Lake Wentworth and Crescent Lake Watershed Management Plan

Appendices

In Partnership with:

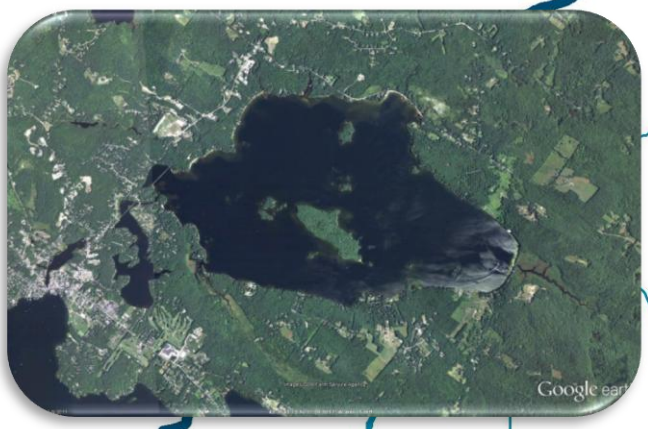
December 2012

Appendices

Appendices (continued)

Appendix A:
Lake Fact Sheets

LAKE FACT SHEET



WATERSHED SUMMARY

Within the Lakes Region of east central New Hampshire, the 35.6 square mile Lake Wentworth and Crescent Lake watershed is located in the towns of Wolfeboro (86.1%), Brookfield (11.3%), and Ossipee (0.3%), in Carroll County, and New Durham (2.3%) in Strafford Counties. Lake Wentworth and Crescent Lake, at 534 ft above sea level, are encompassed by mountainous woodlands in all directions, topped at 1,868 feet above sea level by Copple Crown Mountain south of Lake Wentworth (NHDES, 1999). On a clear day, residents can enjoy the ghostly blue silhouettes of the Belknap Mountains to the south and the Ossipee Mountains to the north (Bowman, 1996). The area experiences moderate rainfall and snowfall, averaging 40.6 inches of precipitation annually. Temperature ranges from minus 35 °F to 102 °F with an average of 20.6 °F in January and 70 °F in July (U.S. National Weather Service, 2011). The growing season extends from May to September over a 120 day period. Winter extends from December to March with ice-out in mid-April to early May (Bowman, 1996).

The watershed is dominated by forestland, covering 83.3% of the land area, and helps protect critical headwater streams in the northern half of the watershed. Development accounts for 6.6% of the watershed, while wetlands and open water (not including the surface areas of Lake Wentworth and Crescent Lake) represent 6.7% of the watershed, a decrease from 17% within the last ten years. Agriculture has increased from 0.3% to 3.3%, and includes cover crops, row crops, pastures, and hayfields. A recent water quality analysis may suggest that new development of residential, commercial, and agricultural land may be affecting the quality of wetlands, lakes and ponds in the watershed

Population

From 2000 to 2010, the populations of Wolfeboro, Brookfield, Ossipee, and New Durham increased by 3.1%, 17.9%, 3.2%, and 18.8%, respectively (NHOEP, 2011). The increase in retirement age seasonal residents in Wolfeboro has led to a seasonal population that is more than double the year-round population. The desirability of Lake Wentworth and Crescent Lake as a recreational destination will likely stimulate continued population growth in the future.

Invasive Species

Variable milfoil (*Myriophyllum heterophyllum*) arrived in Lake Winnipesaukee in 1979, and found its way to Mast Landing at Crescent Lake the following year. In 1991, milfoil was discovered between Allen Albee Beach and Hersey (Tyler) Brook in Lake Wentworth. A NH DES plant survey in 2006 found milfoil common in Heath Brook, Hersey Brook, and Willey Brook tributary coves in Lake Wentworth. Continuing to monitor and control this invasive aquatic plant will help preserve the high quality water in Lake Wentworth and Crescent Lake.

WATER QUALITY

The New Hampshire Volunteer Lake Assessment Program (VLAP) and the New Hampshire Lakes Lay Monitoring Program (LLMP) are the two primary volunteer groups collecting water quality data on lakes in New Hampshire.

Historical water quality monitoring data for Lake Wentworth and Crescent Lake was analyzed to determine long-term trends, in-lake phosphorus levels, and the ability of the lake to resist the effects of increasing levels of pollutants. A watershed model, known as the Lake Loading Response Model (LLRM), was used to develop a water and phosphorus loading budget for the lakes and their tributaries.

In August 2012, the Lake Wentworth Watershed Steering Committee set a water quality goal that would reduce current in-lake total phosphorus (TP) concentrations by 15% in both Lake Wentworth and Crescent Lake. Although Lake Wentworth is within acceptable in-lake TP levels, discharge from Lake Wentworth accounts for 96% of incoming water and 71% of incoming TP loading to Crescent Lake. Consequently, Crescent Lake median P concentrations can be improved only through a reduction in median TP concentrations in Lake Wentworth.

LAKE FACT SHEET

Watershed: Merrimack River
Watershed Towns: Wolfeboro, Brookfield, New Durham, Ossipee
Counties: Carroll, Strafford
State: New Hampshire
Watershed Area: 35.6 acres (14 ha)
Surface Area: 3,018 acres (1,221 ha)
Perimeter: 73,819 ft (22,500 m)
Volume: 73,997,266 m^3
Mean Depth: 21 ft (6.4 m)
Max Depth: 83 ft (25.3 m)
Mean Transparency: 22 ft **(**6.7 m)
Flushing Rate: 0.74 flushes/yr
Drains to: Crescent Lake, Lake Winnipesaukee
Classification: Oligotrophic, Dimictic
Ranking: 9th largest lake in New Hampshire
Watershed Groups: LWA, LWF

LAKE WENTWORTH

Lake Wentworth is nearly four miles long from east to west and 2.5 miles wide from north to south. The average depth is 21 feet (6.4 m) and maximum depth is 83 feet (25.3 m). The surface area of Lake Wentworth is approximately 3,018 acres (1,221 ha) (not including the islands), while the total watershed area is 35.6 square miles (22,784 acres). There are 13 miles of shoreline and 73,997,266 cubic meters of water volume in Lake. The areal water load (the volume of water entering the lake annually, divided by the lake's surface area) is 3.45 m/yr, and the lake water volume flushes completely every other year). Lake Wentworth is also influenced by 19 islands scattered throughout the waterbody, including eight currently inhabited islands (Bass, Cate, Loon, Mink, Poplar, Sister, Trigg's, and Turtle), two previously inhabited islands (Brummitt and Stamp Act), seven uninhabited islands (Flo, Goose, Joe, two Jockey Caps, Min, and Wal), and two unnamed islands with unknown human impact.

Fourteen streams drain directly into Lake Wentworth: Fernald Brook, Heath Brook, Harvey Brook, Hersey (Tyler) Brook, Willey Brook, Warren Brook, Ryefield Brook, Breezy Brook, Claypit Brook, Frost Brook, Townsend Brook East and West, Whitton (Morrill) Brook, and Red Brook (Appendix C). Lily Brook was transformed into a bog in the early 1940's through the construction of the state park. Hersey Brook is the outlet for Sargent's Pond, and Willey Brook (the largest subwatershed) is the outlet for Batson's Pond. Warren, Ryefield, and Heath Brooks are deep enough for small watercraft navigation.

These inlet streams account for 76% of the water and 56% of the phosphorus load entering Lake Wentworth, which makes these tributaries and their associated direct land use critical to the water quality of Lake Wentworth, and ultimately Crescent Lake. It is estimated that discharge from Lake Wentworth accounts for 96% of the water load and 68% of the phosphorus load to Crescent Lake. As a result, improvements in the water quality of Lake Wentworth will be the main means by which Crescent Lake's water quality will be improved.

WATER QUALITY

Water quality data has been collected at three in-lake locations known as Fuller's (Station 1-deep hole), Governor's (Station 12), and Trigg's (Station 2), as well as at the Smith River where Lake Wentworth flows into Crescent Lake. Water quality monitoring data for Lake Wentworth has been collected since 1975. This includes 29 years of secchi disk transparencies, 26 years of phosphorus data (including 19 years of epicore samples), 29 years of chlorophyll-a data, 22 years of color data, and seven years of dissolved oxygen profiles.

NHDES's most recent (2006) trophic state index (TSI) determination numerically scored the trophic state of Lake Wentworth as 4 (Oligotrophic), and considers the water quality of Lake Wentworth to be high based on measures of Secchi disk transparency (SDT), aquatic plant abundance, and chlorophyll-a (Chl-a). The Assimilative Capacity Analysis demonstrates that Lake Wentworth is a Tier 2 or High Quality Water because the median water quality value for total phosphorus is 6.7 ppb. However, Lake Wentworth is also listed as impaired for pH (less than the minimum standard of 6.5) and the presence of exotic milfoil (variable milfoil) in the bays near Heath, Hersey, and Willey Brooks.

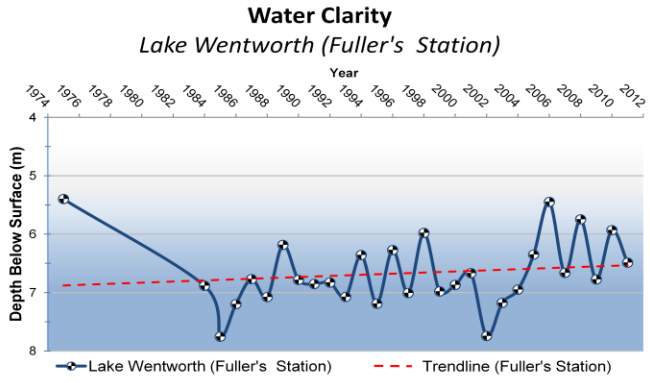
LAKE FACT SHEET

WATER QUALITY TRENDS FOR LAKE WENTWORTH

Mean Annual Sampling Results 1975 - 2011

Lake	Station	Mean Annual Secchi (m)	Mean Annual Chl-a (ppb)	Mean Annual Color (CPU)	Median TP (1986-2011) Median TP (ppb)	Historical (1986-2001) Median TP (ppb)	Recent (2002-2011) Median TP (ppb)
Lake Wentworth	1 - Fullers	*6.7	*1.9	*13.9	6.5	6.4	*6.7
Lake Wentworth	12 - Governors	*6.8	1.9	14.8	6.2	6.5	6.2
Lake Wentworth	2 - Triggs	6.8	*1.7	14.8	6.2	6.6	6.1
Lake Wentworth	1 & 12 Combined	--	--	--	--	6.5	*6.7

**Indicates trend toward declining water quality over time.*



Chlorophyll-a

Chlorophyll-a (Chl-a) is a measurement of the green pigment found in all plants, including microscopic plants such as algae. It is used as an estimate of algal biomass as higher Chl-a equates to greater amount of algae in a lake. Chl-a has ranged from 0.4 to 12.6 ppb with an annual mean of 1.9 ppb at Station 1 – Fuller's. Both Station 1 – Fuller's and Station 2 – Trigg's indicate declining trends (increasing Chl-a) in Chl-a over time. In general, mean annual Chl-a at all stations has remained below 3 ppb, with the exception of Station 2 – Trigg's in 2009.

Color

Color is the influence of suspended and dissolved particles in the water as measured by Chloroplatinate Units (CPU). A variety of sources contribute to the types and amount of suspended material in lake water, including weathered geologic material, vegetation cover, and land-use activity. Color has ranged from 7.7 to 32.6 CPU with an annual mean of 13.9 CPU at Station 1 – Fuller's. Color trends at Station 1 – Fuller's, has increased in color over time. Station 12 – Governor's and Station 2 – Trigg's are slightly more colored at 14.8 CPU, but trends indicate a slight reduction in mean annual color over time.

Water Clarity

Secchi disk transparency (SDT) is a vertical measure of water transparency (the ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Factors that influence transparency include algal growth, water color, or the amount of dissolved or particulate materials in a lake, potentially resulting from human disturbance. SDT readings have been conducted since 1975 at Station 1 – Fuller's and since 1987 at Station 12 – Governor's and Station 2 – Trigg's. Trends in water clarity in Lake Wentworth have shown a slight decline since 2002 with mean annual SDT between 6.7 - 6.8 m for the three stations.

Dissolved Oxygen

DO is the concentration of oxygen dissolved in the water, and is vital to fish, algae, macrophytes, and chemical reactions that support lake functioning. DO levels below 5 parts per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species. Recent DO profiles show DO depletion in deep areas of the lake starting at 40 feet (12 m). Low DO at the bottom of the lake is of particular concern because it can result in the release of phosphorus from bottom sediments, leading to increased algal production.

Total Phosphorus

Phosphorus is an essential element for plant growth, yet it is found in limited amounts in lake systems. Therefore, small increases in phosphorus can lead to substantial increases in algal growth. Total phosphorus (TP) has ranged from 3.2 to 11.5 ppb with a median of 6.5 ppb at Station 1 – Fuller's. Median TP at Station 12 – Governor's and Station 2 – Trigg's is 6.2 ppb. Recent TP results (2002-2011) have increased by 0.3 ppb at Station 1 – Fuller's compared to the historical period (1991-2001). In contrast, median TP at Station 12 – Governor's and Station 2 – Trigg's has decreased by 0.3 ppb and 0.5 ppb, respectively. The long-term goal for Lake Wentworth is to reduce in-lake phosphorus concentrations by 1 ppb, a 15% reduction that will ultimately improve conditions in Lake Wentworth and help achieve High Quality Water status once again for Crescent Lake.

LAKE FACT SHEET

Watershed: Merrimack River
Watershed Towns: Wolfeboro, Brookfield, New Durham, Ossipee
Counties: Carroll, Strafford
State: New Hampshire
Watershed Area: 35.6 acres (14 ha)
Surface Area: 148 acres (60 ha)
Perimeter: 20,013 ft (6,100 m)
Volume: 1,814,665 m^3
Mean Depth: 9.8 ft (3 m)
Max Depth: 21 ft (6.4 m)
Mean Transparency: 16.7 ft (5.1 m)
Flushing Rate: 31.27 flushes/yr
Drains to: Lake Winnipesaukee
Classification: Oligotrophic, Dimictic
Watershed Groups: Lake Wentworth Foundation, Lake Wentworth Association

CRESCENT LAKE

Crescent Lake is hydrologically connected to Lake Wentworth, by a narrow stream channel known as the Smith River. The surface area of Crescent Lake is 0.23 square miles (147 acres) with a mean depth of 9.9 feet (3 m) and maximum depth of 21 feet (6.4 m). There are 20,013 feet (6,100 m) of shoreline and 1,814,665 cubic meters of water volume in Crescent Lake. The areal water load (the volume of water entering the lake annually, divided by the lake's surface area) is 35.62 m/yr, and the lake water volume flushes 31 times each year. Approximately 13.2% of Crescent Lake is considered ponded as a result of the dam on the Smith River. Water from Lake Wentworth flows into Crescent Lake flows southwest via the lower Smith River into New Hampshire's largest waterbody, Lake Winnipesaukee.

There are minor drainages to Crescent Lake, including one from Kingswood High School and Middle School through the golf course and holding pond to the lake. Two streams flow through the golf course where steep slopes may be causing erosion during major rain storms. In addition, Crescent Lake is fed from a wetland behind the hospital that receives a large volume of stormwater from the South Main Street storm drains. The majority of water (96%) and phosphorus load (68%) entering Crescent Lake comes from Lake Wentworth via the Smith River. Recent watershed modeling estimates that 2.8 times more phosphorus enters Crescent Lake from Lake Wentworth than from the direct Crescent Lake watershed.

WATER QUALITY

Water quality monitoring data for Crescent Lake has been collected since 1984 at a single location known as Crescent Lake Center (Station 1 – deep hole). This includes 27 years of Secchi disk transparency readings, 22 years of phosphorus data, 27 years of chlorophyll-a data, 25 years of color data, and 7 years of dissolved oxygen profiles.

The NHDES's most recent (2002) trophic state index (TSI) determination numerically ranked the trophic state of Crescent Lake as 3 (Oligotrophic). NHDES considers the water quality of Crescent Lake to be high based on measures of SDT, aquatic plant abundance, and chlorophyll-a (Chl-a). The potential for nuisance algal blooms on Crescent Lake is therefore low. However, the presence of exotic milfoil (variable milfoil), first found in Crescent Lake at Mast Landing in 1980, continues to plague this lake. Herbicides have been used in combination with hand-pulling to help control this species. The goal for Crescent Lake is to improve existing water quality by reducing median phosphorus in-lake concentrations by 1.2 ppb (from 7.9 ppb to 6.7 ppb), so that Crescent Lake will meet New Hampshire's High Quality Water designation.


Photo: FBE

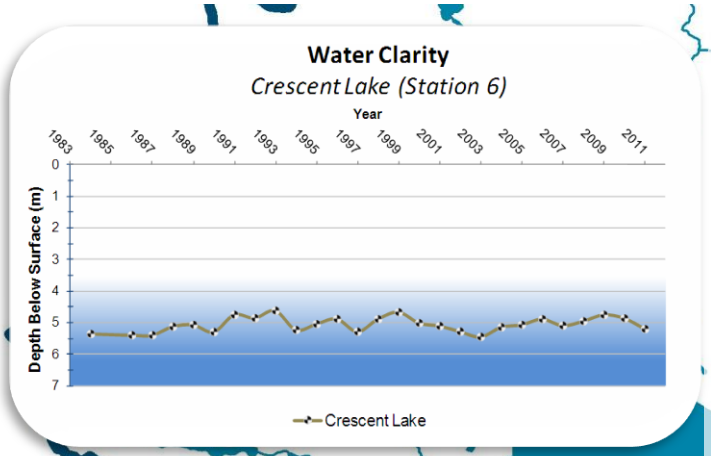
LAKE FACT SHEET

WATER QUALITY TRENDS FOR CRESCENT LAKE

Mean Annual Sampling Results 1984 - 2011

Lake	Station	Mean Annual Secchi (m)	Mean Annual Chl-a (ppb)	Mean Annual Color (CPU)	Median TP (ppb)	Historical (1986-2001) Median TP (ppb)	Recent (2002-2011) Median TP (ppb)
Crescent Lake	6 – Center	5.1	2.3	15.8	7.6	6.8	*7.9

**Indicates trend toward declining water quality over time.*



Chlorophyll-a

Chlorophyll-a (Chl-a) is a measurement of the green pigment found in all plants, including microscopic plants such as algae. It is used as an estimate of algal biomass as higher Chl-a equates to greater amount of algae in a lake. Chl-a ranged from 0.5 to 19.4 ppb with an annual mean of 2.3 ppb at Station 6 – Crescent. Mean annual Chl-a trends appear to be improving since 1984.

Color

Color is the influence of suspended and dissolved particles in the water as measured by Chloroplatinate Units (CPU). A variety of sources contribute to the types and amount of suspended material in lake water, including weathered geologic material, vegetation cover, and land use activity. Color ranges from 8.8 to 34.4 CPU with an annual mean of 15.8 CPU at Station 6 – Crescent. Mean annual color trends at Station 6 – Crescent appear to be decreasing slightly over time.

Water Clarity

Secchi disk transparency (SDT) is a vertical measure of water transparency (the ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Factors that influence transparency include algal growth, water color, or the amount of dissolved or particulate materials in a lake, potentially resulting from human disturbance. SDT readings have been conducted since 1984 at Station 6 – Crescent. Trends in water clarity in Crescent Lake have remained stable, ranging from 3.2 to 6.5 m with a mean annual SDT of 5.1 m (16.7 ft).

Dissolved Oxygen

DO is the concentration of oxygen dissolved in the water, and is vital to fish, algae, macrophytes, and chemical reactions that support lake functioning. DO levels below 5 parts per million (ppm) stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species. Recent DO profiles show little stratification and little to no DO depletion at depth. The majority of the profile ranges from 6 to 8 ppm in DO. Therefore, the potential for phosphorus to leave the bottom sediments and become available to algae (internal loading) is low in Crescent Lake.

Total Phosphorus

Phosphorus is an essential element for plant growth, yet it is found in limited amounts in lake systems. Therefore, small increases in phosphorus in lakes and streams can lead to substantial increases in algal growth. Total phosphorus (TP) in Crescent Lake has ranged from 1.1 to 20.7 ppb with a median of 7.6 ppb over the past ten years (2011-2011), representing a significant increase in the in-lake TP concentration from 6.8 ppb during the historical sampling period (1984-2001).

Phosphorus levels in Crescent Lake can be improved only through a reduction of phosphorus levels in Lake Wentworth. Yet, reductions in the direct watershed of Crescent Lake are also necessary for long-term water quality preservation.

Appendix B:
Site Specific Project Plan

SITE SPECIFIC PROJECT PLAN FOR:
DEVELOPMENT OF THE LAKE WENTWORTH/CRESCENT LAKE WATERSHED PLAN: PHASE 1
(NHDES Project # B-11-M-03)

Under the New Hampshire Section 319 Nonpoint Source Grant Program QAPP
RFA# 08262
October 17, 2008

Final Draft **(09/27/11)**

Prepared by:
FB Environmental Associates
97A Exchange Street, Suite 305
Portland, ME 04101

For Review:

Project Co-Manager: _____
Signature/Date
Robert Houseman, Town of Wolfeboro

Technical Project Manager: _____
Signature/Date
Forrest Bell, FBE

Task Manager/QA Officer: _____
Signature/Date
Jennifer Jespersen, FBE

Technical Engineer: _____
Signature/Date
Ben Lundsted, CEI

Modeling Support:
_____
Signature/Date
Don Kretchmer, LWF

NHDES Project Manager: _____

Signature/Date
Andy Chapman, NHDES

Program Quality Assurance Coordinator: _____

Signature/Date
Jillian E. McCarthy, NHDES

NHDES Quality Assurance Manager: _____

Signature/Date
Vincent Perelli, NHDES

For Receipt:

EPA Nonpoint Source Program Coordinator: _____

Signature/Date
Erik Beck, EPA Region 1

Table of Contents

Tables

Figures

1- Distribution List

Table 1 lists people who will receive copies of the approved Site Specific Project Plan (SSPP) under the *New Hampshire Section 319 Nonpoint Source Grant Program Quality Assurance Project Plan* dated October 17, 2008.

Table 1. SSPP Distribution List

SSPP Recipient Name	Project Role	Organization	Telephone number and e-mail address
Robert Houseman	Project Co-Manager	Town of Wolfeboro	wolftwnplnr@metrocast.net 603-569-5970
Jack O'Connell	Project Co-Manager	Lake Wentworth Foundation	jackoc1@myfairpoint.net 603-569-2278
Forrest Bell	Technical Project Manager	FB Environmental	info@fbenvironmental.com 207-221-6699
Jennifer Jespersen	Task Manager	FB Environmental	jenj@fbenvironmental.com 207-215-8506
Cayce Dalton	Technical Team-Land Use Modeling	FB Environmental	cayced@fbenvironmental.com 207-221-6699
Ben Lundsted	Project Engineer	Comprehensive Environmental, Inc.	blundsted@ceiengineers.com 800-725-2250 x 317
Rebecca Balke	Technical Engineer	Comprehensive Environmental, Inc.	rbalke@ceiengineers.com 800-725-2250
Don Kretchmer	Modeling Support	Lake Wentworth Foundation	dkretchmer@metrocast.net 603-569-3261
Andy Chapman	NHDES Project Manager	NHDES, Watershed Management Bureau	Andrew.chapman@des.nh.gov 603-271-5334
Jillian McCarthy	Program QA Coordinator	NHDES, Watershed Management Bureau	jillian.mccarthy@des.nh.gov 603-271-8475
Vincent Perelli	NHDES QA Manager	NHDES, Planning, Prevention, & Assistance Unit	vincent.perelli@des.nh.gov 603-271-8989
Erik Beck	USEPA Project Manager	USEPA New England	beck.erik@epa.gov 617-918-1606

2- Project Organization

The Town of Wolfeboro, New Hampshire received funding under Section 319 of the Clean Water Act from the NH Department of Environmental Services (NHDES) in order to develop a Watershed Management Plan (WMP) for the Lake Wentworth/Crescent Lake Watershed. Additional funding for the project was provided by the Lake Wentworth Foundation (LWF).

FB Environmental Associates (FBE) was selected as the technical consultant to help complete the scope of services for the Town of Wolfeboro. FBE Technical Project Manager Forrest Bell will provide project oversight, technical expertise, and serve as the main point of contact for the Lake Wentworth/Crescent Lake Watershed Plan Steering Committee.

Jennifer Jespersen will serve as Task Manager and QA Officer for the project. She will work closely with the Town of Wolfeboro and the Steering Committee to ensure that the project stays on time and within budget. Jennifer is in charge of managing key project personnel and coordinating tasks with the Project Engineer, Ben Lundsted. Ben will oversee Comprehensive Environmental, Inc. (CEI) field efforts, BMP matrix preparation and conceptual designs. He will work directly on the BMP reduction calculations and preliminary BMP designs. Technical Engineer Rebecca Balke will provide technical support for lake modeling tasks, as well as QA/QC for the BMP reduction calculations and the land use modeling.

Jennifer will provide technical expertise and oversight for key modeling tasks including the land use modeling, in-lake phosphorus and assimilative capacity analysis, buildout analysis, and pollutant load reduction estimates. Jennifer will also conduct the water quality analysis. Technical Engineer Rebecca Balke will provide technical support for lake modeling tasks, as well as QA/QC for the BMP reduction calculations and the land use modeling. As the QA officer, Jennifer will ensure that survey results and modeling results have been reviewed and double-checked for potential inconsistencies.

Figure 1 outlines the organization structure of the project personnel.

Figure 1. Project Organizational Chart

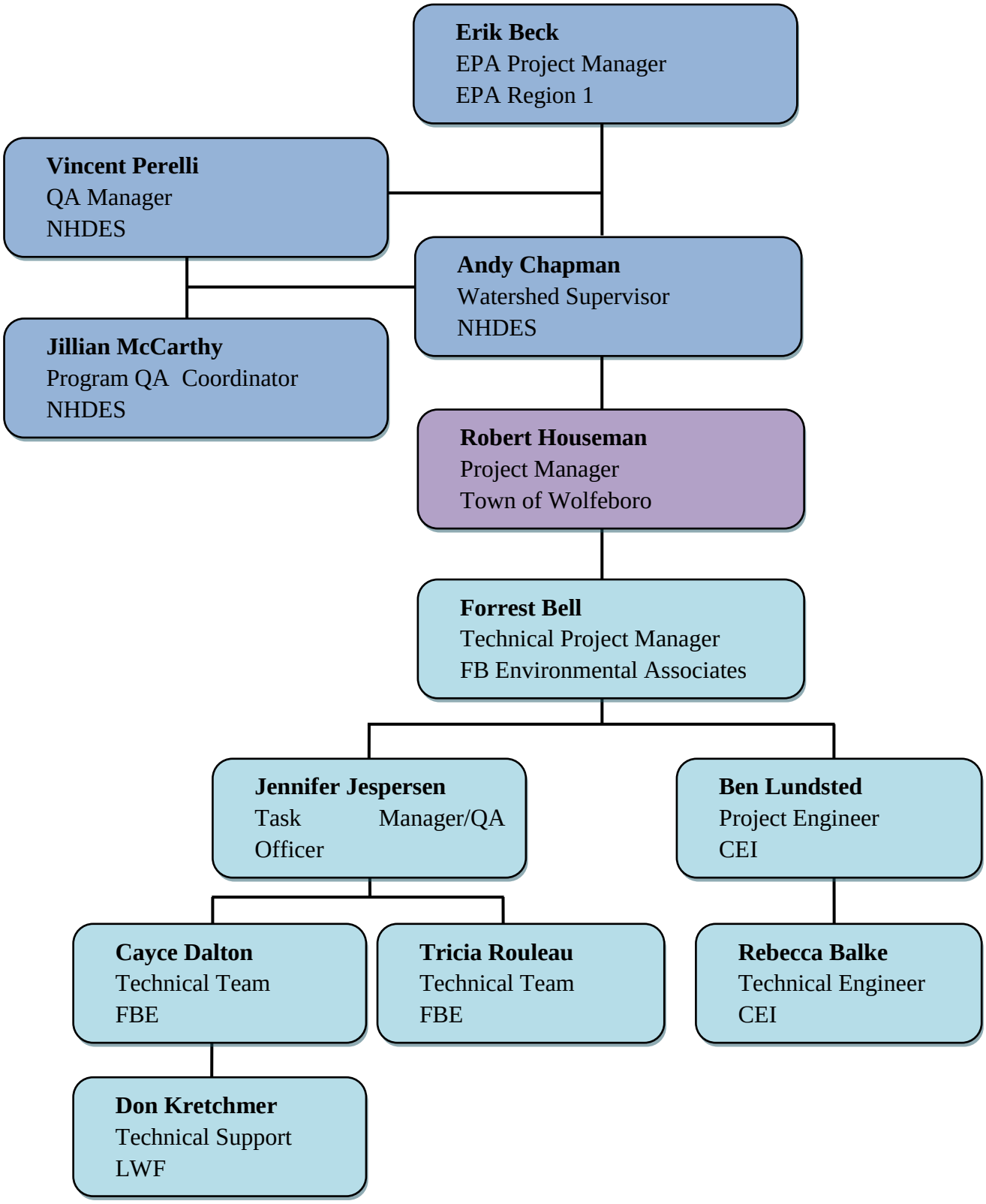


Table 2. Key Project Personnel Responsibilities and Qualifications

Name and Affiliation	Responsibilities	Qualifications
Robert Houseman Town of Wolfeboro	Project Manager	On file at Town of Wolfeboro
Forrest Bell FB Environmental	Senior Scientist; Project Manager	On file at FB Environmental
Jennifer Jespersen FB Environmental	Task Manager; Project QA/QC Officer	On file at FB Environmental
Ben Lundsted Comprehensive Environmental Inc.	Project Engineer	On file at CEI
Don Kretchmer Lake Wentworth Foundation	Modeling Support	On file at AECOM
Andy Chapman, NHDES Watershed Management Bureau	Reviews and oversees development of the Lake Wentworth WMP	On file at NHDES
Jillian McCarthy, NHDES Watershed Management Bureau	Reviews QAPP preparation and other QA/QC activities	On file at NHDES
Vince Perelli, NHDES Planning Prevention & Assistance Unit	Reviews and approves QAPPs	On file at NHDES
Erik Beck US EPA Region I	EPA Project Manager	On file at US EPA

3- Site Information

Lake Wentworth and Crescent Lake are considered by the New Hampshire Department of Environmental Services (NHDES) to be high-quality waters. High-quality waters are those which have sufficient water quality data, or indicators of high water quality, to show that they exceed state water quality standards.

The project area is located in the Lake Wentworth/Crescent Lake watershed in the towns of Wolfeboro, Brookfield, and New Durham, New Hampshire. The vast majority of the watershed is located in the Town of Wolfeboro and is located within the larger Lake Winnipesaukee watershed. Lake Wentworth is four miles long and three miles wide, with a total area of 3,108 acres. The lake has 17 islands and 11 year-round streams, including Breezy Brook, Claypit East and West Brooks, Fernald Brook, Frost Brook, Harvey Brook, Heath Brook, Ryefield Brook, Townsend Brook East, Tyler Brook, Townsend Brook West, Warren Brook and Wiley Brook. The Smith River is the navigable connector between Lake Wentworth and downstream Crescent Lake.

Crescent Lake is 148.4 acres in size and is located between Lake Wentworth and Back Bay of Lake Winnipesaukee. The water level in both Lake Wentworth and Crescent Lake is controlled by a dam on the Smith River at the outlet of Crescent Lake. This dam has the ability to change

the water level of Lake Wentworth by 3-4 feet. There is a two-foot drawdown of Lake Wentworth and Crescent Lake each fall. Every five years there is a 3.5-foot drawdown. A single deep reference site is located in Crescent Lake (approximately 18 feet), while three deep reference sites are located in Lake Wentworth that range from approximately 55 to 80 feet deep.

Development of summer camps on Lake Wentworth dates back to 1884, which initiated a cottage building boom on the shoreline and the islands. Since then, the shoreline has slowly been developed to accommodate both seasonal and year-round residences. Today, there are an estimated 500 properties around the lake and on the islands. A recent GIS analysis conducted by FB Environmental as part of the septic system and stormwater survey identified 610 parcels with buildings within 250 feet of the lakes, streams or ponds in the watershed.

4- Project Rationale

Phosphorus is a limiting nutrient in freshwater ecosystems. Excess phosphorus in these systems can lead to nuisance algal blooms and low water clarity. High levels of phosphorus in freshwater lakes and streams are often associated with human activities resulting from stormwater runoff, excessive use of fertilizer, and poorly maintained/malfunctioning septic systems. Over the past several years, there has been an increase in the amounts of algae in both Lake Wentworth and Crescent Lake, and historical Lake Wentworth profiling data indicate anoxic conditions below 35 feet. Anoxia is a concern because it can release phosphorus bound to sediments into the water column, thereby making more phosphorus available to algae. Reducing the amount of nonpoint source pollution entering Lake Wentworth and Crescent Lake will help reverse the trend towards increasing productivity.

The purpose of this portion of the project is to conduct modeling and analysis to support the development of a Watershed-Based Management Plan that will help maintain or improve the high-quality waters of the Lake Wentworth/Crescent Lake watershed. The modeling will estimate total phosphorus loading to both Lake Wentworth and Crescent Lake, assess loading from major tributaries, predict loading from future development, and help establish water quality goals.

5- Project Approach/Study Design

On-the-ground surveys, combined with in-depth water quality analysis and computer modeling, will be used to identify sources of pollution and to estimate pollutant load reductions needed to accommodate future watershed development. Several different tools, techniques and models will be used to complete this component of the watershed management plan.

A. Water Quality Analysis

Historical water quality monitoring data will be used for determining the median phosphorus values, the indirect phosphorus load to Crescent Lake and Lake Wentworth, the internal load, the assimilative capacity, and for determining the water quality goal for each of the lakes. The analysis will include a historic (1984-1999), recent (2000-present), and a seasonal analysis (samples collected between May 15 and September 30 under the 5/23/11 *Lake Wentworth/Crescent Lake Watershed Management Plan Implementation-Phase I* for water quality monitoring, approved under RFA#10154 *The New Hampshire Center for Freshwater Biology and Lakes Lay Monitoring Program Programmatic QAPP* prepared by Robert Craycraft and Jeffrey Schloss).

Monitoring results will be collected and reviewed from in-lake sources, inlet and outlet flows, and tributaries to calibrate modeling efforts. The New Hampshire Volunteer Lake Assessment Program (VLAP) and the New Hampshire Lakes Lay Monitoring Program (LLMP) are the two primary volunteer groups collecting water quality data on lakes in New Hampshire. Data is also collected by the UNH Center for Freshwater Biology (CFB). UNH Cooperative Extension (UNHCE) manages all data sampled by the LLMP and the CFB. Data from the VLAP is available through the New Hampshire Department of Environmental Services Environmental Monitoring Database (EMD). Only data that is flagged as final in the EMD will be used. UNHCE will provide historical water quality data for the analysis from 1984 to present. Data from the UNHCE will only be used if QA/QC measures have been documented and follow the New Hampshire Center for Freshwater Biology and Lakes Lay Monitoring Program Programmatic QAPP (UNH, 2010). As explained above, separate Site Specific Project Plan was developed by CFB and UNHCE to document the water quality monitoring for Lake Wentworth and Crescent Lake Watershed Management Plan (UNH, 2011).

Phosphorus and flow data (where available) for the major streams flowing into Lake Wentworth/Crescent Lake will be used to assess pollutant levels entering and leaving the lakes and to provide an assessment of inputs by subwatershed. Water quality data will be combined into a common spreadsheet for each waterbody, and then sorted by date and station for Quality Assurance/Quality Control (QA/QC) in order to avoid duplicating data sets. All duplicates will be removed. An initial analysis will be conducted to determine median Total Phosphorus (TP) based on all samples regardless of whether it was a grab or epilimnetic core (EC) sample. Minimum, maximum and median TP values will be determined for each station on both lakes, sorted by empilimnion, metalimnion and hypolimnion. Data will be further refined using EC data only to calculate the median EC value (where more than one sample was collected on the same day, a mean will be used for that day). In the event that EC data are limited, grab samples

taken on the same day at multiple depths near the surface may be used in conjunction with the EC samples. Where multiple stations exist on Lake Wentworth, best professional judgment will be used to determine which station is most representative of the whole lake. If needed and if adequate data exist, statistical analysis (*e.g.*, paired t-test) may be used to determine whether significant differences exist between stations on the same lake. Similar methodology will be used to calculate average Chl *a* and Secchi disk transparency (SDT).

B. Assimilative Capacity & Water Quality Goal Setting

Threats to the high-quality waters of Lake Wentworth and Crescent Lake include sediment and nutrients from existing and future development, aging septic systems and roads in the watersheds. All of these land uses have the potential to deliver phosphorus, the limiting nutrient in freshwater systems, via stormwater runoff to streams and lakes in the watershed. As such, the water quality goals for Lake Wentworth and Crescent Lake will focus on Total Phosphorus export from the watershed.

Once the median water quality has been determined for each lake, the total, reserve and remaining assimilative capacity for each lake will be determined using procedures described in the Standard Operating Procedures for Assimilative Capacity Analysis for New Hampshire Waters (NH DES, 2008), on file on the NHDES Watershed Management Bureau network drive (H Drive). Tier 2, or high-quality waterbodies are described as having water quality in which one or more parameters is better than the standard plus the reserve capacity (the reserve capacity is 10% of the total assimilative capacity). Tier 2 waters have some assimilative capacity remaining, whereas impaired and Tier 1 waters do not.

The process of establishing water quality goals will be guided by data analyses conducted by FB Environmental (FBE). FBE will first determine whether the current median water quality of each waterbody is greater than the reserve assimilative capacity. If median water quality values for each waterbody are greater than the reserve assimilative capacity (Tier 2- exceeds standards), then the water quality goal will be considered based on the current median value and historic water quality data. If the median water quality values fall within the reserve capacity (Tier 1), then the water quality goal will be determined based on historical water quality and potential reductions needed to get water quality values back to the high quality range.

A duplicate analysis will be conducted to calculate the median water quality values and the assimilative capacity. Once the initial calculations have been completed, the Steering Committee, or a subcommittee consisting of town officials, planning board members,

representatives of the Lake Wentworth Association and the Lake Wentworth Foundation, UNH Cooperative Extension and NH DES staff will help finalize the water quality goals.

C. Loading Models

Watershed Loading Model

Geographical Information Systems (GIS) data will be obtained by FB Environmental to assist with the land use assessment and specifically for determining the total land use area by land use type (in acres) for input into the watershed loading model (see below for model selection criteria). GIS land use data are available from the State of New Hampshire GIS website (GRANIT). The NH Land Cover Assessment 2001 or NHLC01, consists of the most recent and detailed classification of land cover in New Hampshire based on satellite images acquired between 1990 and 1999, with further revisions in 2001 (GRANIT). This data will be used for the land use loading analysis as described below in the section titled, "*Future Loading Model/Build-Out Analysis*. GIS land use coverages will be ground-truthed in the field by FB Environmental and CEI personnel to ensure the best coverages for input into the model.

The Lake Loading Response Model (LLRM) (also called SHEDMOD or ENSR-LRM) will be used to assess current nutrient loads from the watershed, and the load reductions that would result from the implementation of different best management practices (BMPs). The model was developed by AECOM for use in New England and modified for New Hampshire lakes by incorporating New Hampshire land use total phosphorus (TP) export coefficients and adding septic system loading into the model (AECOM, 2009). This model provides the best fit for the watershed and has been used extensively for more than 30 recent Lake TMDLs in New Hampshire. The most recent LLRM model, which includes a BMP effectiveness tool, will be provided to FBE by Don Kretchmer along with the most recent User Guide.

