Adams Pond and Knickerbocker Lake

Watershed Protection Plan

Photo by Jonne Trees

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Boothbay Region Water District
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BOOTHBAY REGION WATER DISTRICT

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1. Background Information

A. Document Purpose and Scope

The purpose of this Watershed Based Plan, herein after referred to as the "plan", is to lay out a strategy and schedule for NPS mitigation and water quality protection efforts for the Adams Pond and Knickerbocker Lake watersheds over the next ten years (2015 to 2025).

The plan was developed to satisfy national watershed planning guidelines provided by the EPA. EPA requires nine-element plans for impaired watersheds, but allows alternative plans in several cases including for protection of high quality or unimpaired waters. MDEP accepts alternative plans for unimpaired lakes that have completed a recent watershed survey provided that the plans follow EPA and MDEP guidance and include minimum planning elements. Adams Pond and Knickerbocker Lake meet these eligibility criteria, and the plan was written to include the EPA and MDEP required planning elements (sections 2 through 6 in the plan cover EPA's five elements for alternative watershed-based plans).

B. Watershed Background

Adams Pond and Knickerbocker Lake, located in the town of Boothbay, are the only significant public drinking water sources for the towns of Boothbay, Boothbay Harbor and Southport Island. Currently, public water demand averages about 540,000 million gallons per day and demand peaks to over 1.2 million gallons per day during the summer season. Adams Pond is the primary water supply, but Knickerbocker Lake, with removals currently limited to 51.5 million gallons/year, is also essential to meet the Region's needs for potable water.

These waterbodies and their watersheds are also used recreationally year round by residents and tourists and provide essential habitat for fish and wildlife species.

Adams Pond

Adams Pond has a surface area of about 80 acres, a mean depth of 12 feet, a maximum depth of 22 feet, and a watershed of about 1.5 square miles, about 90 percent of which is forested. Adams Pond is fed by several small streams, as well as groundwater recharge, and discharges at its northern end into a tidal tributary of Cross River. Its flushing rate has been estimated at 2.54 flushes per year.

Two roadways, Route 27, a state road with high traffic volumes, and Adams Pond Road, a side road with little traffic, closely border the eastern and western shores of the pond. Topography to the east and west of the pond is steep with highly erodible soils in areas.

Most development in the Adams Pond watershed has occurred to the east and south of the pond. Residential development is the most frequent land use in the watershed, but there are also commercial and municipal uses.

The Boothbay Region Water District (BRWD) owns 106 acres in the Adams Pond watershed, including virtually all of the Adams Pond shoreline. The BRWD water treatment facility and business office is located on the southwest shore of the pond, the rest of BRWD's property is undeveloped and held for watershed protection.

Boating and swimming are presently not allowed on Adams Pond, but fishing from the Adams Pond Road shoreline is a frequent summer activity of residents and visitors.

Knickerbocker Lake

Knickerbocker Lake has a surface area of about 110 acres, a mean depth of 15 feet, a maximum depth of 32 feet, and a watershed of about 1.6 square miles, about 90 percent of which is forested. Its flushing rate has been estimated at 1.29 flushes per year.

Knickerbocker Lake, fed by small inlet streams and groundwater recharge from the watershed, discharges at it southern end into Campbell Creek and then into West Harbor Pond. The immediate shoreline of Knickerbocker Lake is not accessible directly by public roads. Back River Road stretches along part of the lake's eastern shoreline and numerous private roads and driveways provide access to the shoreline for property owners.

Most development in the watershed is residential, but a few municipal and commercial properties exist, including an auto repair business. Current zoning limits future development in the Knickerbocker Lake watershed to residential use.

Knickerbocker Lake is the only freshwater lake on the Boothbay peninsula with public access. A town-owned property, located on the southern end of the lake, provides public access for swimming, fishing and boating. A nearby YMCA day camp also provides recreational access for its members and day campers. Motor boating on the lake is infrequent (probably due to its small size) and is restricted to engines of 10 HP or less. One private resident of the lake owns a float plane that is moored on the lake's eastern shore.

C. Summary of Prior Watershed Work

Since 2002, the BRWD, Maine Department of Environmental Protection (DEP), Maine Department of Health and Human Services Drinking Water Program (DWP), Knox Lincoln Soil and Water Conservation District (KLSWCD), the Town of Boothbay and community organizations have worked cooperatively and individually to gather data and establish programs to foster protection of Adams Pond and Knickerbocker Lake water quality and their watersheds.

In 2002, the DWP completed its federally mandated evaluation of the vulnerability of Adams Pond and Knickerbocker Lake to contaminant threats. This Source Water Assessment Program (SWAP) report concluded that Adams Pond's overall susceptibility to water quality contamination was high whereas Knickerbocker Lake's susceptibility moderate.

In 2002, BRWD, DEP, KLSWCD and local volunteers conducted the first survey of Adams Pond and Knickerbocker Lake watersheds to identify NPS sites. The 2002 survey identified 106 NPS sites that had a high potential to negatively impact water quality. The watershed report was followed by a successful EPA Section 319 Clean Water Act grant application in 2004, which provided funding to address several major erosion sites along Adams Pond and Knickerbocker Lake.

In 2004, the Town of Boothbay adopted new watershed protection ordinances and defined a Water Reservoirs Protection District (WRPD), a protective zone within 500 feet of each water supply lake and within 75 feet of specific tributary streams, where development and land use are further restricted. BRWD also began providing financial support to the Town of Boothbay for code enforcement activities in the watershed.

