests. Forested buffers may require active stewardship including removal of invasive species and planting native trees and shrubs.

- Finally, a goose management plan should be developed and implemented to reduce the local goose population. This will decrease the fecal coliform loading and the phosphorus loading to Budd Lake. A detailed evaluation of the goose population would be necessary to determine the potential load reduction from a goose management plan. Management may simply include employing a professional to patrol the area with a dog to deter geese. Other strategies including restoring a vegetated buffer along the shoreline and/or native emergent vegetation in the shallows, are other options to deter geese in some places.

Criteria #4: Estimation of the Amounts of Technical and Financial Assistance Needed

For each of the recommended management strategies in Table 21, construction cost estimates and annual maintenance cost estimates are provided in Table 22. The construction cost estimates include engineering design costs, permitting costs, and construction costs. Although grant funding may be available to purchase advanced street sweeping equipment, the leaf collection and street sweeping cost will most likely have to be funded by the municipality/lake community. There are federal and state funding sources that could support the remainder of these management strategies such as the Section 319 grant programs, State Revolving Funds, National Fish and Wildlife Foundation grants, Federal American Rescue Plan Act, the Federal Infrastructure Investment and Jobs Act, and the Highlands Council. Some of these strategies have co-benefits that might be more attractive to various funders. The conversion of traditional detention basins to bioretention basins creates wildlife habitat; such projects are often funded by the National Fish and Wildlife Foundation. The program to install rain gardens to manage stormwater runoff from building rooftops requires an intensive educational and outreach program. These types of efforts are often funded by private foundations.

Criteria #5: Development and Delivery of Informational and Education Component

An information/education component will be needed to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented. Proposed education programs should include:

1. Budd Lake – Problems and Solutions
   This program will educate the public about the current conditions/health of Budd Lake and its importance to the local community as well as people living downstream who rely on clean drinking water from the South Branch Raritan River. The program will identify sources of pollutant loads to the lake, impacts of pollutants on recreation and human health, HABs and the management strategies that could be implemented to reduce these pollutant loads. The water quality monitoring data collected by RHA should be incorporated into this program. Also, this program can be used to launch a citizen science component of the monitoring program.

2. Green Infrastructure for Budd Lake
   This program will provide an overview of green infrastructure practices and how they can be used throughout the Budd Lake watershed. The water quality benefits of green infrastructure will be presented along with the co-benefits such as creating pollinator habitat, sequestering carbon, and reducing localized flooding.

3. What can you do to help Budd Lake?
This program will target property owners to encourage them to adopt pollution reduction strategies, build rain gardens, and install rainwater harvesting systems to help reduce stormwater flows to Budd Lake. This program can give a general overview of lakeside living or living in a lake watershed so people can take personal responsibility for helping protect and restore Budd Lake.

4. How to Build a Rain Garden
This program will complement "What can you do to help Budd Lake?" by providing step-by-step instructions on how to build a rain garden on your own property. Often this program is coupled with a rain garden design session where homeowners can work with engineers and landscape architects to design a rain garden specifically for their home. Also, rain garden rebates can be provided to homeowners who build rain gardens on their property.

5. Floating Wetland Islands Program
This program will engage the community to build floating wetland islands. Youth and adults can participate in this program. This will be an economical way to achieve the goal of 2,500 square feet for floating wetland islands in Budd Lake.

6. River-Friendly Certification Programs
River-Friendly Certification Programs promote clean water and a healthy environment through voluntary action by individuals and institutions. To achieve these goals, the River Friendly Partnership would work with residents, businesses, and schools to improve land stewardship practices. The program works to reduce pollution, conserve water, restore habitat for wildlife and educate the public about becoming better environmental stewards. For more information visit njriverfriendly.org.

These are just a few of the programs that could be offered to the Budd Lake community. Regional programming can also be used to benefit the residents in the Budd Lake watershed. For example, Rutgers Cooperative Extension offers a Master Gardener Program, an Environmental Stewards Program, and a Green Infrastructure Champion Program. Each of these programs could help promote environmental stewardship and advocacy in the Budd Lake watershed.

Mount Olive Township School District can play a significant role in educating the community. The Budd Lake WRPP is an opportunity to engage youngsters in a local environmental issue. Their participation in the betterment of a natural resource in their own backyard will foster a sense of responsibility to protect their legacy. This will ensure continued long-term efforts to make this plan successful.

Criteria #6: Development of a Schedule for Implementing NPS Controls

A schedule for implementing the management strategies will be highly dependent on funding and successful partnership with local community groups and organizations. The first step is to prepare shovel-ready designs for projects that have been identified in this plan. Shovel-ready designs will help the Budd Lake community more easily secure state and federal funds. Often grant applications with shovel-ready designs are the first to be funded. Mount Olive has already applied for funding to install MTDs for several of the lake outfalls. Rutgers Cooperative Extension is already working on developing shovel-ready designs for several of the projects identified in Tables 19 and 20. Table 23 is a step-by-step timeline for implementing the recommended management strategies for the first phase.

Criteria #7: Development of Interim, Measurable Milestones

Milestones for the project include working with local officials and property owners, public outreach and education, locating funding for projects, developing project designs, and project construction. In this Watershed Plan, 21 MTDs, 11 project sites (often with multiple green infrastructure installations), River Friendly Programs and the potential for multiple bioswales outside the 1,000 foot buffers. There are short-term milestones (0 to 3 years), mid-term milestones (4 to 9 years), long-term milestones (10+ years). However, implementation of projects is dependent on available funding sources and other factors. Each of the main project milestones are discussed in Table 23.

Criteria #8: Development of Criteria to Ensure Load Reductions are Being Achieved

For all management practices that are installed, a detailed load reduction calculation will be provided based upon the drainage area being managed and the expected load reduction efficiency of the proposed practice. These load reductions will be tabulated on an annual basis for submittal to NJDEP.

Criteria #9: Development of a Monitoring Component to Evaluate Effectiveness

Appendix E is a draft Budd Lake Water Quality Monitoring Plan.

Table 1: Land use distribution in acres and percentages

Land Use	**HUC 02030105010030**	
	Area (acres)	**Area (%)**
Agriculture	39.6	1.2%
Barren Land	19.3	0.6%
Forest	983.0	30.5%
Urban	1,327.0	41.2%
Water	400.0	12.4%
Wetlands	449.8	14.0%
Totals:	**3,218.6**	**100.0%**

Table 2: Pollutant loads by land cover in lbs/acre/yr

Land Cover	Total Phosphorus (TP) Load (lbs/acre/yr)	Total Nitrogen (TN) Load (lbs/acre/yr)	Total Suspended Solids (TSS) Load (lbs/acre/yr)
High, Medium Density Residential	1.4	15	140
Low Density, Rural Residential	0.6	5	100
Commercial	2.1	22	200
Industrial	1.5	16	200
Urban, Mixed Urban, Other Urban	1.0	10	120
Agriculture	1.3	10	300
Forest, Water, Wetlands	0.1	3	40
Barrenland/ Transitional Area	0.5	5	60