Data needed for input into the LLRM include: water quality monitoring data (TP, Chl *a*, and Secchi) for both lakes; physical characteristics such as lake surface area, volume and flushing rate; tributary monitoring data including discharge; corrected GIS land use data; subwatershed land area; soils data including steepness of slope; precipitation data; septic system data (from the 2011 survey). Cayce Dalton of FBE will be running the model. Cayce is proficient in the use of running watershed loading models, including direct experience with AVGWLF, PREDICT, and the USEPA Region 5 Model. FBE Senior Project Manager Jennifer Jespersen will provide technical oversight and confirm that the information used for the model is correct. Selected data and watershed information will be presented to Don Kretchmer of the LWF and one of the LLRM model developers. Don will provide technical assistance and review of modeling methods and results. Cayce will make edits to the model based on feedback from Don and the Steering Committee and final modeling results will be reviewed by Rebecca Balke. Rebecca has expertise in water resources modeling and design including experience

with Eutromod, STEPL, The Simple Method, GWLF, lake response models, StormCAD, WaterCAD, SWMM and ModFlow.

The LLRM model estimates total phosphorus loading from the watershed, and predicts in-lake concentrations of TP, Chl *a*, SDT and algal bloom probability based on runoff and groundwater land use export coefficients. Attenuation factors such as porous soils, wetlands or existing BMPs that would decrease loading will be accounted for in order to reach a close agreement between predicted in-lake TP and observed median TP. The estimated watershed load (runoff and base flow) will be combined with direct loads (atmospheric, internal load and septic systems) to calculate total phosphorus loading and will be compared to observed in-lake concentrations.

In-Lake Total Phosphorus Concentrations

Results of the total phosphorus modeling will be input into a series of empirical models that provide predictions of in-lake TP concentrations, Chl *a* concentrations, algal bloom frequency and water clarity. Also referred to as total phosphorus retention modeling, the model estimates in-lake phosphorus concentrations based on physical and chemical lake characteristics including lake volume, mean depth, watershed area, flushing rate, and estimated watershed phosphorus loading. Because of the imperfect nature of any model to predict processes within natural systems, the model will compare six different in-lake phosphorus models including: Kirchner-Dillon (1975), Vollenweider (1975), Larsen-Mercier (1976), Jones-Bachman (1976), Reckhow General (1977), and Nürnberg (1998). The average of the six empirical models will be used as the predicted TP value for each of the lakes with some exceptions (it may be determined that one of the models is most representative, or a model could be eliminated as inapplicable). The predicted in-lake TP concentration will be compared to actual in-lake water quality data analysis (see 5A, above). Additional predictions (Chl *a*, water clarity and bloom probability) will be determined based on the average in-lake TP concentration.

Future Loading Model/Build-Out Analysis

FB Environmental will conduct a buildout analysis for analyzing the effects of new development on Lake Wentworth and Crescent Lake. The buildout analysis utilizes GIS zoning data and CommunityViz software to estimate future development within the watershed. The analysis will combine projected population estimates, current zoning restrictions, and a host of additional development constraints (conservation lands, steep slopes, wetlands, existing buildings, soils with development suitability, unbuildable parcels) in order to determine the extent of buildable area in the watershed. Future phosphorus loading will be estimated under full or partial buildout (depending on the timeline of full buildout) and an assessment of the potential effects of future development as it relates to water quality goals. The buildout analysis will be conducted by Tricia Rouleau. Tricia is proficient in the use of CommunityViz,

having used it for several similar watershed-based planning projects in both Maine and New Hampshire. Task manager Jennifer Jespersen will provide QA/QC of the buildout data inputs and results of the analysis.

Load Reduction Estimates

The 'Simple Method' load reduction model (CWP, 2005) will be used to estimate load reductions from approximately 30 BMPs identified through on-the-ground surveys, and can be fed back through the LLRM to evaluate lake response to proposed reductions. This method provides empirical estimates of phosphorus, nitrogen, chemical oxygen demand and biochemical oxygen demand as well as for metals. Load reduction estimates using the "Simple Method" will be conducted by Ben Lunsted with QA/QC by Rebecca Balke of Comprehensive Environmental, Inc. Observations, trends, conclusions, significant QA/QC findings, and limitations in the pollutant load reduction data will be documented and reported in the final report to be submitted in hard copy and electronic format.

6- Project Schedule

Project components are scheduled to be completed at different stages throughout the planning process. Below is a list of targets for completion of individual tasks. Some of these deliverables have been extended due to development of the unanticipated Septic/Stormwater SSPP, timing of the septic survey, and acquisition of the water quality data.

Task 1: Final Site Specific Project Plan- October 1, 2011
Task 2: Conduct Water Quality Analysis – November 1, 2011
Task 3: Determine and Present Water Quality Goal – November 15, 2011
Task 4: Identify Current and Future Pollution Sources by Land Use Type- November 1, 2011
Task 5: Model In-Lake Response- November 1, 2011
Task 6: Model Natural Background, Buildout and Future Development Scenarios- January 15, 2011
Task 7: Estimate Total Load Reductions Needed- February 15, 2012
Task 16: Prepare Draft and Final Watershed Management Plans- October 1, 2012

7- Final Products and Reporting

Final products for this project include the following:

- Approved Site Specific Project Plan under the New Hampshire Section 319 Nonpoint Source Grant Program QAPP for the Septic and Stormwater Survey (RFA# 08262, 10/17/08).
- Summary of methods and calculations to determine Assimilative Capacity.

- Documentation of water quality goal and methods; meeting with steering committee or subcommittee to present the results of the water quality goal.
- GIS maps with refined land use coverage and in-lake response model results.
- Buildout summary report and data; estimation of background levels of phosphorus.
- Final estimate of pollutant load reductions needed to maintain water quality status.
- Load reduction estimates for 30 watershed BMPs.
- Draft and final watershed plans.

8-References

AECOM, 2009. Draft Total Maximum Daily Load for Webster Lake, Franklin, NH. Document Number: 09090-107-28. July 2009. Prepared for US EPA Region 1, Project: EPA-SMP-07-002 by AECOM Environment, Belmont, NH.

CWP, 2005. Simple Method to Calculate Urban Stormwater Loads. Center for Watershed Protection, Stormwater Manager's Resource Center (SMRC), Elliot City, MD.

EMD. New Hampshire Environmental Monitoring Database. New Hampshire Department of Environmental Services. www2.des.state.nh.us/OneStop/Environmental_Monitoring_Menu.aspx.

NH DES. 2008. Standard Operating Procedures for Assimilative Capacity Analysis for New Hampshire Waters. April 15, 2008 (Draft). In: Guidance for Developing Watershed Management Plans in New Hampshire. New Hampshire Department of Environmental Services. May 22, 2008 (Second Draft).

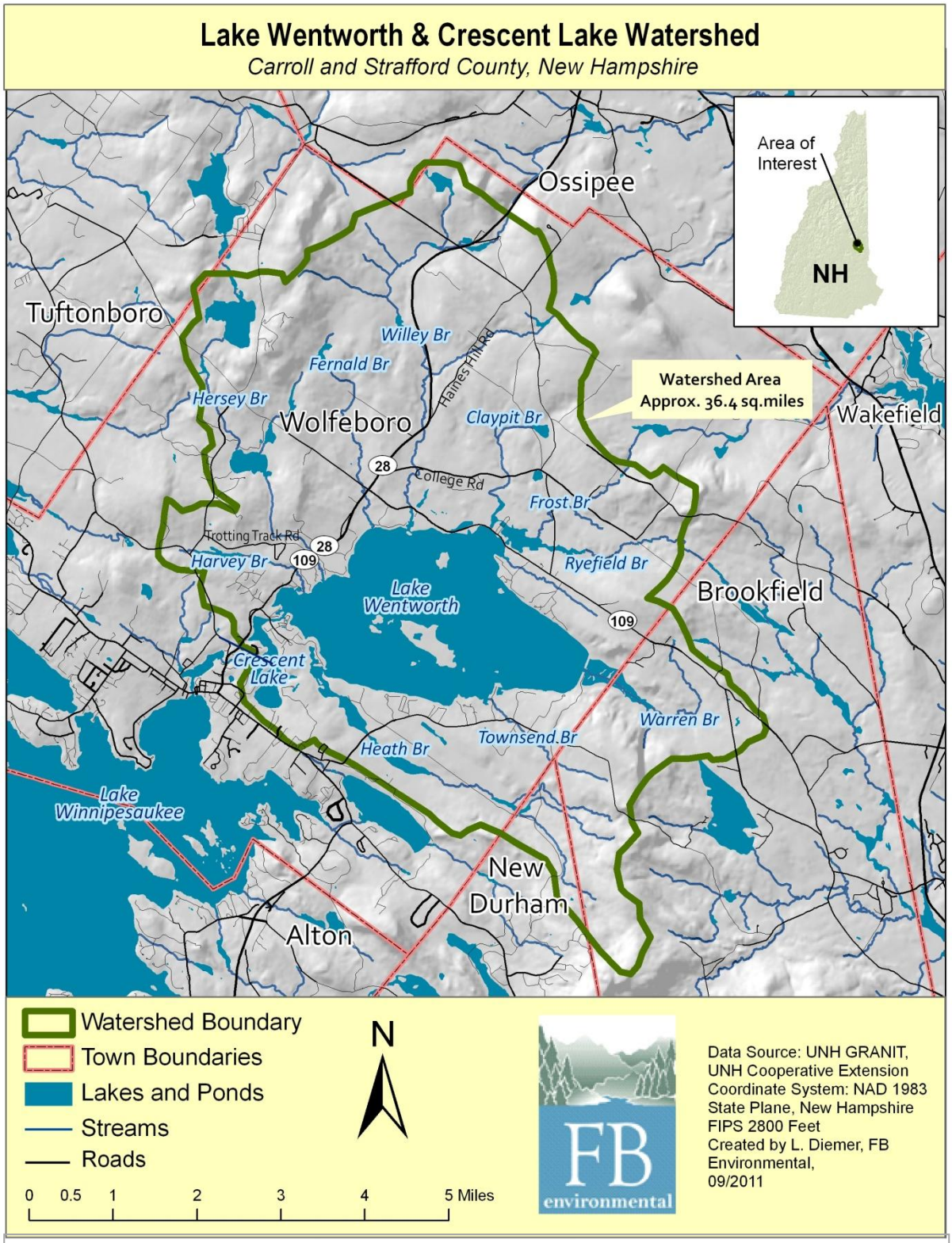
Nürnberg, G.K. 1998. Prediction of annual and seasonal phosphorus concentrations in stratified and polymictic lakes. Limnology and Oceanography. 43(7): 1544-1552.

UNH, 2010. New Hampshire Center for Freshwater Biology and Lakes Lay Monitoring Program Water Quality Monitoring and Lake Surveys Quality Assurance Program Plan. October 20, 2010.

UNH, 2011. Site Specific Project Plan For: Lake Wentworth/Crescent Lake Watershed Management Plan Implementation–Phase 1. UNH Center for Freshwater Biology and UNH Cooperative Extension. May 23, 2011.

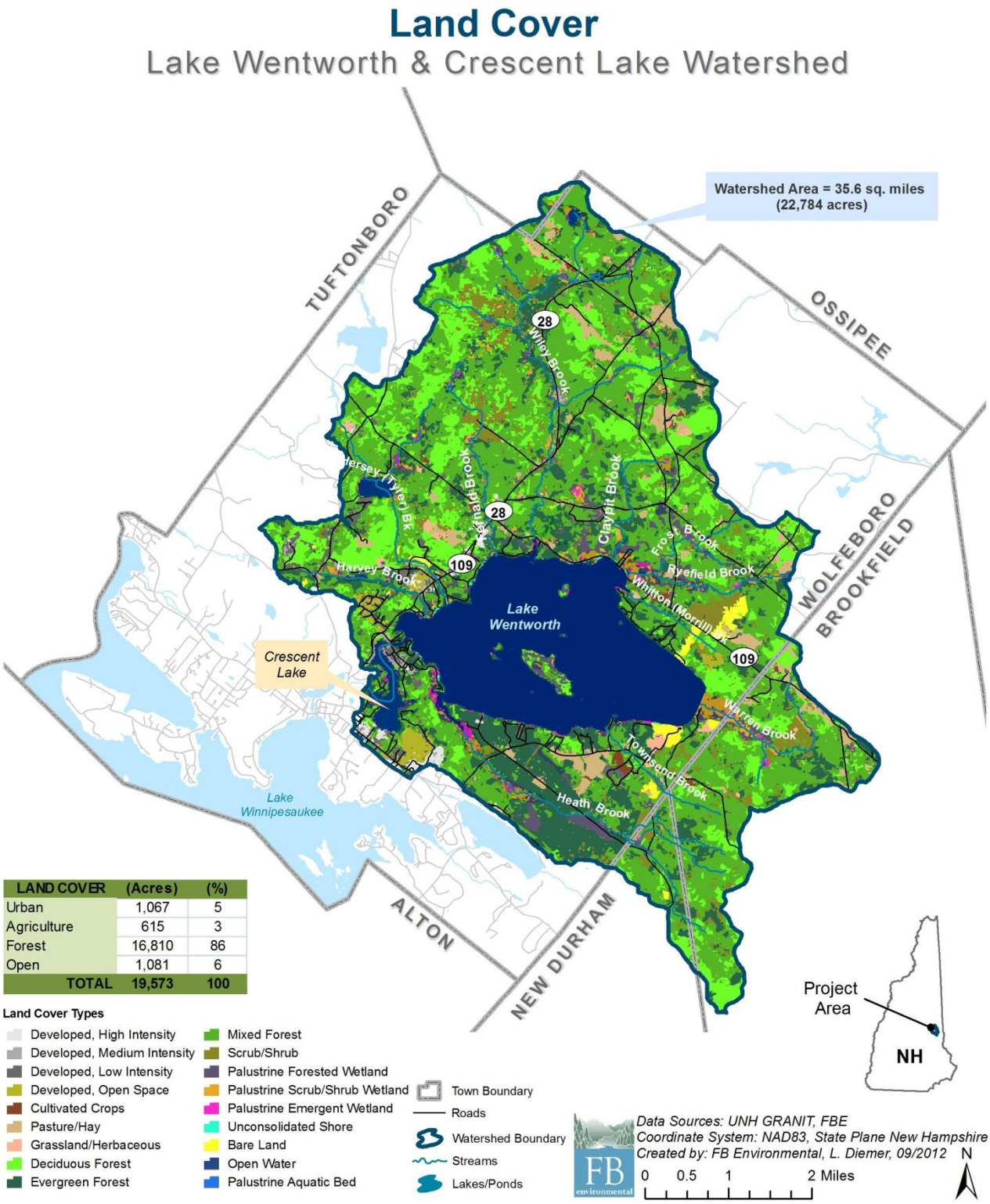
NH GRANIT. www.granit.unh.edu.

Appendix A- Lake Wentworth/Crescent Lake Watershed Map[1]

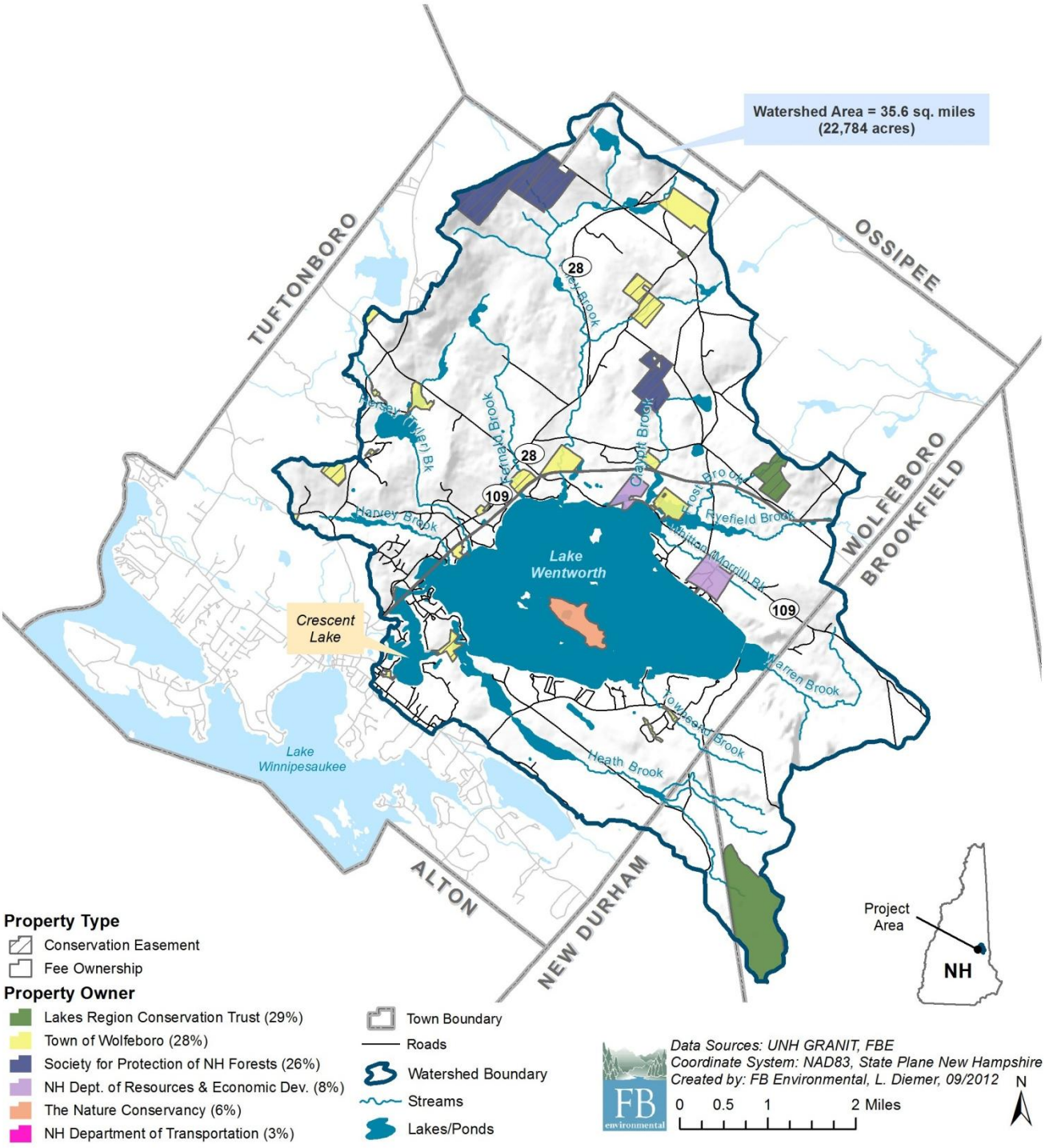


[1] *Note: The map above was submitted to NHDES as part of the SSPP in September 2011 using an original version of the watershed boundary. During development of the watershed management plan, it was determined that Upper Beach Pond is not part of the Lake Wentworth/Crescent Lake watershed. For an accurate map, see watershed maps in Appendix C of the watershed management plan, or on page i. of the watershed management plan.*

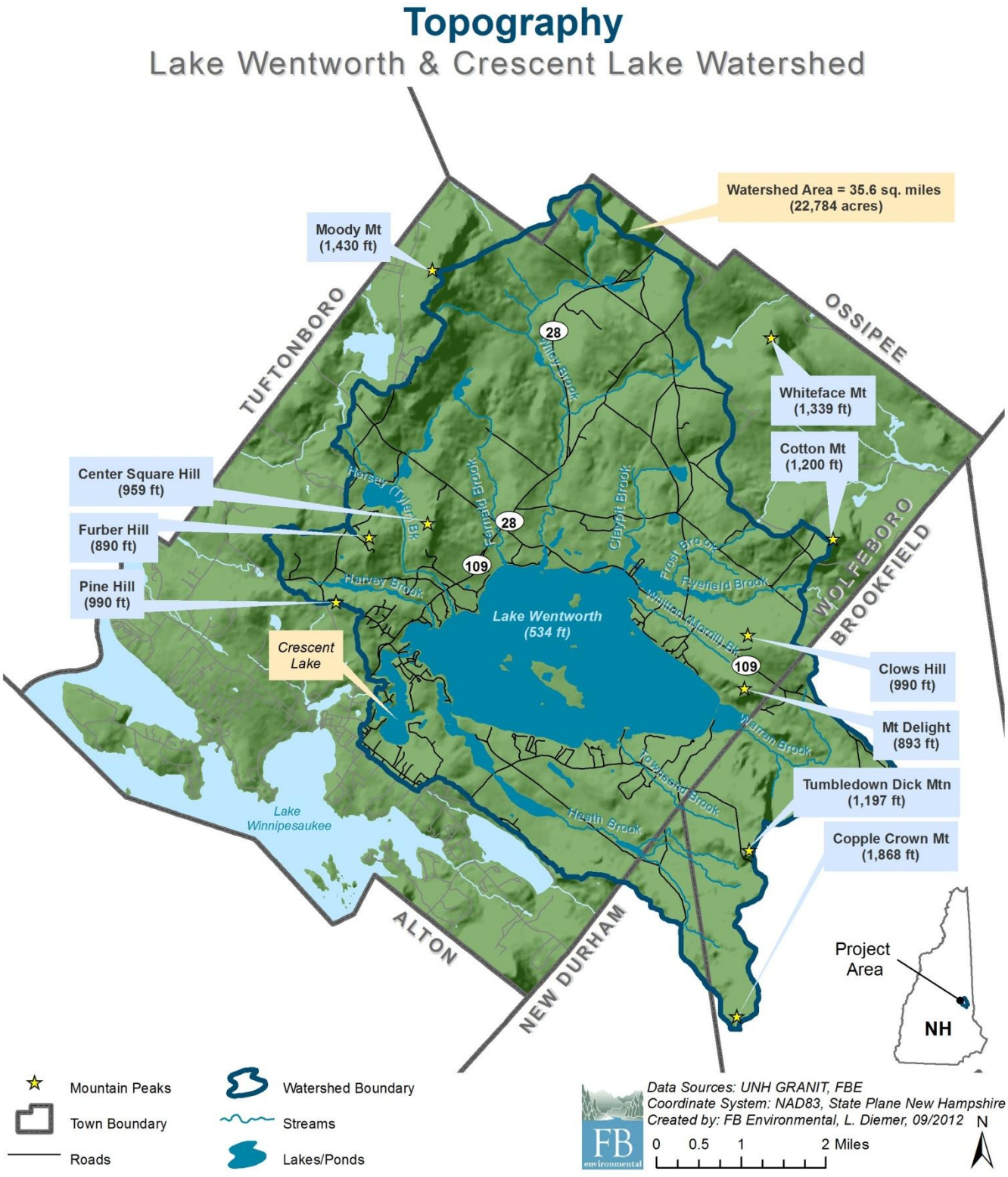
Appendix C:
Thematic GIS Maps


Land Cover
Lake Wentworth & Crescent Lake Watershed
Watershed Area = 35.6 sq. miles
(22,784 acres)
TUFTONBORO
OSSIPEE
WOLFEBORO
BROOKFIELD
ALTON
NEW DURHAM
Lake Wentworth
Crescent Lake
Lake Winnipesaukee
Wiley Brook
Jersey (Tyler) Bk
Leonard Brook
Clay Pit Brook
Frost Brook
Ryefield Brook
Whitton (Morrill) Bk
Harvey Brook
Warren Brook
Townsend Brook
Heath Brook
28
109
LAND COVER (Acres) (%)
Urban 1,067 5
Agriculture 615 3
Forest 16,810 86
Open 1,081 6
TOTAL 19,573 100
Land Cover Types
Developed, High Intensity
Developed, Medium Intensity
Developed, Low Intensity
Developed, Open Space
Cultivated Crops
Pasture/Hay
Grassland/Herbaceous
Deciduous Forest
Evergreen Forest
Mixed Forest
Scrub/Shrub
Palustrine Forested Wetland
Palustrine Scrub/Shrub Wetland
Palustrine Emergent Wetland
Unconsolidated Shore
Bare Land
Open Water
Palustrine Aquatic Bed
Town Boundary
Roads
Watershed Boundary
Streams
Lakes/Ponds
Project Area
NH
Data Sources: UNH GRANIT, FBE
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 0.5 1 2 Miles
N

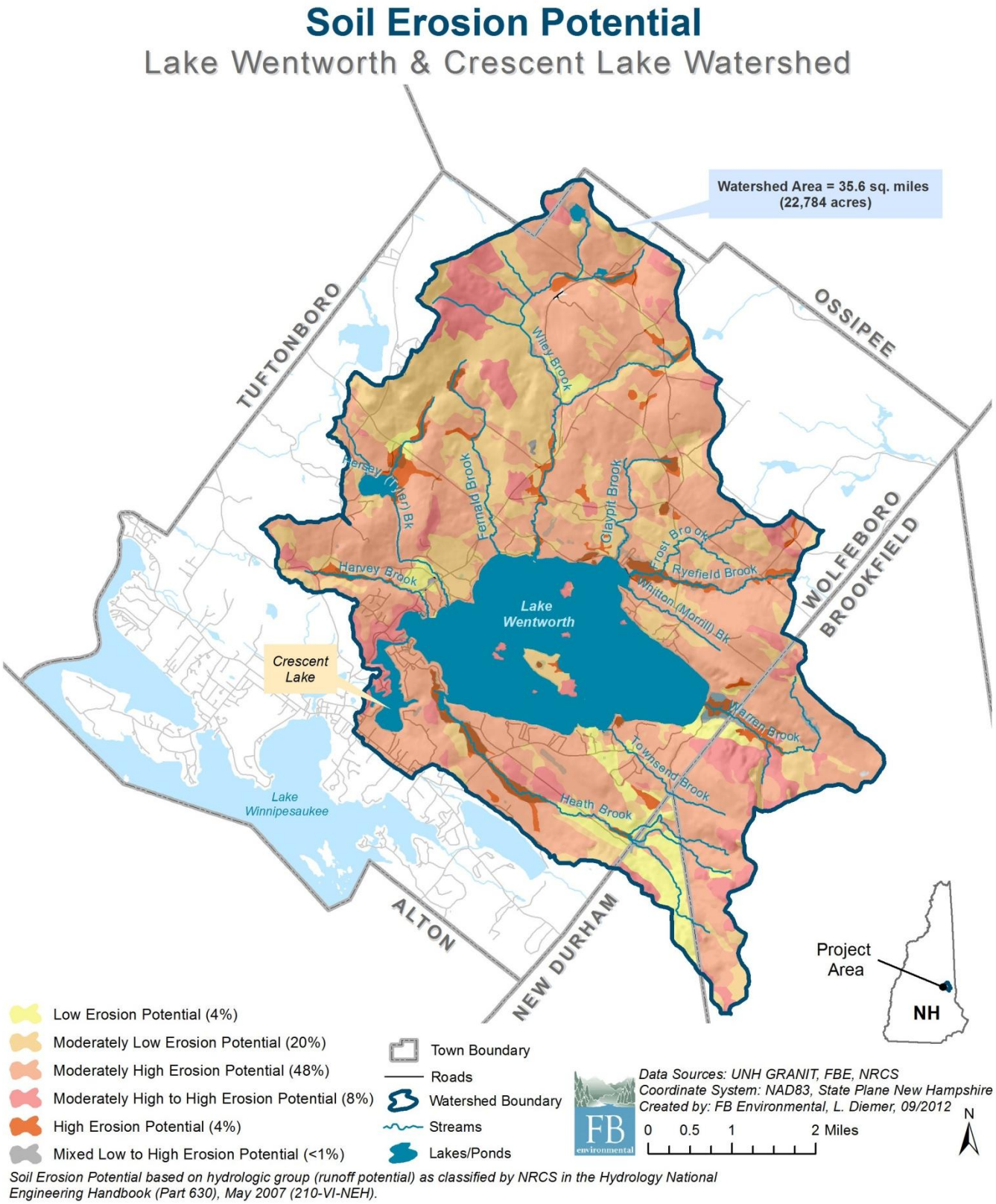
Map 1


Conservation Areas
Lake Wentworth & Crescent Lake Watershed
Watershed Area = 35.6 sq. miles
(22,784 acres)
TUFTONBORO
OSSIPEE
WOLFEBORO
BROOKFIELD
ALTON
NEW DURHAM
Lake Wentworth
Crescent Lake
Lake Winnipesaukee
28
109
Project Area
NH
Property Type
Conservation Easement
Fee Ownership
Property Owner
Lakes Region Conservation Trust (29%)
Town of Wolfeboro (28%)
Society for Protection of NH Forests (26%)
NH Dept. of Resources & Economic Dev. (8%)
The Nature Conservancy (6%)
NH Department of Transportation (3%)
Town Boundary
Roads
Watershed Boundary
Streams
Lakes/Ponds
Data Sources: UNH GRANIT, FBE
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 0.5 1 2 Miles
N

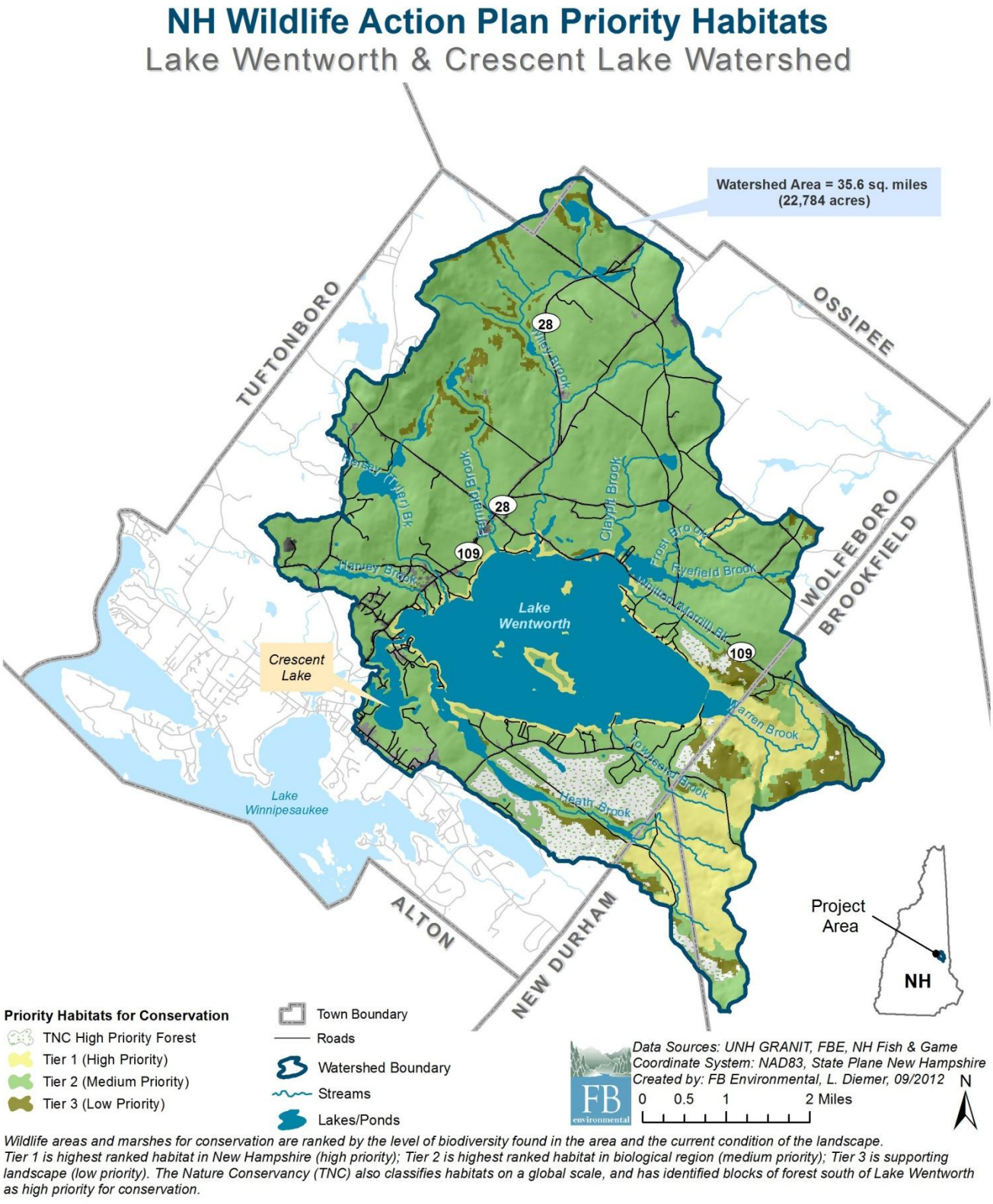
Map 2


Topography
Lake Wentworth & Crescent Lake Watershed
Watershed Area = 35.6 sq. miles (22,784 acres)
Moody Mt (1,430 ft)
Whiteface Mt (1,339 ft)
Cotton Mt (1,200 ft)
Center Square Hill (959 ft)
Furber Hill (890 ft)
Pine Hill (990 ft)
Clows Hill (990 ft)
Mt Delight (893 ft)
Tumbledown Dick Mtn (1,197 ft)
Copple Crown Mt (1,868 ft)
Lake Wentworth (534 ft)
Crescent Lake
Lake Winnipesaukee
TUFTONBORO
OSSIPEE
WOLFEBORO
BROOKFIELD
ALTON
NEW DURHAM
28
109
Project Area
NH
Mountain Peaks
Town Boundary
Roads
Watershed Boundary
Streams
Lakes/Ponds
Data Sources: UNH GRANIT, FBE
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 0.5 1 2 Miles
N

Map 3

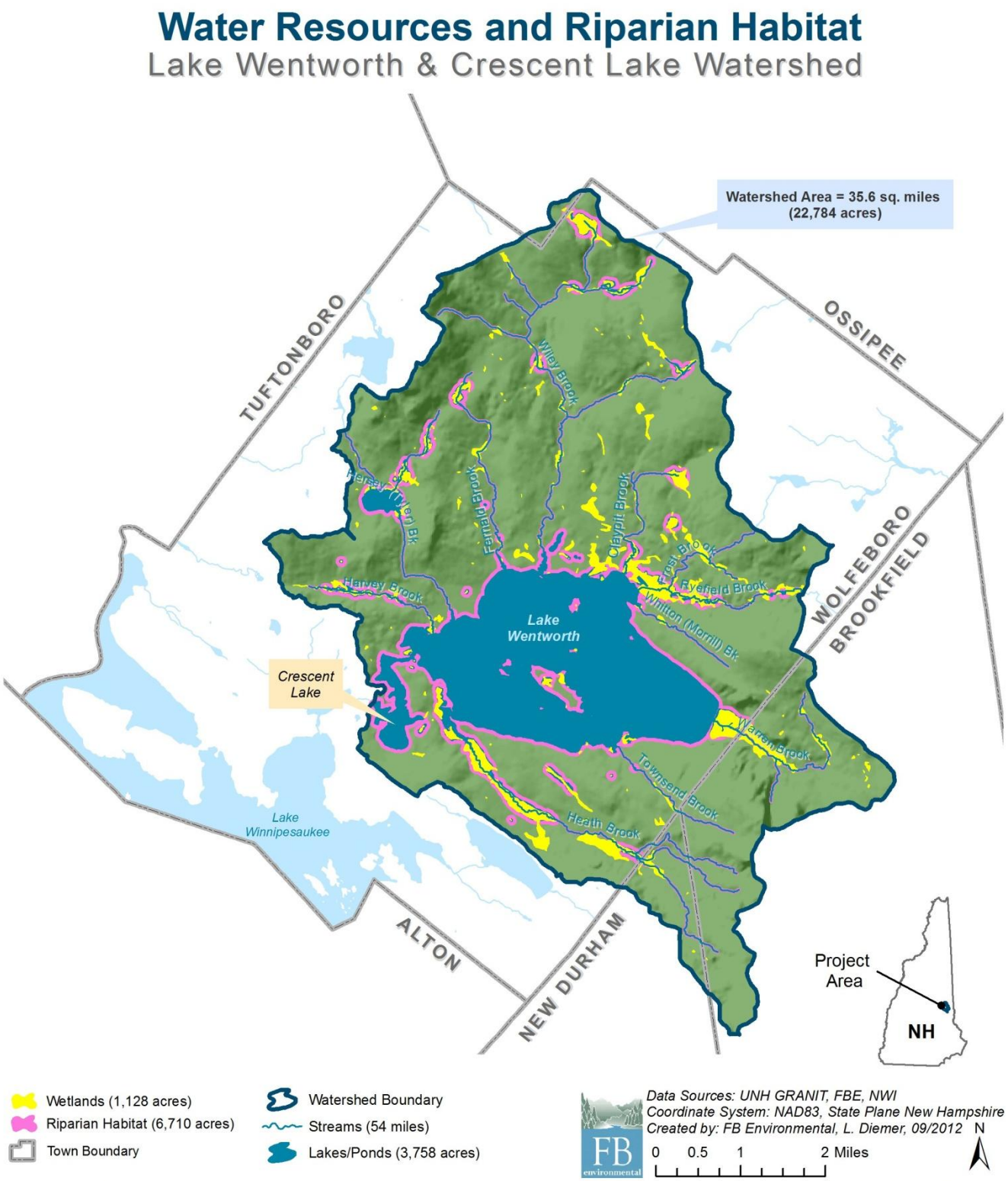

Soil Erosion Potential
Lake Wentworth & Crescent Lake Watershed
Watershed Area = 35.6 sq. miles
(22,784 acres)
TUFTONBORO
OSSIPEE
WOLFEBORO
BROOKFIELD
ALTON
NEW DURHAM
Lake Wentworth
Crescent Lake
Lake Winnipesaukee
Wiley Brook
Fernald Brook
Claypit Brook
Frost Brook
Ryefield Brook
Whitton (Morrill) Bk
Harvey Brook
Warren Brook
Townsend Brook
Heath Brook
Project Area
NH
Low Erosion Potential (4%)
Moderately Low Erosion Potential (20%)
Moderately High Erosion Potential (48%)
Moderately High to High Erosion Potential (8%)
High Erosion Potential (4%)
Mixed Low to High Erosion Potential (<1%)
Town Boundary
Roads
Watershed Boundary
Streams
Lakes/Ponds
Data Sources: UNH GRANIT, FBE, NRCS
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 0.5 1 2 Miles
N
Soil Erosion Potential based on hydrologic group (runoff potential) as classified by NRCS in the Hydrology National Engineering Handbook (Part 630), May 2007 (210-VI-NEH).