To update the 2002 SWAP, BRWD surveyed the WRPD zone of Adams Pond and Knickerbocker Lake in 2009 to assess both point and NPS pollution threats. The 2010 SWAP report included specific management measures to address potential contaminant threats. An application for a 319 grant to address NPS sites subsequent to this survey was not successful.

In the fall of 2013, BRWD hired a part-time watershed program manager to work with town officials, other agencies, community organizations and citizens to: 1) gather data on the watershed and to develop a watershed GIS to support watershed-based management, 2) to identify, address and/or monitor potential pollution sources, 3) to work with the town to revise local ordinances to reflect best available scientific information relative to key watershed areas, best management practices (BMPs) and Low Impact Development (LID) techniques, and 4) to develop public education and outreach programs.

In summer 2014, BRWD, DEP, KLSWCD and community volunteers conducted another watershed survey, which identified 48 NPS sites in the two watersheds. The watershed survey report was completed in September and efforts are now underway to remediate these sites. In October 2014, BRWD contacted affected property owners and also hired Dirigo Engineering to develop plans to address the most significant NPS problems found in the survey. BRWD, with its local community partners, plans to apply for a 319 grant in 2015 for financial support to fix the most significant NPS sites. To address other NPS sites, BRWD, with the assistance of KLSWCD, will conduct outreach programs and provide financial and technical assistance to property owners.

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Stone Wharf Rd
Wendell's Wy
Burning Bush Dr
Rays Ln
BOOTHBAY REGION WATER DISTRICT
WATERSHED MAP FOR
DRINKING WATER SOURCES
ADAMS POND & KNICKERBOCKER LAKES
2015
Watershed boundaries delineated by Wright-Pierce using ArcGIS Spatial Analyst
and DEM data entitled "State of Maine: LIDAR for the North East 2011"
Aerial Imagery Source: Maine OGIS - 2013 6inch Orthos
Contours and Parcels : Maine OGIS
0 250 500 1,000 1,500 2,000
Feet
1 inch = 500 feet
WRIGHT-PIERCE
Engineering a Better Environment

2. Identification of the Causes or Sources of the NPS Threat

A. Water Quality Summary

BRWD, as part of the VLMP, has monitored Adams Pond's water quality since 1977 and Knickerbocker Lake's water quality since 1991. Based on these data, both lakes appear to have been affected by NPS pollution. Algal blooms occurred in Adams Pond in the past, but not in the last ten years. Recent data suggest Knickerbocker Lake is now more likely to experience an algal bloom.

Adams Pond's water quality is considered below average and Knickerbocker Lake's slightly below average, based on measures of Secchi disk transparency depth, total phosphorus and chlorophyll-a. Based on these data, DEP has concluded the potential for nuisance algal blooms in Adams Pond is low to moderate and the potential for phosphorus to leave the bottom sediments and become available in the water column is low. Recent dissolved oxygen (DO) profiles in Knickerbocker Lake show high DO depletion in deep areas of the lake, which increases the potential for phosphorus to leave bottom sediments and become available to algae in the water column. DEP considers the potential for nuisance algal blooms in Knickerbocker Lake to be moderate and the potential for phosphorus to leave the bottom sediments and become available in the water column is high.

B. Threatened Status

Adams Pond and Knickerbocker Lake currently meet state water quality standards, but both are listed on Chapter 502 of the Maine Stormwater Law as "Most at Risk from New Development" and on Maine's NPS Priority Watersheds List. Adams Pond, Knickerbocker Lake and the other unimpaired lakes were placed on these lists because they were identified by MDEP as being particularly sensitive to eutrophication based on current water quality, potential for internal recycling of phosphorus, potential as a cold water fishery, volume or flushing rate, or projected growth rate in the watershed. Considering Boothbay's population trend, the availability of land within the watershed and the central location of the watershed, the potential for increased watershed development and a greater NPS threat is high.

C. Watershed NPS Threats

The greatest threat to Adams Pond and Knickerbocker Lake is NPS pollution associated with development. Boothbay's population is growing at a rate higher than the state average. Data from the Lincoln County Regional Planning Commission indicate Boothbay's population has grown 18% and there has been a 44% increase in housing units since 1990. Residential development is the most common type of development in Boothbay overall and in the Adams Pond and Knickerbocker Lake watersheds. As Boothbay's population grows, residential development is expected to continue to be the dominant development type in the watershed. Analysis of the housing trends in Boothbay shows most residential development has been occurring on a lot-by-lot basis or in small subdivisions, which are subjected to less rigorous environmental review than large subdivisions.

Much of the watershed is undeveloped. Using Boothbay property tax data as a measure, there are about 1,600 acres within the Adams Pond and Knickerbocker Lake watersheds, of which about 430 acres are completely undeveloped and 440 acres partially developed (e.g., a large lot with one house capable of further subdivision). Of these roughly 870 acres of developable property,744 acres consist of properties greater than 10 acres in size.

Two large developments in Boothbay could further stimulate Boothbay's seasonal and year round population growth and increase development pressure on the watershed. The Coastal Maine Botanical Gardens, a 270-acre attraction established in 2007, located partially in the watershed, received over 100,000 visitors in 2014. The Gardens plan a doubling of facilities and estimate visitor numbers will increase to 160,000 yearly by 2024. The Boothbay Harbor Country Club, also partially located in the watershed, is undergoing a major renovation under new owner Paul Coulombe. Coulombe is investing $30 million to establish a PGA level course, new clubhouse, cottages, spa, tennis courts, swimming pools and other amenities. Development associated with these major attractions coupled with the already above average growth trend in Boothbay increases the likelihood of watershed development and the NPS threat to the Adams Pond and Knickerbocker Lake.