Table 3: Pollutant loads for each land use in the study area in lbs/acre/yr

Land Use Code	Land Use Label	Land Use Type	TP	TN	TSS
1110	Residential, High Density or Multiple Dwelling	Urban	1.4	15	140
1120	Residential, Single Unit, Medium Density	Urban	1.4	15	140
1130	Residential, Single Unit, Low Density	Urban	0.6	5	100
1140	Residential, Rural, Single Unit	Urban	0.6	5	100
1200	Commercial/Services	Urban	2.1	22	200
1300	Industrial	Urban	1.5	16	200
1400	Transportation/Communication/Utilities	Urban	1.5	16	200
1419	Bridge Over Water	Water	0.1	3	40
1461	Wetland Rights-Of-Way	Wetlands	0.1	3	40
1463	Upland Rights-Of-Way Undeveloped	Urban	1	10	120
1499	Stormwater Basin	Urban	0.6	5	100
1700	Other Urban Or Built-Up Land	Urban	1	10	120
1800	Recreational Land	Urban	1	10	120
1804	Athletic Fields (Schools)	Urban	0.6	5	100
1850	Managed Wetland In Built-Up Maintained Rec Area	Wetlands	0.1	3	40
2100	Cropland And Pastureland	Agriculture	1.3	10	300
2400	Other Agriculture	Agriculture	1.3	10	300
4110	Deciduous Forest (10-50% Crown Closure)	Forest	0.1	3	40
4120	Deciduous Forest (>50% Crown Closure)	Forest	0.1	3	40
4210	Coniferous Forest (10-50% Crown Closure)	Forest	0.1	3	40
4220	Coniferous Forest (>50% Crown Closure)	Forest	0.1	3	40
4321	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	Forest	0.1	3	40
4322	Mixed Forest (>50% Deciduous With >50% Crown Closure)	Forest	0.1	3	40
4410	Old Field (< 25% Brush Covered)	Forest	0.1	3	40
4420	Deciduous Brush/Shrubland	Forest	0.1	3	40
5100	Streams And Canals	Water	0.1	3	40
5200	Natural Lakes	Water	0.1	3	40
5300	Artificial Lakes	Water	0.1	3	40
6210	Deciduous Wooded Wetlands	Wetlands	0.1	3	40
6231	Deciduous Scrub/Shrub Wetlands	Wetlands	0.1	3	40
6234	Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	Wetlands	0.1	3	40
6240	Herbaceous Wetlands	Wetlands	0.1	3	40
7500	Transitional Areas	Barren Land	0.5	5	60

Table 4: Pollutant loads in lbs/yr for HUC 02030105010030

General Land Use Category	Area (acres)	TP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr)
Agriculture	39.6	51.4	396	11,865
Barren Land	19.3	9.6	96	1,157
Forest	983.0	98.3	2,949	39,319
Urban	1,327.0	1,458.2	14,785	168,172
Water	400.0	40.0	1,200	16,001
Wetlands	449.8	45.0	1,349	17,991
Totals =	**3,218.6**	**1,702.6**	**20,775**	**254,505**

Table 5: Stormwater runoff flows for design storms

Storm	Runoff Volume (Acre-Feet)
	HUC 02030105010030
Water Quality Storm	34.4
2-Year Storm (3.38")	282.3
10-Year Storm (5.00")	556.4
100-Year Storm (8.03")	1,140.2

Table 6: Daily rainfall totals from the Mulhockaway Creek at Van Syckel (RA126) gauge

Date	Daily Totals (inches)	Date	Daily Totals (inches)	Date	Daily Totals (inches)
1/1/2021	0.73	5/5/2021	0.45	8/18/2021	0.1
1/3/2021	0.18	5/8/2021	0.38	8/19/2021	0.92
1/15/2021	0.1	5/9/2021	0.31	8/22/2021	3.68
1/16/2021	0.45	5/26/2021	0.42	8/23/2021	1.99
1/31/2021	0.29	5/28/2021	1.33	8/28/2021	0.12
2/1/2021	2.01	5/29/2021	0.61	9/1/2021	6.34
2/2/2021	0.29	5/30/2021	0.45	9/2/2021	0.2
2/7/2021	0.25	6/3/2021	0.67	9/9/2021	0.45
2/11/2021	0.16	6/4/2021	0.43	9/13/2021	0.29
2/16/2021	0.81	6/7/2021	0.17	9/23/2021	1.98
2/18/2021	0.37	6/8/2021	0.52	9/24/2021	0.13
2/19/2021	0.16	6/11/2021	0.45	10/4/2021	1.06
2/22/2021	0.27	6/19/2021	0.32	10/10/2021	0.14
2/27/2021	0.29	6/21/2021	0.1	10/16/2021	0.54
2/28/2021	0.6	6/22/2021	0.29	10/25/2021	0.45
3/1/2021	0.15	7/1/2021	0.29	10/26/2021	3.02
3/18/2021	0.92	7/2/2021	0.16	10/27/2021	0.1
3/24/2021	1.47	7/3/2021	0.35	10/29/2021	0.5
3/28/2021	0.61	7/6/2021	0.85	10/30/2021	0.66
3/31/2021	0.15	7/8/2021	0.93	10/31/2021	0.32
4/1/2021	0.11	7/9/2021	0.27	11/12/2021	0.58
4/7/2021	0.12	7/11/2021	0.21	11/13/2021	0.51
4/11/2021	0.85	7/12/2021	0.69	11/22/2021	0.15
4/12/2021	0.15	7/17/2021	1.33	11/26/2021	0.22
4/13/2021	0.12	7/18/2021	0.16	12/2/2021	0.23
4/15/2021	0.12	7/28/2021	0.28	12/6/2021	0.16
4/16/2021	0.2	7/29/2021	0.61	12/11/2021	0.23
4/21/2021	0.14	8/1/2021	0.34	12/18/2021	0.13
4/25/2021	0.53	8/10/2021	0.81	12/22/2021	0.38
5/3/2021	0.23	8/11/2021	0.49	12/29/2021	0.34
5/4/2021	0.3				

Table 7: Fecal coliform event mean concentrations (EMC) values for different land uses in CFU/100mL[5]

Land Use	EMC (CFU/100 mL)
Residential	7,750
Commercial	4,500
Industrial	2,500
Undeveloped	3,100
Agriculture	10,000

[5] Theriault, Amelie and Sophie Duchesne, 2015. Quantifying the Fecal Coliform Loads in Urban Watersheds by Hydrologic/Hydraulic Modeling: Case Study of the Beauport River Watershed in Quebec, Water, 7, 615-633; doi: 10.3390/w7020615

Table 8: Fecal coliform loads and annual runoff volumes for HUC 02030105010030 for 2021 rainfall data

HUC14 02030105010030	2021 Runoff Volume (acre-feet)	2021 Fecal Coliform Loads (CFU/yr)
Residential	3,624.0	3.46E+14
Commercial	231.5	1.28E+13
Industrial	4.0	1.24E+11
Agriculture	130.2	1.61E+13
Other	5,280.8	2.12E+14
TOTALS:	9,270.5	5.87E+14

Table 9: Runoff volumes for existing rainfall design storms and climate change extreme rainfall design storms

Storm	Existing Rainfall (inches)	Climate Change Conditions (inches)	Existing Rainfall Runoff Volume (acre-feet)	Climate Change Runoff Volume (acre-feet)
2-Year	3.38	3.86	282.3	330.1
10-Year	5.00	5.78	556.4	651.9
100-Year	8.03	9.46	1,140.2	1,363.4

Table 10: Impervious cover within the Budd Lake watershed

Class	Area (acres)	Area (%)
Building	105.8	3.3%
Other	207.7	6.5%
Road	192.4	6.0%

Table 11: Impervious cover within the 1,000-foot buffer

Class	Area (acres)	Area (%)
Building	21.63	4.5
Other	47.60	10.0
Road	46.36	9.7
Totals =	115.59	24.2

Table 12: Land use within the 1,000-foot buffer

Land Use	Area (acres)	Area (%)
Agriculture	0.004	0.00%
Barren Land	2.03	0.42%
Forest	79.93	16.74%
Urban	238.78	50.01%
Water	2.24	0.47%
Wetlands	154.51	32.36%
Totals =	477.48	100%