Map 4



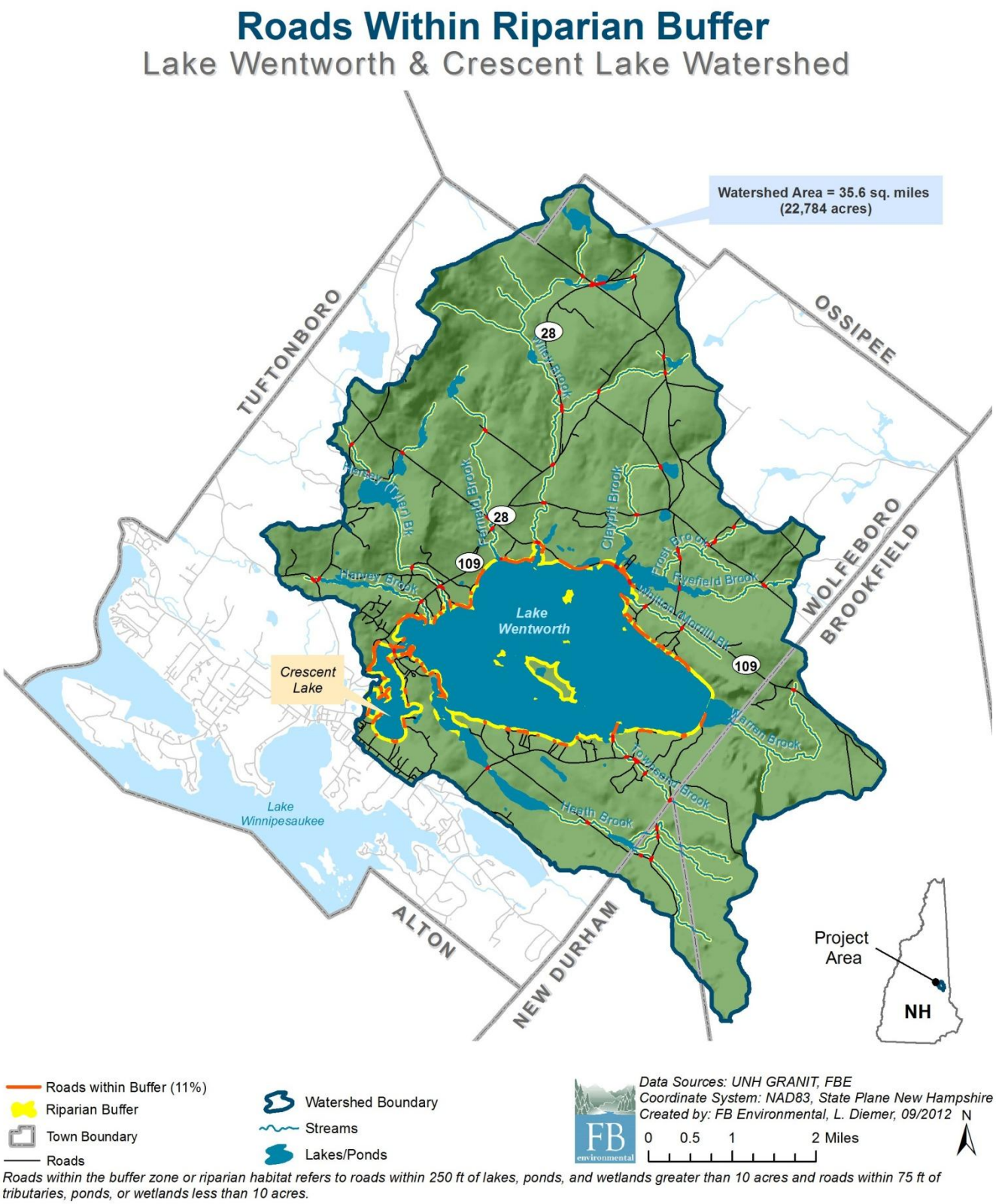
Wildlife areas and marshes for conservation are ranked by the level of biodiversity found in the area and the current condition of the landscape. Tier 1 is highest ranked habitat in New Hampshire (high priority); Tier 2 is highest ranked habitat in biological region (medium priority); Tier 3 is supporting landscape (low priority). The Nature Conservancy (TNC) also classifies habitats on a global scale, and has identified blocks of forest south of Lake Wentworth as high priority for conservation.

Map 5



Riparian habitat refers to the areas adjacent to ponds, lakes, streams, rivers, and wetlands. Riparian habitat is shown here with a 75 foot buffer on each side of streams, and a 250 foot buffer around lakes, ponds, and wetlands greater than 10 acres.

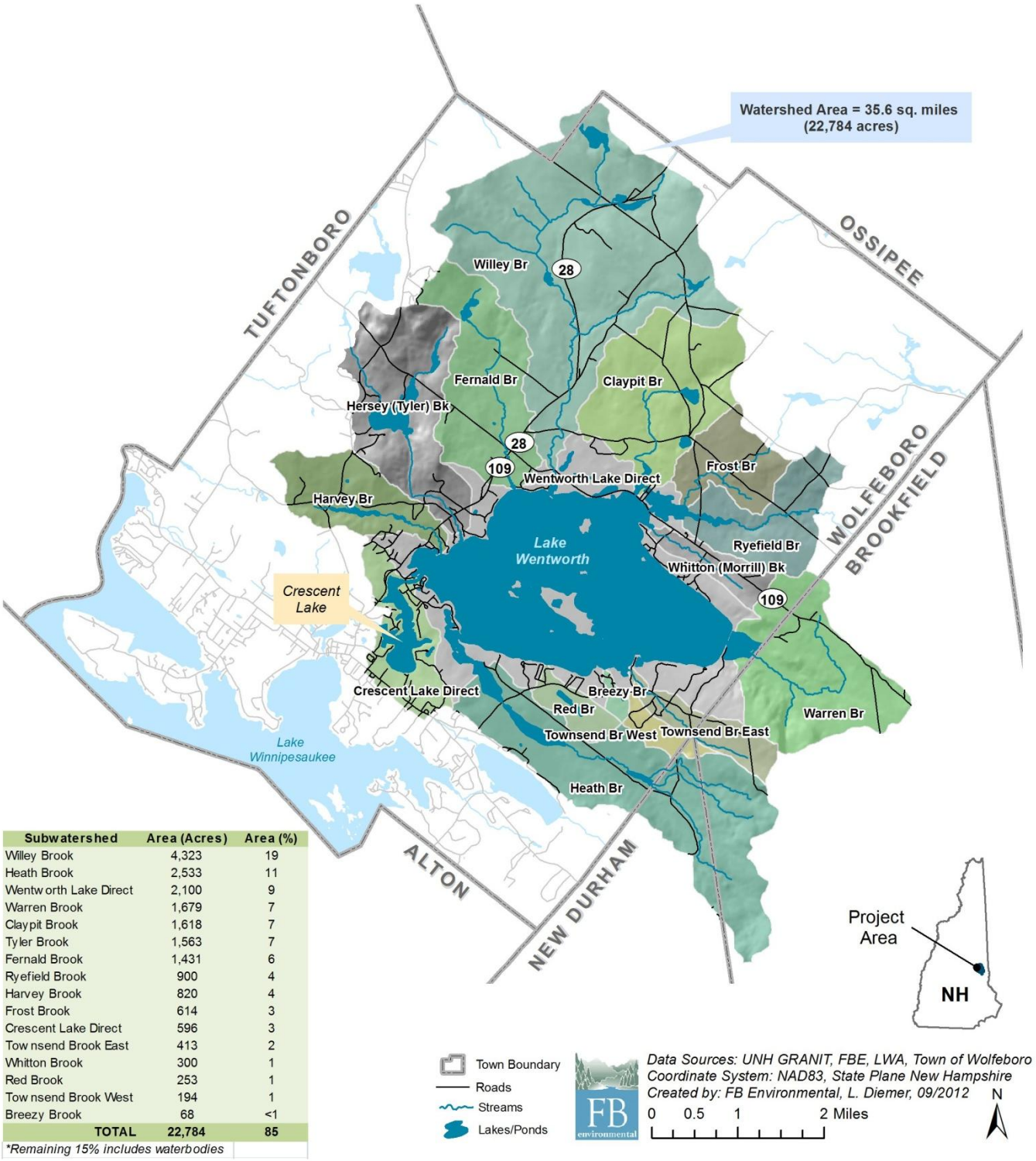
Map 6


Roads Within Riparian Buffer
Lake Wentworth & Crescent Lake Watershed
Watershed Area = 35.6 sq. miles
(22,784 acres)
TUFTONBORO
OSSIPEE
WOLFEBORO
BROOKFIELD
ALTON
NEW DURHAM
Lake Wentworth
Crescent Lake
Lake Winnipesaukee
28
109
Project Area
NH
Roads within Buffer (11%)
Riparian Buffer
Town Boundary
Roads
Watershed Boundary
Streams
Lakes/Ponds
Data Sources: UNH GRANIT, FBE
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 0.5 1 2 Miles
N
Roads within the buffer zone or riparian habitat refers to roads within 250 ft of lakes, ponds, and wetlands greater than 10 acres and roads within 75 ft of tributaries, ponds, or wetlands less than 10 acres.

Map 7

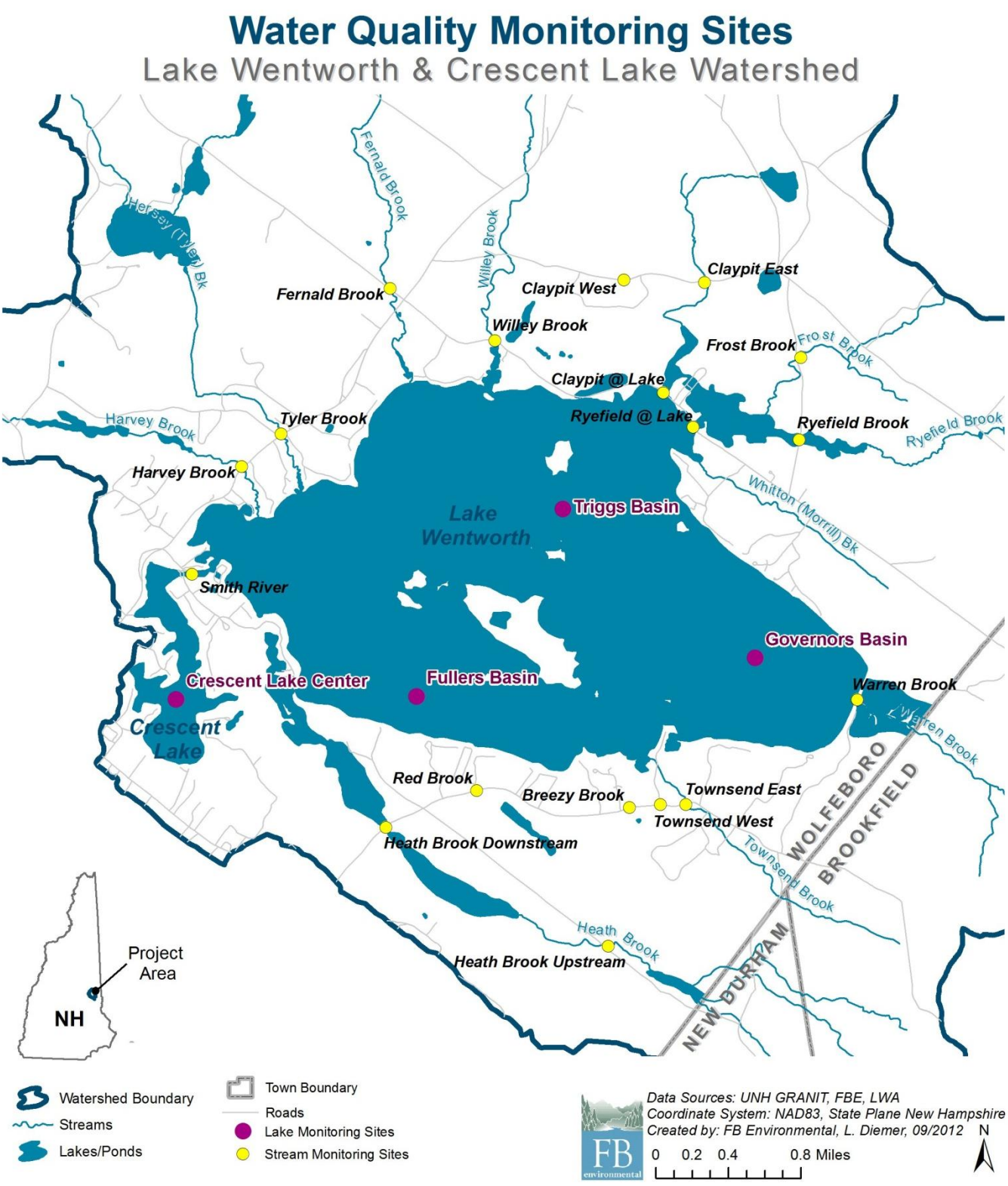
Subwatersheds

Lake Wentworth & Crescent Lake Watershed

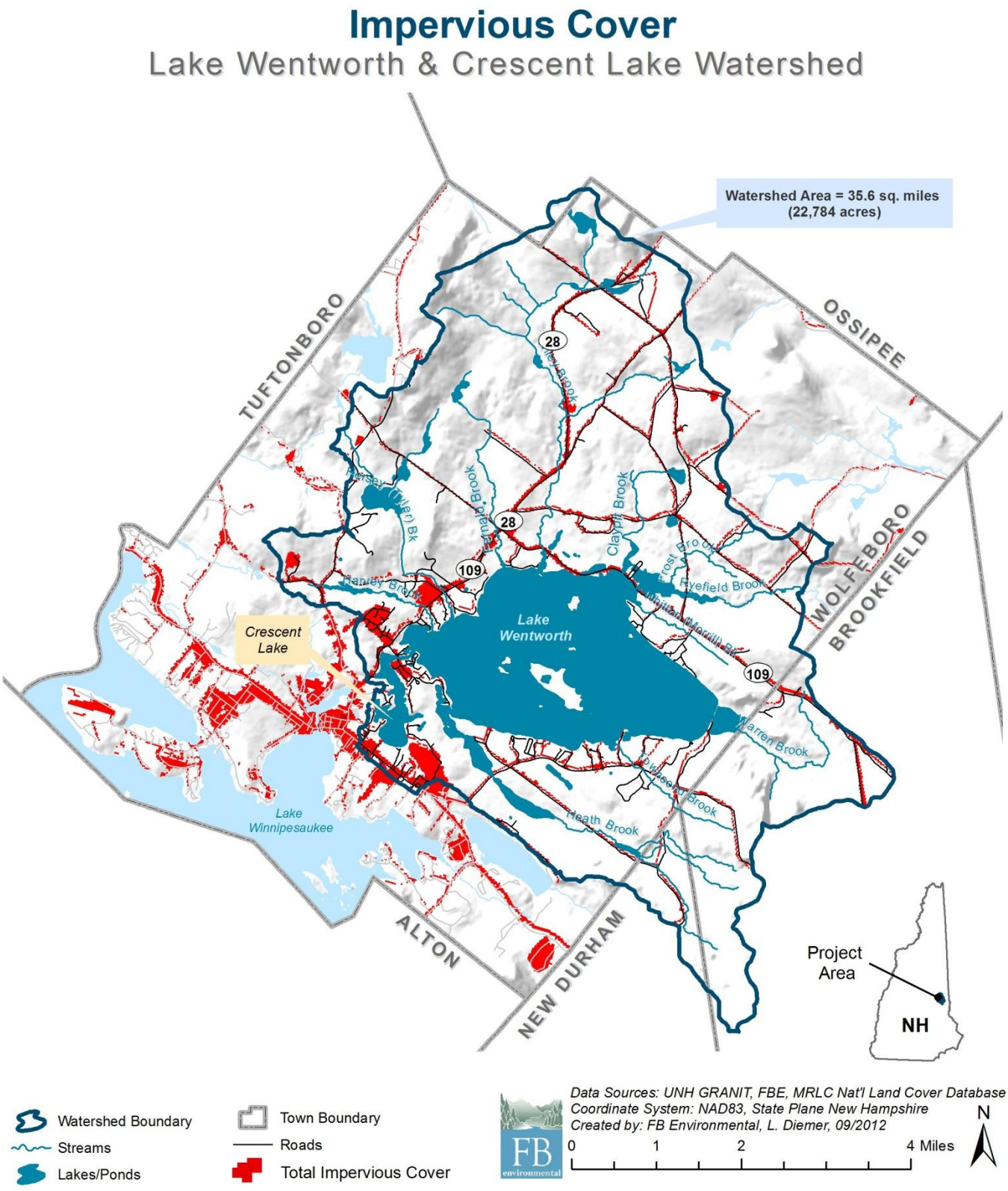


Subwatershed	Area (Acres)	Area (%)
Willey Brook	4,323	19
Heath Brook	2,533	11
Wentworth Lake Direct	2,100	9
Warren Brook	1,679	7
Claypit Brook	1,618	7
Tyler Brook	1,563	7
Fernald Brook	1,431	6
Ryefield Brook	900	4
Harvey Brook	820	4
Frost Brook	614	3
Crescent Lake Direct	596	3
Townsend Brook East	413	2
Whitton Brook	300	1
Red Brook	253	1
Townsend Brook West	194	1
Breezy Brook	68	<1
TOTAL	**22,784**	**85**
**Remaining 15% includes waterbodies*		

Map 8


Water Quality Monitoring Sites
Lake Wentworth & Crescent Lake Watershed
Fernald Brook
Willey Brook
Hersey (Tyler) Bk
Claypit East
Claypit West
Fernald Brook
Willey Brook
Frost Brook
Frost Brook
Claypit @ Lake
Ryefield @ Lake
Ryefield Brook
Ryefield Brook
Harvey Brook
Tyler Brook
Harvey Brook
Whitton (Morrill) Bk
Lake Wentworth
Triggs Basin
Smith River
Governors Basin
Crescent Lake Center
Fullers Basin
Warren Brook
Warren Brook
Crescent Lake
Red Brook
Breezy Brook
Townsend East
Townsend West
Heath Brook Downstream
WOLFEBORO
BROOKFIELD
Townsend Brook
Heath Brook
Heath Brook Upstream
NEW DURHAM
Project Area
NH
Watershed Boundary
Streams
Lakes/Ponds
Town Boundary
Roads
Lake Monitoring Sites
Stream Monitoring Sites
Data Sources: UNH GRANIT, FBE, LWA
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 0.2 0.4 0.8 Miles
N

Map 9


Impervious Cover
Lake Wentworth & Crescent Lake Watershed
Watershed Area = 35.6 sq. miles
(22,784 acres)
TUFTONBORO
OSSIPEE
WOLFEBORO
BROOKFIELD
ALTON
NEW DURHAM
Crescent Lake
Lake Wentworth
Lake Winnipesaukee
28
109
Project Area
NH
Watershed Boundary
Streams
Lakes/Ponds
Town Boundary
Roads
Total Impervious Cover
Data Sources: UNH GRANIT, FBE, MRLC Nat'l Land Cover Database
Coordinate System: NAD83, State Plane New Hampshire
Created by: FB Environmental, L. Diemer, 09/2012
FB environmental
0 1 2 4 Miles
N

Map 10

Appendix D:
Select Nutrient Modeling Results

Select Nutrient Modeling Results

(Source: Lake Wentworth and Crescent Lake Nutrient Modeling Report, May 2012)

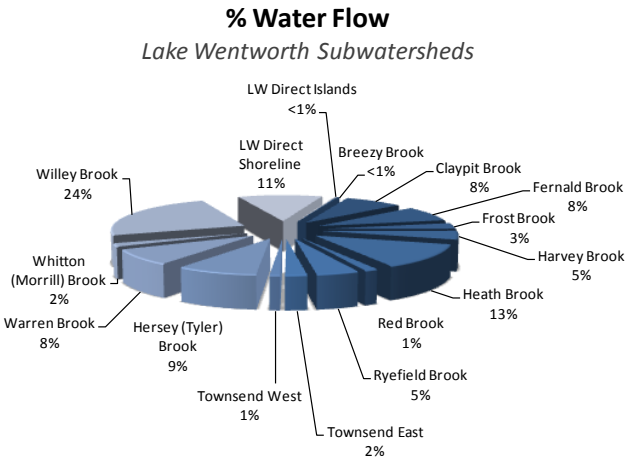
Lake Wentworth total phosphorus (P) and water loading summary

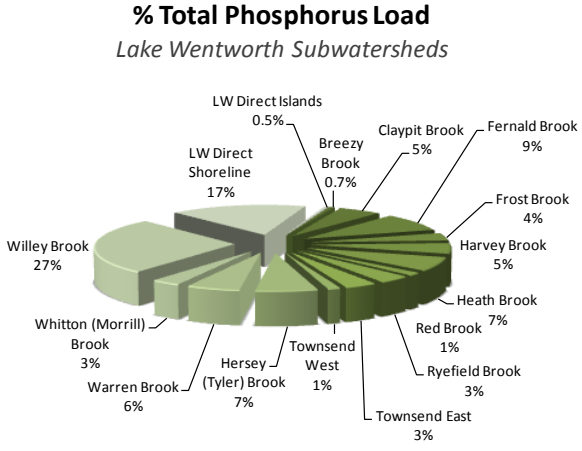
Loads to Lake Wentworth	TP *(kg/year)*	TP *(%)*	Water *(m^3/year)*	Water *(%)*
Atmospheric	244	25%	7,664,541	14%
Internal	0	0%	n/a	n/a
Waterfowl	20	2%	n/a	n/a
Septic System	79	8%	67,009	>0.2%
Watershed Load	643	65%	46,728,516	86%
Total Load To Lake Wentworth	**986**	**100 %**	**54,460,066**	**100%**

Summary of Lake Wentworth total phosphorus (P) loading by tributary basin

Watershed / Tributary	Land Area *(ha)*	Water Flow *(m^3/year)*	P concentration *(mg/L)*	P mass *(kg/year)*	Attenuation Factor†
Breezy Brook	27	153,087	0.043	6.6	0.5
Claypit Brook	655	3,700,727	0.014	50.1	0.5
Fernald Brook	579	3,745,998	0.022	82.3	0.9
Frost Brook	249	1,415,135	0.024	34.6	0.9
Harvey Brook	332	2,118,800	0.022	47.4	0.5
Heath Brook	1025	5,861,878	0.010	60.9	0.5
Red Brook	102	661,647	0.020	13.5	0.6
Ryefield Brook	364	2,109,995	0.015	32.6	0.5
Townsend East	167	1,085,813	0.030	32.1	0.9
Townsend West	78	516,318	0.025	12.8	0.45
Hersey (Tyler) Brook	633	4,047,688	0.015	60.9	0.55
Warren Brook	679	3,851,816	0.014	52.8	0.5
Whitton (Morrill) Brook	121	809,492	0.036	29.3	0.9
Willey Brook	1750	11,175,403	0.022	251.1	0.9
Lake Wentworth Shoreline Drainage – Direct Shore	850	5,367,983	0.030	160.3	0.9
Lake Wentworth Shoreline Drainage - Islands	17	106,734	0.040	4.3	0.9

† *1 = no attenuation, 0 = full attenuation*





% Water Flow and % Total Phosphorus to Lake Wentworth by subwatershed

Appendix E:
List of BMP Sites in the Lake Wentworth and Crescent Lake Watershed

Appendix E-1: BMP Priority Matrix Methodology

Lake Wentworth Watershed Plan
BMP Ranking / Pollutant Removal Estimates
Results and Methodology

Provided below is a description of the Best Management Practices (BMP) ranking selection procedures that were used for the Lake Wentworth Watershed Plan. The purpose of this ranking was to select 4 to 6 most beneficial BMP sites from all the potential sites that were identified during the watershed evaluation conducted in the fall of 2011. This evaluation included field surveys and data collection provided by LWF Steering Committee members, Town of Wolfeboro representatives, FB Environmental (FBE) and Comprehensive Environmental (CEI).

Once the potential BMP sites were identified by all participating parties, CEI compiled the data and performed two phases of ranking to determine the top 4 - 6 most beneficial BMP sites. Based on the ranking process, some of these top sites were selected for conceptual design and implementation to assist in reaching the water quality goals set forth in the Watershed Plan. Attached to this memo is map titled "Figure 1 – Lake Wentworth BMP Ranking Map" that details the Tributary Subwatersheds, all the potential BMP locations and the overall BMP Ranking Results.

CEI utilized a two phased ranking system to prioritize BMP sites. It was originally intended that the first round would reduce all the potential sites down to the top 30 and the second phase would reduce those 30 sites down to the top 4 to 6 BMP sites. The first round of ranking ultimately reduced 108 total sites down the top 30 sites. Based on the first round of ranking criteria, the last 8 sites in the top 30 (ranking positions 23 through 30) were actually tied in ranking position with a total of 29 ranking points. CEI then performed a second detailed ranking process to select the final 4 to 6 BMPs which would minimize ranking position ties. The second ranking process utilized specific watershed data and results from the Lake Loading Response Model (LLRM) provided by FBE. Below is a summary of the methods used for the first and second phases/rounds of BMP ranking process:

First Round – Table 1.0

CEI utilized seven different ranking criteria plus one specific tributary ranking methodology to determine the top 30 BMPs, as seen in Table 1.0. This ranking method utilized a point system for each criterion that were specifically categorized and weighted to determine a total point score for each BMP. The top 30 BMPs with the highest number of points were selected to be analyzed further during the second round of ranking.

The seven criteria used for round one included; Proximity to Lake, Proximity to Tributary, Sediment Accumulation, Ease of Implementation, Subwatershed Land Use, Potential BMP Pollutant Removal and Maintenance Requirements. These criteria were assigned points based on a range of values for each BMP site that can be seen under the notes for Table 1.0.

The following ranking criteria point system was used for the first round:

- "Proximity to Lake": Within 100 feet = 5 points; 101 feet - 1,000 feet = 4 points; 1,001 - 5,000 feet = 3 points; 5,001 - 10,000 feet = 2 ; 10,000+ feet = 1 point
- "Proximity to Tributary": At Crossing = 5 ; Within 500 feet = 3 ; 500+ feet = 1
- "Sediment Accumulation": Severe Sedimentation = 5; Moderate Sedimentation = 3 ; Mild Sedimentation = 1
- "Ease of Implementation": Easy, low number of issues = 5 ; Moderate, possible equipment maneuvering/ access issues = 3 ; Difficult, expensive equipment maneuvering/ road closures = 1
- "Land Use": Urban - Industrial/Commercial = 5; Mixed Use/Major Roadway = 3 ; Low Residential/Forested = 1
- "Potential BMP Pollutant Removal": (focus on TP) High Efficiency (>50%) = 5 ; Moderate Efficiency (50% - 30%) = 3 ; Low Efficiency (<30%) = 1 ; No BMP = 0
- "Maintenance Requirements": Low frequency, easy access, easy tasks = 5 ; Moderate frequency, access issues, several tasks = 3 ; High frequency, difficult to access w/ equipment = 1
- "Tributary Ranking": From Table 1.1 - Priority Points >20 = 5; 17-19 = 4; 14-16 = 3; 12-13 = 2; 10 - 11 = 1

A specific Tributary Ranking Methodology was then used as the eighth and highest weighted criteria for the first round of BMP selection. This tributary analysis incorporated results produced from the Lake Loading Response Model (LLRM) and utilized a separate ranking process to determine a particular ranking score for each of the tributary subwatersheds used in the LLRM. This tributary ranking produced a specific score for each tributary which was then assigned to each of the BMPs based on the tributary they were located in. This process linked the specific watershed modeling procedures performed in the LLRM into the BMP ranking procedures and also resulted in a better "spread" of BMP locations throughout the overall watershed as shown in Figure 1. The Tributary Ranking Methodology, shown in Table 1.1, utilized four criteria from the LLRM data including; Watershed Size, Total Phosphorus Loading, Runoff Volume and Attenuation Factor to assess each potential BMP site and associated Tributary.

The following tributary ranking criteria point system was used for the first round:

- "Total Phosphorus Loading": $\geq$ 0.025 mg/L = 10 ; < 0.025 and $\geq$ 0.020 mg/L = 6 ; < 0.020 mg/L = 2
- "Watershed Size": $\geq$ 1,000 acres = 3 ; < 1,000 and $\geq$ 500 acres = 2 ; < 500 acres = 1
- "Runoff Volume": $\geq$ 100,000,000 cf/year = 5 ; < 100,000,000 and $\geq$ 25,000,000 cf/year = 3 ; < 25,000,000 cf/year = 1
- "Attenuation Factor": $\geq$ 0.67 = 5 ; < 0.67 and $\geq$ 0.34 = 3 ; < 0.34 = 1

Second Round – Tables 2.0 & 2.1

This first round of ranking did produce a good spread of BMPs throughout the watershed, but also produced some BMPs that were located very close to each other and at times of similar type. For this reason, a different BMP ranking methodology was used for the second phase/round to reduce the top 30 down to the top 4 to 6 BMPs and to minimize ties as much as possible. Results of this ranking

methodology can be seen in Table 2.0. The methodology used specific data from the watershed LLRM to analyze each potential BMP for cost and effectiveness.

The ranking process first calculated an approximate subwatershed area for each BMP based on the model data and also where the BMP was located within the specific tributary subwatershed. It utilized this data to estimate an approximate impervious area and Water Quality Volume requirement using the NH Stormwater Manual guidance. This data, combined with the specific phosphorus loading data for the watershed that was used in the LLRM determined a phosphorus loading to each BMP as well as an estimated phosphorus removal rate. The removal rate was also based on literature provided in the NH Stormwater Manual. Based on each BMP size, type, location and other implementation factors, an estimated construction and long term maintenance cost was determined. Finally, the estimated pollutant removal and total BMP costs were used to determine a cost per pollutant removed. The top 30 BMPs were then ranked from the lowest cost per pollutant removed to the highest cost/pollutant removed and the top 4 to 6 BMP sites were selected as shown in Table 3.0. Provided below is a detailed summary of the calculations used for this BMP Ranking Methodology:

In order to correlate BMP loading estimates to the LWF watershed LLRM results, specific methodology was used in lieu of the "Simple Method". The "Simple Method" uses a calculation which multiplies the land use area within a specific BMP subwatershed by a specific rainfall amount to determine a runoff volume for that subwatershed. This runoff volume is multiplied by a specific pollutant concentration for each land use to obtain a pollutant loading to the BMP. The BMP will have a specific pollutant removal efficiency, which will dictate how much of the pollutant loading going to the BMP is actually removed and treated.

Typically, the "Simple Method" uses generic pollutant concentrations that are determined from published literature which can provide results that may not be calibrated to a specific watershed or region. These "un-calibrated" concentrations can lead to loading estimates that vary from the results determined in the LLRM. For this reason, CEI utilized an adjusted methodology to determine the BMP TP pollutant loading and estimated removals. Rather than using published literature to determine concentrations, TP loading information was pulled from the Lake Loading Response Model (LLRM) for each of the studied Tributary Areas and associated land use types. Each BMP subwatershed was broken into different land use types similar to the LLRM. Each land use type was associated with a land use coefficient to represent TP loading per acre of land on an annual basis. A specific BMP TP loading was calculated for each site by multiplying the LLRM TP loading coefficient by the specific BMP subwatershed land use area in acres. Each of the land types and corresponding TP loadings were then added to determine a total TP loading to each BMP. Similar to the "Simple Method", the associated BMP will also have a specific pollutant removal efficiency that is adjusted based on site constraints to determine how much of the estimated pollutant loading going to the BMP is actually removed and treated. This methodology is reflected in the BMP Matrix that was used to rank the top 30 potential BMP sites in Table 2.0.

The calculation for the pollutant removal used in the BMP ranking table is as follows:

For informational purposes, The Total Tributary Area (TTA), determined from the Lake Loading Response Model (LLRM) output (provided by FBE), was compared to the Tributary Total Impervious Area (TTIA also from the LLRM output), Tables 2.2 and 2.3. This comparison determined the Percent Tributary Impervious Area (%TIA) = TTIA / TTA. These tables also provide a rough break down of land

use type per Tributary Area for future BMP TP load estimating. A Tributary Water Quality Volume (TWQv) was also provided in the table and is calculated using the following NH Stormwater Manual formula: TTIA (sf) * 1"/12. These large scale calculations were not used to rank each BMP, but we used as gauges for reviewing purposes to determine if the estimates for each BMP were reasonable and would meet the intent of the project.

Next, a BMP Drainage Area (BMP DA) was drawn in GIS to determine how much runoff (and associated pollutant) is received by a specific BMP. The Total Tributary Area and the estimated BMP Drainage Area were compared to determine a Percent BMP Drainage Area ratio (%BMP DA = BMP DA / TTA). This number with the Tributary Total Impervious Area was used to compare results from the following calculations. The BMP DA was then broken up into different land use types based on the 5 general land type categories using the same GIS layer information and aerial photography:

- Urban (High & Medium Residential, Commercial & Industrial)
- Forest Land
- Open Land (Meadow & Low Density Residential)
- Agricultural Land
- Open Land (Bare soil, Mining, etc.)

Each of these land use types (LU) were assigned an average impervious area based on data from the State of New Hampshire Stormwater Manual. Urban land averaged 75% impervious, Forest land average 1% impervious, Open Land averaged 5% impervious and Agricultural land averaged 15% impervious. The land use areas (LUA) times the percent impervious, were added together to determine a weighted average impervious area per BMP (Σ LUA x IMP% = BMP IMP).

Similar to the Total Tributary Water Quality Volume, a specific BMP Water Quality Volume Required was determined using the weighted impervious areas and the following NH Stormwater Manual formula: (BMP WQv R) = BMP IMP (sf) * 1"/12.

A BMP TP Loading was also determined using this land use type breakdown. Specific land use coefficients (TP_{coeff}) for each of the 5 land types were determined from the LLRM. These were multiplied by the land use area in each BMP subwatershed to determine a total BMP TP Loading (BTPL) for each individual BMP (Σ LUA x TP_{coeff} = BTPL). The Tributary TP Loading (TTPL), determined from the LLRM output, was compared to the BMP TP Loading (BTPL) to determine if the individual estimated TP loads were reasonable.

A BMP Water Quality Volume Provided (BMP WQv P) was estimated from GIS and Ortho plans based on the available space that was present to install the BMP. These volume calculations used in the spreadsheet are all different based on available space, assumed depths, typical BMP widths and different material porosities. A BMP Sizing Factor (BMP SF) was determined using the available space information and volume provided compared to the BMP Water Quality Volume Required so a ratio could be determined based on the following formula: BMP SF = BMP WQv P / BMP WQv R.

Each type of BMP was then analyzed to determine a BMP TP Pollutant Removal Efficiency (BMP TP PRE) based on published literature from the NH Stormwater Manual. This efficiency was adjusted based on the BMP Sizing Factor Ratio and literature based removal rates to determine a BMP Actual TP

Pollutant Removal Efficiency using the following formula: (BMP ATP PRE) = BMP TP PRE * BMP SF. Finally, a BMP Annual TP Pollutant Removal was determined using the adjusted BMP loading estimate and the adjusted BMP removal efficiency: (BMP ATP PR = BMP TPL * BMP ATP PRE).

Finally, an estimated conceptual construction cost for each BMP was determined based on type, size, location and complexity of construction. Cost data was provided from published literature and historical construction costs from previously completed BMP projects. Contingencies were also carried for construction and project specific costs like stabilization techniques and dredging costs. An engineering design and permitting cost was added to these construction cost estimates to calculate total BMP costs. It should be noted that these costs were presented for ranking purposes only and actual construction and engineering estimates should be refined once these BMPs are selected for implementation and full scale design completed. An estimated annual maintenance cost was also determined for each BMP and the construction costs and projected maintenance estimates were summed to determine a total 10 year cost per BMP. The BMP Annual TP Pollutant Removal estimates were multiplied by 10 to determine the total pollutant removed over 10 years and these results were divided into the total 10 year projected costs to determine a cost per amount of pollutant removed.

BMP Ranking Results

This two phased BMP ranking methodology produced 6 BMP sites that were located near the most urbanized areas of both Lake Wentworth and Crescent Lake as shown in Table 3.0 and Figure 1. The top 6 sites are estimated to treat 84 acres of the watershed study area and approximately 37 acres of impervious area. It is projected that the top 6 sites will remove approximately 19.5 kg (43.0 pounds) of phosphorus per year from the watershed, which accounts for approximately 17% of the total estimated removal for the top 30 sites shown in Table 2.0. It is anticipated over a 10 year period, that these top 6 BMP sites will cost an average of $2,100 per kilogram of phosphorus removed from the watershed. Four of these top 6 sites have been conceptualized and preliminary designs have been prepared for implementation. These four BMPs are estimated to reduce the total TP loading by nearly 16 kg/year.