NPS sources

Like many Maine lakes, Adams Pond and Knickerbocker Lake's water quality is most threatened by phosphorus inputs from developed areas. Phosphorus attached to sediments and organic matter in stormwater runoff from developed sites can lead to nutrient enrichment in lakes, declining water quality and algal blooms.

The 2014 survey identified 48 NPS sites in the Adams Pond and Knickerbocker Lake watersheds. Roads, private residences, beach access sites and driveways were the most frequent land uses associated with NPS sites in the survey (Table 1).

Roads that ring Adams Pond and border Knickerbocker Lake are significant sources of NPS pollution. In both the 2002 and 2014 watershed surveys, roads of all types were the land use most frequently associated with NPS sites, with town roads dominant. Two town roads, in particular, were associated with numerous NPS sites. The proximity of the Adams Pond Road to the pond provides little buffer between the shoreline and road maintenance activities, human access and runoff from steep slopes. On Back River Road along Knickerbocker Lake, storm water runoff from steep slopes is concentrated and carried through culverts under the road. At times, high velocity runoff causes severe erosion to residential lakefront properties that are at the tail end of road culverts. In both watersheds, lack of properly designed and installed stormwater management infrastructure and poor maintenance of existing infrastructure are either exacerbating or causing additional NPS pollution.

Private residences were the second most common land use associated with NPS sites. Most of the residential NPS sites were in the Knickerbocker Lake watershed. Many of the residential erosion

problems identified could be addressed with low cost BMPs. The survey showed a need for outreach to property owners about lake-friendly practices.

Beach access was the third most common land use associated with NPS sites in the 2014 survey. The lack of defined public access to Adams Pond has led to several car pullouts along the shore and eroded footpaths to the water. At the Knickerbocker Lake public access, a poorly defined parking area and a poorly maintained road are contributing runoff and have resulted in the destruction of a vegetated buffer.

Table 1. Categorization of NPS sites identified in the 2014 Adams Pond/Knickerbocker Lake watershed survey by land use and impact rating.

Site category	High Impact	Medium Impact	Low Impact	Total
Beach/shore access	**1**	**2**	**3**	**6**
Commercial	**0**	**2**	**0**	**2**
Driveway	**2**	**2**	**0**	**4**
Municipal	**1**	**0**	**0**	**1**
Residential	**2**	**4**	**3**	**9**
Private Road	**2**	**2**	**0**	**4**
Town Road	**4**	**9**	**2**	**15**
Trail/Path	**0**	**2**	**0**	**2**
State Road	**0**	**2**	**3**	**5**
Total	**12**	**25**	**11**	**48**

Other NPS threats

Presently, septic systems within the watershed are not monitored by the town or BRWD to ensure they are operating and maintained properly. Improperly constructed, sited or maintained on-site septic systems can cause nutrient and microbial contamination of ground and surface waters. Many residential septic systems around Knickerbocker Lake are old and sited closer to the shoreline than permissible under current state standards. These septic systems pose a potential threat to water quality. Home heating oil tanks are another potential source of contamination not currently monitored to ensure tanks are appropriately sited and maintained to reduce risk of leaks or spills.

The plan envisions developing an appropriate monitoring system for high risk septic systems and heating oil tanks and tracking monitoring data through the watershed GIS. The Town of Boothbay is also currently investigating the extension of public sewer along the Route 27 stretch of the Adams Pond watershed.

3. Watershed Plan Goals and Objectives

The overall goal of the Adams Pond and Knickerbocker Lake Watershed Protection Plan is to maintain or improve water quality for the long-term health of the community. This goal will be achieved by remediating existing pollution sources, by developing local management programs to reduce the likelihood of future contaminant threats, and by developing community support for watershed and water supply protection.

Goal 1 - Reduce phosphorus inputs: To achieve this goal, priority will be placed on remediating NPS sites identified in the 2014 watershed survey. BRWD has contracted with Dirigo Engineering to develop plans for remediating 25 NPS sites that have been judged to be the most significant and the most accessible to remediation. These sites will be included in an application for a 319 NPS remediation grant in 2015. BRWD, with technical assistance from KLSWCD, will also start a local grant/outreach program in 2015 to provide financial and technical assistance to private property owners for addressing other NPS sites.

Goal 2 - Increase community support for watershed protection: Developing an informed and engaged community is key to achieving watershed and water quality protection over the long term. Working with the Town of Boothbay, KLSWCD and other local partners, BRWD will continue to develop and disseminate community outreach materials and educational opportunities to foster watershed protection.

Goal 3 - Improve information base for management: A third goal is to develop a sound watershed-based approach to local management. To accomplish this, BRWD has contracted with Wright-Pierce to develop a watershed GIS to map and monitor key watershed features and characteristics, both natural and man-made, e.g., water flows, slopes, soils, infrastructure, impervious cover, NPS sites, septic systems. BRWD's water quality monitoring program also will be reevaluated and revised as needed to ensure data collected are timely and meaningful.

Goal 4 - Improve local watershed ordinances and management systems to prevent new contaminant inputs: Local ordinances should reflect the best available scientific information if watersheds and water quality are to be protected. The Town of Boothbay Planning Board plans to update and revise watershed ordinances to better address both point and nonpoint sources of contaminants and best available information. BRWD and the Town will also develop a watershed monitoring plan for NPS and point source pollution threats.