Table 13: Pollutant loads from land uses within the 1,000-foot buffer

Land Use	Area (acres)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Total Suspended Solids (lbs/yr)
Agriculture	0.004	0.00	0.04	1.07
Barren Land	2.03	1.01	10.13	121.53
Forest	79.93	7.99	239.79	3,197.24
Urban	238.8	305.4	3,178.8	32,983.2
Wetlands	154.51	15.45	463.52	6,180.31
Totals =	475.25	329.84	3,892.2	42,483.4

Table 14: Fecal coliform loads and annual runoff volumes for 1,000-foot buffer area for 2021 rainfall data

HUC14	2021 Runoff Volume (ac-ft)	2021 Fecal Coliform Loads (CFU/yr)
Residential	609.7	5.83E+13
Commercial	45.9	2.55E+12
Industrial	0.0	0.00E+00
Agriculture	0.012	1.45E+09
Other	880.7	3.59E+13
TOTALS:	1,536.3	9.68E+13

Table 15: Loading from roadways in HUC14

Land Use	Area (acres)	TP (lbs/year)	TN (lbs/year)	% of TP Load	% of TN Load
Roadways	192.4	384.8	2,963.0	22.6%	14.3%
All Land Use	3,218.6	1,702.6	20,775	100%	100%

Table 16: Roadway load reduction from street sweeping using maximum reduction values from the Chesapeake Bay Program

Land Use	Area (acres)	TP (lbs/year)	TN (lbs/year)	TP Reduction (lbs/yr)	TN Reduction (lbs/yr)
Roads in the entire HUC 14	192.4	384.8	2,963.0	38.5	118.5
Roads in the 1,000-foot buffer	46.36	92.7	713.9	9.3	28.6

Table 17: Total phosphorus load reduction due to leaf collection coupled with street sweeping from late September through November

Land Use	Area (acres)	TP (lbs/year)	TP Reduction (lbs/yr)
Residential land use in entire HUC 14	1,100.7	1,155.8	196.5
Residential land use in 1,000-foot buffer	185.2	224.5	38.2

Table 18: Total phosphorus load reduction for MTDs to treat stormwater runoff from urban land uses within the 1,000-foot buffer along the east side of Budd Lake

Land Use	Area (acres)	TP (lbs/year)	TP Reduction (lbs/yr)
Urban land use in the 1,000-foot buffer along the east side of Budd Lake	209.64	279.18	139.59

Table 19: Proposed retrofit sites with drainage area to be treated and size of green infrastructure practices

Site Name and Address	Lot Area (sq.ft.)	Impervious Cover for Lot (sq.ft.)	Total Drainage Area to be Managed (sq.ft.)	Size of Rain Garden Practice (sq.ft.)	Size of Porous Asphalt Practice (sq.ft.)	Size of Cistern Practice (gallons)
Peace Abiding Lutheran Church, 305 US-46 East	125,071	44,264	21,488	2,000	3,500	430
BJ Sandwich Shop, 329 US-46 East	16,759	21,691	13,016	200	4,200	0
Elizabeth Ln adjacent to Budd Lake Diner, 120 US-46 West	NA	NA	2,030	510	0	0
Budd Lake Union Chapel, 54 Sand Shore Rd	17,657	11,249	3,685	400	1,120	0
Eagle Rock Village, 36 Anthony Ct.	2,212,676	456,390	228,195	21,197	42,774	0
Lou Nelson Park, Sand Shore Rd/Warren Drive	173,715	9,641	3,283	650	0	0
Pax Amicus Castle Theatre, 23 Lake Shore Rd	136,058	16,504	5,489	1,100	0	0
Special Technical Services & Atlantis Aerial Survey, 295 US-46 East	40,969	28,211	14,820	0	4,500	0
The Pavilion Lounge, 44 Sand Shore Rd	173,886	32,315	20,675	7,750	0	0
Turkey Brook Park, 120 US-46 West	2,312,149	386,977	120,597	31,305	0	0
St Jude Thaddeus Roman Catholic Church, 17 Mt Olive Rd	315,998	124,864	51,890	432	7,258	0
Totals:	**5,524,937**	**1,132,108**	**477,798**	**65,544**	**63,352**	**430**

Table 20: Load reductions for proposed retrofit sites

Site Name and Address	Loading reduction with underdrain			Loading reduction w/o underdrain		
	TP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	TSS (lbs/yr)
Peace Abiding Lutheran Church, 305 US-46 East	0.78	4.09	99.1	1.17	12.27	111.5
BJ Sandwich Shop, 329 US-46 East	0.50	2.64	64.0	0.76	7.92	72.0
Elizabeth Ln adjacent to Budd Lake Diner, 120 US-46 West	0.07	0.38	9.3	0.11	1.15	10.5
Budd Lake Union Chapel, 54 Sand Shore Rd	0.15	0.79	19.1	0.23	2.37	21.5
Eagle Rock Village, 36 Anthony Ct.	5.63	30.18	751.2	8.45	90.55	845.1
Lou Nelson Park, Sand Shore Rd/Warren Drive	0.05	0.27	8.7	0.08	0.81	9.8
Pax Amicus Castle Theatre, 23 Lake Shore Rd	0.09	0.45	14.5	0.14	1.36	16.3
Special Technical Services & Atlantis Aerial Survey, 295 US-46 East	0.56	2.93	71.0	0.84	8.78	79.8
The Pavilion Lounge, 44 Sand Shore Rd	0.82	4.31	104.4	1.23	12.92	117.5
Turkey Brook Park, 120 US-46 West	2.09	10.46	334.8	3.14	31.38	376.6
St Jude Thaddeus Roman Catholic Church, 17 Mt Olive Rd	1.72	9.03	218.8	2.59	27.08	246.2
Totals:	**12.27**	**64.4**	**1,667.9**	**18.41**	**193.24**	**1,876.3**

Table 21: Load reductions for proposed management strategies

Management Strategy	**TP Reduction (lb/yr)**
Street sweeping	38.5
Leaf collection and street sweeping	196.5
Manufactured treatment devices (MTDs) (21 outfalls to treat urban land uses within 1,000-ft buffer)	139.59
Green infrastructure for proposed retrofit sites	18.41
Rain gardens for 25% of buildings	99.9
Bioswales for 25% of roadways outside of the 1,000-ft buffer	78.8
Converting existing detention basins to bioretention basins	42.4
Floating wetland islands (10 - 250 square feet)	100.0
TOTAL =	**714.1**

Table 22: Costs for proposed management strategies

Action	Management Strategy	Construction Cost	Annual Maintenance
1	Street sweeping (Currently sweeping twice per year - increasing to sweeping weekly)[6]. This is an annual cost.	$100,000[7]	
2	Leaf collection and street sweeping (Currently picking up bagged leaves weekly in the fall but must add extra street sweeping to obtain the full TP reduction credit. If the township increases street sweeping to weekly as identified in Action #1, the cost of this action is zero). This is an annual cost.	$10,000[8]	
3	Manufactured treatment devices (MTDs) (21 outfalls to treat urban land uses within 1,000-ft buffer).	$2,100,000[9]	$105,000
4	Green infrastructure for proposed retrofit sites	$1,924,202[8]	$96,210
5	Rain gardens for 25% of a rooftop for 25% of the buildings	$2,877,683[8]	
6	Bioswales for 25% of roadways outside of the 1,000-ft buffer	$3,179,880[8]	$159,000
7	Converting existing detention basins to bioretention basins	$200,113[8]	
8	Floating Wetland Islands	$240,000[8]	$12,000
	Total construction cost estimate =	$10,631,878	
	Total annual maintenance cost estimate =		$372,210
9	Baseline Lake Assessment (estimate from Princeton Hydro)	$35,000	
10	Water Quality Monitoring Program (10 years: estimated $20,000 per year)	$200,000	

[6] Mount Olive currently conducts street sweeping twice per year for a cost of $4,000.
[7] This does not include the cost of a new street sweeper.
[8] If Action #1 is not implemented, the cost is $10,000. If Action #1 is implemented, the cost would be zero.
[9] This is a design and construction cost.