Appendix E.2 – Top 6 BMP Locations

Map ID	Top 30 ID	BMP Description	Tributary	BMP Drainage Area (acres)	BMP Impervious Drainage Area (acres)	BMP TP Loading (kg/year)	BMP Type	BMP Workable Area	BMP WQv Provided (cf)	BMP Sizing Factor	BMP TP Pollutant Removal Efficiency	BMP Annual TP Pollutant Removal (kg/year)	Conceptual BMP Cost Estimate	BMP Annual Maintenance Cost Estimate	10 yr Cost Per Pound TP Pollutant Removed ($/kg)	Rank
39	**R-11**	Wentworth State Park BMPs	Lake Wentworth	5.70	0.86	2.15	Stabilization & Infiltration BMPs	13,660	3,124	100%	60%	1.29	$19,607	$500	$1,908	1
67	**R-13**	Next to the Lake Motel - South Main Street Drainage Outlet	Crescent Lake	30.83	17.82	19.42	Detention Area / Gravel Wetlands	16,800	64,686	100%	55%	10.68	$203,197	$250	$1,926	2
40	**R-4**	Gov Went Hwy Shoulder & Pull-Off #2	Lake Wentworth	5.33	2.86	3.58	Infiltration BMPs	10,700	10,370	100%	60%	2.15	$46,069	$500	$2,375	3
70	**R-6**	Camp Bernadette Beach Area / Access	Lake Wentworth	14.78	6.31	7.31	Infiltration BMPs	7,800	9,360	41%	60%	1.79	$38,285	$500	$2,416	4
96	**R-28**	Crescent Lake Ave - Old Failed Level Lip Spreader	Crescent Lake	13.26	4.60	5.66	Treatment Swales	15,000	15,000	90%	25%	1.27	$26,029	$500	$2,441	5
79	**R-25**	Pleasant Valley Rd @ DeVyler Farm	Townsend Brook East	14.38	4.40	7.98	Bioretention Area	5,000	7,000	44%	65%	2.27	$52,211	$500	$2,516	6
TOTALS:				**84.28**	**36.85**	**46.10**						**19.46**	**$385,398**	**$2,750**		

Appendix E.3 – Top 30 BMP Locations by Watershed

Lake Wentworth BMP Ranking														
Map ID	Top 30 ID	BMP Description	Tributary	BMP TP Loading (kg/year)	BMP Impervious Drainage Area (acres)	BMP WQv Required (cf)	BMP Type	BMP Annual TP Pollutant Removal (kg/year)	Conceptual BMP Construction Cost	Conceptual BMP Design Cost	Conceptual BMP Permitting Cost	Conceptual BMP Cost Estimate	BMP Annual Maintenance Cost Estimate	10 yr Cost Per Pound TP Pollutant Removed ($/kg)	Rank
21	**R-2**	Wentworth State Park BMPs	Lake Wentworth	2.15	0.86	3,124	Stabilization & Infiltration BMPs	1.29	$9,607	$5,000	$5,000	$19,607	$500	$1,908	1
19	**R-8**	Gov Went Hwy Shoulder & Pull-Off #2	Lake Wentworth	3.58	2.86	10,370	Infiltration BMPs	2.15	$33,569	$7,500	$5,000	$46,069	$500	$2,375	2
103	**R-18**	Camp Bernadette Beach Area / Access	Lake Wentworth	7.31	6.31	22,909	Infiltration BMPs	1.79	$25,785	$7,500	$5,000	$38,285	$500	$2,416	3
20	**R-9**	Pleasant Valley Rd @ DeVyler Farm	Townsend Brook East	7.98	4.40	15,973	Bioretention Area	2.27	$39,711	$7,500	$5,000	$52,211	$500	$2,516	4
36	**R-14**	Gov Went Hwy Pull Off #1	Lake Wentworth	2.56	2.04	7,394	Infiltration Trenches	1.24	$16,529	$5,000	$5,000	$26,529	$500	$2,534	5
22	**R-10**	Trite Enterprise - South	Fernald Brook	8.62	7.78	28,256	Stormwater Wetlands	2.41	$48,485	$7,500	$2,500	$58,485	$500	$2,629	6
39	**R-11**	Red Brook Circle @ Lake Wentworth - Culvert / Outfall	Lake Wentworth	4.26	3.14	11,413	Bioretention Area	2.77	$56,592	$10,000	$5,000	$71,592	$500	$2,763	7
40	**R-4**	Trite Enterprise - North	Fernald Brook	3.75	3.20	11,599	Stormwater Wetlands	1.69	$31,954	$7,500	$2,500	$41,954	$500	$2,780	8
70	**R-6**	120 Townsend Shore Rd	Lake Wentworth	1.87	0.49	1,765	Vegetated Buffers	0.43	$2,479	$2,500	$2,500	$7,479	$500	$2,906	9
74	**R-7**	Birchmont Camp - Beach parking area	Morrill Brook	4.37	3.08	11,192	Bioretention Area	1.21	$23,603	$5,000	$5,000	$33,603	$500	$3,196	10
84	**R-26**	Fern Ave Beach	Lake Wentworth	1.49	0.52	1,870	Treatment Swales	0.37	$2,061	$2,500	$2,500	$7,061	$500	$3,229	11

Appendix E.3 continued

Lake Wentworth BMP Ranking															
Map ID	Top 30 ID	BMP Description	Tributary	BMP TP Loading (kg/year)	BMP Impervious Drainage Area (acres)	BMP WQv Required (cf)	BMP Type	BMP Annual TP Pollutant Removal (kg/year)	Conceptual BMP Construction Cost	Conceptual BMP Design Cost	Conceptual BMP Permitting Cost	Conceptual BMP Cost Estimate	BMP Annual Maintenance Cost Estimate	10 yr Cost Per Pound TP Pollutant Removed ($/kg)	Rank
37	**R-24**	Albee Beach	Lake Wentworth	0.68	0.39	1,418	Vegetated Buffers	0.30	$1,953	$1,500	$1,500	$4,953	$500	$3,268	12
44	**R-19**	125 Turtle Island Rd	Lake Wentworth	1.82	1.24	4,500	Vegetated Buffers	0.82	$12,398	$5,000	$5,000	$22,398	$500	$3,350	13
38	**R-3**	Willey Brook Sediment Delta	Wiley Brook	251.10	N/A	N/A	Dredging	57.33	$235,917	$5,000	$15,000	$255,917	$0	$4,464	14
45	**R-12**	Fernald Brook Sediment Delta	Fernald Brook	82.30	N/A	N/A	Dredging	20.00	$82,315	$5,000	$15,000	$102,315	$0	$5,115	15
95	**R-22**	7-11 Store Parking Lot	Fernald Brook	0.72	0.67	2,437	Bioretention Area	0.47	$12,082	$5,000	$5,000	$22,082	$500	$5,756	16
90	**R-17**	Cotton Valley Rail-Trails - Lake Wentworth	Lake Wentworth	0.80	0.11	410	Vegetated Filter Strip	0.19	$5,000	$2,500	$5,000	$12,500	$500	$9,109	17
92	**R-27**	Center St & Trotting Track Rd @ Hersey Brook	Hersey Brook	9.98	7.74	28,095	Leaching Catch Basins	0.13	$50,000	$10,000	$5,000	$65,000	$500	$54,759	18
79	**R-25**	Birchmont Camp - Steep Access Road	Lake Wentworth	1.13	0.91	3,300	Treatment Swales & LCBs	0.07	$30,000	$7,500	$5,000	$42,500	$300	$61,620	19
82	**R-16**	Center St @ Fernald Brook	Fernald Brook	3.84	3.33	12,087	Leaching Catch Basins	0.09	$40,000	$7,500	$5,000	$52,500	$400	$61,733	20
104	**R-30**	Orchard Drive & Pleasant Valley Rd @ Townsend Brook	Townsend Brook East	1.63	1.28	4,629	Leaching Catch Basins	0.05	$20,000	$5,000	$5,000	$30,000	$200	$63,201	21
23	**R-23**	North Line Rd & Gov Went Hwy @ Wiley Brook	Wiley Brook	1.58	0.98	3,560	Leaching Catch Basins	0.06	$32,000	$7,500	$5,000	$44,500	$200	$72,723	22
LAKE WENTWORTH TOTALS:				**403.52**	**51.32**	**186,301**		**97.16**				**$1,057,539**	**$9,100**		

Appendix E.3 continued

Crescent Lake BMP Ranking

Map ID	Top 30 ID	BMP Description	Tributary	BMP TP Loading (kg/year)	BMP Impervious Drainage Area (acres)	BMP WQv Required (cf)	BMP Type	BMP Annual TP Pollutant Removal (kg/year)	Conceptual BMP Construction Cost	Conceptual BMP Design Cost	Conceptual BMP Permitting Cost	Conceptual BMP Cost Estimate	BMP Annual Maintenance Cost Estimate	10 yr Cost Per Pound TP Pollutant Removed ($/kg)	Rank
67	**R-13**	Next to the Lake Motel - South Main Street Drainage Outlet	Crescent Lake	19.42	17.82	64,686	Detention Area / Gravel Wetlands	10.68	$178,197	$20,000	$5,000	$203,197	$250	$1,926	1
96	**R-28**	Crescent Lake Ave - Old Failed Level Lip Spreader	Crescent Lake	5.66	4.60	16,702	Treatment Swales	1.27	$18,529	$5,000	$2,500	$26,029	$500	$2,441	2
68	**R-1**	Kingswood Condos - Lower Condos & Lake Access	Crescent Lake	5.17	3.53	12,824	Bioretention Area	1.98	$37,488	$7,500	$5,000	$49,988	$500	$2,777	3
66	**R-15**	Next to the Lake Motel - South Main Street Entrance	Crescent Lake	5.30	4.76	17,285	Bioretention Area	2.46	$61,091	$10,000	$5,000	$76,091	$500	$3,300	4
65	**R-5**	Kingswood Condos - Upper Area & Gravel Access	Crescent Lake	1.73	1.39	5,058	Treatment Swales	0.43	$5,574	$2,500	$1,500	$9,574	$500	$3,371	5
63	**R-21**	Huggins Hospital - Back Parking Area	Crescent Lake	1.30	1.21	4,381	Bioretention Area	0.85	$21,723	$5,000	$5,000	$31,723	$500	$4,341	6
48	**R-20**	Cotton Valley Rail-Trails - Crescent Lake	Crescent Lake	0.43	0.06	223	Infiltration Trenches	0.26	$5,000	$2,500	$5,000	$12,500	$500	$6,732	7
100	**R-29**	South Main Street & Coves End Road	Crescent Lake	2.43	2.36	8,549	Leaching Catch Basins	0.10	$50,000	$10,000	$2,500	$62,500	$500	$66,013	8
CRESCENT LAKE TOTALS:				**41.44**	**35.73**	**129,708**		**18.03**				**$471,602**	**$3,750**		

Appendix E.4 – Prioritization of Potential BMP Locations (108 sites)

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
68	**71**	Kingswood Condos - Lower Condos & Lake Access	Crescent Lake	3	5	5	5	5	5	5	3	36	1
21	**21**	Trite Enterprise - North	Fernald Brook	3	5	5	5	4	5	5	3	35	2
38	**38**	Gov Went Hwy Pull Off #1	Wentworth Lake	5	5	3	5	5	3	5	3	34	3
40	**41, 42, 43**	Gov Went Hwy Shoulder & Pull-Off #2	Wentworth Lake	5	5	3	5	5	3	5	3	34	3
65	**68**	Kingswood Condos - Upper Area & Gravel Access	Crescent Lake	3	3	5	5	5	5	5	3	34	3
70	**73, 74**	Camp Bernadette Beach Area / Access	Wentworth Lake	5	5	3	3	5	5	5	3	34	3
74	**78**	Red Brook Circle @ Lake Wentworth - Culvert / Outfall	Wentworth Lake	5	5	5	5	5	1	5	3	34	3
19	**19**	7-11 Store Parking Lot	Fernald Brook	3	5	3	5	4	5	5	3	33	8
20	**20**	Center St @ Fernald Brook	Fernald Brook	3	5	3	5	4	3	5	5	33	8
22	**22**	Trite Enterprise - South	Fernald Brook	3	3	5	5	4	5	5	3	33	8
39	**39,40**	Wentworth State Park BMPs	Wentworth Lake	5	5	1	5	5	3	5	3	32	11
45	**48**	Cotton Valley Rail-Trails - Lake Wentworth	Wentworth Lake	5	5	3	3	5	3	3	5	32	11
67	**70**	Next to the Lake Motel - South Main Street Drainage Outlet	Crescent Lake	3	3	5	3	5	5	5	3	32	11
36	**36**	Center St & Trotting Track Rd @ Hersey Brook	Hersey Brook	3	5	3	5	2	3	5	5	31	14

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
66	**69**	Next to the Lake Motel - South Main Street Entrance	Crescent Lake	2	3	3	5	5	5	5	3	31	14
82	**86**	Orchard Drive & Pleasant Valley Rd @ Townsend Brook	Townsend Brook East	3	5	3	5	4	1	5	5	31	14
90	**94**	Birchmont Camp - Steep Access Road	Wentworth Lake	4	3	3	1	5	5	5	5	31	14
103	**No Previous**	Fernald Brook Sediment Delta	Fernald Brook	5	5	5	1	4	5	5	1	31	14
44	**47**	Albee Beach	Wentworth Lake	5	5	1	3	5	3	3	5	30	19
48	**51**	Cotton Valley Rail-Trails - Crescent Lake	Crescent Lake	3	5	3	3	5	3	5	3	30	19
63	**66**	Huggins Hospital - Back Parking Area	Crescent Lake	3	3	1	5	5	5	5	3	30	19
95	**99**	125 Turtle Island Rd	Wentworth Lake	5	3	1	5	5	1	5	5	30	19
23	**23**	North Line Rd & Gov Went Hwy @ Wiley Brook	Wiley Brook	3	5	1	5	4	1	5	5	29	23
37	**37**	Fern Ave Beach	Wentworth Lake	5	5	3	5	4	3	1	3	29	23
79	**83**	Pleasant Valley Rd @ DeVyler Farm	Townsend Brook East	3	3	3	5	4	3	5	3	29	23
84	**88**	120 Townsend Shore Rd	Wentworth Lake	4	1	3	5	5	1	5	5	29	23
92	**96**	Birchmont Camp - Beach parking area	Morrill Brook	5	2	3	1	5	5	5	3	29	23
96	**100**	Crescent Lake Ave - Old Failed Level Lip Spreader	Crescent Lake	2	1	5	3	5	3	5	5	29	23

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
100	**104**	South Main Street & Coves End Road	Crescent Lake	2	1	3	5	5	3	5	5	29	23
104	**No Previous**	Willey Brook Sediment Delta	Wiley Brook	5	5	5	1	4	3	5	1	29	23
43	**46**	Center St @ Harvey Brook	Harvey Brook	3	5	3	3	3	3	5	3	28	31
46	**49**	Center St @ Evans Brothers	Crescent Lake	3	3	5	1	5	3	3	5	28	31
51	**54**	Crescent Lake Boat Launch - Upper Parking Area	Crescent Lake	3	5	3	3	5	3	1	5	28	31
52	**55**	Crescent Lake Boat Launch - Boat Access & Lower Parking Area	Crescent Lake	3	5	3	3	5	3	5	1	28	31
54	**57**	33 Crystal Shore Lane	Crescent Lake	3	3	3	5	5	1	3	5	28	31
55	**58**	41 Crystal Shore Lane	Crescent Lake	3	3	3	5	5	1	3	5	28	31
56	**59**	4 Shady Lane	Wentworth Lake	3	3	3	5	5	1	5	3	28	31
57	**60**	6 Shady Lane	Wentworth Lake	3	3	3	5	5	1	5	3	28	31
58	**61**	60 Holden Shore Rd	Wentworth Lake	3	3	3	5	5	1	5	3	28	31
59	**62**	92 Holden Shore Rd	Wentworth Lake	3	3	3	5	5	1	3	5	28	31
61	**64**	242 McNamus Rd	Crescent Lake	3	3	3	5	5	1	3	5	28	31
72	**76**	88 Churchill Rd	Wentworth Lake	5	3	5	1	5	1	3	5	28	31

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant	Maintenance Requirements	Priority Points	Rank
73	**77**	96 Churchill Rd	Wentworth Lake	5	3	5	1	5	1	3	5	28	31
30	**30**	Middle Rd @ Harvey Brook	Harvey Brook	2	5	3	5	3	1	3	5	27	44
32	**32**	Beach Pond Rd @ Harvey Brook	Harvey Brook	2	5	3	5	3	1	5	3	27	44
35	**35**	Center St @ Albee Contractors	Hersey Brook	3	3	5	3	2	5	1	5	27	44
78	**82**	Pleasant Valley Rd @ Townsend Brook (West)	Townsend Brook East	3	5	1	1	4	3	5	5	27	44
85	**89**	100 Townsend Shore Rd	Wentworth Lake	4	3	3	3	5	1	3	5	27	44
89	**93**	Warren Sands Rd @ Warren Brook (Gravel Pit)	Wentworth Lake	4	1	5	3	5	1	5	3	27	44
91	**95**	Birchmont Camp - Outside of the beach	Morrill Brook	5	2	3	1	5	5	1	5	27	44
99	**103**	Fire Station	Crescent Lake	2	1	1	3	5	5	5	5	27	44
14	**14**	Center St @ Wiley Brook (South)	Wiley Brook	2	5	1	1	4	3	5	5	26	52
24	**24**	Bryant Rd @ Frost Brook	Frost Brook	3	5	1	5	3	1	3	5	26	52
33	**33**	Trotting Track Rd (East) @ Harvey Brook	Harvey Brook	3	3	1	5	3	1	5	5	26	52
47	**50**	Whitten Neck & Lake Went @ Crescent Lake	Crescent Lake	3	5	1	1	5	1	5	5	26	52
49	**52**	8 Zephyr Lane	Crescent Lake	3	3	3	3	5	1	3	5	26	52

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
50	**53**	Silver St @ Crescent Lake Boat Launch	Crescent Lake	3	3	1	5	5	3	1	5	26	52
60	**63**	59 Kings Pine Rd	Crescent Lake	3	3	1	5	5	1	3	5	26	52
62	**65**	204 McNamus Rd	Crescent Lake	3	3	3	3	5	1	5	3	26	52
64	**67**	Christian Ridge Road	Crescent Lake	3	3	3	5	5	1	1	5	26	52
69	**72**	Kingswood Regional High School	Crescent Lake	3	1	1	5	5	5	5	1	26	52
87	**91**	Brackett Corner Rd @ Townsend Brook	Townsend Brook East	3	5	3	5	4	1	0	5	26	52
101	**No Previous**	Townsend Brook Streambank Erosion	Townsend Brook East	4	5	5	1	4	1	3	3	26	52
2	**2**	Pork Hill Rd @ Unnamed Pond & Wiley Brook	Wiley Brook	1	5	1	5	4	1	3	5	25	64
16	**16**	College Rd @ Wiley Brook	Wiley Brook	3	5	1	5	4	1	1	5	25	64
18	**18**	North Line Rd @ Fernald Brook	Fernald Brook	3	5	1	1	4	1	5	5	25	64
71	**75**	Pleasant Valley Rd @ Heath Brook	Heath Brook	3	5	3	5	2	1	1	5	25	64
75	**79**	Red Brook Circle / Wentworth Estates - Upper Drainage	Red Brook	4	3	5	5	1	1	1	5	25	64
77	**81**	Point O Pines @ Townsend Brook	Townsend Brook East	4	5	3	3	4	1	0	5	25	64
80	**84**	Pleasant Valley Rd @ Townsend Brook (East)	Townsend Brook East	3	5	3	1	4	3	1	5	25	64

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
86	**90**	Pleasant Valley Rd - Residential Site	Wentworth Lake	4	3	5	1	5	1	1	5	25	64
88	**92**	Pleasant Valley Rd @ 3 Lot Subdivision	Townsend Brook East	3	1	5	5	4	1	1	5	25	64
93	**97**	Martin Hill Rd	Morrill Brook	3	1	5	5	4	1	1	5	25	64
97	**101**	Huggins Hospital - Old Storm Water Detention Pond	Crescent Lake	2	1	3	3	5	5	3	3	25	64
98	**102**	Christian Ridge Road - Wetlands	Crescent Lake	2	3	5	1	5	3	3	3	25	64
102	**No Previous**	Trotting Track Rd Drainage Swale	Hersey Brook	3	3	5	3	2	3	3	3	25	64
107	**No Previous**	Townsend Brook Sediment Delta	Townsend Brook East	5	5	3	1	4	1	5	1	25	64
10	**10**	Center St @ Wiley Brook (North)	Wiley Brook	2	3	1	1	4	3	5	5	24	78
41	**44**	Bryant Rd @ Ryefield Brook	Ryefield Brook	3	5	1	5	1	1	3	5	24	78
42	**45**	Turtle Island Rd @ Morrill Brook	Morrill Brook	4	5	3	1	4	1	1	5	24	78
76	**80**	New Garden Rd @ Heath Brook	Heath Brook	2	5	3	5	2	1	1	5	24	78
83	**87**	Stoneyfield Farm Rd @ Townsend Brook	Townsend Brook East	3	5	3	3	4	1	0	5	24	78
106	**No Previous**	Harvey Brook Sediment Delta	Harvey Brook	5	5	3	1	3	1	5	1	24	78
12	**12**	Stoddard Rd @ Wiley Brook (North)	Wiley Brook	1	1	5	5	4	1	1	5	23	84

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
17	**17**	College Rd @ Clay Pit Brook	Clay Pit Brook	3	5	1	5	2	1	1	5	23	84
25	**25**	Cotton Valley Rd @ Frost Brook	Frost Brook	2	1	3	5	3	1	3	5	23	84
29	**29**	Cotton Valley Rd @ Ryefield Brook	Ryefield Brook	2	5	3	5	1	1	1	5	23	84
53	**56**	37 Blackberry Lane	Crescent Lake	3	3	0	5	5	1	1	5	23	84
94	**98**	Wentworth Farm Rd @ Morrill Brook	Morrill Brook	3	5	3	1	4	1	1	5	23	84
105	**No Previous**	Hersey Brook Sediment Delta	Hersey Brook	5	5	3	1	2	1	5	1	23	84
26	**26**	Jenness Farm Rd @ Frost Brook	Frost Brook	2	1	5	5	3	1	0	5	22	91
108	**No Previous**	Kingswood Golf Club	Crescent Lake	3	1	1	3	5	3	3	3	22	91
1	**1**	Pork Hill Rd @ Batson Pond & Wiley Brook	Wiley Brook	1	3	1	3	4	1	3	5	21	93
3	**3**	Center St by Johnson Rd @ Unnamed Pond	Wiley Brook	1	5	1	3	4	3	1	3	21	93
11	**11**	Haines Hill @ Wiley Brook	Wiley Brook	1	1	3	5	4	1	1	5	21	93
31	**31**	Middle Rd & Beach Pond Rd @ Harvey Brook	Harvey Brook	2	3	1	5	3	1	1	5	21	93
34	**34**	Trotting Track Rd & Private Rd @ Hersey Brook	Hersey Brook	3	5	5	1	2	1	1	3	21	93
7	**7**	Sargents Pond Rd @ Sargents Pond	Hersey Brook	2	1	1	5	2	1	3	5	20	98

Appendix E.4 continued

Map ID	Previous Map ID	BMP Description	Tributary	Proximity to Lake	Proximity to Tributary	Sediment Accumulation	Ease of Implementation	Tributary Ranking	Land Use	Potential BMP Pollutant Removal	Maintenance Requirements	Priority Points	Rank
8	**8**	North Line Rd @ Sargents Pond	Hersey Brook	2	1	1	5	2	1	3	5	20	98
15	**15**	Bickford @ Clay Pit Brook	Clay Pit Brook	2	5	1	3	2	1	1	5	20	98
81	**85**	Orchard Drive #41 & #59	Townsend Brook West	3	1	1	5	3	1	1	5	20	98
13	**13**	Stoddard Rd @ Wiley Brook (South)	Wiley Brook	1	1	1	5	4	1	1	5	19	102
28	**28**	Cotton Mtn Rd @ Ryefield Brook	Ryefield Brook	2	1	3	5	1	1	1	5	19	102
6	**6**	Beach Pond Rd @ Sargents Pond	Hersey Brook	1	1	1	1	2	1	5	5	17	104
4	**4**	Unknown Rd @ Wiley Pond	Wiley Brook	1	5	1	3	4	1	0	0	15	105
9	**9**	Tribbets Rd @ Fernald Book	Fernald Brook	2	5	0	0	4	1	0	0	12	106
27	**27**	Stoneham Rd @ Frost Brook	Removed	2	1	1	5	0	1	0	0	10	107
5	**5**	North Line Rd @ Upper Beach Pond	Removed	1	0	0	0	0	1	0	0	2	108

Explanation of Ranking

Proximity to Lake: Within 100 feet = 5; 101 feet - 1,000 feet = 4; 1,001 - 5,000 feet = 3; 5,001 - 10,000 feet = 2; 10,000+ feet = 1

Proximity to Tributary: At Crossing = 5; within 500 feet = 3; 500+ feet = 1

Sediment Accumulation: Severe Sedimentation = 5; Moderate Sedimentation = 3; Mild Sedimentation = 1

Ease of Implementation: Easy, low number of issues = 5; Moderate, possible equipment maneuvering/ access issues = 3; Difficult, expensive equipment maneuvering/road closures = 1

Tributary Ranking: From Table 1.1 - Priority Points >20 = 5; 17-19 = 4; 14-16 = 3; 12-13 = 2; 10 - 11 = 1

Land Use: Industrial/Commercial = 5; Mixed Use/Major Roadway = 3; Residential/Forested = 1

Potential BMP Pollutant Removal: (focus on TP) High Efficiency (>50%) = 5; Moderate Efficiency (50% - 30%) = 3; Low Efficiency (<30%) = 1; No BMP = 0

Maintenance Requirements: Low frequency, easy access, easy tasks = 5; Moderate frequency, access issues, several tasks = 3; High frequency, difficult to access w/ equipment = 1

Appendix E.5 – Lake Wentworth BMP Ranking Map

FIGURE 1 - LAKE WENTWORTH BMP RANKING MAP

Legend

BMP Ranked Locations

- High
- Medium
- Low

Roads

Waterbodies

Streams

Data Source: GRANIT, Town of Wolfeboro, FB Environmental

0 2,150 4,300 8,600 12,900 Feet

Appendix F:
BMP Conceptual Designs

SITE 1 - TREATMENT/INFILTRATION SWALES AND SITE STABILIZATION AT WENTWORTH STATE PARK

DESCRIPTION:

PROPOSED BMPS AT WENTWORTH STATE PARK WILL INCLUDE STABILIZATION TECHNIQUES AND INFILTRATION DEVICES TO MANAGE POLLUTANT LADEN STORMWATER FROM RUNNING OVER THE BEACH AND PARK AREA AND WASHING DIRECTLY INTO LAKE WENTWORTH. STABILIZATION TECHNIQUES WILL INCLUDE EROSION CONTROL FABRICS, VEGETATION, MULCH, FILTER SOX TO PROTECT BARE SOIL AND EXPOSED TREE ROOTS AND PERVIOUS MATERIALS TO PROVIDE FORMAL FOOTPATHS AND VEHICLE PARKING. INFILTRATION DEVICES WILL INCLUDE RAIN GARDENS AND INFILTRATION TRENCHES TO REDUCE THE AMOUNT OF RUNOFF FROM THE PARK AND ROADWAY ONTO THE BEACH AREA.

DESIGN:

TOPOGRAPHIC SURVEY AND TEST PITS TO CONFIRM GROUNDWATER DEPTH AND SOIL TYPE ARE RECOMMENDED TO COMPLETE THE DESIGN OF THESE BMPS. FINAL DESIGN SHOULD INCLUDE ADEQUATE SIZING, LOCATING AND SPECIFYING OF STABILIZATION MATERIALS AND PROPER BMP VOLUME SIZING TO ENSURE COMPLIANCE WITH LOCAL AND STATE STORMWATER STANDARDS FOR INFILTRATION DEVICES.

LAND ACCESS:

ALL PROPOSED WORK WILL BE LIMITED TO THE TOWN OF WOLFEBORO RIGHT OF WAY AND WENTWORTH STATE PARK WHICH IS OWNED AND OPERATED BY THE STATE OF NEW HAMPSHIRE. COORDINATION WILL BE REQUIRED TO OBTAIN PERMISSION FROM THE STATE.

PERMITTING:

WORK WILL OCCUR WITHIN BUFFERS OF LAKE WENTWORTH, BUT NO ACTIVITIES WILL BE PROPOSED TO LAND UNDER WATER OR DESIGNATED WETLANDS. LOCAL PERMISSION THROUGH THE CONSERVATION COMMISSION AND POSSIBLY STATE PERMISSION THROUGH THE PERMIT BY NOTIFICATION PROCESS WILL BE REQUIRED FOR THIS WORK.

CONSTRUCTION:

NO SPECIAL CONSTRUCTION WILL BE REQUIRED FOR THIS PROJECT SITE. STANDARD MATERIALS CAN BE USED AND CUSTOMARY CONSTRUCTION PRACTICES CAN BE EMPLOYED TO IMPLEMENT THESE BMPS. BASED ON THE PROXIMITY TO THE LAKE AND THE PRESENCE OF STANDING WATER AT THE TIME OF SITE VISITS, SOME EXCAVATIONS WILL ENCOUNTER GROUNDWATER AND REQUIRE PUMPING.

MAINTENANCE:

STABILIZATION BMPS WILL REQUIRE ROUTINE MAINTENANCE TO ENSURE HEALTHY VEGETATIVE COVER INCLUDING WATERING, VEGETATION MONITORING, REPAIRS, RE-SEEDING, MOWING AND POSSIBLY WEEDING. INFILTRATION BMPS WILL REQUIRE STANDARD MAINTENANCE TO MAKE REPAIRS AND REMOVE SEDIMENT AS NEEDED TO MAINTAIN INFILTRATING CAPABILITIES.

LOCUS

PROJECT DETAILS:

SUBWATERSHEDS: LAKE WENTWORTH

TREATED AREA = 5.70 ACRES
IMPERVIOUS AREA = 0.86 ACRES

ESTIMATED COSTS: $18,000 - $24,000

STORM WATER DESIGN STANDARD	TARGET (cubic feet)	ACHIEVED (cubic feet)
PRE-TREATMENT VOLUME	300	300
WATER QUALITY VOLUME	3,100	3,100
RECHARGE VOLUME	470	2,000
STORM WATER QUALITY BENEFIT	**TARGET** (KG/YEAR)	**ACHIEVED** (KG/YEAR / %)
ANNUAL TP LOADING / REMOVAL	2.15	1.29 (60%)
ANNUAL TSS LOADING / REMOVAL	10.91	9.82 (90%)

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 1 - BMP Description

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 1 - BMP Overview

LAKE WENTWORTH FOUNDATION

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PHOTO #1

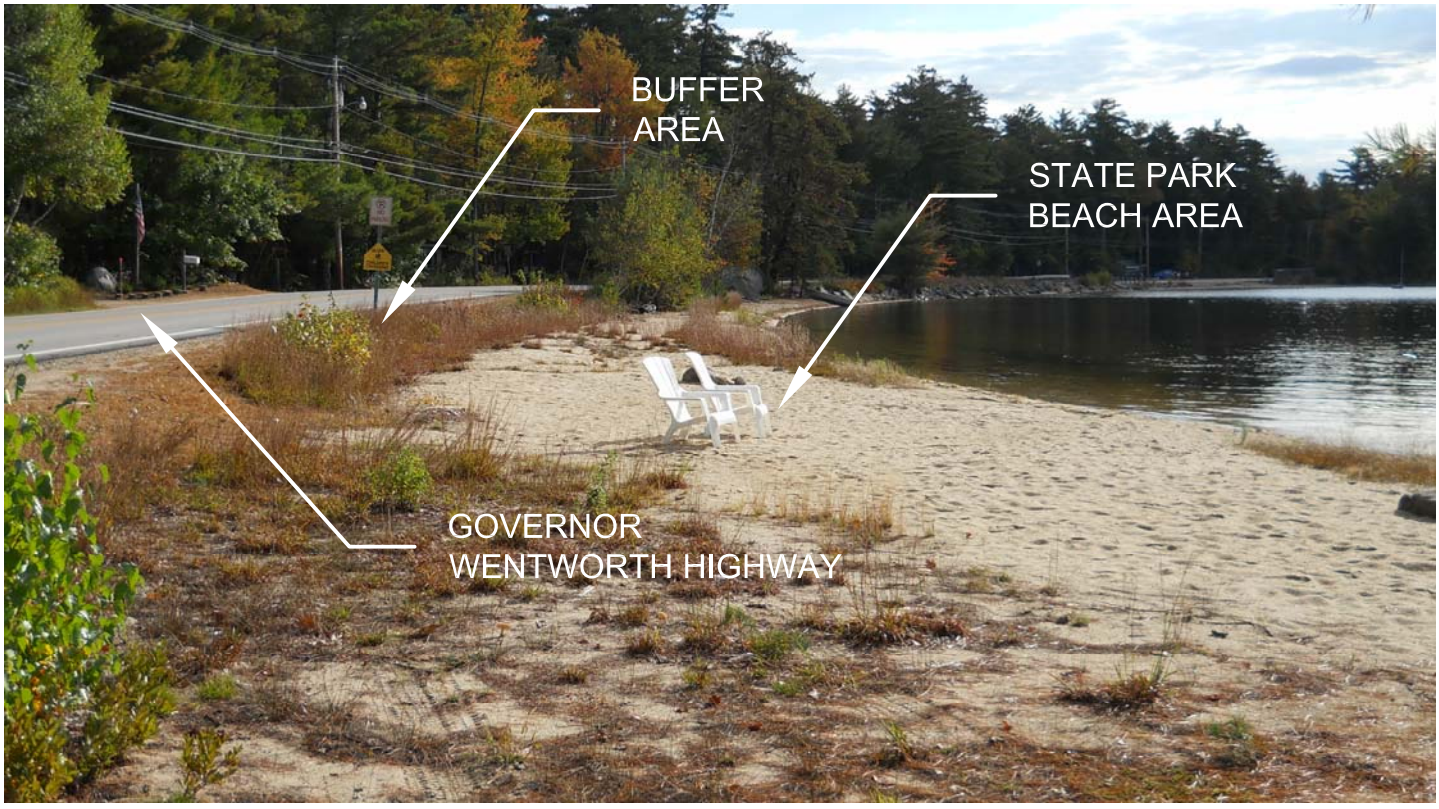

PHOTO #2

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 1 - BMP Site Photos

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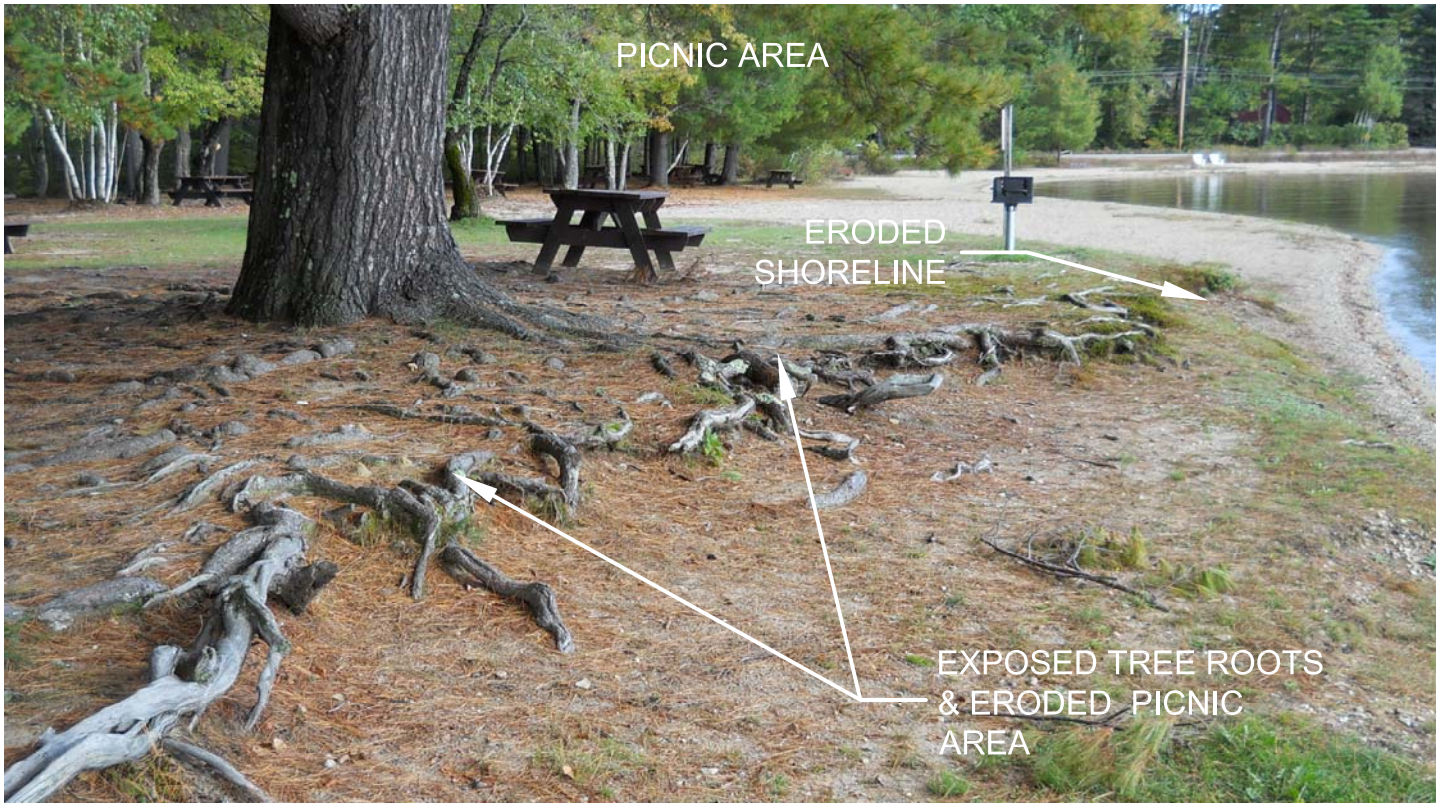

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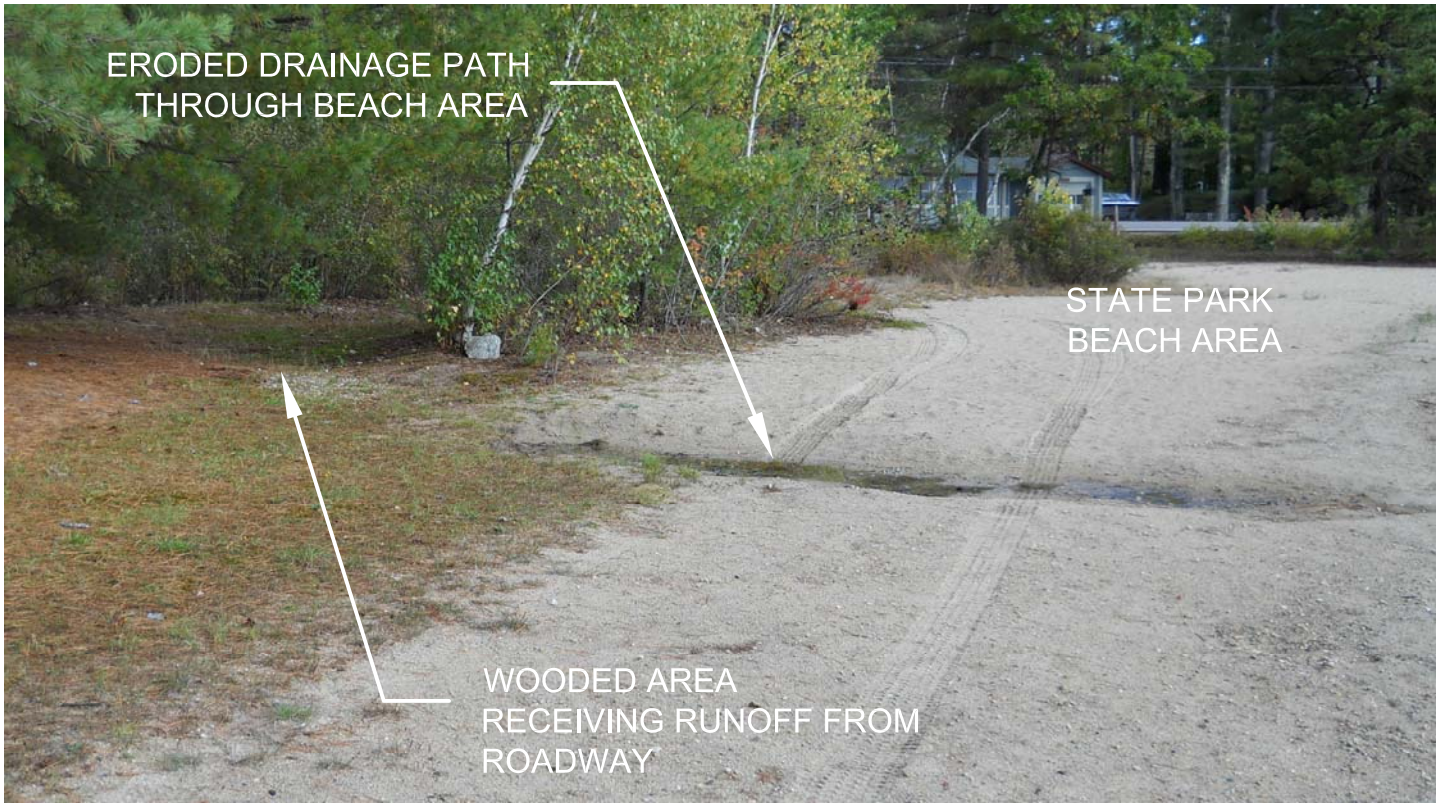

PHOTO #4

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 1 - BMP Site Photos

LAKE WENTWORTH FOUNDATION

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SITE 2 - TREATMENT PONDS AND SWALES FOR SOUTH MAIN STREET DRAINAGE

DESCRIPTION:

PROPOSED BMPS FOR S. MAIN ST DRAINAGE WILL INCLUDE CONVEYANCE BMPS AND STORMWATER HANDLING DEVICES TO MANAGE STORMWATER RUNNING THROUGH A WOODED AREA AND ERODING SOILS PRIOR TO DISCHARGE INTO CRESCENT LAKE. CONVEYANCE BMPS WILL INCLUDE STABILIZED TREATMENT SWALES FITTED WITH CHECK DAMS, PLUNGE POOLS AND EROSION CONTROLS. STORMWATER HANDLING DEVICES WILL INCLUDE A FOREBAY, LINED TREATMENT POND AND GRAVEL FILTERS TO HANDLE PEAK RUNOFF FLOWS FROM VARYING SIZE STORMS AND TO IMPROVE WATER QUALITY FROM THE SOUTH MAIN STREET DRAINAGE SYSTEM . THESE BMPS WILL BE DESIGNED AND LOCATED TO MINIMIZE IMPACTS TO THE PROPERTY FROM UNCONTROLLED RUNOFF.

DESIGN:

TOPOGRAPHIC SURVEY, CERTIFIED WETLAND REVIEW FOR RESOURCES AREAS AND TEST PITS TO CONFIRM GROUNDWATER DEPTHS ARE RECOMMENDED TO COMPLETE THE DESIGN OF THESE BMPS. FINAL DESIGN SHOULD INCLUDE SIZING, LOCATING AND SPECIFYING OF STABILIZATION MATERIALS FOR USE IN THE CONVEYANCE SWALES. PROPER BMP SIZING WILL BE USED TO ENSURE COMPLIANCE WITH LOCAL AND STATE STORMWATER STANDARDS FOR TREATMENT PONDS TO ADEQUATELY STORE PRETREATMENT, WATER QUALITY, RECHARGE VOLUMES AND TO SAFELY CONTROL LARGER STORM EVENTS.

LAND ACCESS:

ALL PROPOSED WORK WILL BE LOCATED ON TWO PRIVATE PROPERTIES IN THE TOWN OF WOLFEBORO. ONE PROPERTY WILL REQUIRE PERMISSION FOR SITE ACCESS, WHILE THE OTHER PROPERTY WILL REQUIRE PERMISSION FOR CONSTRUCTION OF THE BMPS. SPECIAL COORDINATION WILL BE REQUIRED TO OBTAIN BOTH TEMPORARY CONSTRUCTION ACCESS AND PERMANENT MAINTENANCE EASEMENTS FROM THESE PROPERTY OWNERS.