Goal 5 - Acquire key watershed areas for long-term conservation: BRWD holds about 100 acres in the Adams Pond watershed and 16 acres in the Knickerbocker Lake watershed for both water treatment and watershed conservation. If water quality is to be preserved, BRWD should develop a watershed land conservation program with local partners.

4. Schedule and Milestones to Guide Plan Implementation

A. Action Plan and Schedule

Action items, an estimated schedule and milestones were developed to prevent new NPS problems and address existing NPS sites with the highest impact and phosphorus loading to Adams Pond and Knickerbocker Lake. The number and types of sites targeted in the plan was based on local knowledge about potential funding sources, landowner cooperation and other considerations. The plan is designed to be implemented over a ten year period, and an estimated schedule is provided for each action (Table 2).

This watershed protection plan envisions a local watershed program funded and directed primarily by BRWD, in consultation and coordination with the Town of Boothbay, DEP, DWP, KLSWCD, local community organizations, property owners and the community at large. BRWD will be primarily responsible for plan implementation and coordination and will commit funds and resources to ensure that the actions proposed in this plan are completed. Although this plan anticipates significant local funding, it is less likely to achieve its goals, particularly remediating major NPS sites, without state and federal financial support via the EPA 319 grant program, the DWP Source Water Protection grant program and other grant programs. Potential funding sources and key partners were identified for each action (Table 3).

Table 2. Implementation Schedule.

Action Items	Time frame
Engage local partners for watershed protection/monitoring Obtain DWP Source Water Protection grant for education/outreach Complete watershed survey, watershed report, and pre and post survey outreach to property owners Watershed survey data collected in GIS Develop watershed education/outreach programs Ensure watershed conservation is included in Boothbay comprehensive plan update Contract with Wright Pierce for watershed GIS development Contract with Dirigo Engineering to develop NPS plans Continue water quality monitoring Contract with forester for Adams Pond forest management plan	2014 - Completed
Continue education/outreach programs Complete and submit Watershed Protection Plan Apply for EPA Section 319 CWA funds to address major NPS sites identified in survey (June 2015) Continue to develop watershed GIS and collect watershed data Apply for DWP SWP grant (March 2015) Implement small grant program to help private property owners to address NPS sites Develop watershed land conservation policy and acquisition criteria Continue water quality monitoring Conduct stream corridor surveys; infrastructure surveys	2015-2016
If funded, implement structural BMPs to remediate major NPS sites in watershed. Track remediation project with GIS. Work with Boothbay Planning Board to revise and enact watershed ordinances Summarize water quality data and evaluate water quality monitoring program Continue education/outreach programs Seek grant/loan opportunities for land acquisition Develop and implement monitoring plan for NPS and point source pollution in watershed	2015-2025

Table 3. Action Items and Milestones	Schedule	Who	Potential Funding
Goal 1: Reduce phosphorus loading by addressing existing NPS sites			
A. Install BMPs at high and medium impact sites			
Town Roads - 14 sites	2015-2020	TOWN/BRWD	EPA 319
Shore Access sites- 4 sites	2015-2020	BRWD/TOWN	EPA 319
Private Road - 1 site	2015-2020	BRWD/Private	EPA 319
Driveway - 2 sites	2015-2020	BRWD/Private	EPA 319
Municipal/BRWD property - 2 sites	2015-2020	BRWD/TOWN	EPA 319
Residential - 2 sites	2015-2020	BRWD/Private	EPA 319
B. Offer financial and technical assistance for BMP installation on private property	2015-2020	BRWD	BRWD
Driveway - 2 sites	2015-2018	BRWD	BRWD
Private Road - 2 sites	2015-2018	BRWD	BRWD
Shore Access - 1 site	2015-2018	BRWD	BRWD
Trail - 2 sites	2015-2018	BRWD	BRWD
Residential - 6 sites	2015-2018	BRWD	BRWD

Table 3. Action Items and Milestones	Schedule	Who	Potential Funding
C. Apply for EPA Section 319 Clean Water Act grant through MDEP to address major NPS sites	2015	BRWD/Partners	BRWD
D. Apply for DWP Source Water Protection grant to support cost sharing	2015	BRWD	BRWD
E. Improve relationship with ME DOT regarding state road maintenance in watershed	2016	BRWD/TOWN	
Goal 2: Increase community support for watershed protection			
Prepare and issue press releases/reports/newsletters and direct outreach to property owners on watershed surveys and other watershed activities	Ongoing	BRWD	BRWD
Produce outreach brochures to guide lake-friendly private property development in watershed	2015	BRWD/KLSWCD	DWP
Produce watershed educational videos for public access TV and social media	2015	BRWD/BRCTV	DWP
Install kiosk and signage at Knickerbocker Lake public access for outreach/education	2015	BRWD	DWP
Support and conduct watershed-related education projects with local high and middle school students	Ongoing	BRWD	BRWD
Hold annual watershed information meetings	Ongoing	KLA/WHPWA	
Goal 3: Improve information base for management			
Water quality monitoring - continue, expand and revise, as needed	Ongoing	BRWD	BRWD