11	Education and Outreach Programs (first 4 years: estimated $15,000 per year; years 5-10: $2,000 per year)	$78,000	
	Total project cost estimate =	$11,317,088	

Table 23: Management strategy implementation schedule and measurable milestones.

Management/Implementation Strategy (milestones)	**Time Frame**
Mount Olive Township will review its leaf collection and street sweeping program. Since on average 43% of the annual phosphorus load is discharged during the fall, the street sweeping program should be adapted to address this issue. The township should begin soliciting grant funding for additional advanced street sweeping equipment.	0 to 6 Months
The drainage areas for the 21 lake outfalls must be identified so MTDs can be designed to manage stormwater runoff from these drainage areas. This is a great project for an organized group of volunteers with some supervision from the Mount Olive Department of Public Works.	0 to 12 Months
RHA and Rutgers will submit grants for funding the projects targeted in this Watershed Plan and for expansion beyond the 1,000-foot buffer around Budd Lake; this will begin within 12 months and extend throughout the project timeframe.	0 to 12 Months
Rutgers will develop designs for 2 to 4 MTDs and for green infrastructure projects at 3-6 of the 11 sites will be completed. The MTDs and green infrastructure projects will be constructed within 36 months.	0 to 12 Months
The River Friendly Resident, River Friendly Schools, and River Friendly Business outreach programs will be implemented and continue for the duration of the project.	0 to 12 Months
Develop and deliver the educational programming, particularly focusing on encouraging residents to adopt pollution reduction strategies, build rain gardens, and install rainwater harvesting systems to help reduce stormwater flows to Budd Lake; seek funding to support rain garden installation by private property owners; RHA can be the lead on this effort with support from Rutgers Cooperative Extension.(4 programs to be delivered within 3 years)	12 to 36 Months

Develop a floating wetland island program to begin constructing 2,500 square feet of wetland islands. (3 to be built and deployed within 3 years)	12 to 36 Months
The MTDs and green infrastructure site project designs completed in year 1 will be constructed.	12 to 36 Months
Four 250-square foot floating wetland islands will be built and deployed.	12 to 36 Months
Retrofit designs for the 5 detention basins will be completed (and constructed within 3 years).	12 to 36 Months
Designs for an additional 6 MTDs, green infrastructure projects at 5 additional sites will be completed, and 5 bioswales will be designed for outside the 1,000-foot buffer (construction to occur within 3 years).	12 to 36 Months
Four additional 250-square foot floating wetland islands will be built and deployed.	12 to 36 Months
Designs for all remaining MTD and green infrastructure projects will be completed.	4 to 6 years
All MTDs, green infrastructure project sites, bioswales (outside the 1,000-foot buffer zone) and detention basin retrofits designed in years 2-3 will be constructed.	4 to 6 years
Two to 4 bioswale projects will be constructed	4 to 6 years
Remaining 2 floating islands will be built and deployed	4 to 6 years
All remaining MTDs and green infrastructure project sites designed in years 4-6 will be constructed. Two to 4 bioswale projects designed in years 4-6 will be constructed.	7 to 9 years
Designs for 8 to 12 bioswale projects will be completed.	7 to 9 years
All MTDs and green infrastructure projects will be completed.	10 years

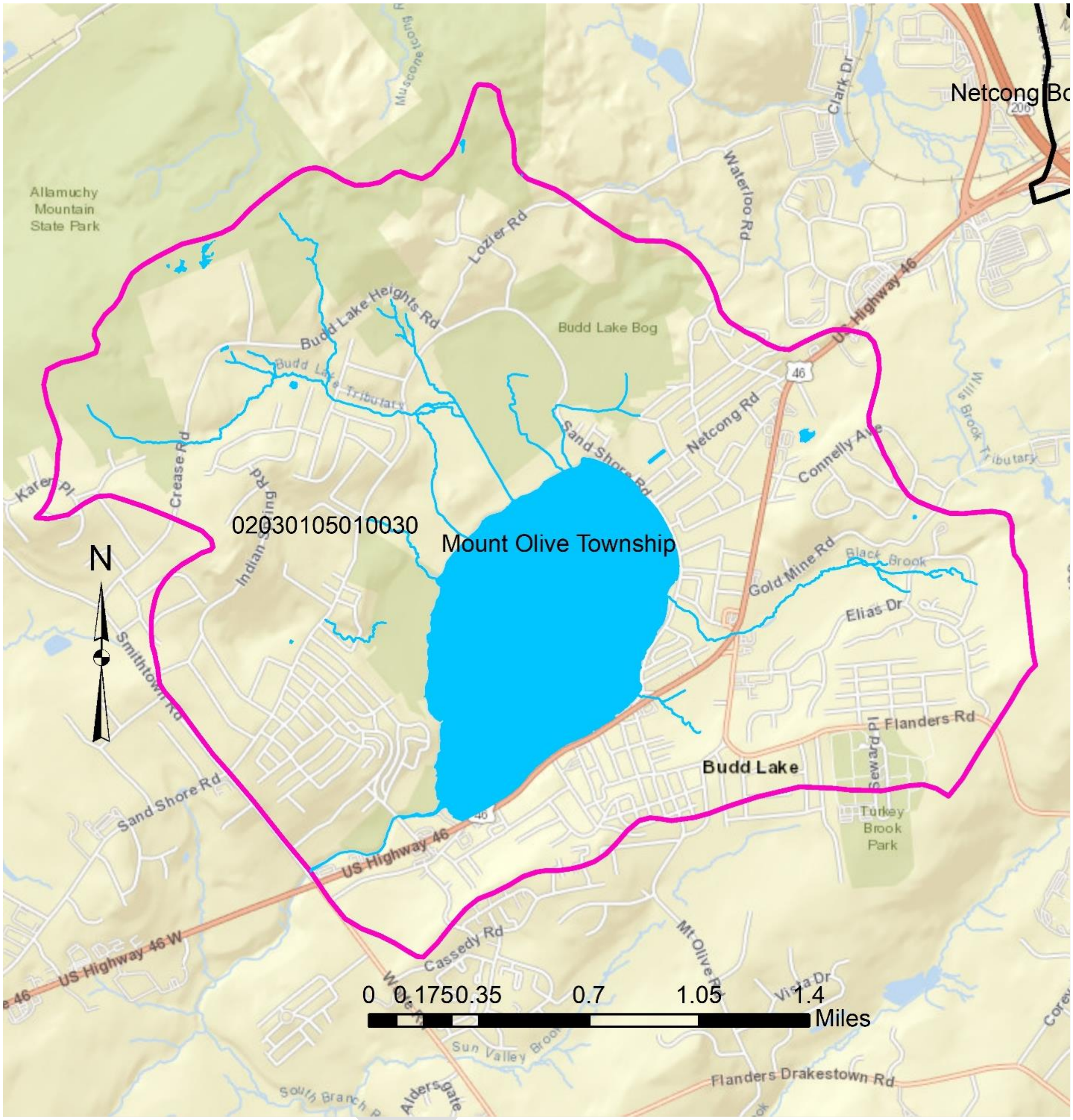

Figure 1: The Budd Lake watershed (outlined in pink)