PERMITTING:

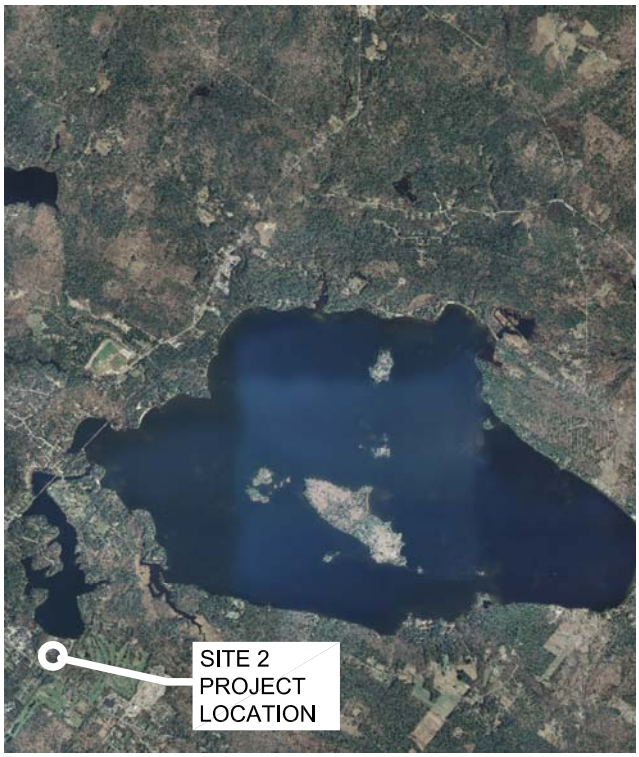
BMPS MAY REQUIRE STATE AND LOCAL PERMITS TO PERFORM THE WORK. LOCAL PERMISSION THROUGH THE CONSERVATION COMMISSION WILL BE REQUIRED. STATE PERMISSION THROUGH THE DREDGE AND FILL APPLICATION PROCESS MAY BE NEEDED IF ANY WETLANDS ARE ENCOUNTERED AND IMPACTED. IMPACTS SHOULD BE KEPT TO A MINIMUM TO PREVENT THE NEED FOR AN ALTERATION OF TERRAIN PERMIT.

CONSTRUCTION:

STANDARD MATERIALS CAN BE USED AND CUSTOMARY CONSTRUCTION PRACTICES CAN BE EMPLOYED TO IMPLEMENT THESE BMPS. SOME LARGE PRECAST CONCRETE STRUCTURES WILL BE REQUIRED WITH CONSIDERABLE EXCAVATION. A SIGNIFICANT AMOUNT OF SITE CLEARING IS REQUIRED FOR THESE BMPS AND ACCESS ROADS WILL BE CONSTRUCTED. SOME GROUND AND SURFACE WATER HANDLING WILL BE REQUIRED DURING CONSTRUCTION.

MAINTENANCE:

BMPS WILL REQUIRE ROUTINE MAINTENANCE TO ENSURE HEALTHY VEGETATIVE COVER INCLUDING WATERING, VEGETATION MONITORING, EROSION REPAIRS, MOWING AND WOODY MATERIAL REMOVAL. TREATMENT BMPS WILL REQUIRE STANDARD MONITORING AND MAINTENANCE TO ENSURE PROPER FUNCTION AND REMOVAL SEDIMENT AS NEEDED TO MAINTAIN TREATMENT CAPABILITIES.



LOCUS

PROJECT DETAILS:

SUBWATERSHEDS: CRESCENT LAKE

TREATED AREA = 30.83 ACRES
IMPERVIOUS AREA = 17.82 ACRES

ESTIMATED COSTS: $200,000 - $210,000

STORM WATER DESIGN STANDARD	TARGET (cubic feet)	ACHIEVED (cubic feet)
PRE-TREATMENT VOLUME	6,500	6,500
WATER QUALITY VOLUME	64,700	64,700
RECHARGE VOLUME	9,700	20,000
STORM WATER QUALITY BENEFIT	**TARGET** (KG/YEAR)	**ACHIEVED** (KG/YEAR / %)
ANNUAL TP LOADING / REMOVAL	19.42	10.68 (55%)
ANNUAL TSS LOADING / REMOVAL	26.85	22.82 (85%)

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 2 - BMP Description

LAKE WENTWORTH FOUNDATION

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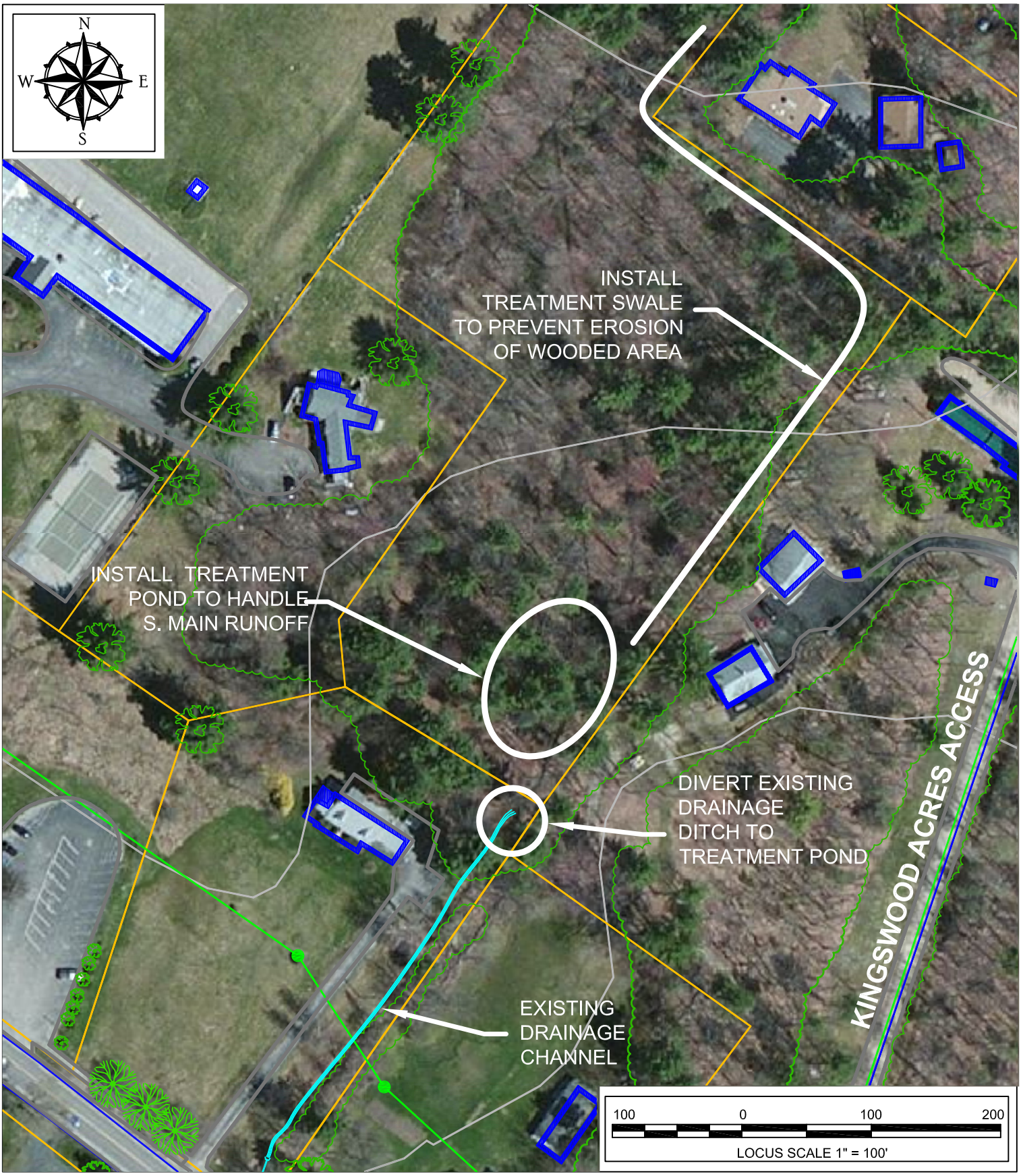

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 2 - BMP Overview

LAKE WENTWORTH FOUNDATION

FB environmental

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PHOTO #1

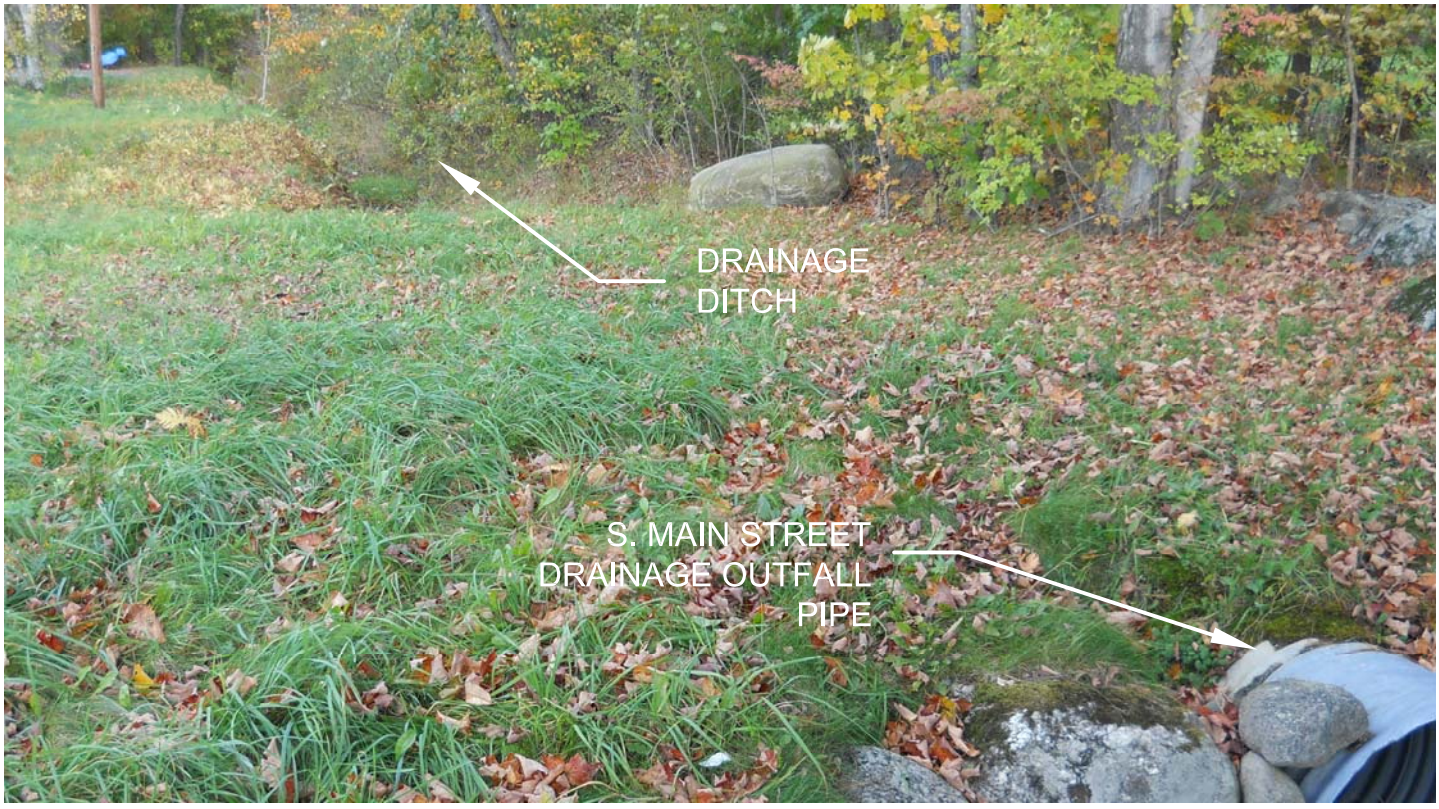

PHOTO #2

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 2- BMP Site Photos

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

PHOTO #3

PHOTO #4

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 2- BMP Site Photos

LAKE WENTWORTH FOUNDATION

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SITE 3 - FILTER MEDIA STRIPS AND SHORELINE STABILIZATION ALONG GOVERNOR WENTWORTH HIGHWAY

DESCRIPTION:

PROPOSED BMPS ALONG THE GOV. WENTWORTH HIGHWAY NEAR CLAY PIT AND RYEFIELD BROOK WILL INCLUDE DRAINAGE IMPROVEMENTS, STABILIZATION TECHNIQUES AND INFILTRATION DEVICES TO MANAGESTORMWATER FROM WASHING OFF THE ROADWAY DIRECTLY INTO LAKE WENTWORTH. STABILIZATION TECHNIQUES WILL INCLUDE EROSION CONTROLS AND RIPRAP TO PROTECT BARE SOIL AND ERODED AREAS ALONG THE SHORE LINE. INFILTRATION DEVICES WILL INCLUDE MEDIA FILTER STRIPS ADJACENT TO THE LAKE TO REDUCE VOLUMES AND IMPROVE WATER QUALITY OF RUNOFF. DRAINAGE IMPROVEMENTS WILL INCLUDE DRAINAGE SWALES AND PLUNGE POOLS TO MANAGE STORMWATER ALONG ROADWAY PULL-OFFS AND CAPTURE POLLUTANTS PRIOR TO DISCHARGE INTO BOTH TRIBUTARIES.

DESIGN:

TOPOGRAPHIC SURVEY AND TEST PITS TO CONFIRM GROUNDWATER DEPTH AND SOIL TYPE ARE RECOMMENDED TO COMPLETE THE DESIGN OF THESE BMPS. FINAL DESIGN SHOULD INCLUDE SIZING, LOCATING AND SPECIFYING OF STABILIZATION MATERIALS. PROPER BMP SIZING TECHNIQUES WILL BE USED TO ENSURE COMPLIANCE WITH LOCAL AND STATE STORMWATER STANDARDS FOR INFILTRATION DEVICES.

LAND ACCESS:

PROPOSED WORK WILL OCCUR WITHIN THE RIGHT OF WAY, WENTWORTH STATE PARK AND ON THREE PRIVATE PROPERTIES. INSTALLATION OF FILTER MEDIA STRIPS AND SHOULDER STABILIZATION WILL OCCUR WITHIN RIGHT OF WAYS. PERMISSION FOR SHORELINE STABILIZATION FROM THE STATE WILL BE NEEDED. THE HIGHWAY IS ALSO A MUNICIPALLY MANAGED STATE ROAD, WHICH WILL REQUIRE COORDINATION WITH THE NH DOT. COORDINATION WILL BE REQUIRED TO OBTAIN BOTH CONSTRUCTION ACCESS AND EASEMENTS FROM THESE PROPERTY OWNERS FOR THE DRAINAGE IMPROVEMENTS AND PLUNGE POOLS.

PERMITTING:

WORK WILL OCCUR WITHIN BUFFERS OF LAKE WENTWORTH. TEMPORARY IMPACTS TO LAND UNDER WATER COULD OCCUR DURING CONSTRUCTION OF BMPS ALONG THE SHORELINE STABILIZATION. LOCAL PERMISSION THROUGH THE CONSERVATION COMMISSION AND POSSIBLY STATE PERMISSION THROUGH THE DREDGE AND FILL PROCESS WILL BE REQUIRED FOR THIS WORK.

CONSTRUCTION:

SPECIAL WATER HANDLING PROCEDURES AND CONSTRUCTION TECHNIQUES WILL BE EMPLOYED FOR THESE BMPS TO MINIMIZE IMPACTS TO LAKE WENTWORTH. IMPACTS TO THE ROADWAY MAY REQUIRE PAVEMENT CUTTING, EXCAVATION AND REPAIR. BASED ON THE PROXIMITY TO THE LAKE AND ROADWAY, CAREFUL EXCAVATION MUST BE USED TO MINIMIZE LAKE WATER FROM ENTERING THE TRENCHES AND TO PREVENT UNDERMINING OF PAVEMENT. SPECIAL TRAFFIC CONTROL AND PUBLIC SAFETY PRACTICES WILL BE REQUIRED DURING CONSTRUCTION OF THESE BMPS.

MAINTENANCE:

STABILIZATION BMPS WILL REQUIRE ROUTINE MAINTENANCE TO ENSURE HEALTHY VEGETATIVE COVER INCLUDING WATERING, VEGETATION MONITORING, REPAIRS, DEBRIS REMOVAL, RE-SEEDING, MOWING AND WOODY MATERIAL REMOVAL.

LOCUS

PROJECT DETAILS:

SUBWATERSHEDS: LAKE WENTWORTH, FROST BROOK, RYEFIELD BROOK

TREATED AREA = 5.33 ACRES
IMPERVIOUS AREA = 2.86 ACRES

ESTIMATED COSTS: $46,000 - $51,000

STORM WATER DESIGN STANDARD	TARGET (cubic feet)	ACHIEVED (cubic feet)
PRE-TREATMENT VOLUME	1,000	1,000
WATER QUALITY VOLUME	10,300	10,300
RECHARGE VOLUME	1,560	7,100
STORM WATER QUALITY BENEFIT	**TARGET** (KG/YEAR)	**ACHIEVED** (KG/YEAR / %)
ANNUAL TP LOADING / REMOVAL	3.58	2.15 (60%)
ANNUAL TSS LOADING / REMOVAL	8.82	7.94 (90%)

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 3 - BMP Description

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 3 - BMP Overview

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

PHOTO #1

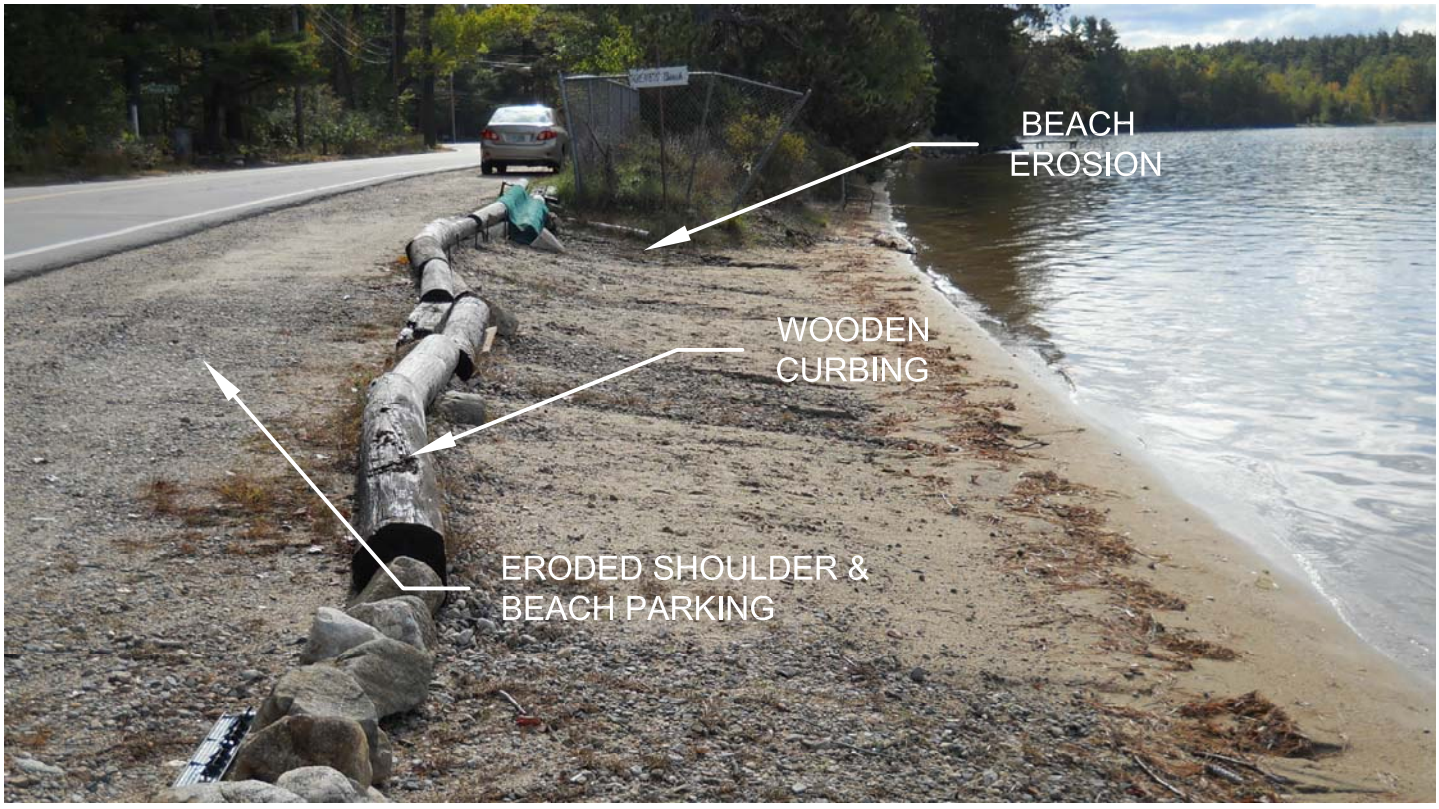


PHOTO #2

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 3 - BMP Site Photos

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

PHOTO #3

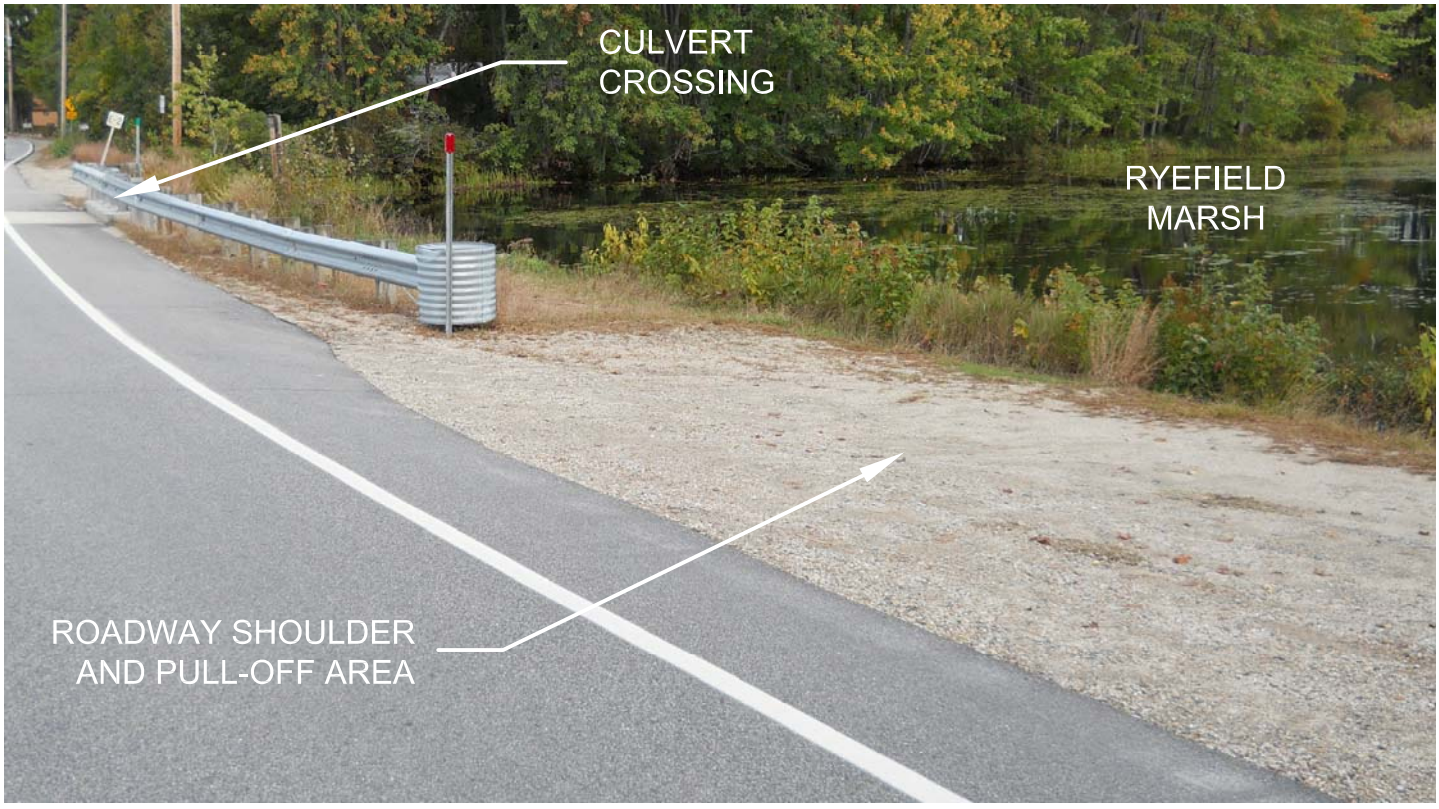


PHOTO #4

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

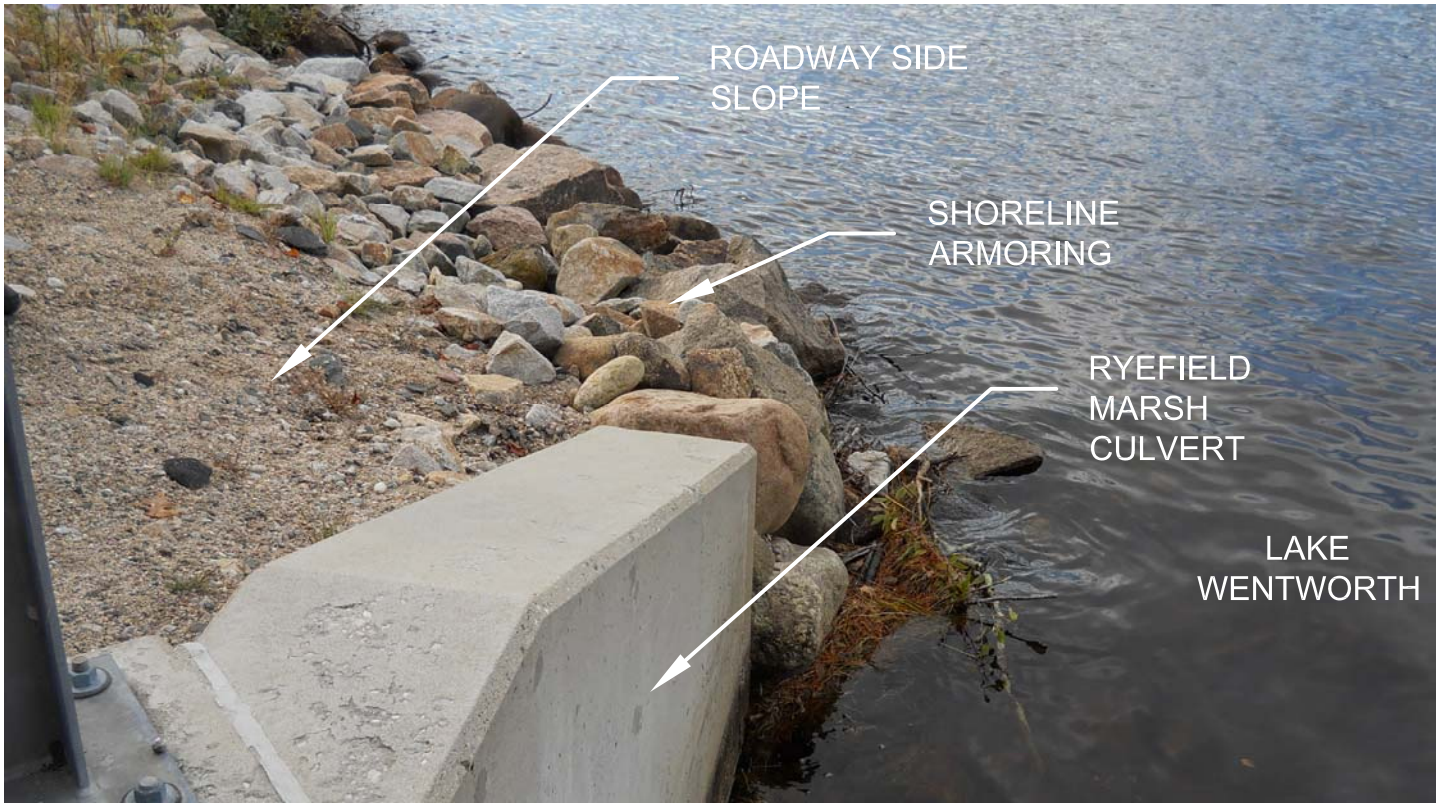
TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 3 - BMP Site Photos

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



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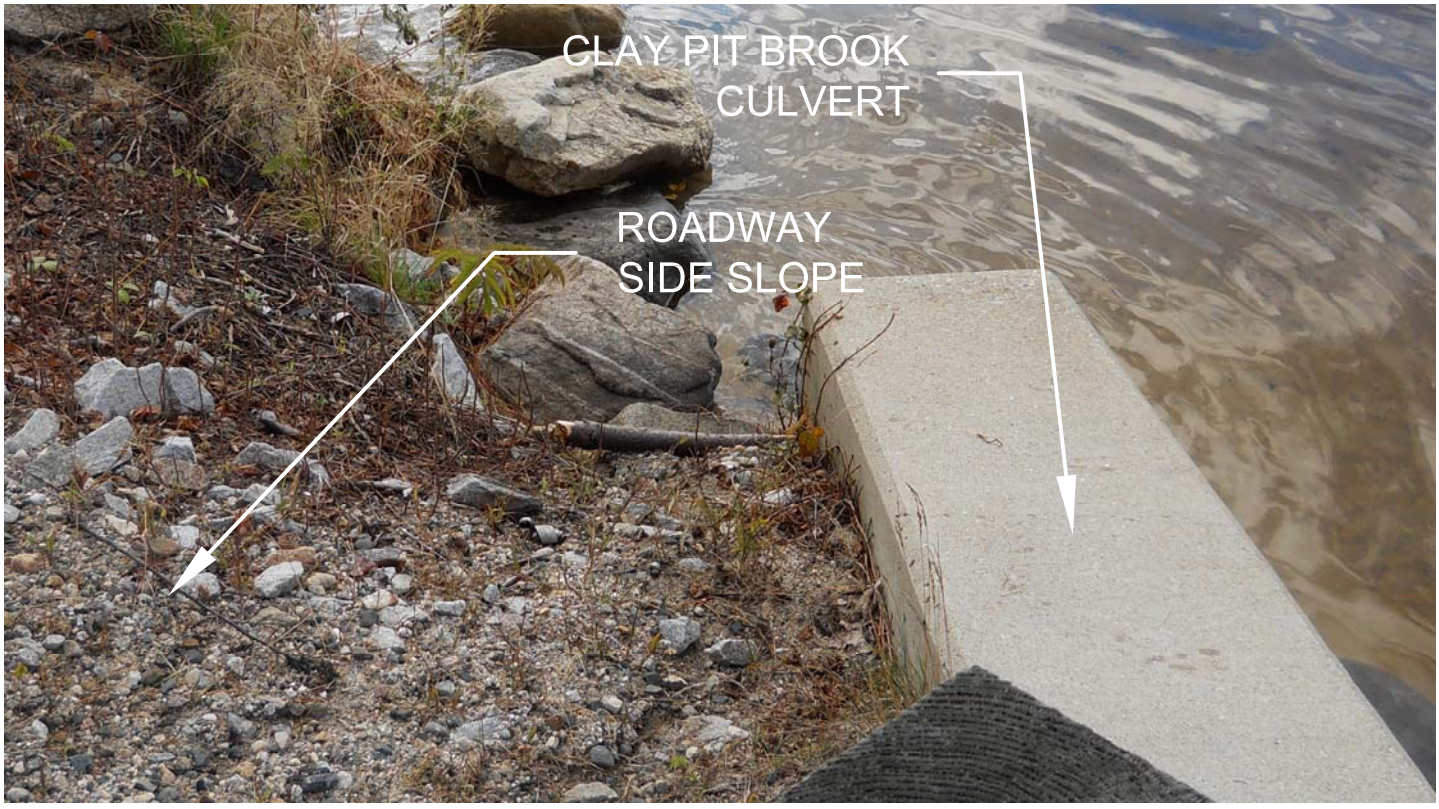


PHOTO #6

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 3 - BMP Site Photos

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

SITE 4 - TREATMENT/INFILTRATION DEVICES AND SITE STABILIZATION AT CAMP BERNADETTE

DESCRIPTION:

PROPOSED BMPS AT CAMP BERNADETTE WILL INCLUDE STABILIZATION AND INFILTRATION TECHNIQUES TO MANAGE POLLUTANT LADEN STORMWATER FROM PAVED SURFACES AND A BEACH AREA IN LAKE WENTWORTH. STABILIZATION TECHNIQUES WILL INCLUDE EROSION CONTROL FABRICS AND VEGETATION TO PROTECT BARE SOIL AND POROUS PAVERS OR EROSION CONTROL MULCH TO PROVIDE FORMAL FOOTPATHS AND BOAT RAMP ACCESS. INFILTRATION DEVICES WILL INCLUDE A RAIN GARDEN AND INFILTRATION/GROUNDWATER CUT-OFF TRENCH TO REDUCE THE AMOUNT OF RUNOFF FROM THE CAMP ONTO THE BEACH AREA.

DESIGN:

TOPOGRAPHIC SURVEY AND TEST PITS TO CONFIRM GROUNDWATER DEPTH AND SOIL TYPE ARE RECOMMENDED TO COMPLETE THE DESIGN OF THESE BMPS. FINAL DESIGN SHOULD INCLUDE ADEQUATE SIZING, LOCATING AND SPECIFYING OF STABILIZATION MATERIALS AND PROPER BMP VOLUME SIZING TO ENSURE COMPLIANCE WITH LOCAL AND STATE STORMWATER STANDARDS FOR INFILTRATION DEVICES.

LAND ACCESS:

ALL PROPOSED WORK WILL BE LOCATED ON ONE PRIVATE PROPERTY IN THE TOWN OF WOLFEBORO. SPECIAL COORDINATION WILL BE REQUIRED TO OBTAIN TEMPORARY CONSTRUCTION ACCESS FROM THESE PROPERTY OWNERS.

PERMITTING:

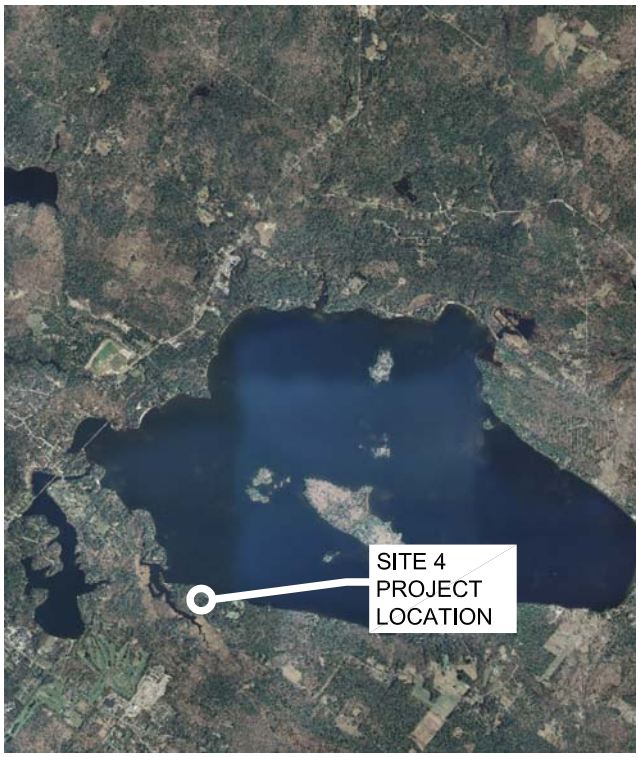
WORK WILL OCCUR WITHIN BUFFERS OF LAKE WENTWORTH, BUT NO ACTIVITIES WILL BE PROPOSED TO LAND UNDER WATER OR DESIGNATED WETLANDS. LOCAL PERMISSION THROUGH THE CONSERVATION COMMISSION AND POSSIBLY STATE PERMISSION THROUGH THE PERMIT BY NOTIFICATION PROCESS WILL BE REQUIRED FOR THIS WORK.

CONSTRUCTION:

NO SPECIAL CONSTRUCTION WILL BE REQUIRED FOR THIS PROJECT SITE. STANDARD MATERIALS CAN BE USED AND CUSTOMARY CONSTRUCTION PRACTICES CAN BE EMPLOYED TO IMPLEMENT THESE BMPS. SOME GROUND AND SURFACE WATER HANDLING WILL BE REQUIRED DURING CONSTRUCTION.

MAINTENANCE:

STABILIZATION BMPS WILL REQUIRE ROUTINE MAINTENANCE TO ENSURE HEALTHY VEGETATIVE COVER INCLUDING WATERING, VEGETATION MONITORING, REPAIRS, DEBRIS REMOVAL, RE-SEEDING, MOWING AND POSSIBLY WOODY MATERIAL REMOVAL. INFILTRATION BMPS WILL REQUIRE STANDARD MAINTENANCE TO MAKE REPAIRS AND REMOVE SEDIMENT AS NEEDED TO MAINTAIN INFILTRATING CAPABILITIES.