Table 3. Action Items and Milestones	Schedule	Who	Potential Funding
Stream corridor, invasive aquatic plants, infrastructure surveys	2015-2017	BRWD	BRWD
Develop GIS to track watershed data, both natural and manmade features	2014--2016	BRWD	BRWD
Create, maintain and update watershed GIS	Ongoing	BRWD	BRWD
Assess success of 319 BMP installation and NPS remediation, if funded	2019-2025		BRWD
Goal 4: Reduce potential for future NPS and point source pollution sites			
Revise local ordinances to reflect best scientific information on watershed, BMPs, and LID techniques	2016-2020	TOWN/BRWD	TOWN
Ensure town road maintenance uses BMPs in watershed	Ongoing	TOWN	TOWN
Maintain Knickerbocker Lake public access site to reduce NPS and point source pollution; define and maintain public access to Adams Pond.	Ongoing	TOWN/BRWD	TOWN
Continue public education and financial assistance for lake friendly development	Ongoing	BRWD	BRWD
Develop monitoring program for potential point sources, e.g., septic, oil	2016-2019	TOWN/BRWD	BRWD
Use GIS to track changes in watershed over time and assess need for additional management actions	Ongoing	BRWD	BRWD
Offer Lake Smart assessments/financial assistance for property owners	2016-2025	BRWD/KLSWCD	BRWD
Goal 5: Protect key areas of watershed from development			

Table 3. Action Items and Milestones	Schedule	Who	Potential Funding
Develop watershed land conservation policy and prioritization criteria	2015-2017	BRWD	BRWD
Purchase priority land for conservation, as it becomes available	Ongoing	BRWD	BRWD/ DWP
Develop management and public access plan for land held for conservation	2017-2019	BRWD	BRWD
Update and revise local ordinances as needed.	Ongoing	TOWNS	TOWNS

B. Plan Oversight and Partner Roles

The plan envisions a community-led protection effort coordinated by the BRWD. A steering committee comprised of the BRWD, local towns, KLSWCD and community organizations will provide oversight and direction. Other specific roles are defined below:

BRWD will take the lead on gathering watershed and water quality data and on developing a watershed GIS, watershed reports, grant applications, and outreach/education programs. BRWD will coordinate watershed plan actions and ensure partners and the community are informed of watershed-related developments. BRWD will address NPS sites on its own property and will provide financial and technical assistance to accomplish NPS remediation at other sites. BRWD will provide oversight of any NPS grant that may be obtained.

Town of Boothbay will work to address NPS problems and ensure maintenance of town property and town roads uses BMPs. The Town Planning Board will update watershed ordinances to incorporate the best scientific information.

Town of Boothbay Harbor will work to address watershed NPS problems and ensure maintenance of town roads within the watershed use BMPs.

Town of Southport will serve as a community partner and may provide support for specific projects.

KLSWCD will provide technical assistance to BRWD and to watershed property owners for NPS remediation and lake-friendly solutions. KLSWCD will also develop education and outreach materials.

Boothbay Region YMCA will work to address NPS sites on its property and will conduct watershed education programs at their youth camp at Knickerbocker Lake.

Knickerbocker Lake Association and West Harbor Pond Watershed Association will assist with outreach and education programs, communication with property owners and on specific projects.

Boothbay Region Land Trust will serve as a community partner and may assist with land conservation within the watershed.

MDEP will provide technical assistance on all aspects of watershed management and will provide the opportunity for financial assistance through the 319 NPS grants program.

DWP may provide financial assistance through its Source Water Protection Grant Program and through its Land Acquisition Loan Program.

EPA may provide funds through the CWA 319 NPS grants program.

C. Plan Outputs and Milestones

Organizational Outputs

- BRWD applies for DWP Source Water Protection grant
- BRWD applies for 319 grant for Phase I project
- NPS Tracker created, maintained, and used to prompt maintenance
- Contact made with all property owners and/or road associations with medium to high priority NPS sites identified in watershed survey
- Kiosk and signage installed at Knickerbocker Lake public access/watershed
- Stream Corridor, invasive aquatic plants, and infrastructure surveys completed

NPS Mitigation Outputs

- Number of NPS sites fixed by landowners through private funding
- Number of NPS sites fixed with cost sharing assistance
- Number of technical assistance visits
- Estimated pollutant load reductions achieved by installed BMPs

Water Quality Outcomes

- Meets lake GPA standards in MDEP's biennial 303d reports
- Stable or improved trend for lake water clarity and dissolved oxygen

5. Proposed Management Measures

The Adams Pond and Knickerbocker Lake Watershed Survey Report (Appendix A) recommends management measures and individual actions needed to ensure watershed and water quality protection. Tables 2 and 3 of this plan outline management actions that have been begun or are planned to reduce the threat of existing pollution sources and to minimize the likelihood of future sources.

This plan proposes both structural BMPS and non-structural BMPS to address the NPS pollution threat in the watershed. The structural BMPs proposed in this plan are intended to achieve the goal of reducing phosphorus and sediment input to the waterbodies by stabilizing culverts and bare soils and by installing structures and vegetated buffers to divert, filter and/or allow runoff to infiltrate before reaching the lake. Non-structural BMPs include public education and outreach programs, data collection and monitoring activities, ordinance revision and financial and technical assistance. Both structural and non-structural solutions are essential to the success of the overall plan.

BRWD's watershed GIS will be used to track NPS sites, site remediation and pollutant load estimates. Maintenance of installed BMPs is crucial to the plan's success. BRWD will work with the Town of Boothbay and private landowners to ensure required maintenance is accomplished and will

dedicate funds and staff to this effort. BRWD staff and the Boothbay CEO (position partly funded by BRWD) will assess the status of installed BMPs annually.

Common problems observed in the watershed survey and structural recommendations to address these are outlined below. The plan's success in remediating the major sites identified below is dependent upon financial assistance from grant programs, such as the 319 NPS remediation grant program.

The Adams Pond and Knickerbocker Lake watershed survey categorized NPS sites by land use, potential impact, the types of NPS problems found, and the BMPs recommended to fix problem sites (Appendix B).