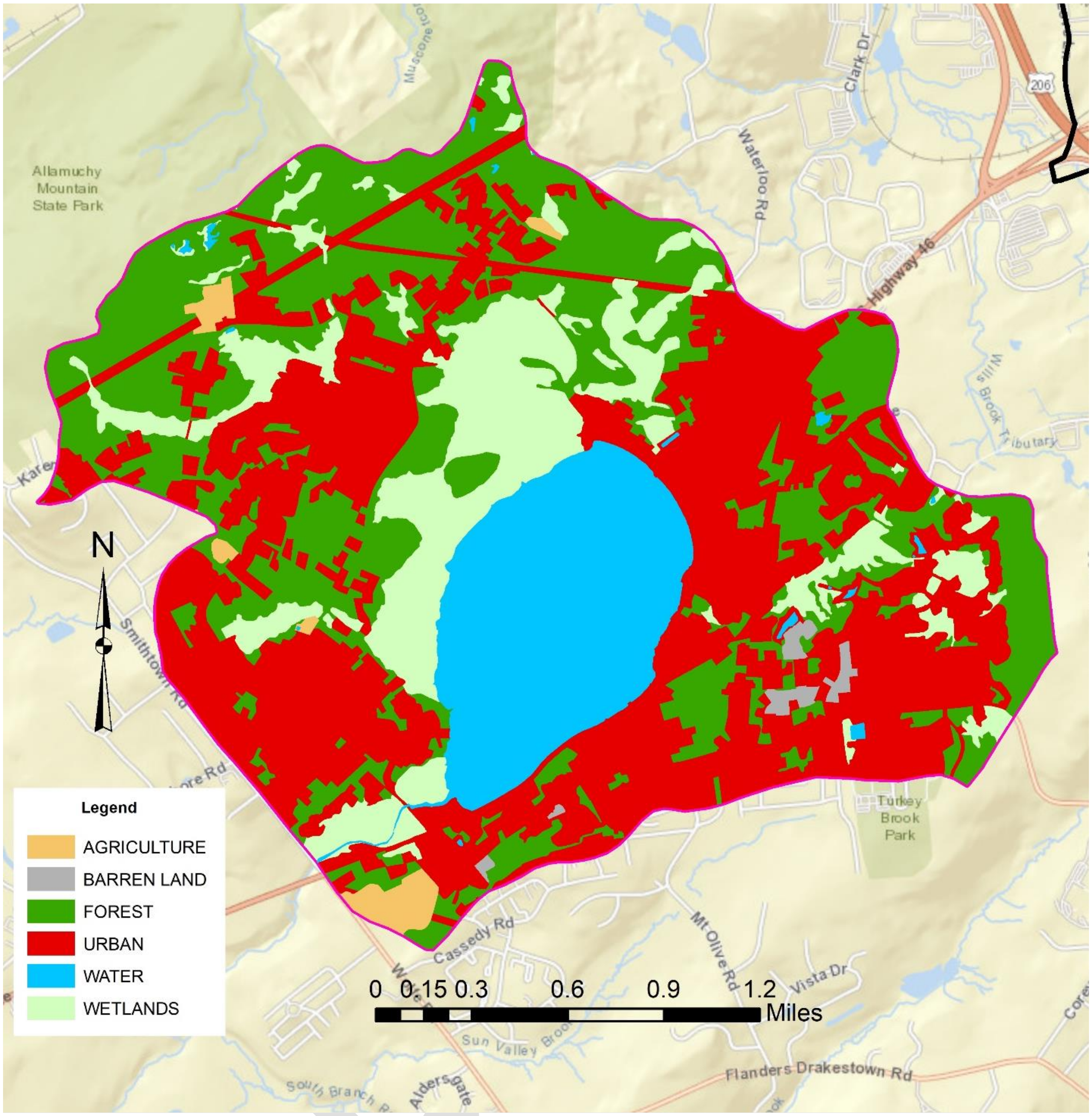

Figure 2: Land use land cover in the Budd Lake watershed (NJDEP 2015 data)