LOCUS

PROJECT DETAILS:

SUBWATERSHEDS: LAKE WENTWORTH, HEATH BROOK

TREATED AREA = 14.78 ACRES
IMPERVIOUS AREA = 6.31 ACRES

ESTIMATED COSTS: $38,000 - $43,000

STORM WATER DESIGN STANDARD	TARGET (cubic feet)	ACHIEVED (cubic feet)
PRE-TREATMENT VOLUME	2,300	900
WATER QUALITY VOLUME	22,900	9,400
RECHARGE VOLUME	3,500	5,000
STORM WATER QUALITY BENEFIT	**TARGET** (KG/YEAR)	**ACHIEVED** (KG/YEAR / %)
ANNUAL TP LOADING / REMOVAL	7.31	2.46 (35%)
ANNUAL TSS LOADING / REMOVAL	13.44	5.38 (40%)

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 4 - BMP Description

LAKE WENTWORTH FOUNDATION

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COMPREHENSIVE ENVIRONMENTAL INCORPORATED

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 4 - BMP Overview

LAKE WENTWORTH FOUNDATION

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COMPREHENSIVE ENVIRONMENTAL INCORPORATED

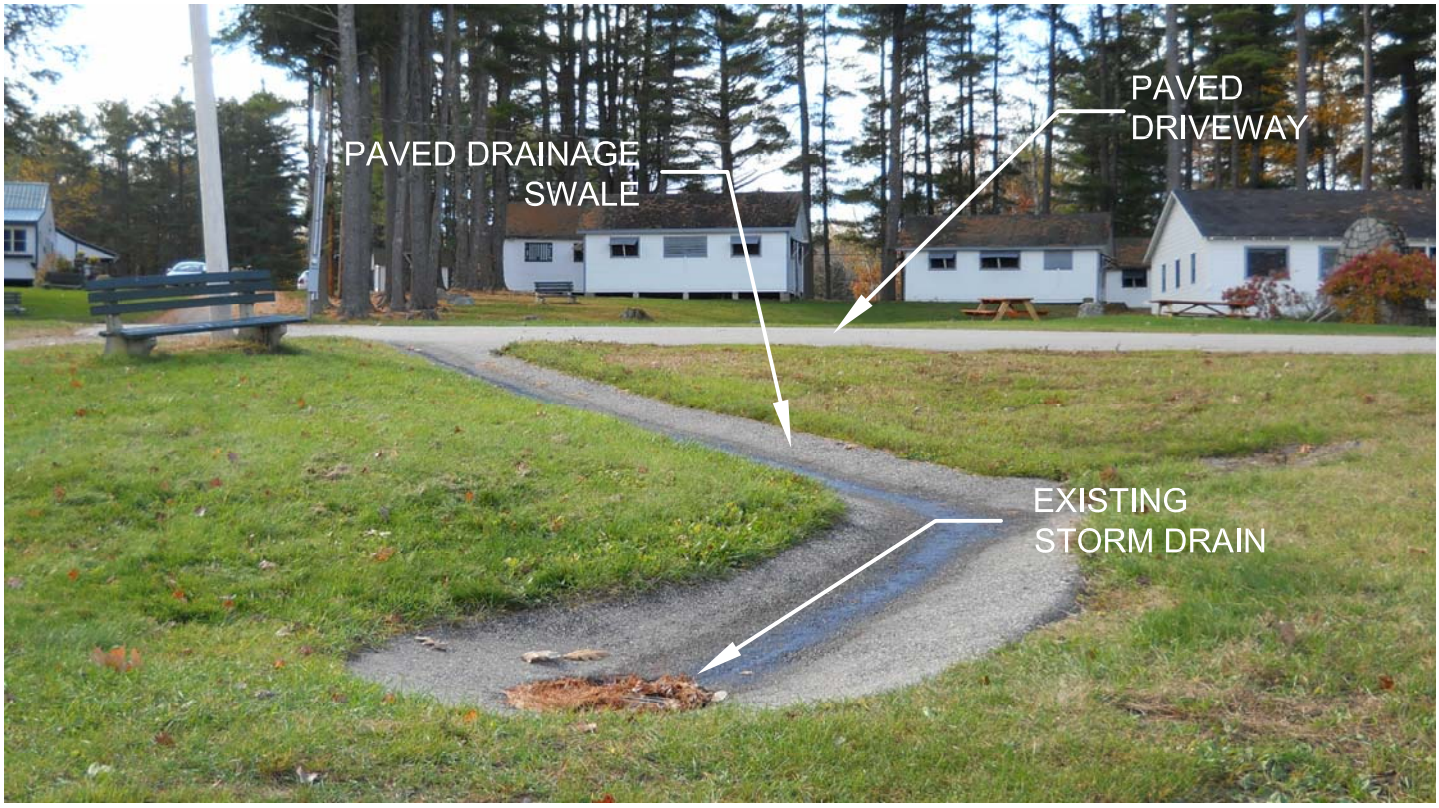

PHOTO #1

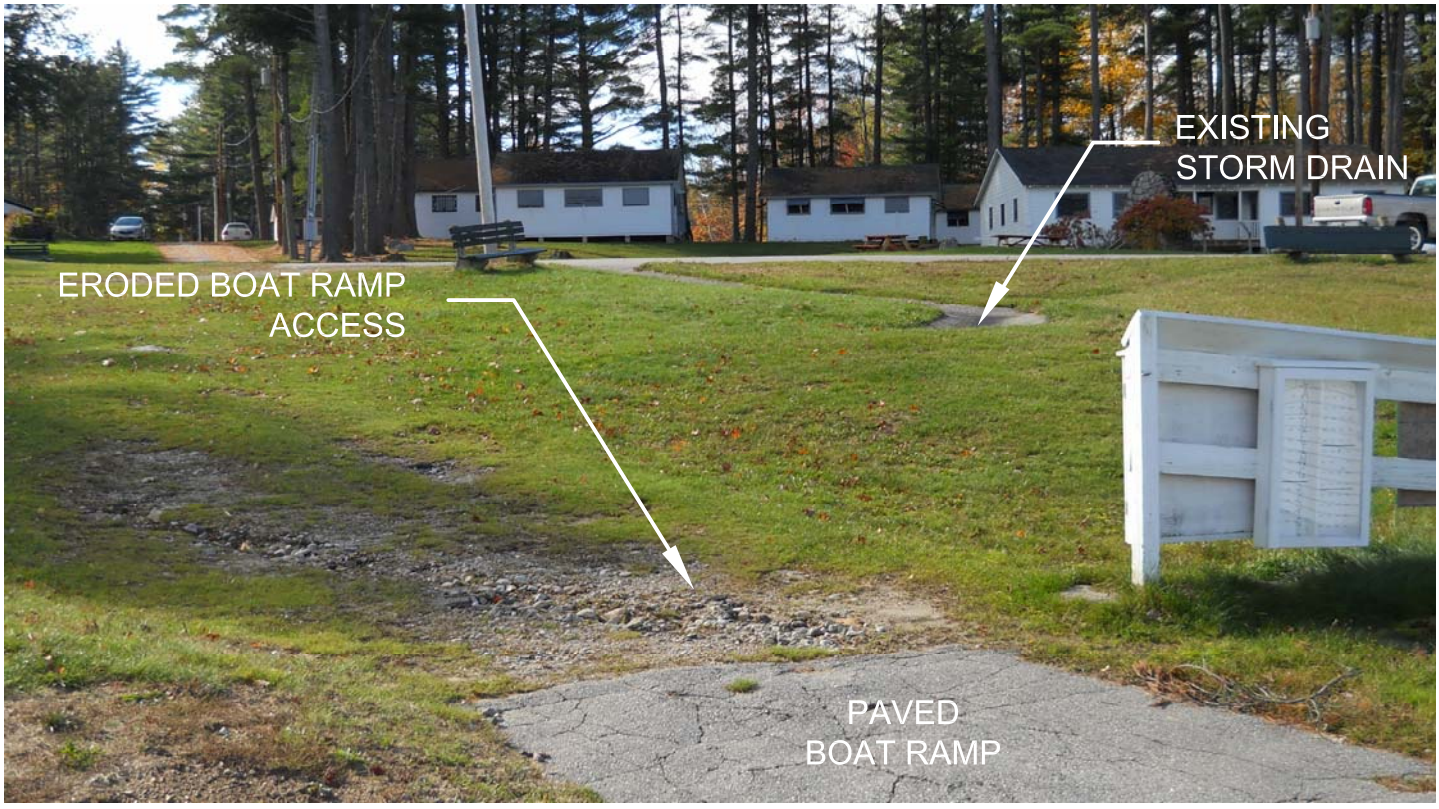

PHOTO #2

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 4 - BMP Site Photos

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

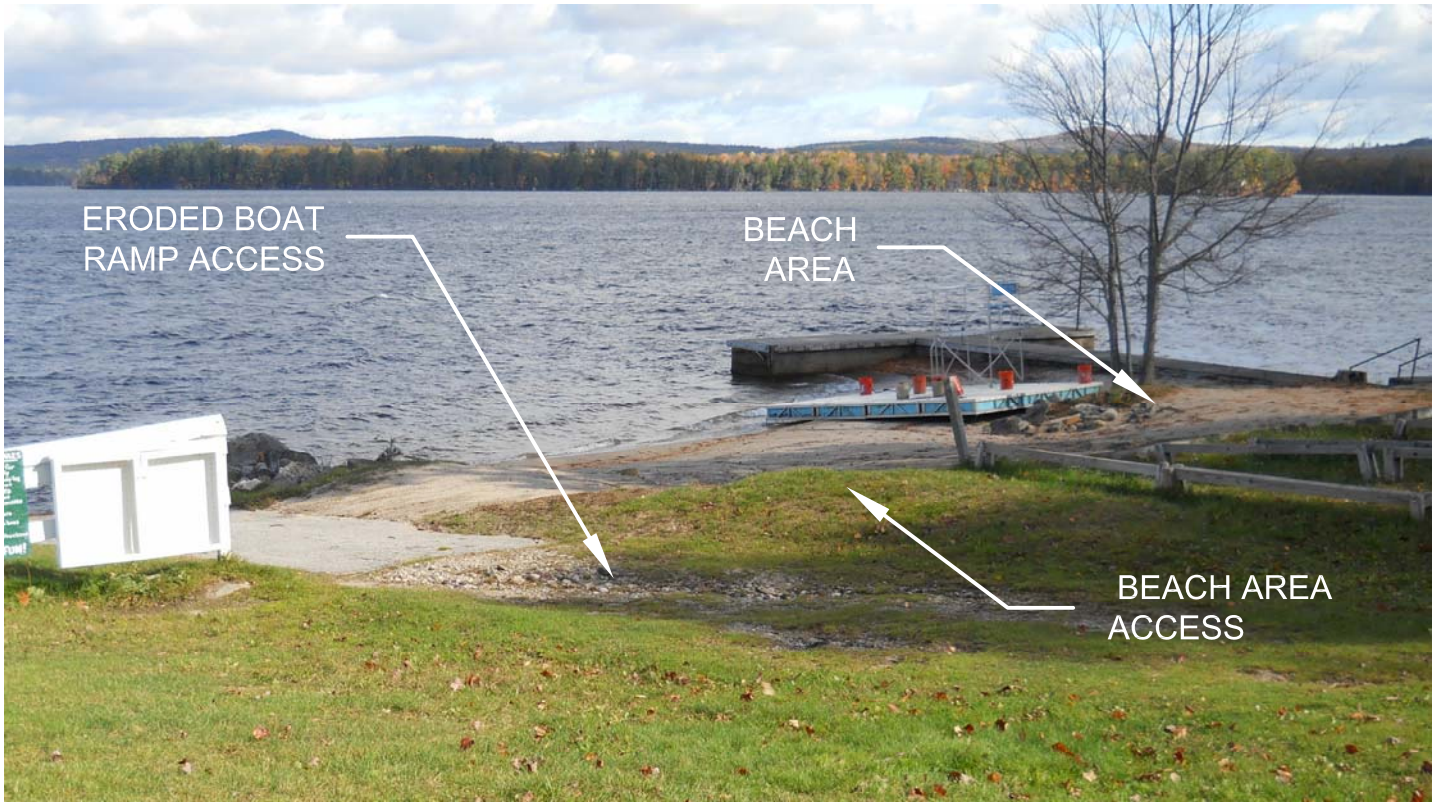

PHOTO #3

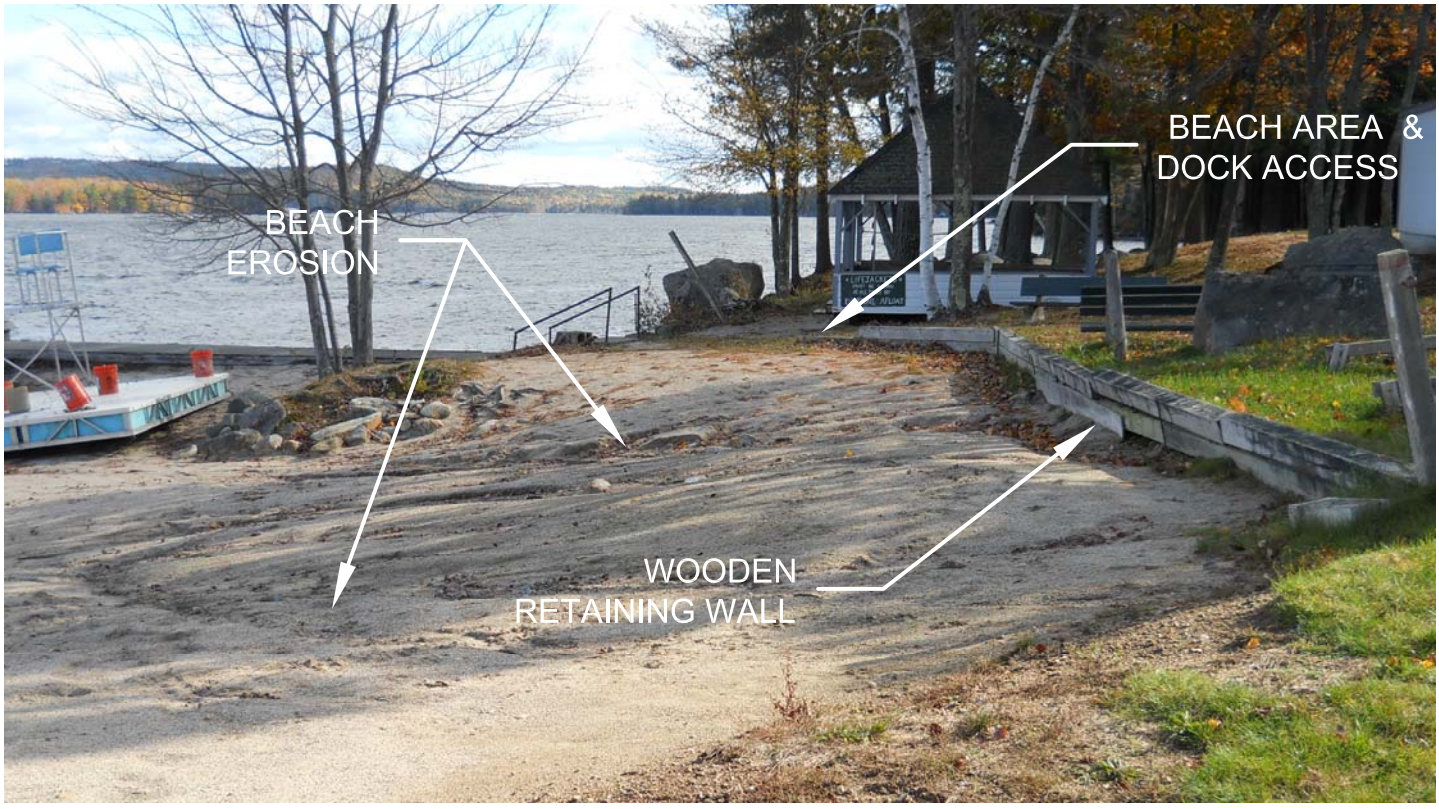

PHOTO #4

GENERAL NOTES

1. MAP BASED ON TOWN OF WOLFEBORO GIS AND STATE OF NEW HAMPSHIRE (GRANIT) GIS DATABASES

2. MAP SCALES ARE APPROXIMATE

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Site 4 - BMP Site Photos

LAKE WENTWORTH FOUNDATION

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COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Appendix G:
Preliminary BMP Plans

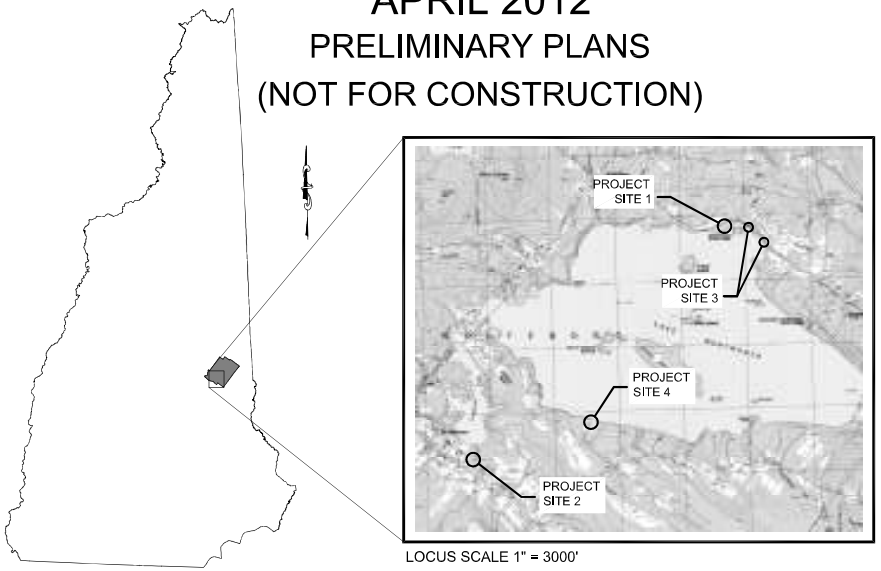
LAKE WENTWORTH FOUNDATION

LAKE WENTWORTH & CRESCENT LAKE STORMWATER IMPROVEMENTS WOLFEBORO, NH

APRIL 2012

PRELIMINARY PLANS

(NOT FOR CONSTRUCTION)



LOCUS SCALE 1" = 3000'

CLEINT REPRESENTATIVES

JACK O'CONNELL - PRESIDENT
SHELDON JONES - VICE PRESIDENT
LINDA CROOTOF - SECRETARY
KENNETH ROBERTS - TREASURER
LWF TRUSTEES

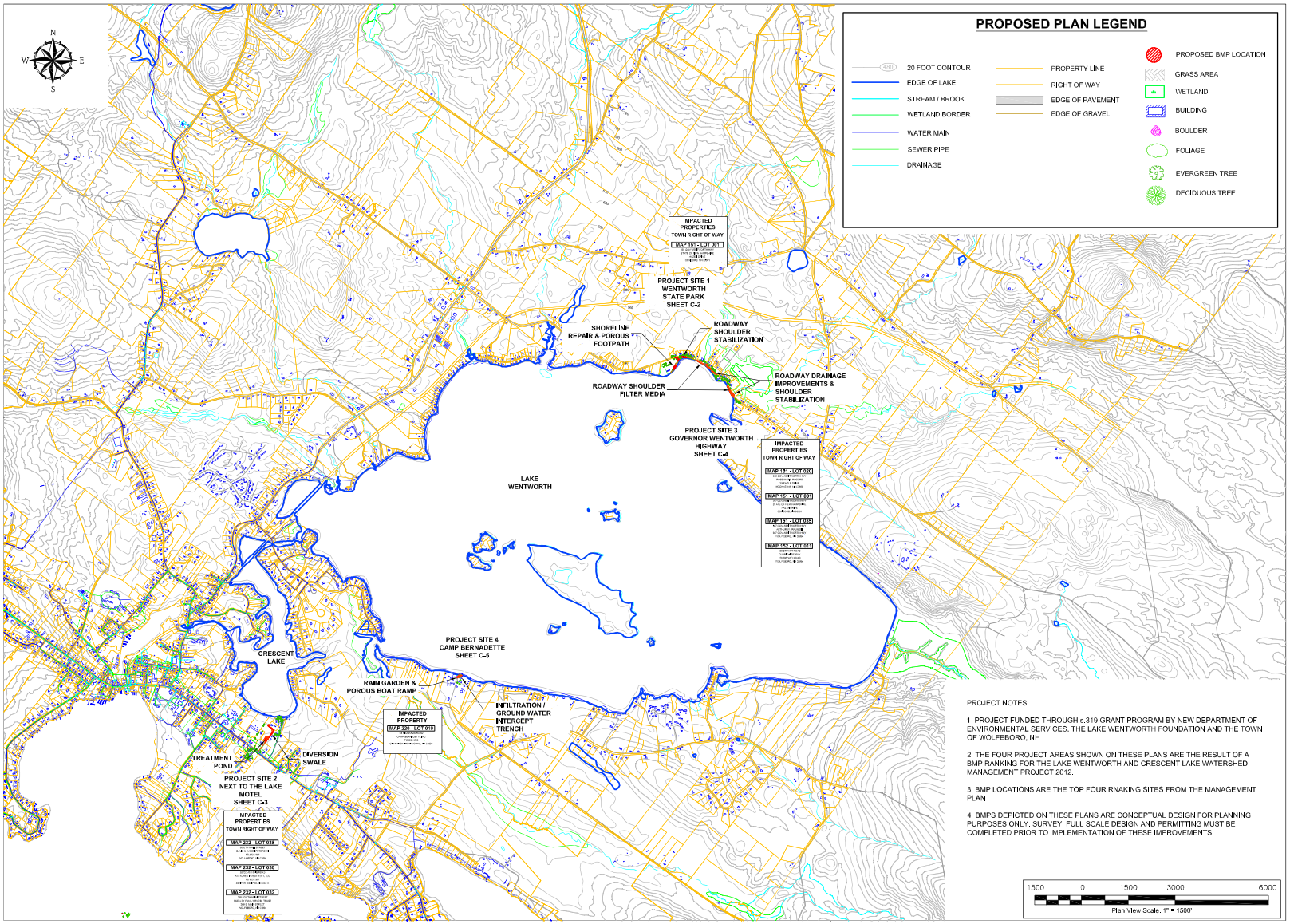
IN COORDINATION WITH:

LAKE WENTWORTH ASSOCIATION
TOWN OF WOLFEBORO
F.B. ENVIRONMENTAL
NEW HAMPSHIRE DEPARTMENT
OF ENVIRONMENTAL SERVICES

PROJECT FUNDED THROUGH THE
U.S. EPA / NH DES s.319 WATERSHED
ASSISTANCE GRANT PROGRAM.

SHEET	TITLE
C-1	PROJECT OVERVIEW
C-2	SITE 1 - PROPOSED IMPROVEMENTS
C-3	SITE 2 - PROPOSED IMPROVEMENTS
C-4	SITE 3 - PROPOSED IMPROVEMENTS
C-5	SITE 4 - PROPOSED IMPROVEMENTS
C-6	GENERAL DETAILS
C-7	GENERAL DETAILS
C-8	GENERAL DETAILS

COMPREHENSIVE ENVIRONMENTAL INCORPORATED • MERRIMACK, NEW HAMPSHIRE



LAKE WENTWORTH & CRESCENT LAKE OVERVIEW

SCALE: 1" = 1500'

General Notes

1. DRAWINGS BASED ON NH GIS GRANIT LAYER INFORMATION FOR THE TOWN OF WOLFEBORO, NH AND SUPPLEMENTAL GIS INFORMATION PROVIDED BY THE TOWN OF WOLFEBORO, NH.

2. CONCEPTUAL PLANS AND LOCALIZED PROPERTY BASE MAPS ARE BASED ON FBE FIELD INVESTIGATIONS CONDUCTED IN THE FALL OF 2011 AND CEI FIELD INVESTIGATIONS CONDUCTED BETWEEN NOVEMBER 17, 2011 AND NOVEMBER 22, 2011.

2. WETLAND DELINEATION FOR BORDERING VEGETATED WETLANDS HAVE NOT BEEN COMPLETED. ALL RESOURCE AREA DELINEATIONS ARE BASED ON GIS DATA FROM NH GRANIT.

3. THE LOCATION OF UNDERGROUND UTILITIES HAVE NOT BEEN VERIFIED OR INSPECTED.

4. RIGHT OF WAY LOCATIONS AND PROPERTY BOUNDS HAVE NOT BEEN SURVEYED.

5. THE PROPOSED STORMWATER IMPROVEMENTS DEPICTED ON THESE PLANS ARE NOT FOR CONSTRUCTION AND INTENDED FOR CONCEPTUAL PURPOSES ONLY.

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

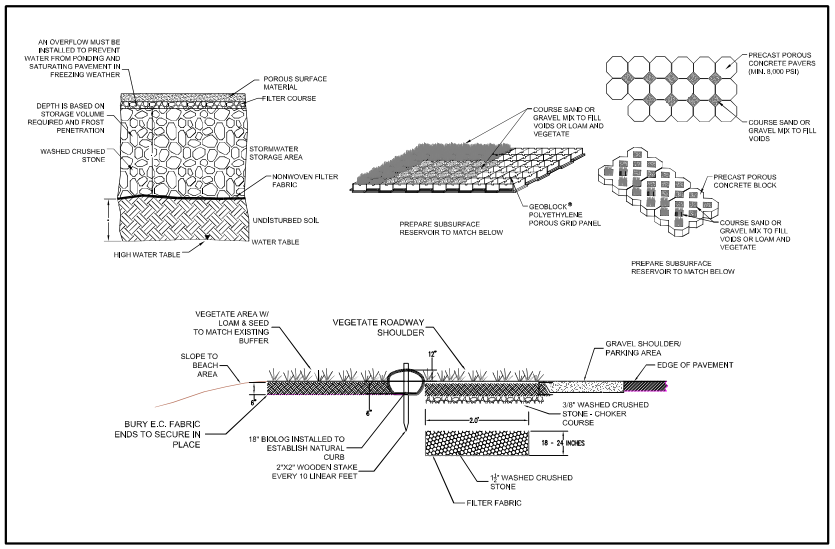
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED
21 DEPOT STREET
MERRIMACK, NH 03054

PROJECT OVERVIEW

LAKE WENTWORTH FOUNDATION
PO BOX 2235
WOLFEBORO, NH 03894

Project: NO. 655-2 Date: 4/2012	Sheet: C-1
Designed by: BCL Checked by: MLL	
Scale: As Shown	

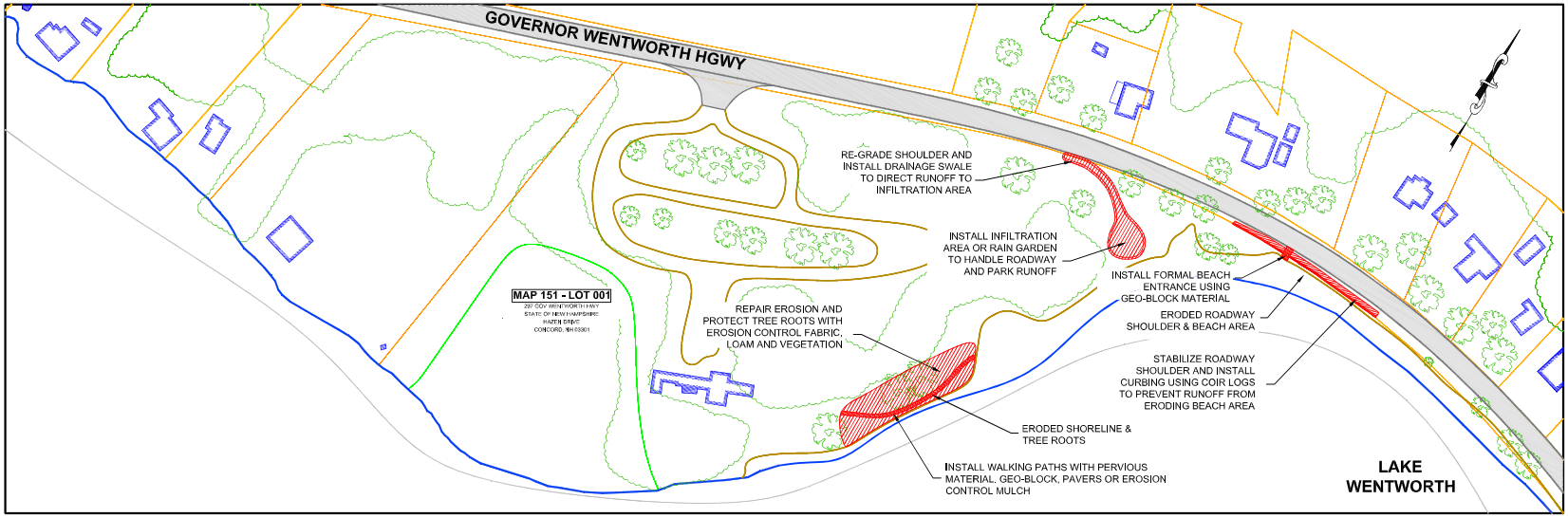


SITE 1 - PROPOSED DETAILS

NOT TO SCALE

SITE 1 - ORTHO OVERVIEW

SCALE: 1" = 100'



SITE 1 - PROPOSED IMPROVEMENTS

SCALE: 1" = 60'

60 0 60 120

Plan View Scale: 1" = 60'

General Notes

1. DRAWINGS BASED ON NH GIS GRANIT LAYER INFORMATION FOR THE TOWN OF WOLFEBORO, NH AND SUPPLEMENTAL GIS INFORMATION PROVIDED BY THE TOWN OF WOLFEBORO, NH.

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2. WETLAND DELINEATION FOR BORDERING VEGETATED WETLANDS HAVE NOT BEEN COMPLETED. ALL RESOURCE AREA DELINEATIONS ARE BASED ON GIS DATA FROM NH GRANIT.

3. THE LOCATION OF UNDERGROUND UTILITIES HAVE NOT BEEN VERIFIED OR INSPECTED.

4. RIGHT OF WAY LOCATIONS AND PROPERTY BOUNDS HAVE NOT BEEN SURVEYED.

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PRELIMINARY PLANS
NOT FOR CONSTRUCTION

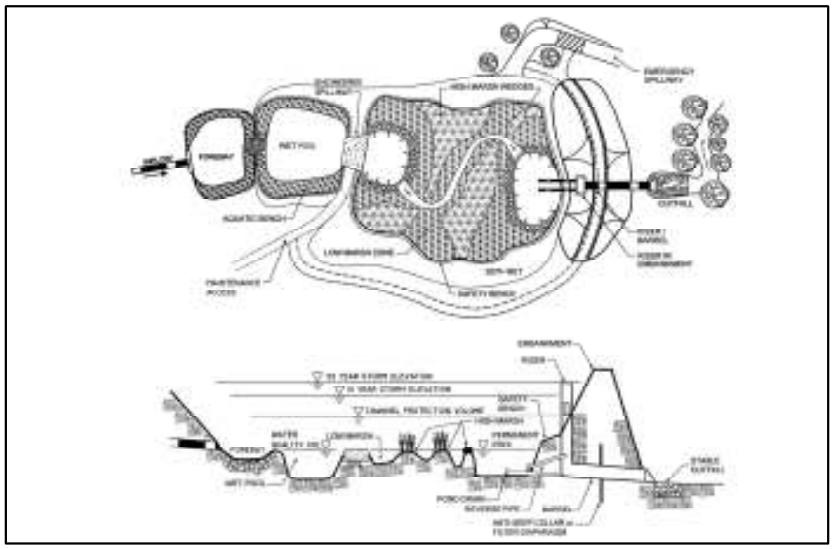
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED
21 DEPOT STREET
MERRIMACK, NH 03054

SITE 1 - PROPOSED IMPROVEMENTS

LAKE WENTWORTH FOUNDATION
PO BOX 2235
WOLFEBORO, NH 03894

Project: NO. 655-2 Date: 4/2012	Sheet: C-2
Designed by: BCL Checked by: MLL	
Scale: As Shown	

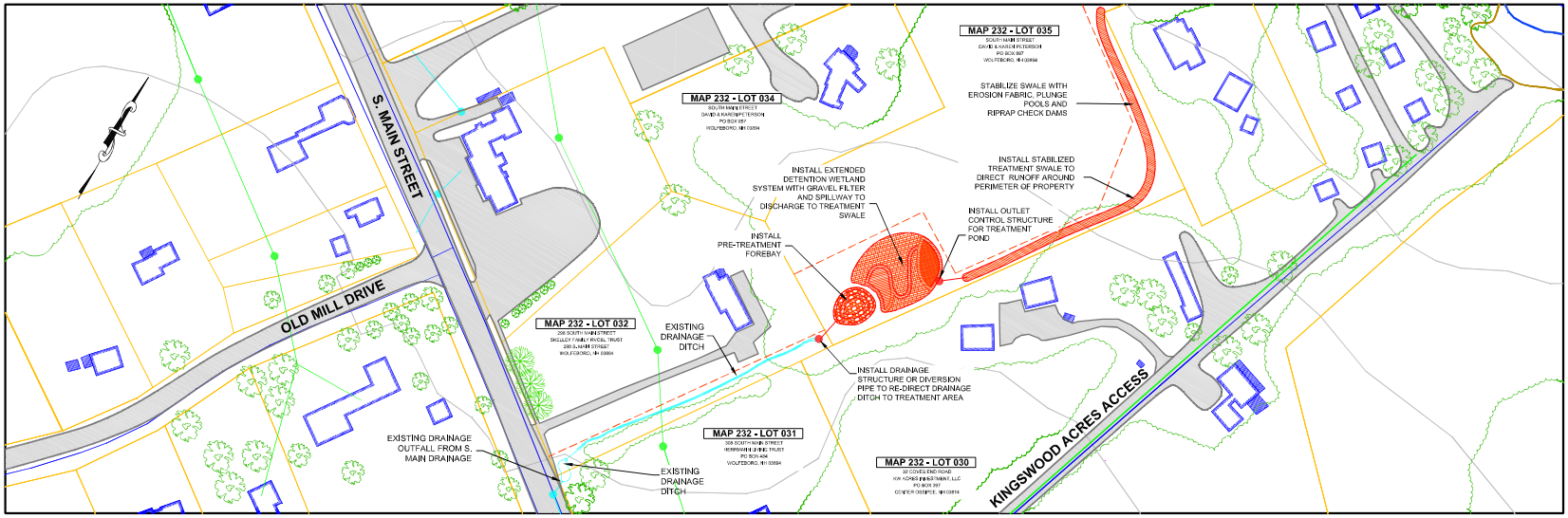


SITE 2- PROPOSED DETAILS

NOT TO SCALE

SITE 2 - ORTHO OVERVIEW

SCALE: 1" = 100'



SITE 2 - PROPOSED IMPROVEMENTS

SCALE: 1" = 70'

70 0 70 140

Plan View Scale: 1" = 70'

General Notes

1. DRAWINGS BASED ON NH GIS GRANIT LAYER INFORMATION FOR THE TOWN OF WOLFEBORO, NH AND SUPPLEMENTAL GIS INFORMATION PROVIDED BY THE TOWN OF WOLFEBORO, NH.

2. CONCEPTUAL PLANS AND LOCALIZED PROPERTY BASE MAPS ARE BASED ON FBE FIELD INVESTIGATIONS CONDUCTED IN THE FALL OF 2011 AND CEI FIELD INVESTIGATIONS CONDUCTED BETWEEN NOVEMBER 17, 2011 AND NOVEMBER 22, 2011.

2. WETLAND DELINEATION FOR BORDERING VEGETATED WETLANDS HAVE NOT BEEN COMPLETED. ALL RESOURCE AREA DELINEATIONS ARE BASED ON GIS DATA FROM NH GRANIT.

3. THE LOCATION OF UNDERGROUND UTILITIES HAVE NOT BEEN VERIFIED OR INSPECTED.

4. RIGHT OF WAY LOCATIONS AND PROPERTY BOUNDS HAVE NOT BEEN SURVEYED.

5. THE PROPOSED STORMWATER IMPROVEMENTS DEPICTED ON THESE PLANS ARE NOT FOR CONSTRUCTION AND INTENDED FOR CONCEPTUAL PURPOSES ONLY.

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

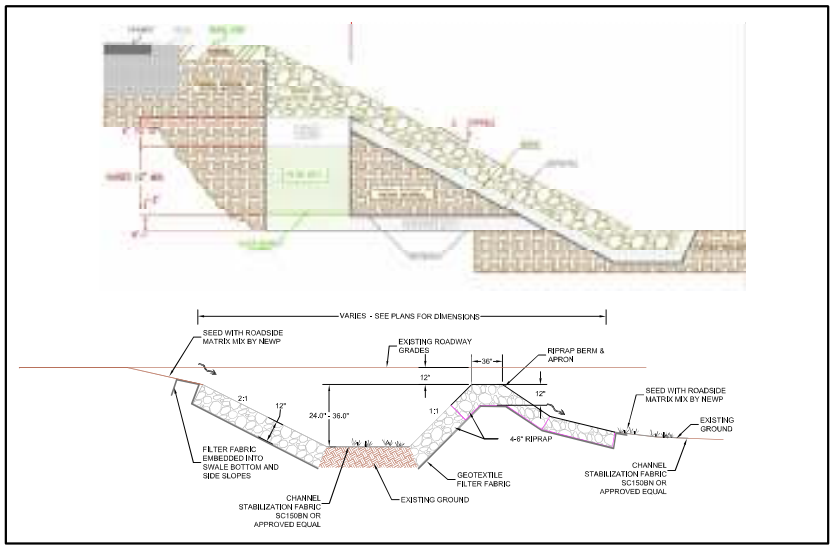
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED
21 DEPOT STREET
MERRIMACK, NH 03054

SITE 2 - PROPOSED IMPROVEMENTS

LAKE WENTWORTH FOUNDATION
PO BOX 2235
WOLFEBORO, NH 03894

Project: NO. 655-2 Date: 4/2012	Sheet: C-3
Designed by: BCL Checked by: MLL	
Scale: As Shown	

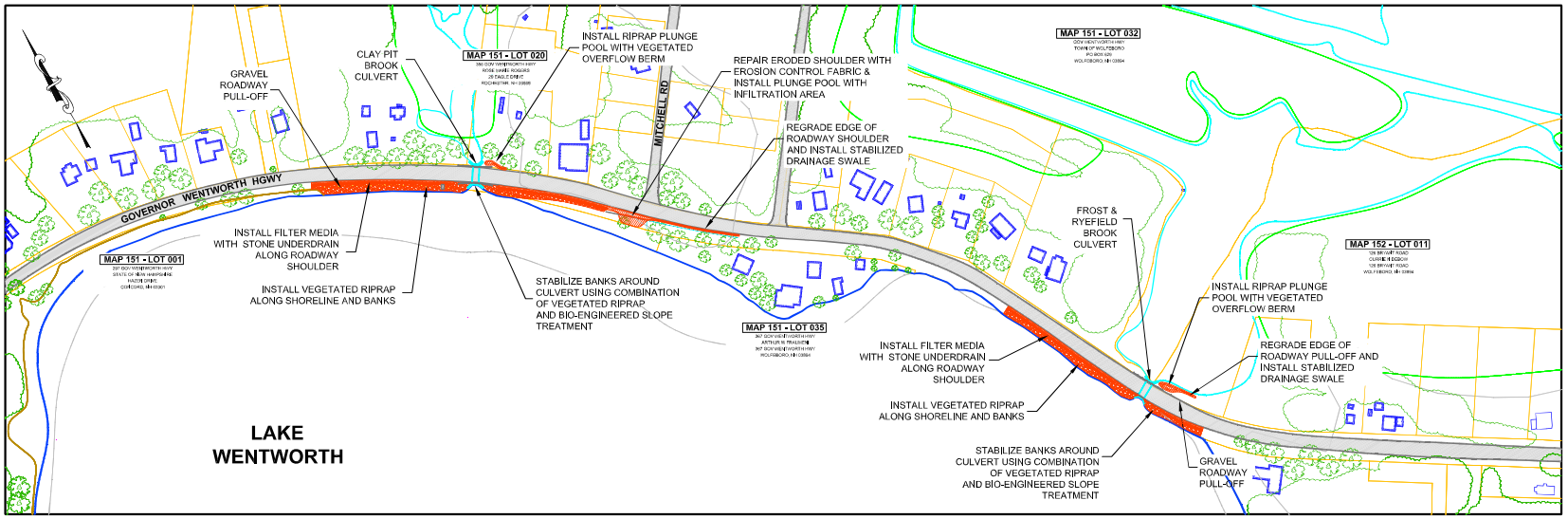


SITE 3 - PROPOSED DETAILS

NOT TO SCALE

SITE 3 - ORTHO OVERVIEW

SCALE: 1" = 200'



SITE 3 - PROPOSED IMPROVEMENTS

SCALE: 1" = 100'

General Notes

1. DRAWINGS BASED ON NH GIS GRANIT LAYER INFORMATION FOR THE TOWN OF WOLFEBORO, NH AND SUPPLEMENTAL GIS INFORMATION PROVIDED BY THE TOWN OF WOLFEBORO, NH.

2. CONCEPTUAL PLANS AND LOCALIZED PROPERTY BASE MAPS ARE BASED ON FBE FIELD INVESTIGATIONS CONDUCTED IN THE FALL OF 2011 AND CEI FIELD INVESTIGATIONS CONDUCTED BETWEEN NOVEMBER 17, 2011 AND NOVEMBER 22, 2011.

2. WETLAND DELINEATION FOR BORDERING VEGETATED WETLANDS HAVE NOT BEEN COMPLETED. ALL RESOURCE AREA DELINEATIONS ARE BASED ON GIS DATA FROM NH GRANIT.

3. THE LOCATION OF UNDERGROUND UTILITIES HAVE NOT BEEN VERIFIED OR INSPECTED.

4. RIGHT OF WAY LOCATIONS AND PROPERTY BOUNDS HAVE NOT BEEN SURVEYED.

5. THE PROPOSED STORMWATER IMPROVEMENTS DEPICTED ON THESE PLANS ARE NOT FOR CONSTRUCTION AND INTENDED FOR CONCEPTUAL PURPOSES ONLY.