A. Town Roads

The watershed survey identified 15 NPS sites associated with town roads, four of these were high impact, nine medium impact and two low impact. Some of these sites were associated with road culverts and had significant downstream effects on shorefront properties. Addressing road-associated NPS sites is key to the plan's success.

Common NPS road problems were unstable culverts, surface and road shoulder erosion, ditch erosion and clogged culverts and plunge pools. Recommendations to address these sites include armoring culverts, armoring and reshaping ditches, installing plunge pools and vegetating road shoulders. The plan proposes to address all the town road NPS sites identified in the survey and will include 14 of these sites in a 319 NPS grant application. The one town road site not to be included in the 319 grant application can be addressed by low cost measures.

B. Residential

The survey found nine NPS sites associated with residences. Two were high impact, four medium impact and three were low impact. Common problems observed were surface and ditch erosion, bare soils, shoreline erosion and roof runoff erosion. Recommendations proposed to address these include installing runoff diverters, defining foot paths, vegetating or mulching bare soils and creating buffers. The plan proposes to remediate one high impact and one medium impact residential NPS site as part of the 319 grant process. BRWD will provide financial and technical assistance to encourage homeowners to address three medium and three low impact sites. The remaining high impact site was due to construction without proper use of BMPs and has been addressed.

C. Shore Access

The survey identified six NPS sites associated with shore access, one high impact, two medium impact and three low impact sites. Common problems observed were surface and road shoulder erosion, erosion and bare soil related to foot traffic and poorly defined parking areas and ditch erosion. Recommendations to fix these sites include stabilizing foot paths, defining parking areas,

applying erosion control mulch and installing runoff diverters The plan proposes to include BMP installation at four of these sites in a 319 grant application, to address one site directly (on BRWD property) and to offer financial and technical assistance to one private landowner to address the remaining shore access site.

D. State Roads

Five NPS sites were associated with state roads, two medium impact and three low impact. Common problems observed were ditch erosion, road shoulder and surface erosion and unstable culverts. Recommendations to address these include armoring culverts, ditches and shoulders and installing a plunge pool. The plan proposes to install structural BMPs at one medium impact site associated with a state road on BRWD property along Adams Pond shoreline. The other sites associated with state roads were determined to be not as significant (farther from water bodies) and more difficult to correct when considering cost and Maine Department of Transportation's priorities.

E. Driveways

Four NPS sites were associated with residential driveways: two of these were high impact and two medium impact. Surface and shoulder erosion were the problems observed at each driveway site. Recommendations to fix these include installing runoff diverters and turnouts and adding new surface material. The plan proposes to address two of these sites directly as part of a 319 grant application (one is on BRWD property and the other is impacting downslope properties) and to offer financial and technical assistance to property owners to address the other two.

F. Private Roads

Private roads accounted for four NPS sites, two high impact and two medium impact. Common problems observed were surface and shoulder erosion, a clogged culvert and bare soil. Recommendations to address these include reshaping roads, adding surface material, installing runoff diverters and culverts. The plan proposes to include BMP installation at one high impact site associated with the YMCA camp in its 319 grant application and to offer financial and technical assistance to private landowners to address two other sites. A clogged culvert associated with a fourth site has been addressed.

G. Commercial

Two commercial sites were associated with NPS sites, both designated as medium impact. Parking lot drainage was a common problem in both cases. In one, sediment from the parking lot overwhelmed small central collection points. In the second, parking lot drainage is causing severe ditch erosion. The plan proposes outreach and technical assistance to encourage property owners to address NPS problems at these two sites.

H. Trails

Trails were associated with two NPS sites, both medium impact. Problems observed were a crushed culvert, surface erosion and bare soil. Recommendations to address these include replace culvert, stabilize path, install runoff diverter and seed bare soil. The plan proposes to offer financial and technical assistance to address one of these sites and outreach to address the other, where only seeding was recommended.

I. Municipal

One high impact municipal site, characterized by surface erosion and an unstable culvert, was identified in the survey. Armoring of the culvert with redirection of parking lot runoff was recommended. Remediation of this site will be included in the 319 grant application.

J. Non-structural BMPs

Non-structural BMPs are essential to the success of this plan and are outlined in Table 3, Goals 2-5. A primary goal of this plan is to raise community awareness of the connection between human activities and water quality. BRWD will work with community partners to increase public support for watershed protection through public education and outreach programs (watershed brochure, video, press releases, lakescaping project, watershed signs, public access kiosk and outreach, school education projects and public meetings).

BRWD will also continue water quality monitoring and will conduct new surveys within the watershed to better identify stream and tributary corridors, wetland habitats, invasive aquatic plants, water flows and potential human impacts. Watershed GIS is being developed to aid in watershed understanding, as well as, local management and monitoring programs.

Updating local ordinances to ensure best scientific information is used in local development decisions is another non-structural BMP included in this plan. The Town of Boothbay, in collaboration, with BRWD will update and revise local watershed protection ordinances to incorporate best available information on BMPs and the watershed.

BRWD has protected about 100 acres within the Adams Pond watershed and 16 acres in the Knickerbocker Lake watershed. BRWD's land acquisition program for watershed/water quality protection is another key non-structural BMP. BRWD will develop a land acquisition policy, prioritization matrix for acquisition and begin outreach to landowners regarding conservation/protection strategies. Funds for land acquisition are set aside annually in the BRWD budget.