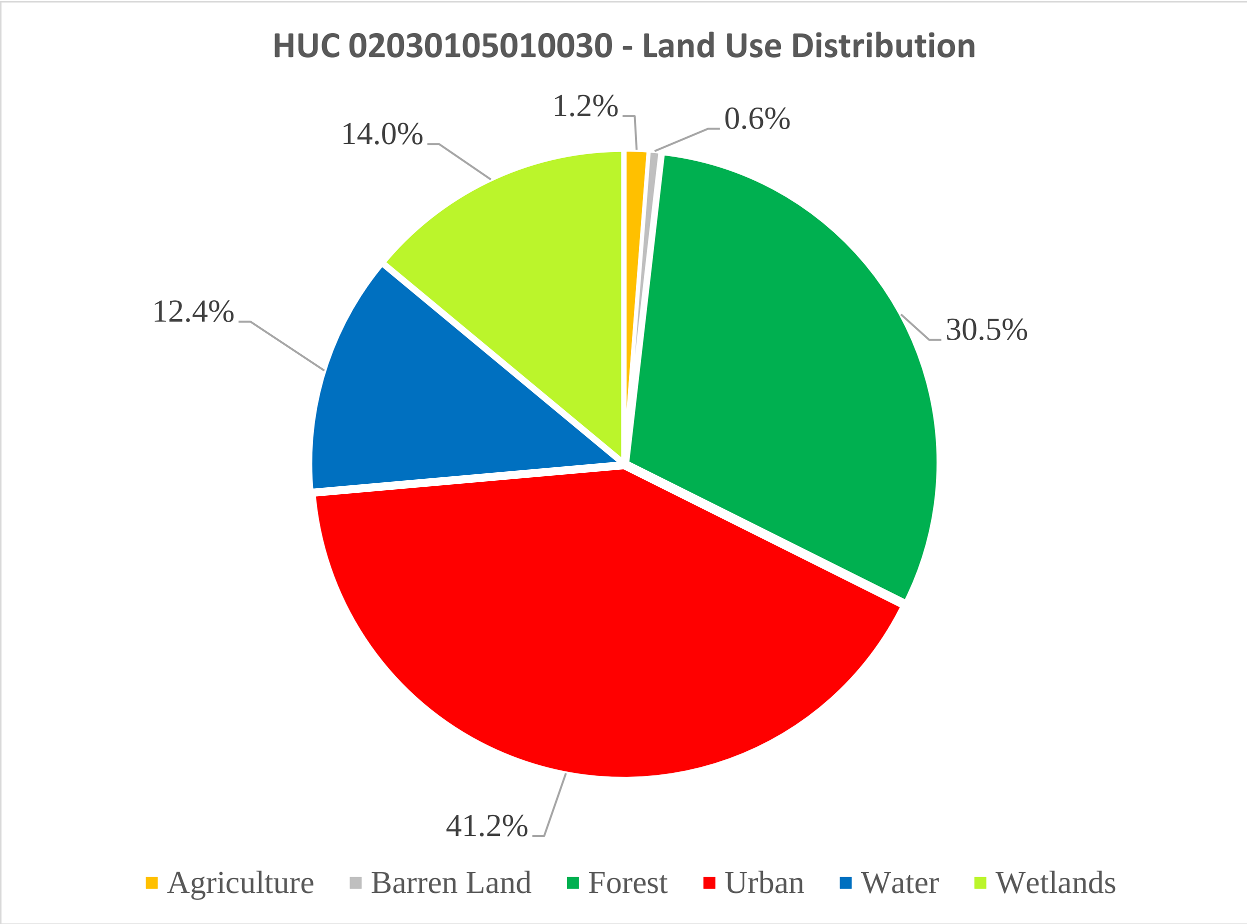

Figure 3: Land use distribution in the Budd Lake watershed

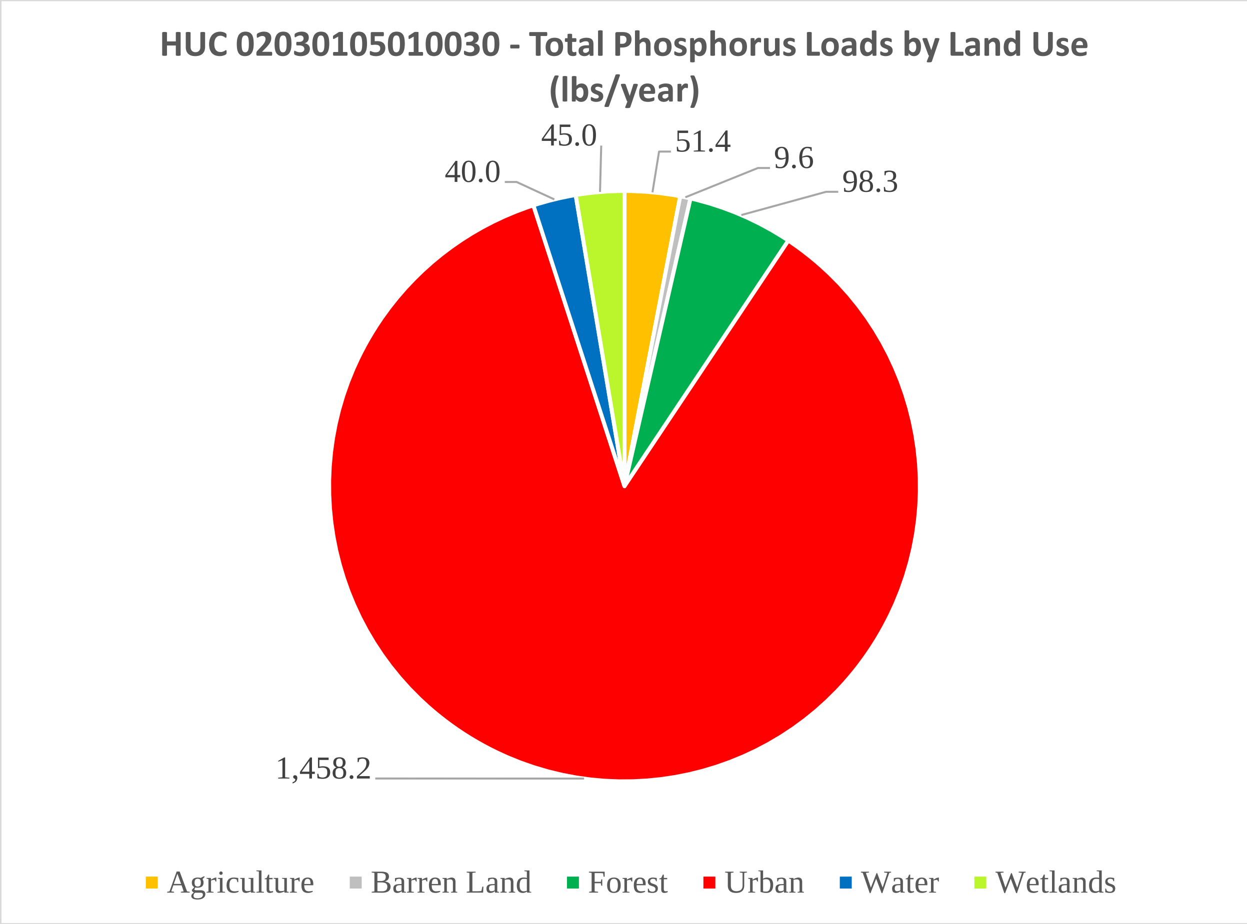

Figure 4: Total phosphorus pollutant loads for the Budd Lake watershed in lbs/yr

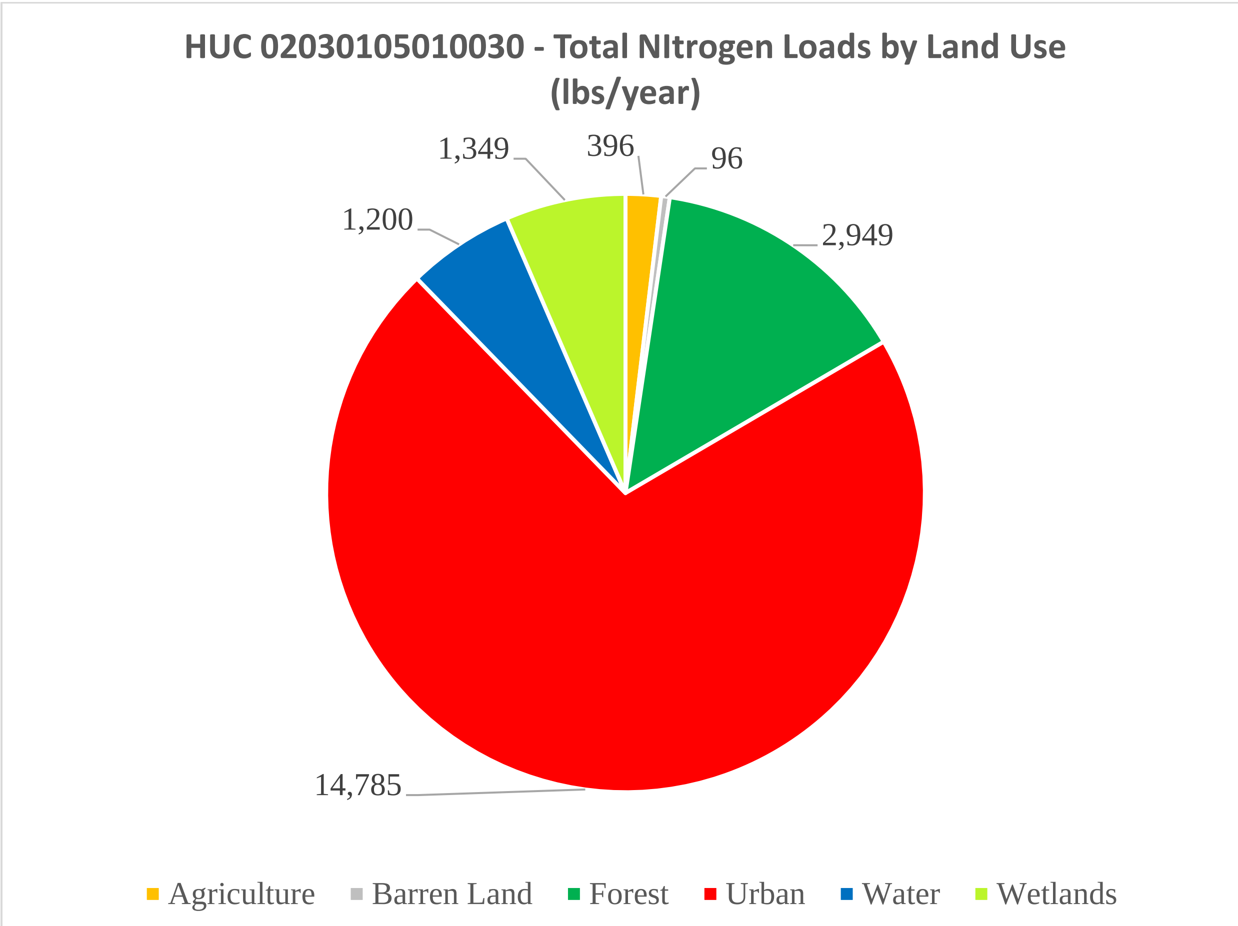

Figure 5: Total nitrogen pollutant loads for the Budd Lake watershed in lbs/yr