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

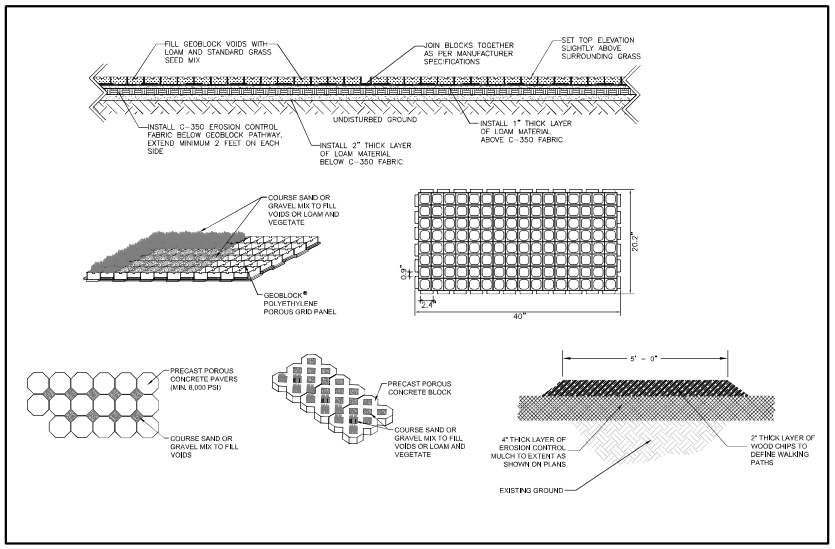
No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED
21 DEPOT STREET
MERRIMACK, NH 03054

SITE 3 - PROPOSED IMPROVEMENTS

LAKE WENTWORTH FOUNDATION
PO BOX 2235
WOLFEBORO, NH 03894

Project: NO. 655-2 Date: 4/2012	Sheet: C-4
Designed by: BCL Checked by: MLL	
Scale: As Shown	

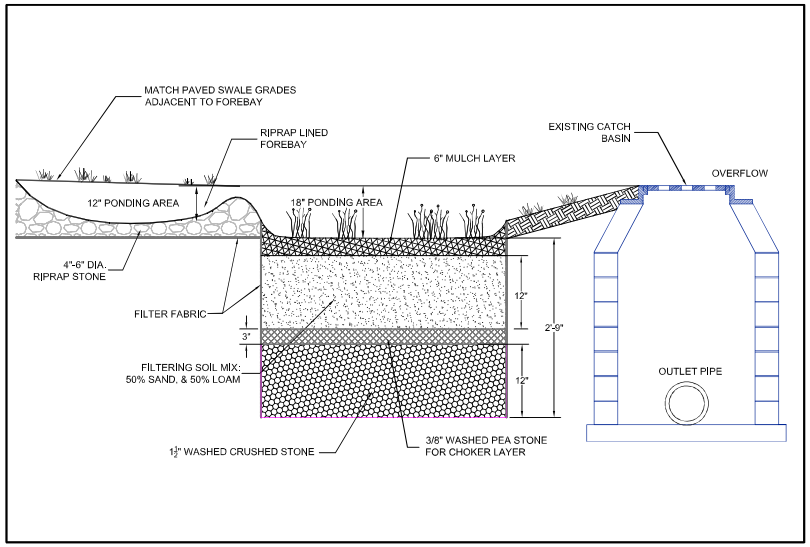


SITE 4 - PROPOSED DETAILS

NOT TO SCALE

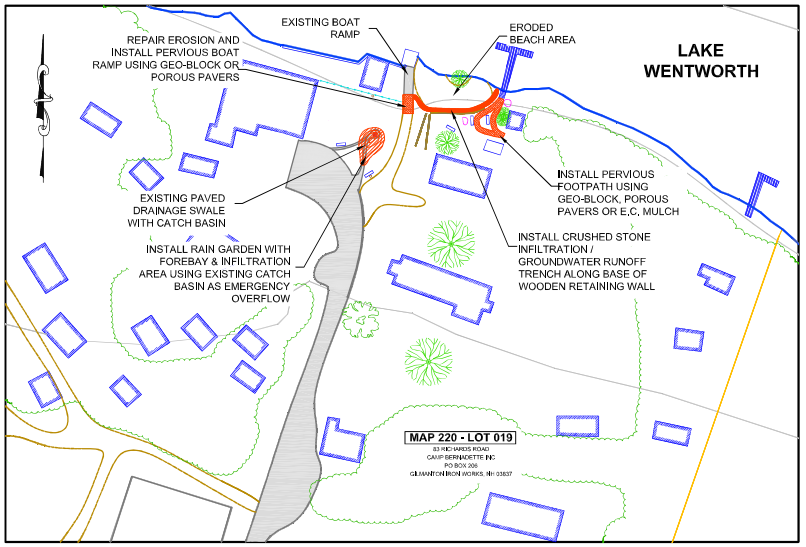
SITE 4 - ORTHO OVERVIEW

SCALE: 1" = 100'



SITE 4 - PROPOSED DETAILS

NOT TO SCALE



SITE 4 - PROPOSED IMPROVEMENTS

SCALE: 1" = 60'

60 0 60 120

Plan View Scale: 1" = 60'

General Notes

1. DRAWINGS BASED ON NH GIS GRANIT LAYER INFORMATION FOR THE TOWN OF WOLFEBORO, NH AND SUPPLEMENTAL GIS INFORMATION PROVIDED BY THE TOWN OF WOLFEBORO, NH.

2. CONCEPTUAL PLANS AND LOCALIZED PROPERTY BASE MAPS ARE BASED ON FBE FIELD INVESTIGATIONS CONDUCTED IN THE FALL OF 2011 AND CEI FIELD INVESTIGATIONS CONDUCTED BETWEEN NOVEMBER 17, 2011 AND NOVEMBER 22, 2011.

2. WETLAND DELINEATION FOR BORDERING VEGETATED WETLANDS HAVE NOT BEEN COMPLETED. ALL RESOURCE AREA DELINEATIONS ARE BASED ON GIS DATA FROM NH GRANIT.

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5. THE PROPOSED STORMWATER IMPROVEMENTS DEPICTED ON THESE PLANS ARE NOT FOR CONSTRUCTION AND INTENDED FOR CONCEPTUAL PURPOSES ONLY.

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

COMPREHENSIVE ENVIRONMENTAL INCORPORATED
21 DEPOT STREET
MERRIMACK, NH 03054

SITE 4 - PROPOSED IMPROVEMENTS

LAKE WENTWORTH FOUNDATION
PO BOX 2235
WOLFEBORO, NH 03894

Project: NO. 655-2 Date: 4/2012	Sheet: C-5
Designed by: BCL Checked by: MLL	
Scale: As Shown	

Appendix H:
Typical BMPs

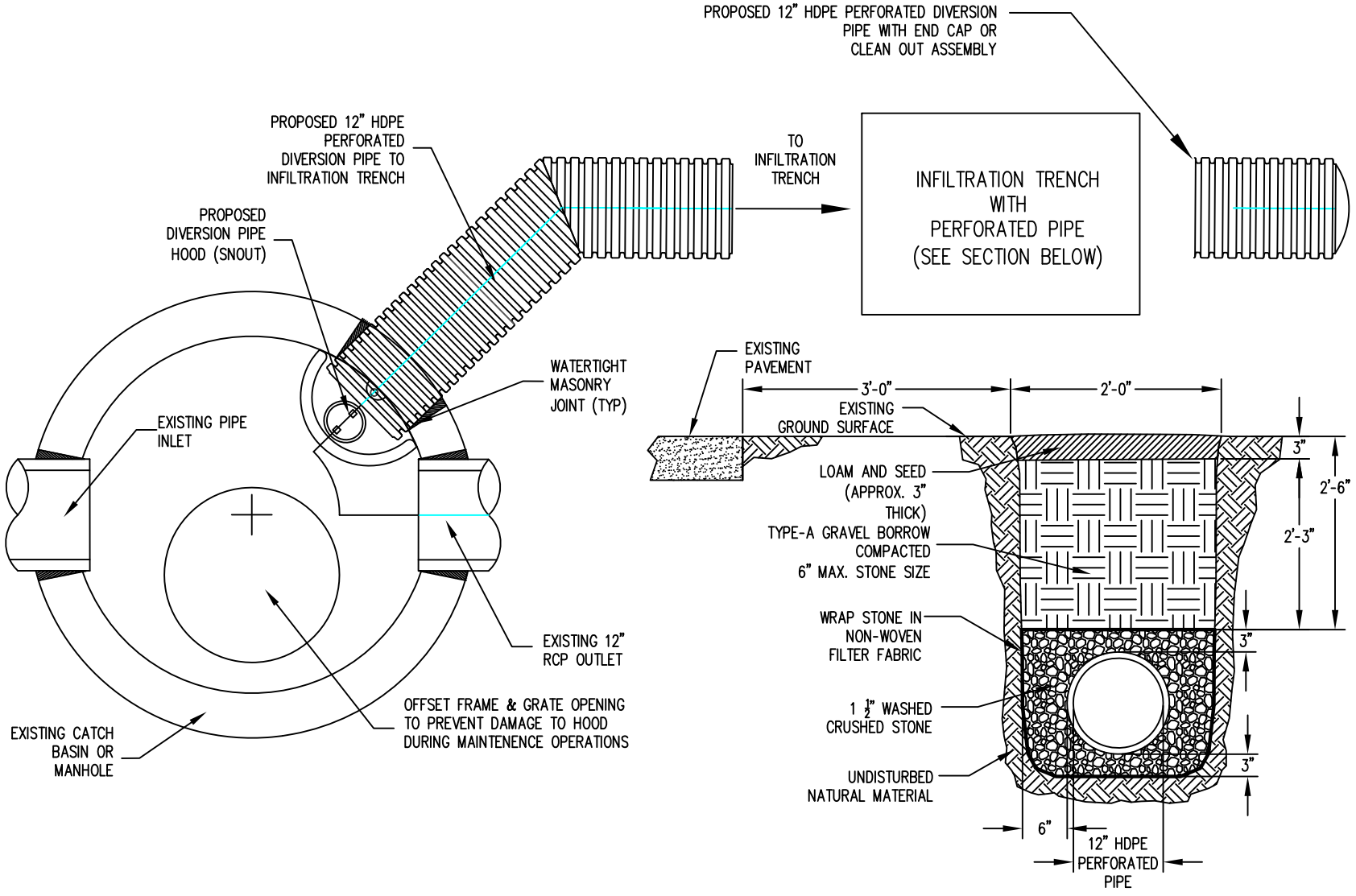
GENERAL NOTES

INFILTRATION
BMP DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

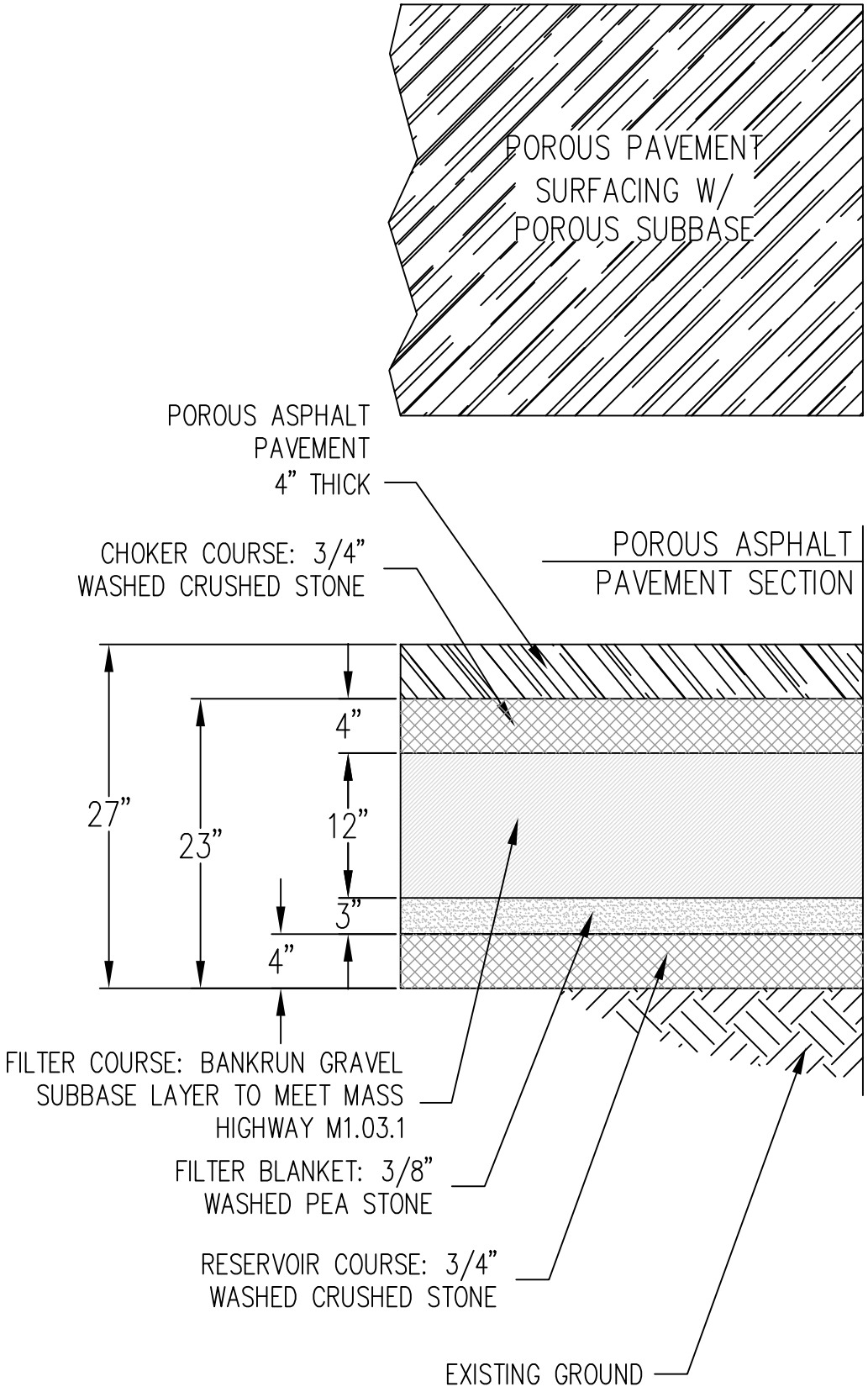
Lake Wentworth
Watershed Management Plan
Typical Details

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



INFILTRATION TRENCH RETROFIT
TYPICAL DETAIL

NOT TO SCALE



POROUS PAVEMENT TYPICAL DETAIL

NOT TO SCALE

GENERAL NOTES

INFILTRATION
BMP DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details

LAKE WENTWORTH FOUNDATION

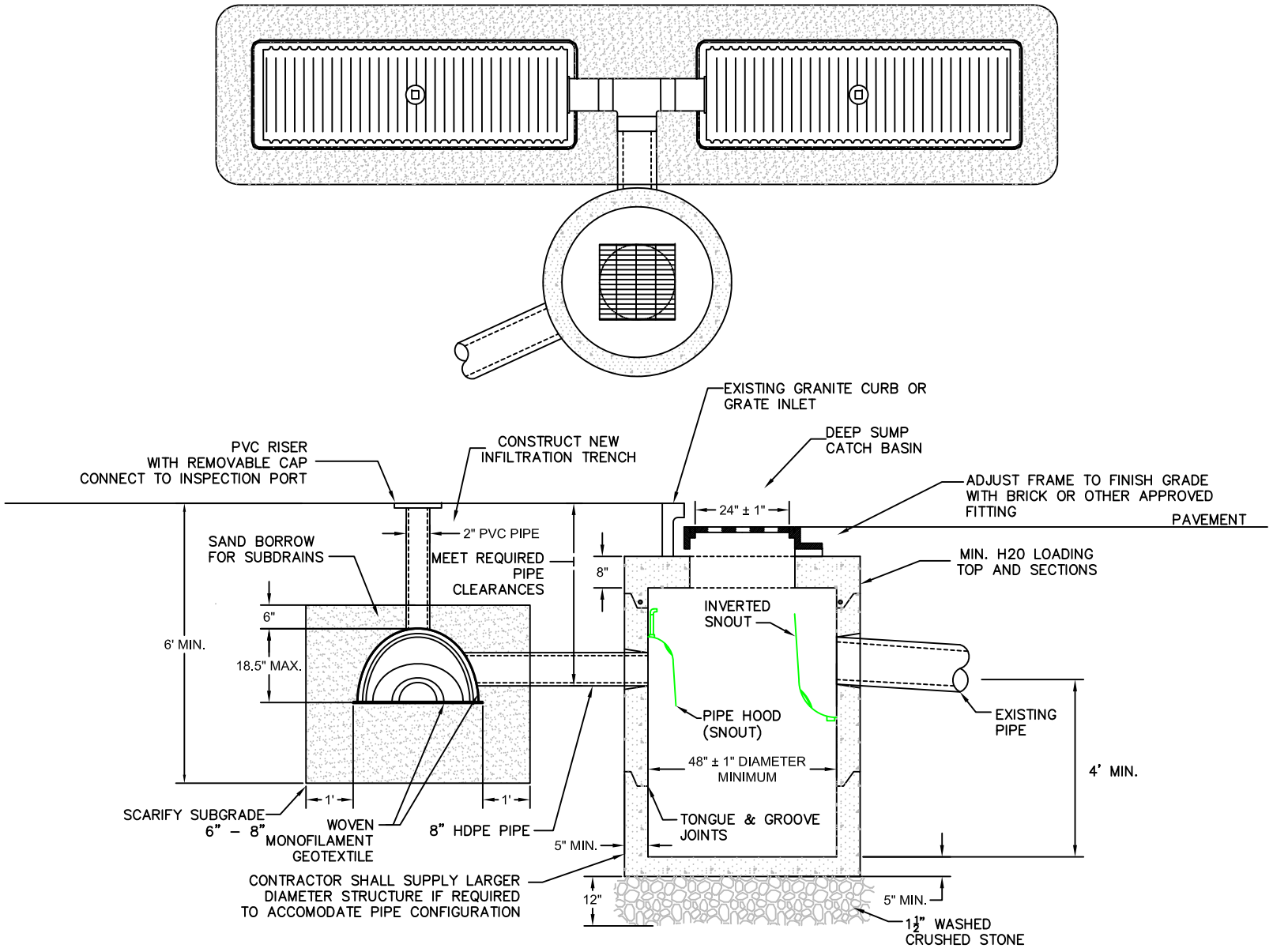
FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

GENERAL NOTES

INFILTRATION
BMP DETAILS

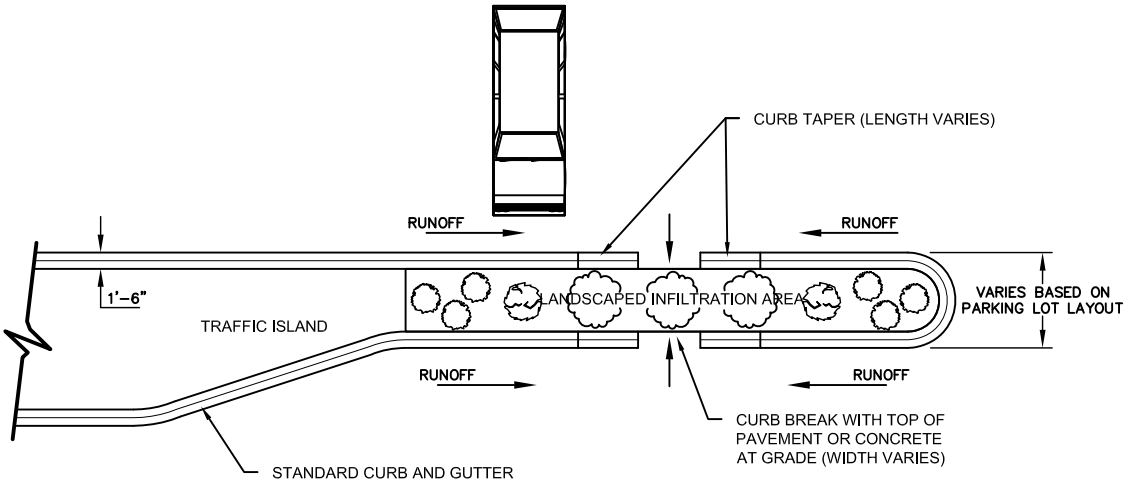
TOWN OF WOLFEBORO
NEW HAMPSHIRE
Lake Wentworth
Watershed Management Plan
Typical Details



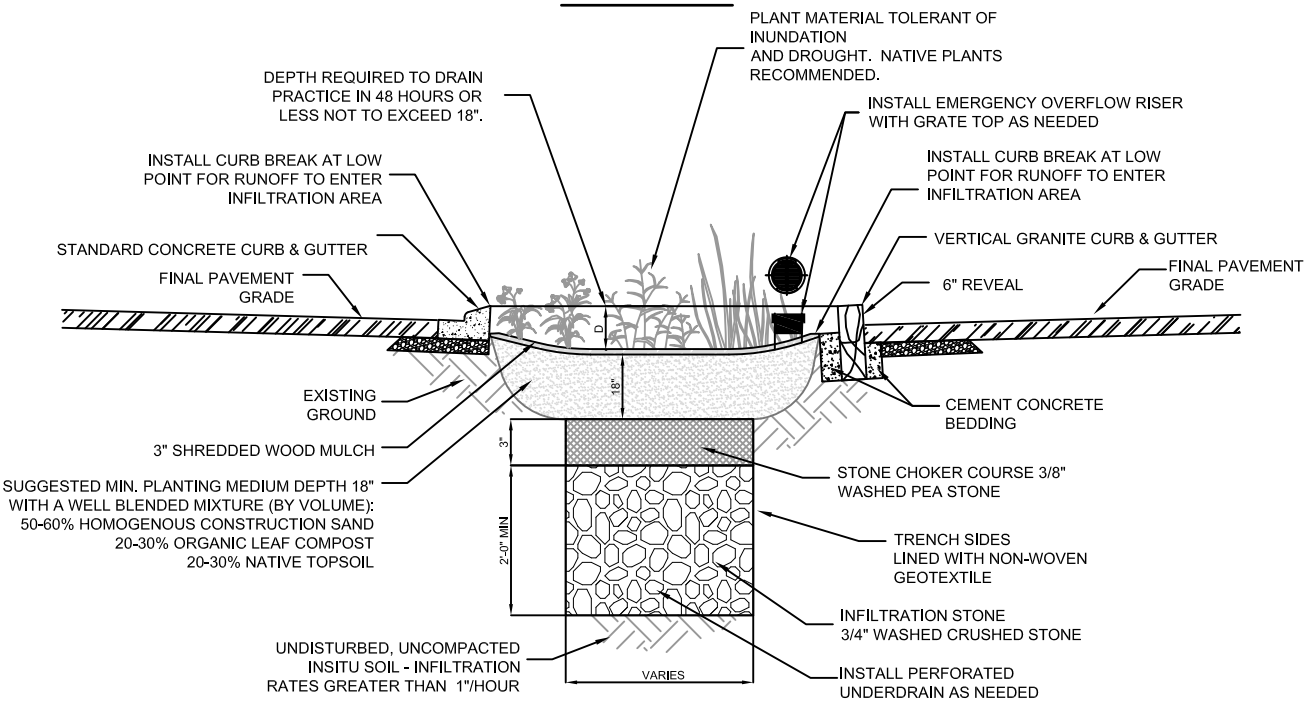
UNDERGROUND INFILTRATION CHAMBER
TYPICAL DETAIL

NOT TO SCALE

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



LANDSCAPED INFILTRATION DIVIDER
PLAN VIEW



LANDSCAPED INFILTRATION DIVIDER
SECTION

INFILTRATION DIVIDER TYPICAL DETAIL

NOT TO SCALE

GENERAL NOTES

INFILTRATION BMP DETAILS

TOWN OF WOLFEBORO
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FB environmental

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TOWN OF WOLFEBORO
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Lake Wentworth
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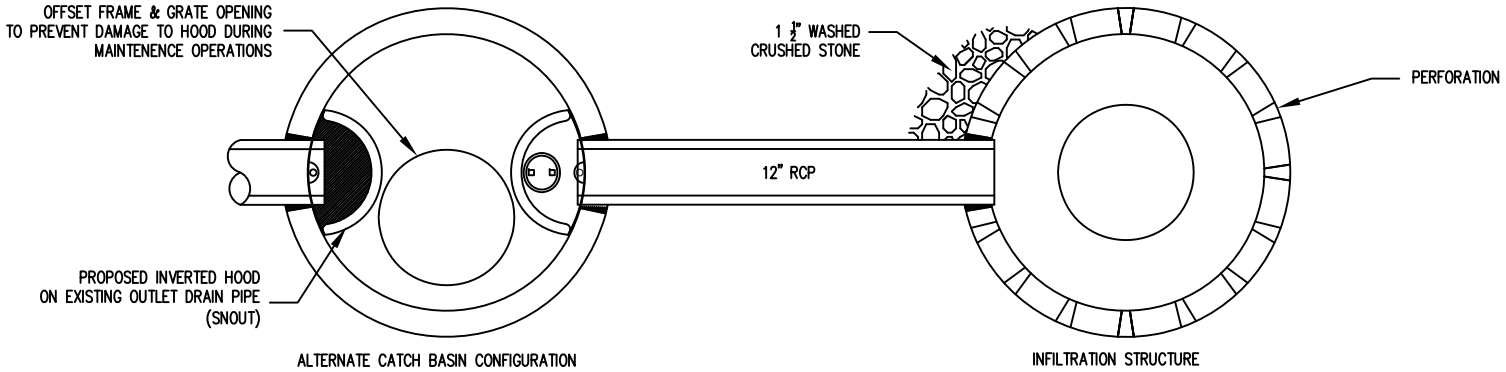
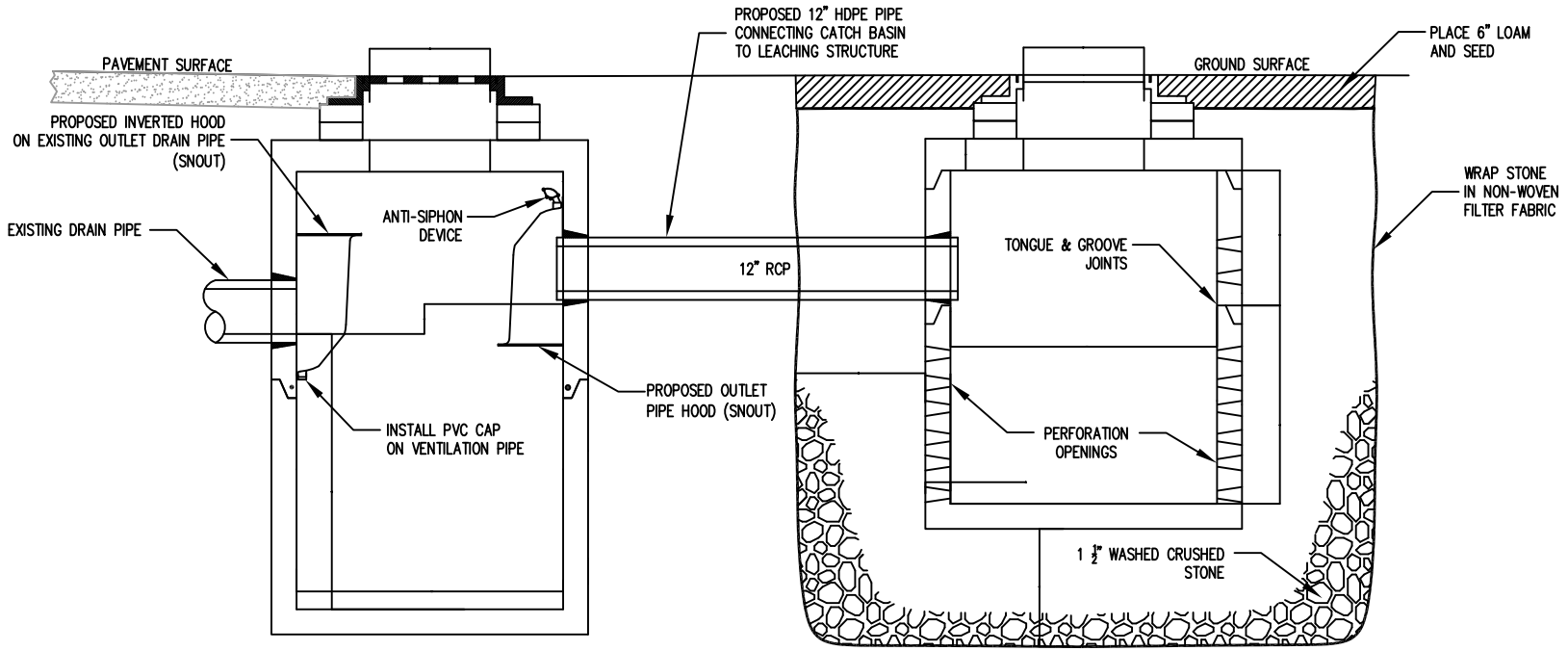
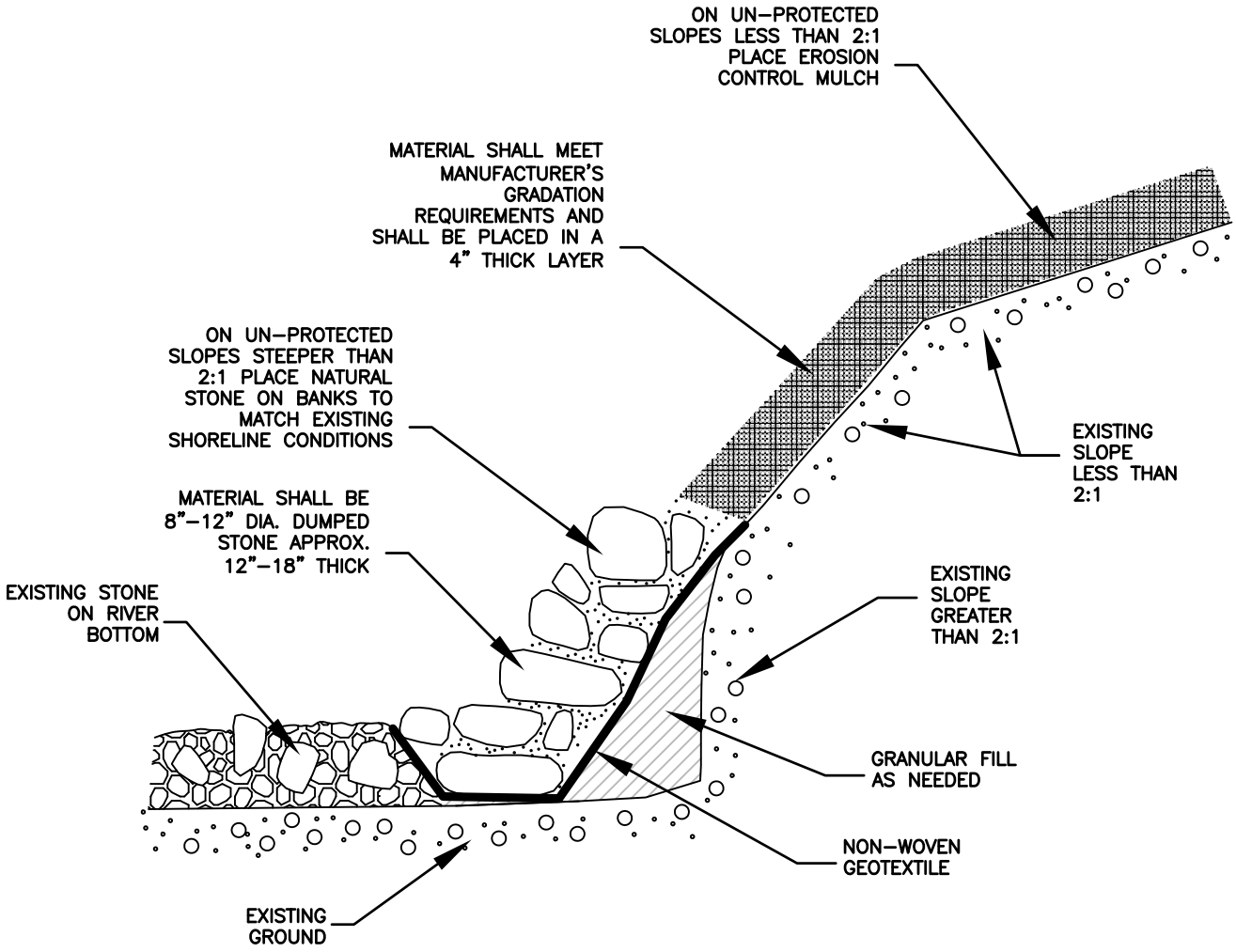
COMPREHENSIVE ENVIRONMENTAL INCORPORATED





LEACHING CATCH BASIN
TYPICAL DETAIL

NOT TO SCALE



STREAM BANK SLOPE TREATMENT-E.C. MULCH & STONE
TYPICAL DETAIL

NOT TO SCALE

GENERAL NOTES

STABILIZATION
DETAILS

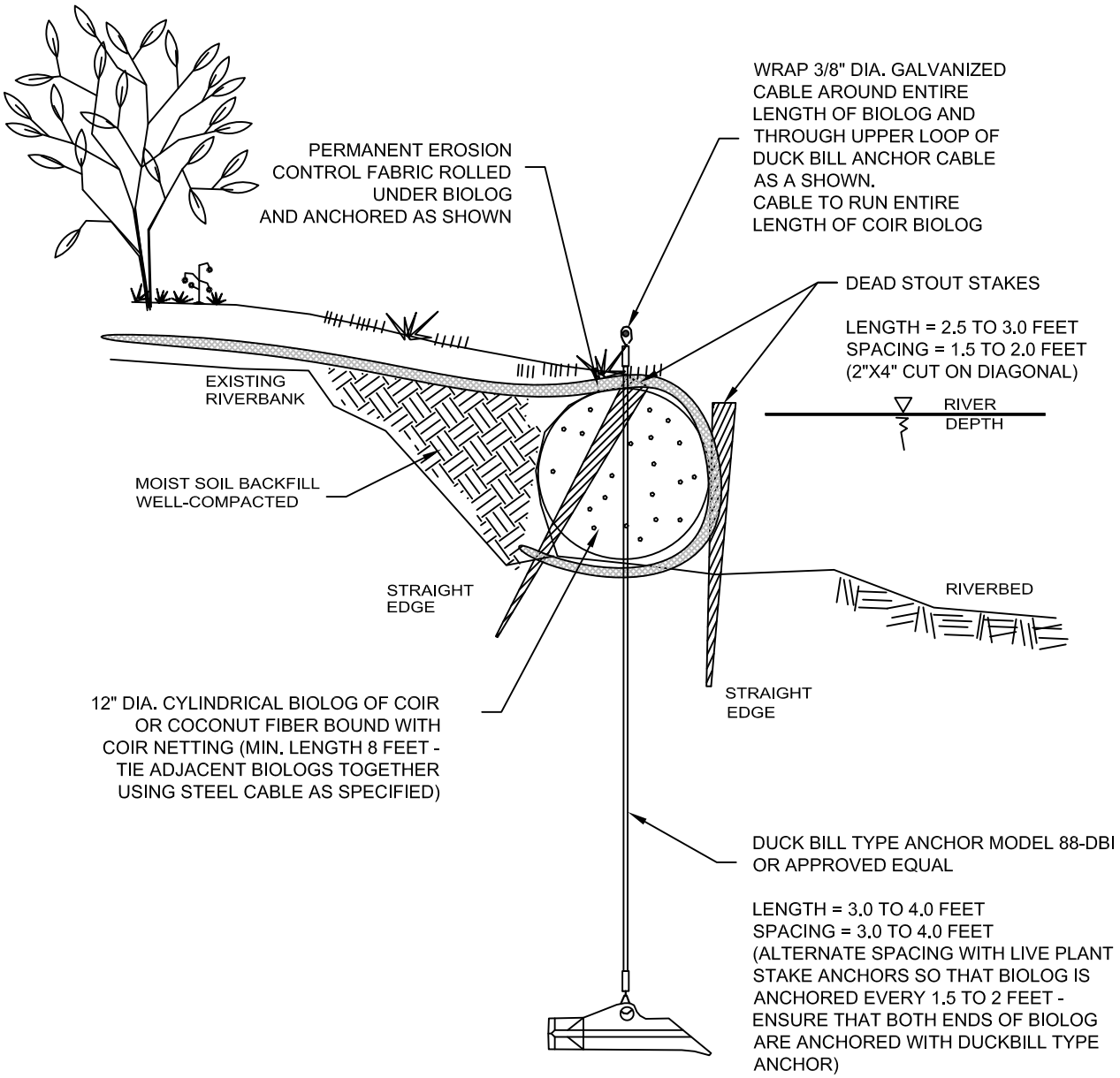
TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



STREAM BANK SLOPE TREATMENT-COIR LOG W/ ANCHOR TYPICAL DETAIL

NOT TO SCALE

GENERAL NOTES

STABILIZATION DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

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Watershed Management Plan
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LAKE WENTWORTH FOUNDATION

FB environmental

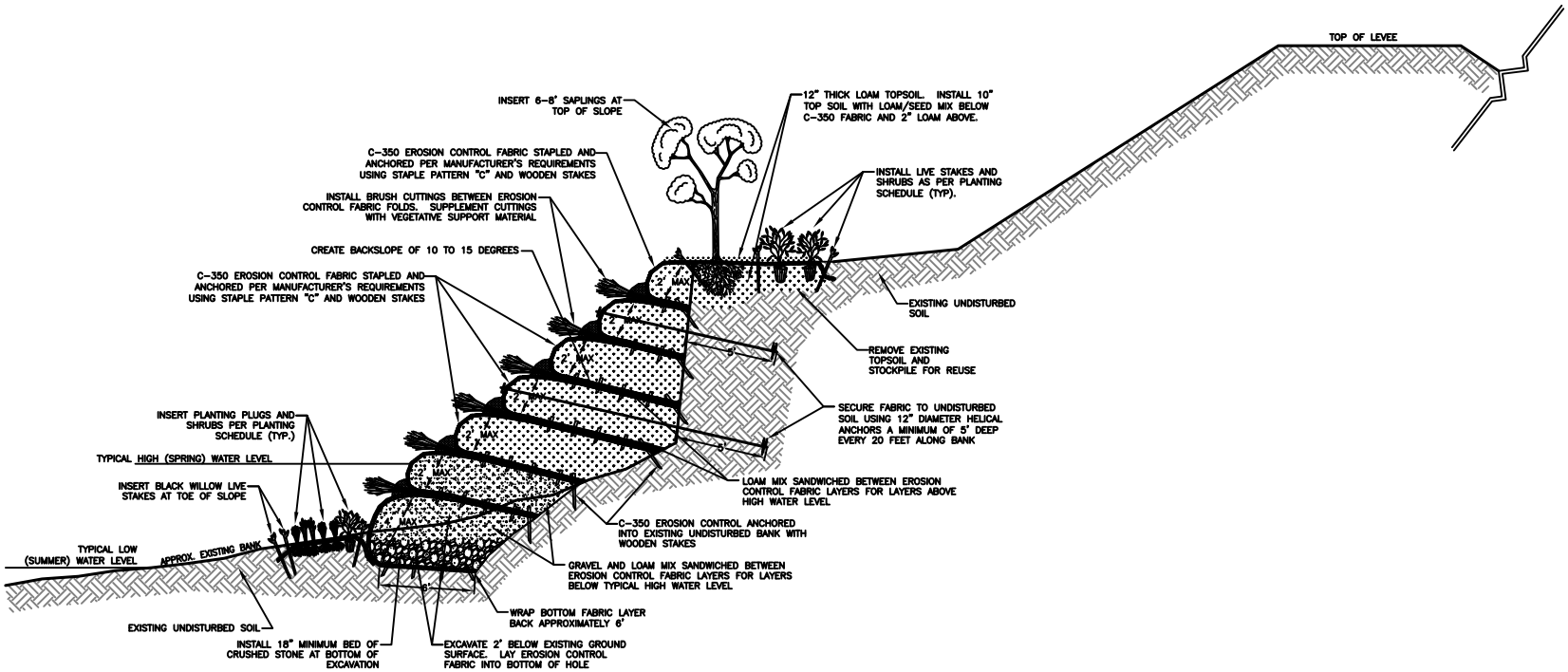
COMPREHENSIVE ENVIRONMENTAL INCORPORATED