6. Pollutant Load Reductions

Pollutant load estimates, using EPA/DEP approved methods, were made for many of the NPS sites identified in the watershed survey in July 2014 with DEP assistance (Appendix C). Additional sites may be assessed in 2015. These estimates will be provided to DEP as a measure of success for any BMPs installed through a 319 grant.

7. Water Quality Results Monitoring

The goal of the watershed protection plan is to maintain or improve water quality conditions in Adams Pond and Knickerbocker Lake. BRWD will continue to monitor Adams Pond and Knickerbocker Lake water quality both to meet water treatment needs and to assess water quality trends. The need to revise and expand water quality monitoring will be assessed as part of the watershed protection plan.

BRWD samples the following parameters from early June through September at one site near the water intake in each pond: Chlorophyll-a, total phosphorus, dissolved oxygen, temperature, pH, iron, manganese, conductivity and color. Chlorophyll-a and total phosphorus levels are sampled once monthly in both water bodies. Two water samples, a 12' deep grab and a 12' water column sample, are collected and analyzed at the Maine Health and Environmental Testing Lab for each parameter. Dissolved oxygen and temperature depth profiles are collected every two weeks in each water body. BRWD also assesses Secchi disk transparency depth and pH, iron, manganese, conductivity and color at four depths (one near surface, two mid depth and one near bottom) twice monthly.

Because of concerns that old nearshore, septic systems may be affecting Knickerbocker Lake, BRWD collects waters samples for E.coli once weekly at 12 sites in Knickerbocker Lake, from late July through August. BRWD also tracks drinking water withdrawals, lake water levels and precipitation daily - year round at Adams Pond and from late April to late November at Knickerbocker Lake.

Data collected are provided to the Volunteer Lake Monitoring Program. MDEP assesses water quality trend data as part of their Water Quality Monitoring and Assessment report. Water quality data and DEP analyses will provide a quantitative assessment of the plan's ability to meet its goal of maintaining or improving water quality over time.

Appendix B. NPS sites identified during June 2014 survey of Adams Pond and Knickerbocker Lake watersheds by land use, type of problems, recommendations to fix, and impact rating. Sites tentatively planned for inclusion in 319 grant application noted with an *; sites where BRWD plans to offer small grants marked with ^.

Site	Land use	Type of Problem	Recommendations	Impact
1.13*	Municipal	Severe surface erosion; unstable culvert; moderate road shoulder erosion	Armor culvert	High
1.18*	Residential	Severe ditch erosion	Engineering design TBD	High
2.01	Residential	Severe construction related surface erosion	Cover soil piles; establish buffer; BMPs	High
2.03*	Beach access	Moderate surface erosion from roadway and parking; unstable culvert inlet	Armor culvert, define parking area, crown road and install runoff diverter	High
2.07*	Town Road	Severe surface erosion; bare soil	Install plunge pool; install runoff diverters, rain garden and buffer	High
2.08^	Driveway	Severe surface erosion	Add new surface material; install runoff diverter	High
2.09^	Driveway	Moderate surface erosion	Add new surface material; install runoff diverter, catch basin; define parking	High
2.13*	Town Road	Unstable, clogged, undersized culvert; severe ditch erosion; moderate shoulder erosion	Armor culvert outlet; remove clog; enlarge, lengthen; vegetate shoulder	High
3.02^	Private road	Moderate surface and road shoulder erosion; inadequate shoreline vegetation	Add new surface material; crown road and vegetate shoulder; install runoff diverter, rain garden and buffer	High
3.05*	Private road	Severe surface and road shoulder erosion	Install culvert, reshape ditch, install ditch, check dams, build up and reshape road	High
4.7*	Town Road	Moderate surface erosion, ditch erosion	Armor culvert outlet, plunge pools	High

4.8*	Town Road	Moderate surface erosion, severe ditch erosion, unstable inlet culvert	Armor culvert, plunge pools	High
1.02*	Town Road	Moderate road shoulder erosion; winter sand; lack of shoreline vegetation	Install larger riprap, sand collection berm, remove winter sand	Med
1.03*	Shore Access	Moderate surface and road shoulder erosion; lack of shoreline vegetation and shore erosion; bare soil	Timber retainment at edge of parking area; remove roadside berm to south	Med
1.04*	Town Road	Moderate surface erosion; clogged, undersized culvert; ditch bank failure, bare soil	Remove clog; armor ditch back slope with stone or erosion control mix (ECM)	Med
1.07*	Residential	Moderate surface erosion from steep slope runoff	Install plunge pool	Med
1.08*	Driveway	Moderate surface and road shoulder erosion	Remove grader/plow berm; add gravel to shoulder; install runoff diverter	Med
1.09*	Town Road	Moderate surface and road shoulder erosion; bare soil	armor ditch shoulder with stone	Med
1.10*	Town Road	Moderate surface and road shoulder erosion; unstable culvert	Armor culvert; install turnouts, add gravel	Med
1.11	Commercial	Severe surface erosion	Install catch basin	Med
1.16	State Road	Moderate ditch erosion; slight road shoulder erosion	Armor ditch with stone; vegetate shoulder	Med
1.17*	State Road	Unstable, undersized culvert; severe ditch erosion	Replace culvert with larger one; install plunge pool	Med
1.19	Commercial	Parking lot sediment drains to central storm drains	Enlarge catch basin and improve maintenance	Med