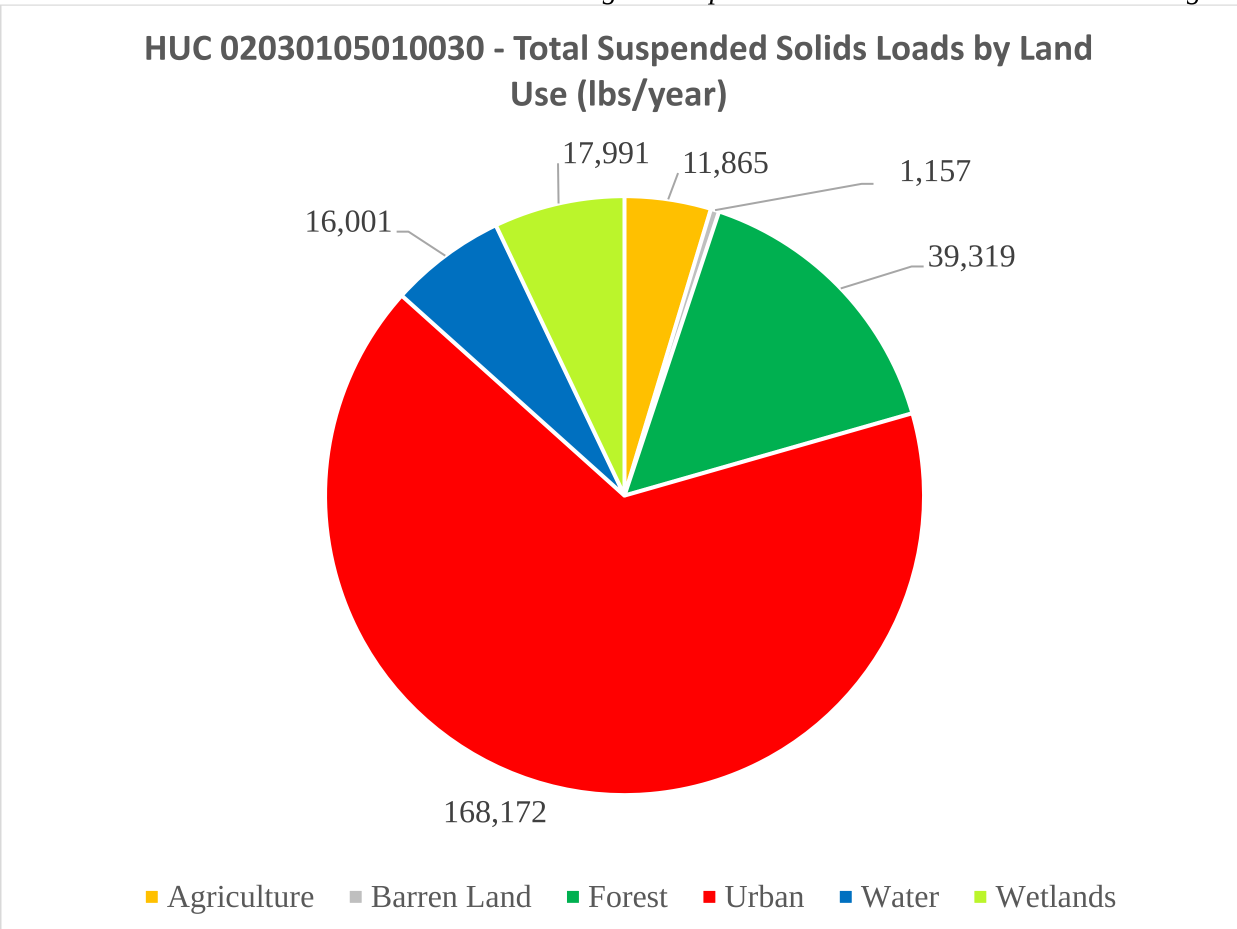

Figure 6: Total suspended solids loads for the Budd Lake watershed in lbs/yr

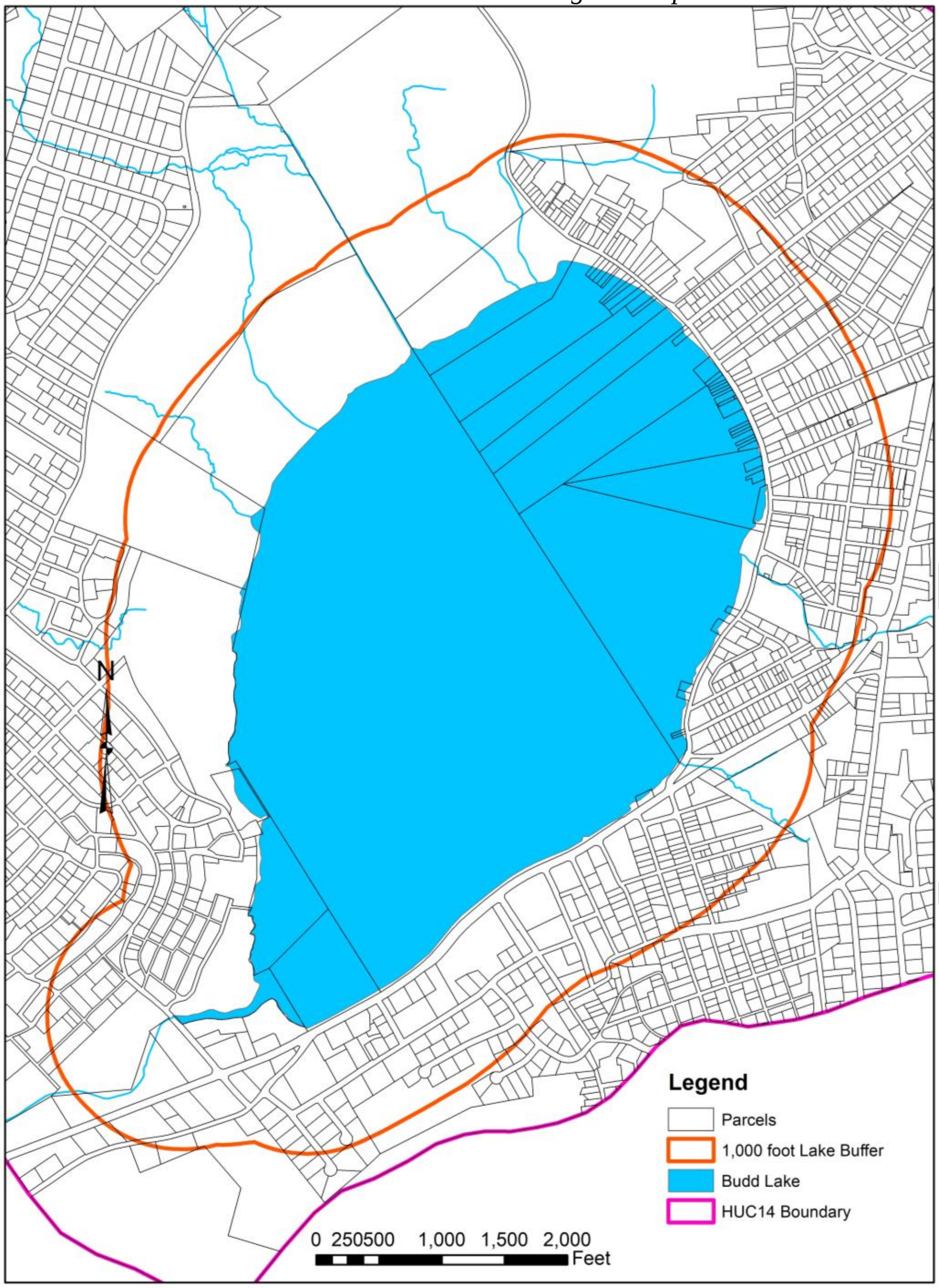

Figure 7: 1,000-foot buffer around Budd Lake

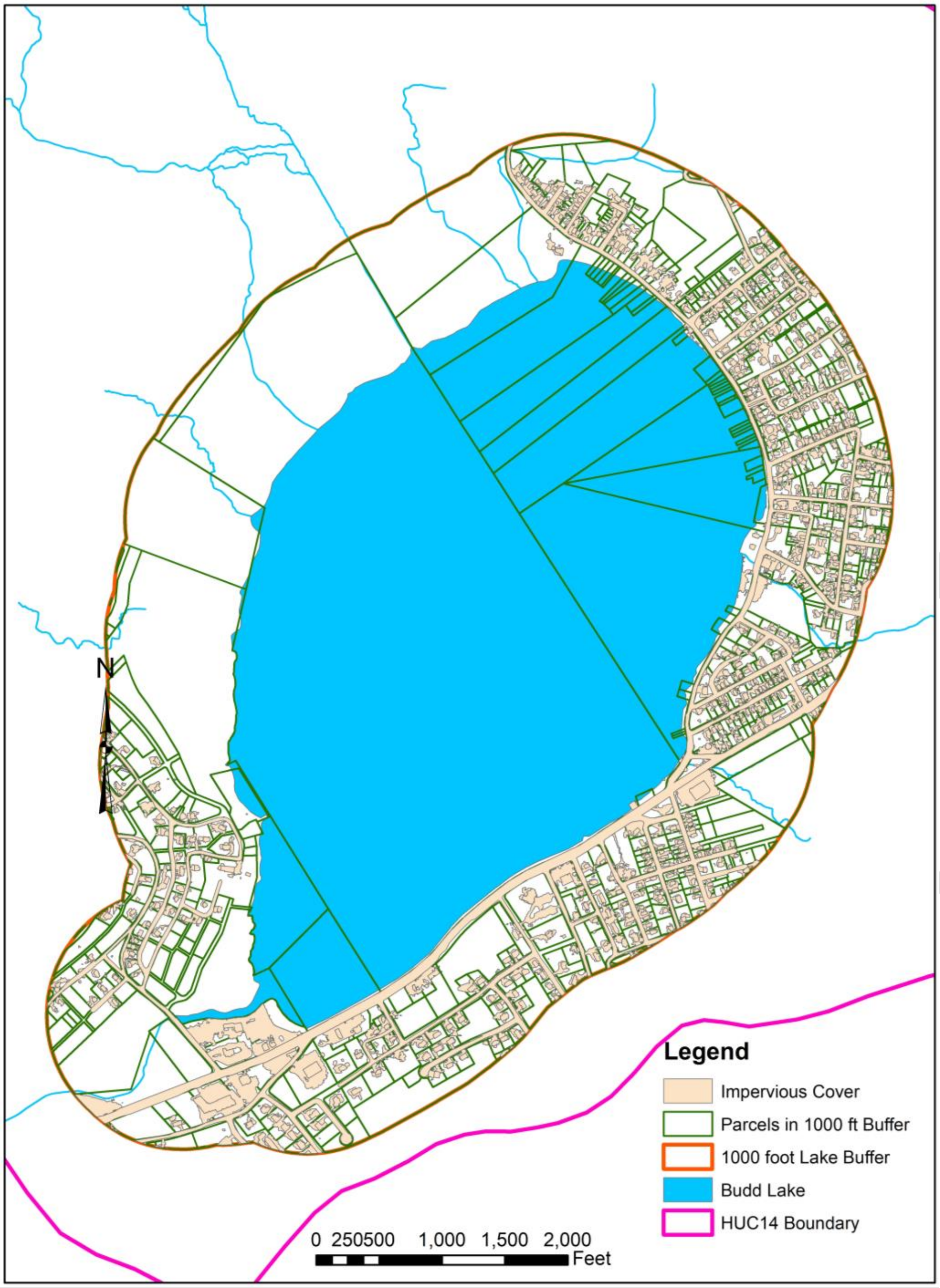

Figure 8: Impervious cover within the 1,000-foot buffer

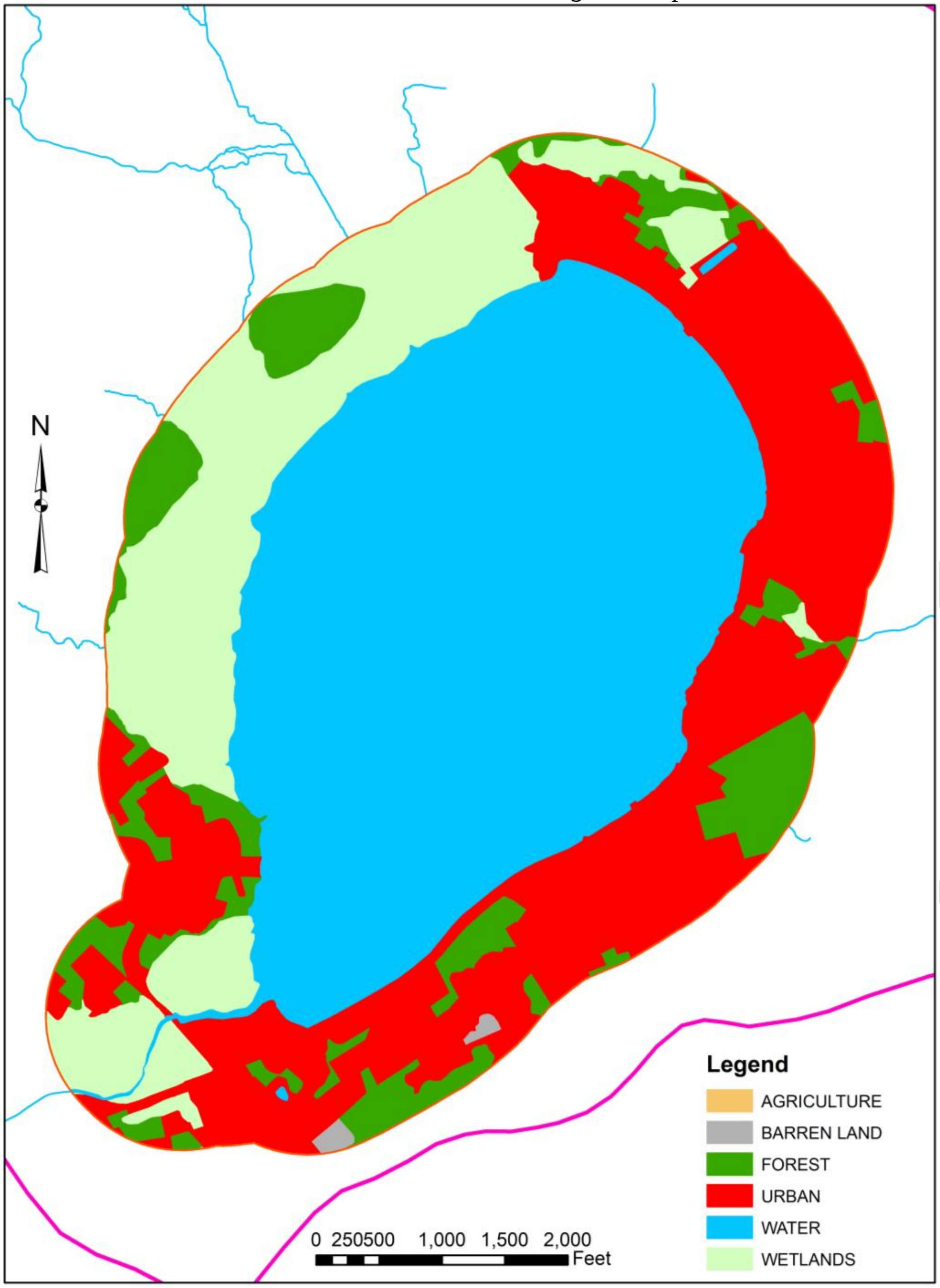

Figure 9: Land use within the 1,000-foot buffer

Appendix A: Curve Numbers Based upon Land Use and Hydrologic Soil Group

Appendix B: Fecal Coliform Loading Calculations

Appendix C: Budd Lake Outfall Locations

Appendix D: Budd Lake Green Infrastructure Sites – Concept Plans

APPENDIX E: Budd Lake Water Quality Monitoring Plan