1.20	Town Road	Severe road shoulder erosion; uncovered soil pile	Cover soil pile or move; add gravel; use silt fence EC berms	Med
1.21*	Town Road	Severe road shoulder erosion	Vegetate shoulder; add material	Med
1.22*	Shore Access	Moderate surface and road shoulder erosion;	Install timber retaining wall; define foot path; mulch/ECM	Med
2.02^	Trail	Severe surface erosion; crushed culvert	Replace culvert; stabilize foot path, install runoff diverter	Med
2.06*	Town Road	Clogged, undersized culvert; moderate ditch erosion, moderate road shoulder erosion	Replace culvert with larger one; vegetate shoulder	Med
2.10*	Driveway	Moderate surface erosion	Install runoff diverters and turnouts	Med
2.11^	Residential	Moderate surface erosion	Define foot path/seating; infiltration steps, install runoff diverter, rain garden, buffer	Med
2.12*	Town Road	Unstable culvert; slight ditch erosion; culvert plunge pool filled	Armor culvert; install plunge pool; armor and reshape ditch, install turnouts	Med
3.03	Private road	Clogged culvert; bare soil	Remove clog; install sediment pools	Med
3.06^	Private road	Moderate surface erosion	Reshape road, install runoff diverters	Med
3.08^	Trail/Path	Moderate surface erosion; bare soil	Stabilize foot path; seed	Med
4.03^	Residential	Moderate surface & shoreline erosion; bare soil	Mulch/ECM; add to buffer	Med
4.05^	Residential	Moderate surface erosion; bare soil; roof runoff erosion	Install runoff diverters; infiltration trench at dripline; mulch/ECM; add to buffer	Med
4.06*	Town Road	Moderate road shoulder erosion; unstable culvert	Armor culvert; vegetate shoulder	Med
1.01*	Shore Access	Moderate surface erosion; bare soil; shoreline erosion and unstable access	Stabilize foot path	Low

1.05*	Town Road	Moderate surface and road shoulder erosion; lack of shoreline vegetation and shore erosion; bare soil; undercut shoreline	Remove grader/plow berm; vegetate shoulder	Low
1.12	State Road	Moderate surface and road shoulder erosion; unstable outlet culvert, bare soil	Armor culvert and shoulder	Low
1.14	State Road	Surface and ditch erosion; ditch bank failure; moderate road shoulder erosion	Armor ditch with stone	Low
1.15	State Road	Slight road shoulder erosion; parking lot runoff direct to drain	Add new surface material; vegetate shoulder, install rain garden	Low
2.04^	Residential	Slight surface erosion; lack of shoreline vegetation and unstable access	Stabilize foot path; establish buffer; install ramp and mulch path	Low
2.14	Shore Access	Slight surface erosion	Stabilize foot path; mulch	Low
3.07^	Shore Access	Undersized culvert; moderate ditch erosion	Armor ditch with stone; reshape ditch; install check dams, runoff diverter	Low
4.01*	Town Road	Slight surface, ditch and shoulder erosion; clogged, crushed outlet culvert	Remove clog; armor ditch with stone and remove debris; reshape road crown	Low
4.02^	Residential	Slight surface erosion; inadequate shoreline vegetation and bare soil	Mulch/ECM; establish buffer	Low
4.04^	Residential	Moderate surface erosion, shoreline: undercut, inadequate vegetation and erosion	Install runoff diverter at top of driveway, add to shoreline buffer	Low

Appendix C. Pollutant load estimates for certain 2014 watershed survey NPS sites. Data collected July 2014 with DEP Technical Assistance.

Adams Pond

Site	**Soil loss (tons /year)**	**Phosphorus (lbs/year)**	**Estimate method**
1.13	0.16	0.14	Region 5 Gully Erosion
1.03	1.58	1.35	Region 5 Gully Erosion
1.17	0.41	0.35	Region 5 Gully Erosion
1.07	1.65	1.41	Region 5 Gully Erosion
1.21	0.17	0.14	Region 5 Gully Erosion
1.22	1.27	1.08	Region 5 Gully Erosion
1.09	1.13	0.96	Region 5 Gully Erosion
1.20	1.06	0.91	Region 5 Gully Erosion
1.09W	0.30	0.26	Region 5 Gully Erosion
1.10	0.64	0.55	Region 5 Gully Erosion
1.10	0.06	0.05	Region 5 Gully Erosion
1.18	1.24	1.05	Region 5 Roadbank Erosion
1.13	0.67	0.57	Region 5 Roadbank Erosion
1.04	0.63	0.54	Region 5 Roadbank Erosion
1.17	1.22	1.05	Region 5 Roadbank Erosion
1.07	0.13	0.11	WEPP
Total	12.20	10.4	

Knickerbocker Lake

Site	Soil loss (tons /year)	Phosphorus (lbs/year)	Estimate method
2-13	0.15	0.13	Region 5 Gully Erosion
2-13	0.04	0.04	Region 5 Gully Erosion
2-7	0.30	0.26	Region 5 Gully Erosion
2-7	0.29	0.24	Region 5 Gully Erosion
2-9	0.23	0.19	Region 5 Gully Erosion
3-5	0.05	0.04	Region 5 Gully Erosion
3-5	0.03	0.02	Region 5 Gully Erosion
3-5	0.03	0.02	Region 5 Gully Erosion
3.8	0.05	0.04	Region 5 Gully Erosion
4.1	0.58	0.49	Region 5 Gully Erosion
4.1	0.19	0.16	Region 5 Gully Erosion
4.6	1.49	1.26	Region 5 Gully Erosion
2.8	0.26	0.22	WEPP
2.9	0.09	0.08	WEPP
3.2	0.15	0.13	WEPP
2.3	0.03	0.03	WEPP
2.3	0.49	0.42	WEPP
2.10	0.16	0.14	WEPP
Total	4.59	3.92	