GENERAL NOTES

STABILIZATION DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

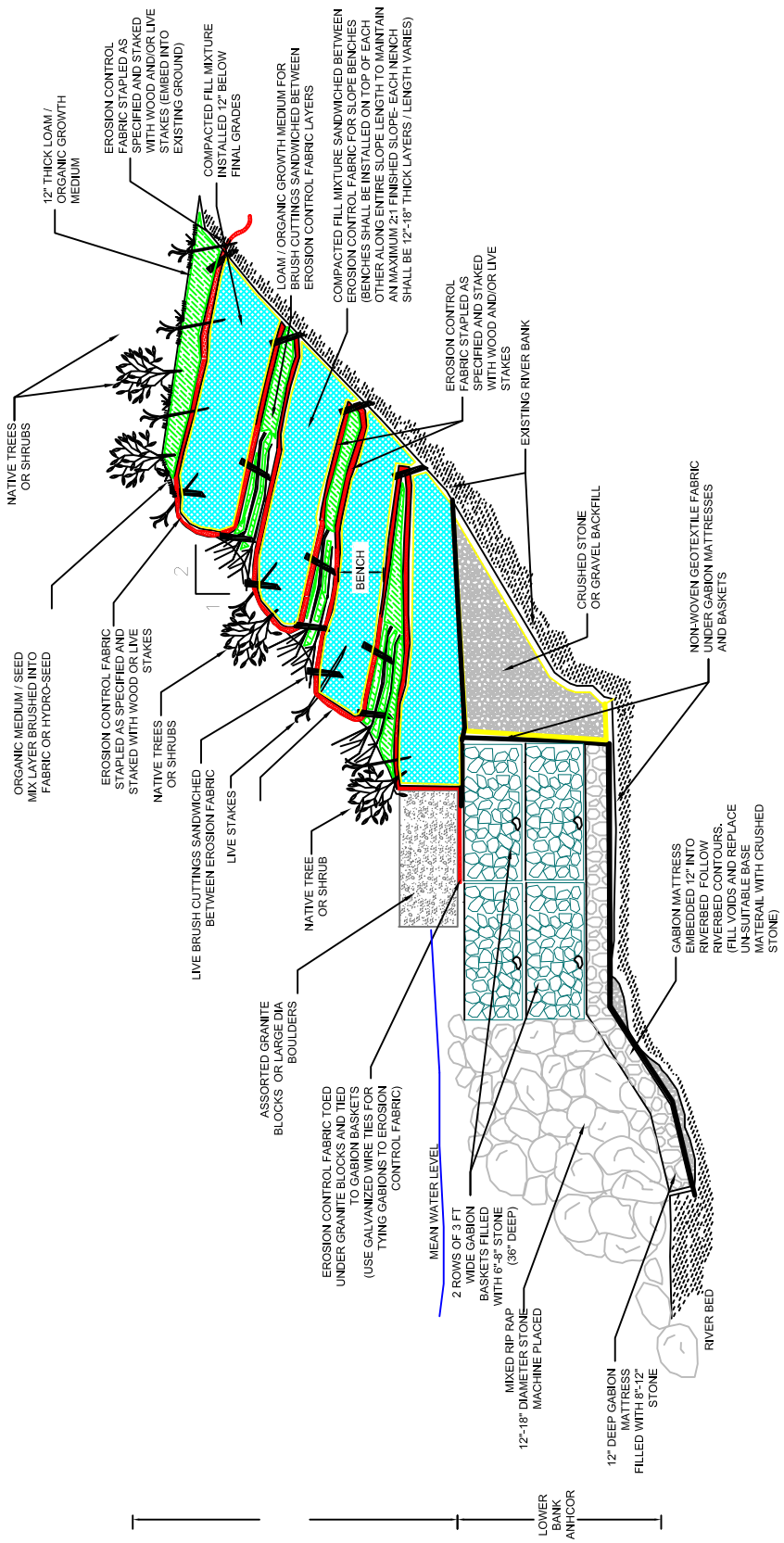
Lake Wentworth
Watershed Management Plan
Typical Details



STREAM BANK SLOPE TREATMENT-FABRIC
& BRUSH LAYERS (NATURAL BASE)
TYPICAL DETAIL

NOT TO SCALE

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



NOT TO SCALE

STREAM BANK SLOPE TREATMENT-FABRIC & BRUSH LAYERS (STRUCTURAL BASE) TYPICAL DETAIL

GENERAL NOTES

STABILIZATION DETAILS

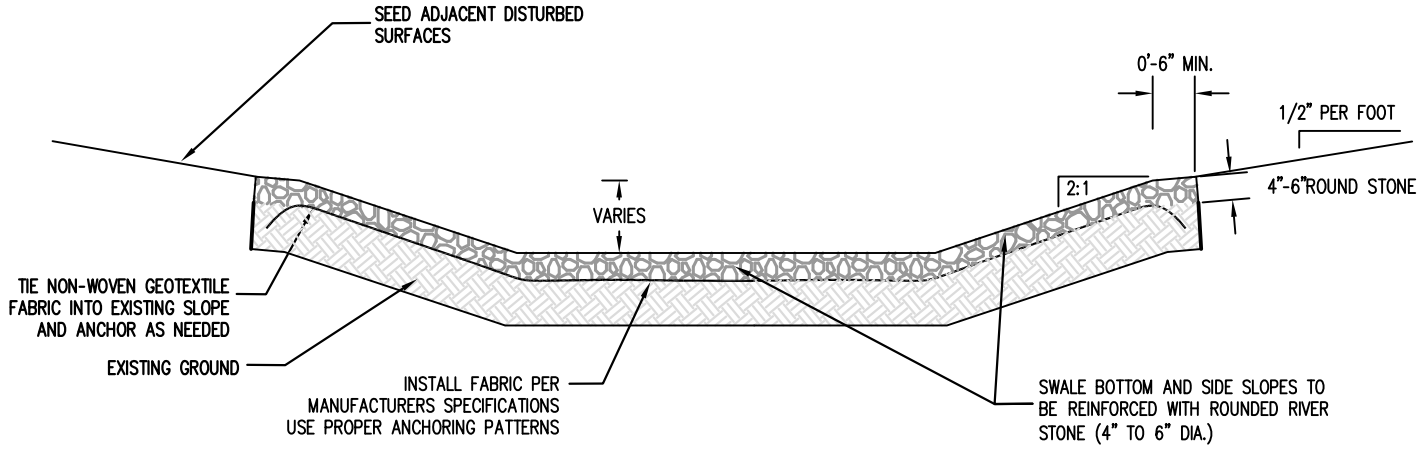
TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details

LAKE WENTWORTH FOUNDATION

FB environmental

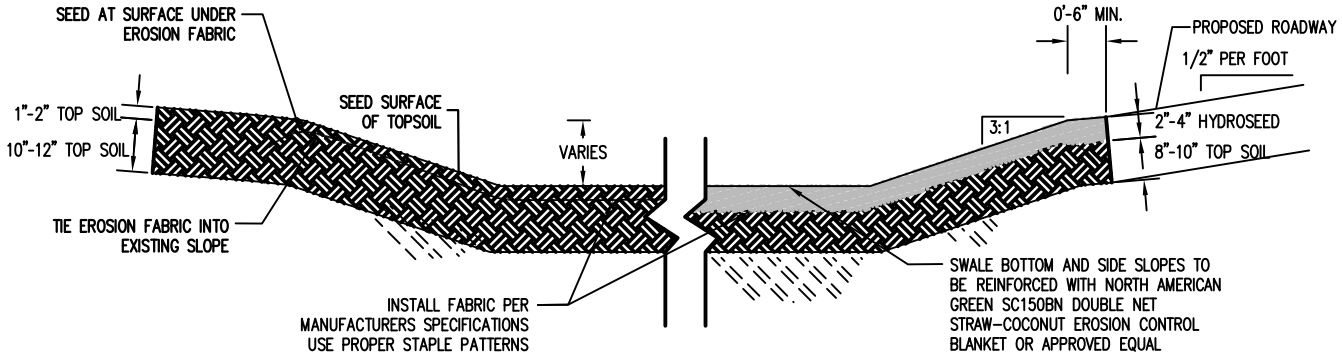
COMPREHENSIVE ENVIRONMENTAL INCORPORATED



ROUNDED RIVER STONE
SWALE SECTION

SWALE STABILIZATION WITH STONE
TYPICAL DETAIL

NOT TO SCALE



TOP SOIL AND SEED
SECTION

HYRDO-SEED & TOP SOIL
SECTION

SWALE STABILIZATION WITH VEGETATION
TYPICAL DETAIL

NOT TO SCALE

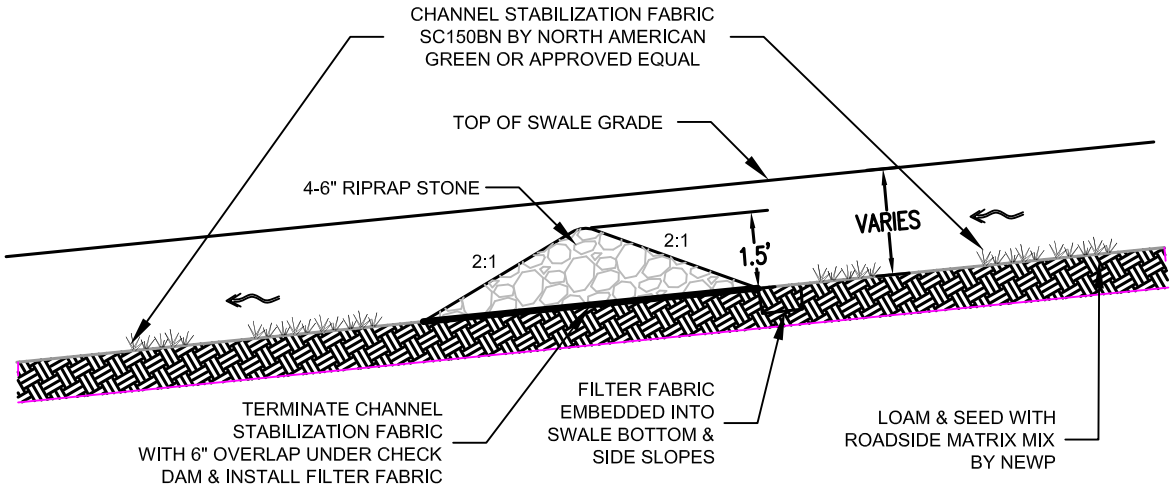
GENERAL NOTES

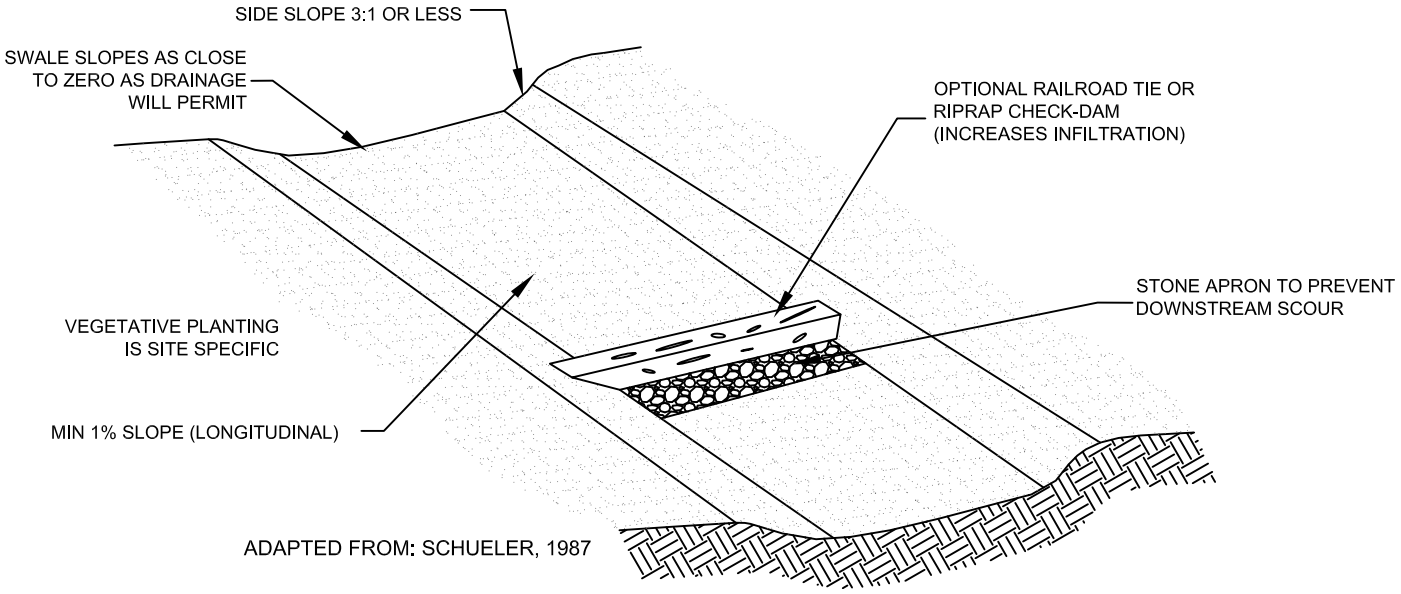
STABILIZATION
DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details

COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED





SWALE WITH CHECK DAM
TYPICAL DETAIL

NOT TO SCALE

GENERAL NOTES

STABILIZATION
DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
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Typical Details

LAKE WENTWORTH FOUNDATION

FB environmental

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

GENERAL NOTES

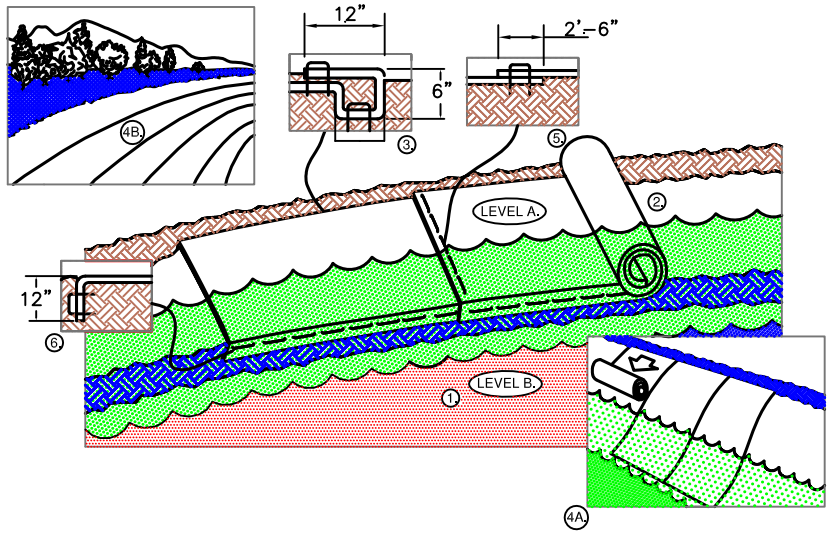
STABILIZATION DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

SLOPE PROTECTION



1. FOR EASIER INSTALLATION, LOWER WATER FROM LEVEL A TO LEVEL B BEFORE INSTALLATION.
2. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED NOTE: WHEN USING CELL-O-SEED, DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
3. BEGIN AT THE TOP OF THE SHORELINE BY ANCHORING THE BLANKET IN A 6" (15cm) DEEP X 6" (15cm) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30cm) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30cm) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30cm) APART ACROSS THE WIDTH OF THE BLANKET.
4. ROLL BLANKETS EITHER (A.) DOWN THE SHORELINE FOR LONG BANKS, (TOP TO BOTTOM) OR (B.) HORIZONTALLY ACROSS THE SHORELINE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING OPTIONAL DOT SYSTEM , STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
5. THE EDGES OF ALL HORIZONTAL AND VERTICAL BLANKET SEAMS MUST BE STAPLED WITH APPROXIMATELY 2"-5" (5cm-12.5cm) OVERLAP. TO ENSURE PROPER SEAM ALIGNMENT BETWEEN ADJACENT BLANKETS, PLACE THE EDGE OF THE OVERLAPPING BLANKET (BLANKET BEING INSTALLED ON TOP) EVEN WITH THE COLORED SEAM STITCH ON THE PREVIOUSLY INSTALLED BLANKET. SECURE ALL OVERLAPS WITH STAPLES SPACED 12" (30cm) APART.

NOTE: * SEAM OVERLAP SHOULD BE SHINGLED ACCORDING TO PREDOMINANT EROSIVE ACTION.

6. THE EDGE OF THE BLANKET AT OR BELOW NORMAL WATER LEVEL MUST BE ANCHORED BY PLACING THE BLANKET IN A 12" (30cm) DEEP X 6" (15cm) WIDE ANCHOR TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30cm) APART IN THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING (STONE OR SOIL MAY BE USED AS BACKFILL.)

NOTE: * IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

TYP. SLOPE OR SWALE STABILIZATION TYPICAL DETAIL

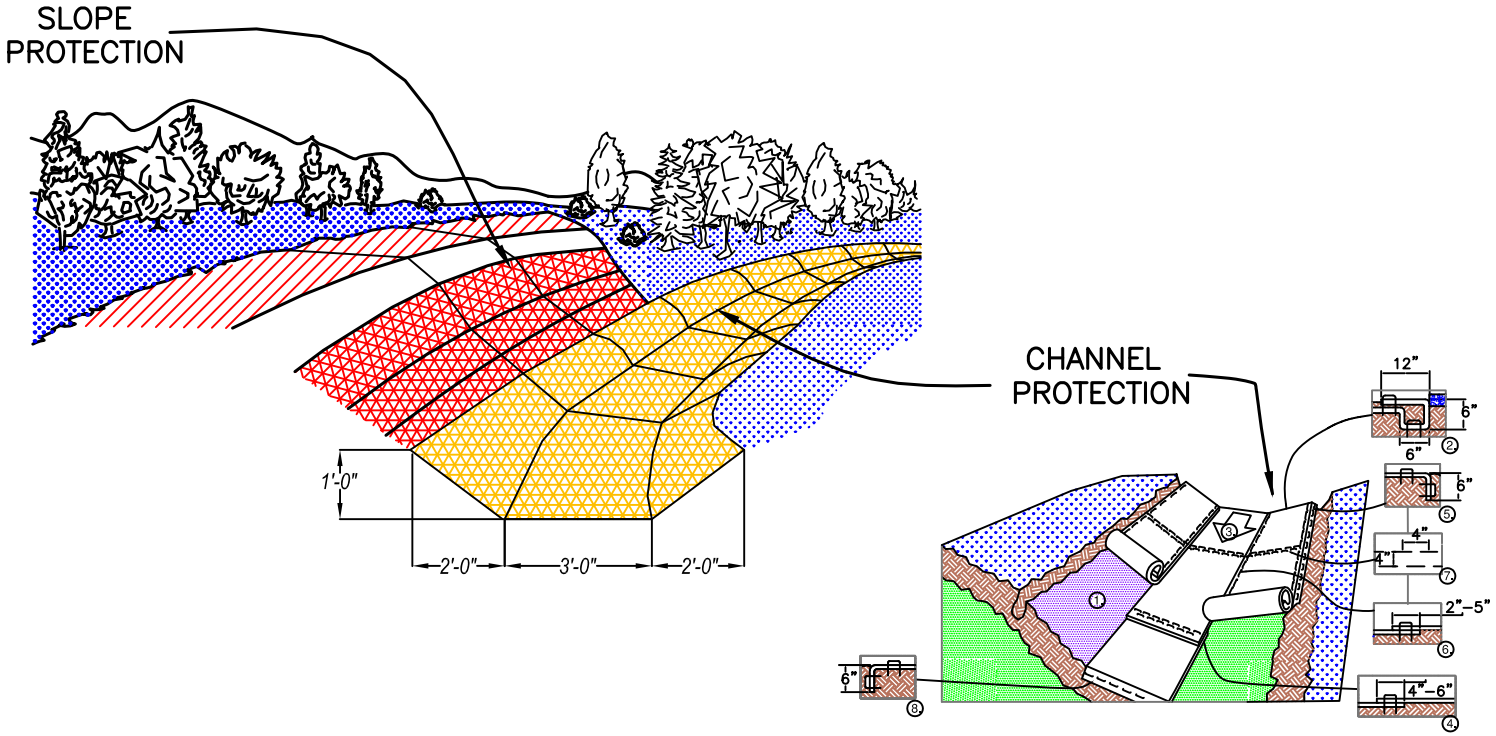
NOT TO SCALE

GENERAL NOTES

STABILIZATION DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details



1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING CELL–O–SEED DO NOT SEED PREPARED AREA. CELL–O–SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.

2. BEGIN AT THE TOP OF THE CHANNEL BY ANCHORING THE BLANKET IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30 CM) OF BLANKET EXTENDED BEYOND THE UP–SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMAPCT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) ACROSS THE WIDTH OF THE BLANKET.

3. ROLL CENTER BLANKET IN DIRECTION OF WATER FLOW IN BOTTOM OF CHANNEL. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE.WHEN USING THE DOT SYSTEM , STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.

4. PLACE CONSECUTIVE BLANKETS END OVER END (SHINGLE STYLE) WITH A 4" – 6" (10 CM –15 CM) OVERLAP. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER TO SECURE BLANKETS.

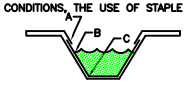
5. FULL LENGTH EDGE OF BLANKETS AT TOP OF SIDE SLOPES MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.

6. ADJACENT BLANKETS MUST BE OVERLAPPED APPROXIMATELY 2" – 5" (5 CM –12.5 CM) (DEPENDING ON BLANKET TYPE) AND STAPLED.

7. IN HIGH FLOW CHANNEL APPLICATIONS, A STAPLE CHECK SLOT IS RECOMMENDED AT 30 TO 40 FOOT (9 M – 12 M) INTERVALS. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER OVER ENTIRE WIDTH OF THE CHANNEL.

8. THE TERMINAL END OF THE BLANKETS MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.

NOTE: * IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.



CRITICAL POINTS
A. OVERLAPS AND SEAMS
B. PROJECTED WATER LINE
C. CHANNEL BOTTOM/SIDE SLOPE VERTICES

NOTE:
* HORIZONTAL STAPLE SPACING SHOULD BE ALTERED IF NECESSARY TO ALLOW STAPLES TO SECURE THE CRITICAL POINTS ALONG THE CHANNEL SURFACE.

** IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 cm) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

TYP. SLOPE OR SWALE STABILIZATION
TYPICAL DETAIL

NOT TO SCALE

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

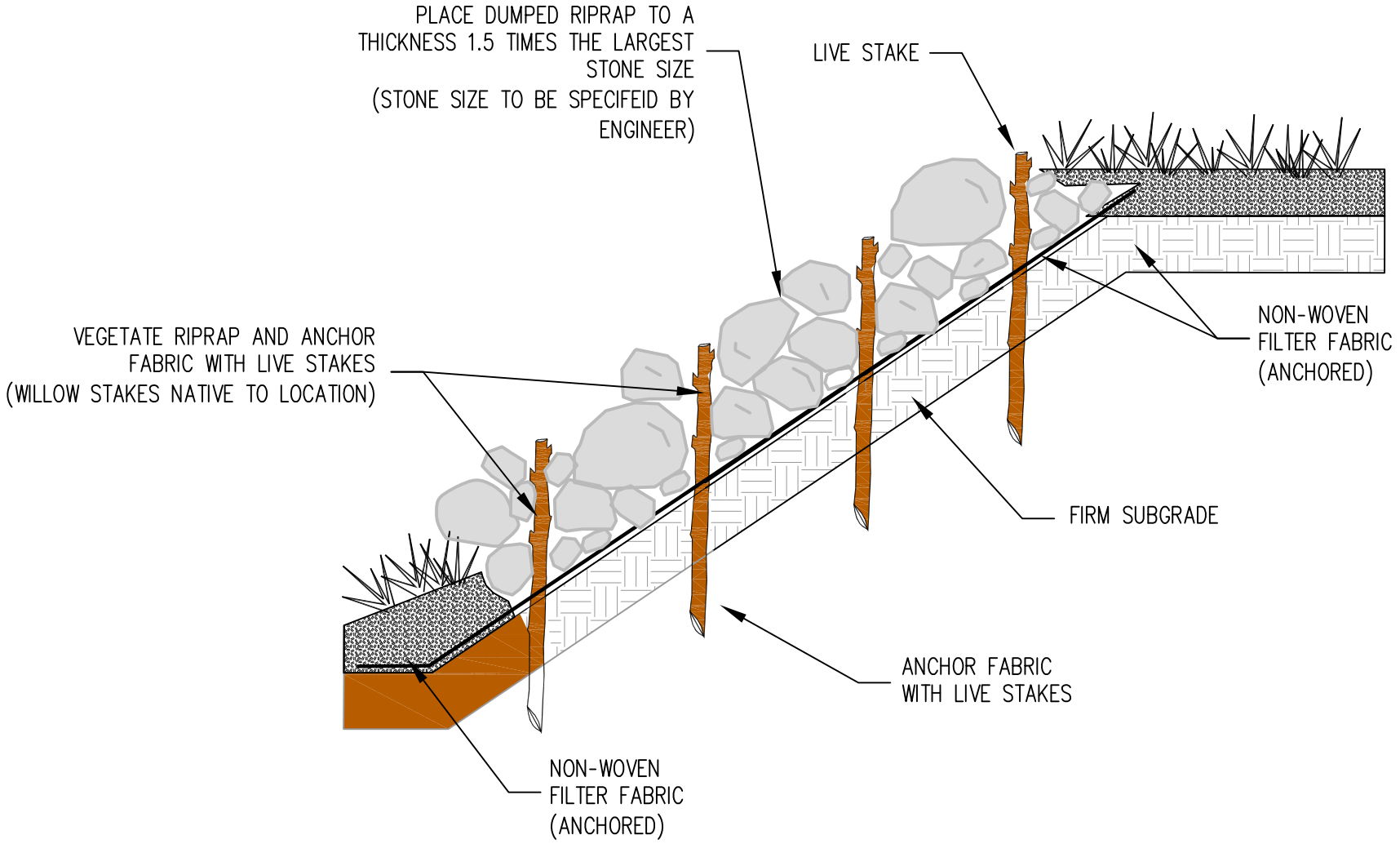
GENERAL NOTES

STABILIZATION DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth Watershed Management Plan
Typical Details

COMPREHENSIVE ENVIRONMENTAL INCORPORATED



VEGETATED RIPRAP SLOPE TREATMENT
TYPICAL DETAIL

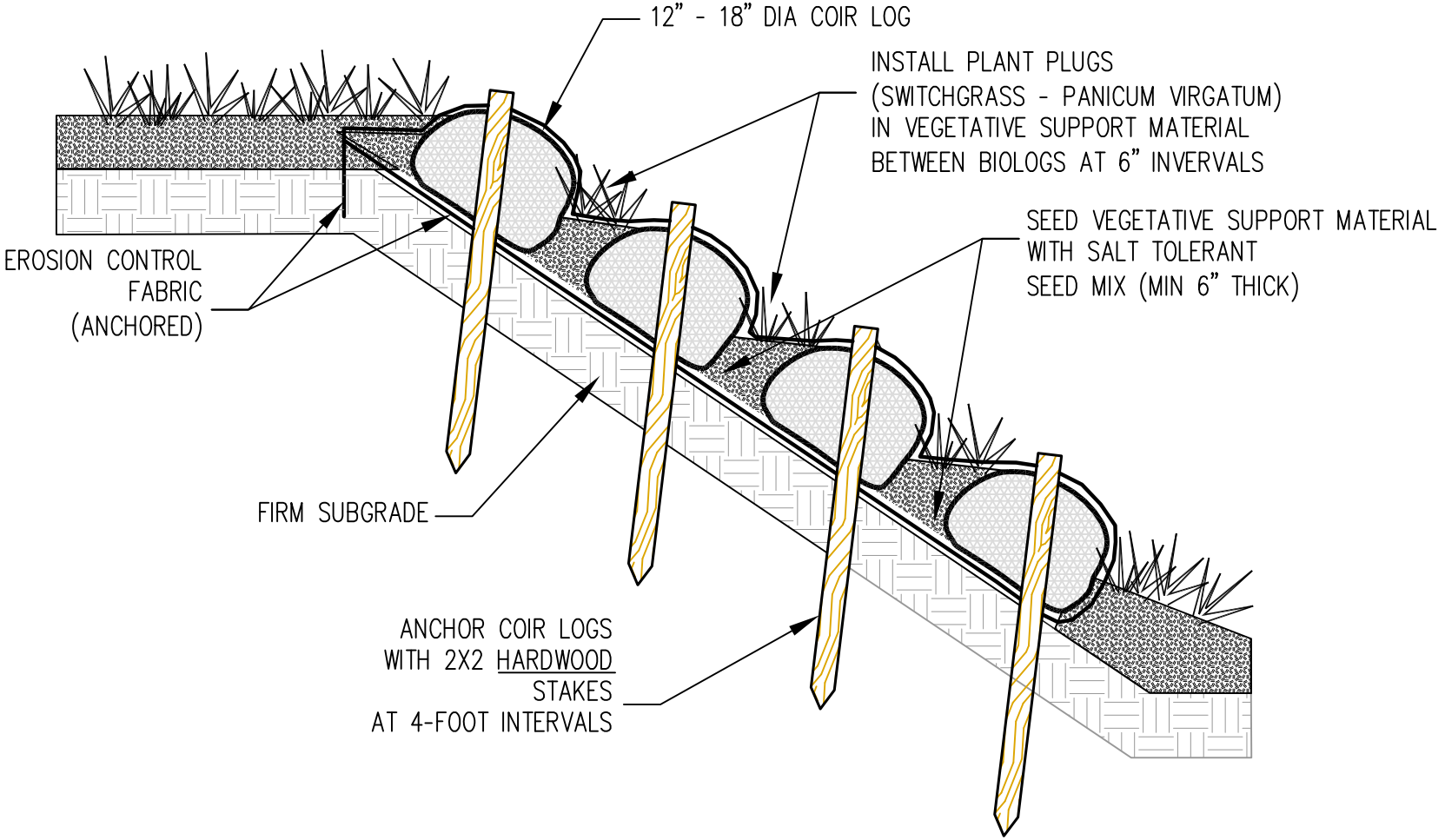
NOT TO SCALE

GENERAL NOTES

STABILIZATION DETAILS

TOWN OF WOLFEBORO
NEW HAMPSHIRE

Lake Wentworth
Watershed Management Plan
Typical Details



COIR BIOLOG SLOPE TREATMENT
TYPICAL DETAIL

NOT TO SCALE

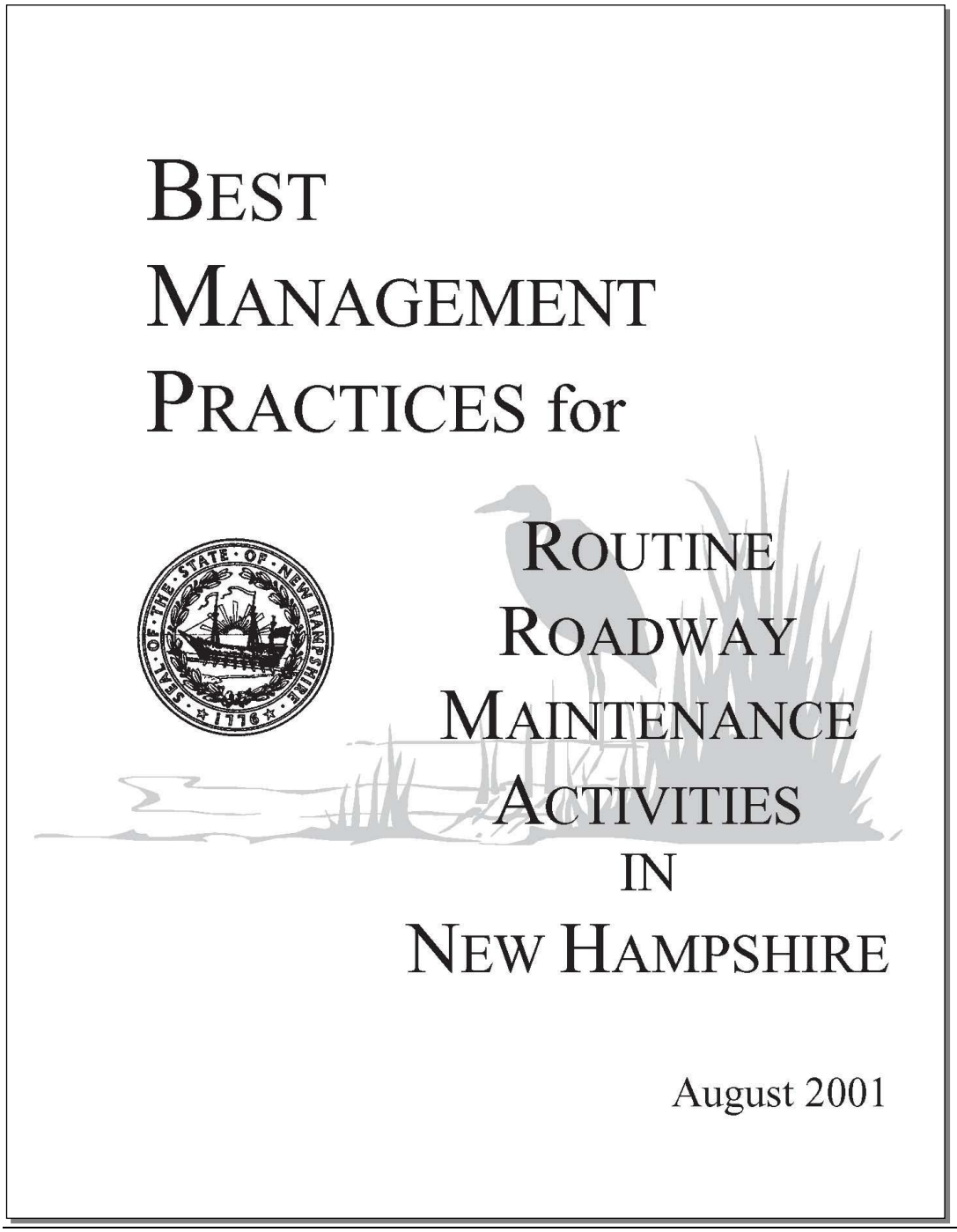
COMPREHENSIVE ENVIRONMENTAL INCORPORATED

Appendix I:
Roadway BMPs

The State of New Hampshire DES - BMPs for Routine Roadway Maintenance Activities in NH manual can be found at the following link:

http://des.nh.gov/organization/divisions/water/wetlands/documents/roadway_bmp.pdf

This manual provides general BMPs, erosion controls and maintenance recommendations for all types of roadways (paved and un-paved) as well as drainage system components.

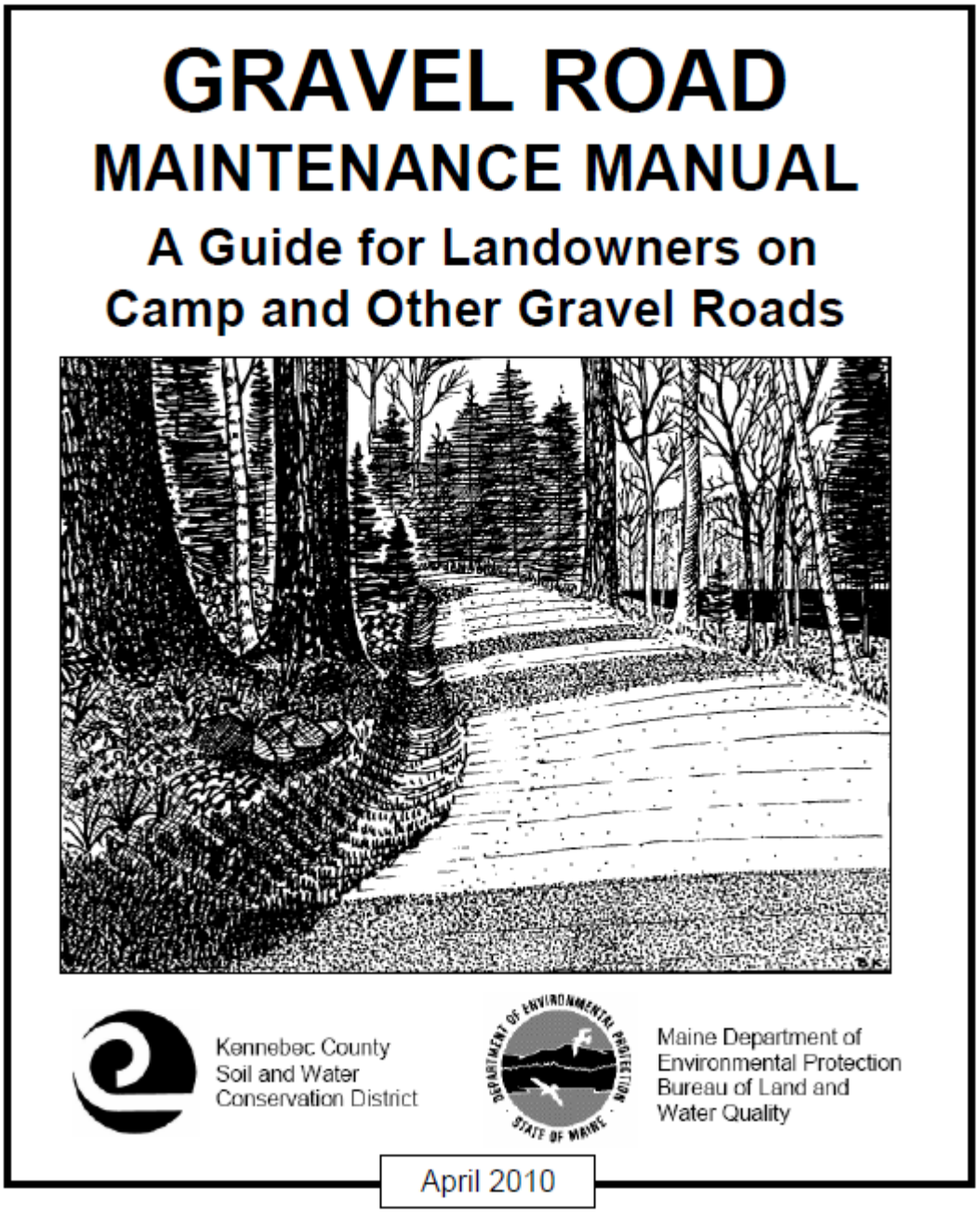


The State of Maine DEP Gravel Road Maintenance Manual can be found at the following links:

http://www.maine.gov/dep/land/watershed/camp/road/index.htm

http://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf

This manual provides both general recommendations and detailed BMPs specifically for gravel and camp roadways.



The following are some general BMPs and guidance from that manual:

Some of the most important recommendations for gravel road maintenance include the proper control of surface water and groundwater on the roadway and within drainage systems:

The following measures are used to help drain water off the road surface:

- ❑ a well-constructed road with proper grading and crowning or super-elevation;
- ❑ stable road ditches;
- ❑ diversions (e.g., water bars); and
- ❑ turnouts and buffers that return runoff to natural drainage areas.

To keep groundwater out of the road base:

- ❑ build the road above the groundwater table;
- ❑ if the road is built just above the water table, have a geotextile base (see page 24);
- ❑ if the road is not above the water table, pass groundwater through the road frequently using rock sandwiches (see page 63) or cross culverts where needed; or
- ❑ as a last option, groundwater can be drained from the road base and directed to a natural or constructed channel capable of handling the flow without eroding, except in vernal pool areas.

Proper gravel road drainage construction and erosion controls make up the majority of beneficial BMPs for minimizing water quality impacts. Some general erosion control recommendations include:

It is difficult to control erosion once it has started, which is why emphasis should be placed on prevention and regular maintenance. Effective erosion control can be best accomplished by observing the following guiding principles:

- ❑ Monitor and maintain your camp road on a regular basis. The best time to inspect your camp road is on a rainy day, when problems are more apparent.
- ❑ Thoroughly plan improvement projects before starting.
- ❑ Work with nature whenever possible – let the natural features and forces help you accomplish the end site design.
- ❑ Drain stormwater off the road surface at frequent intervals, and as quickly as possible.
- ❑ Keep runoff velocities slow.
- ❑ Avoid concentrating runoff (promote dispersion).
- ❑ Avoid discharging runoff directly into natural surface waters.
- ❑ Discharge stormwater runoff into vegetated areas (buffer strips) as sheet flow.
- ❑ Minimize areas of exposed soil on side slopes and ditches.
- ❑ Stabilize and cover bare soils with vegetation or other protection (i.e., mulch or riprap).
- ❑ Limit heavy loads and minimize traffic during early spring (mud season), until frost is out and road is dry.

To prevent erosion and minimize transport of sediments from a gravel road and or drainage way, roadway material selection, proper installation and consistent grading procedures are very important:

MATERIAL & INSTALLATION:

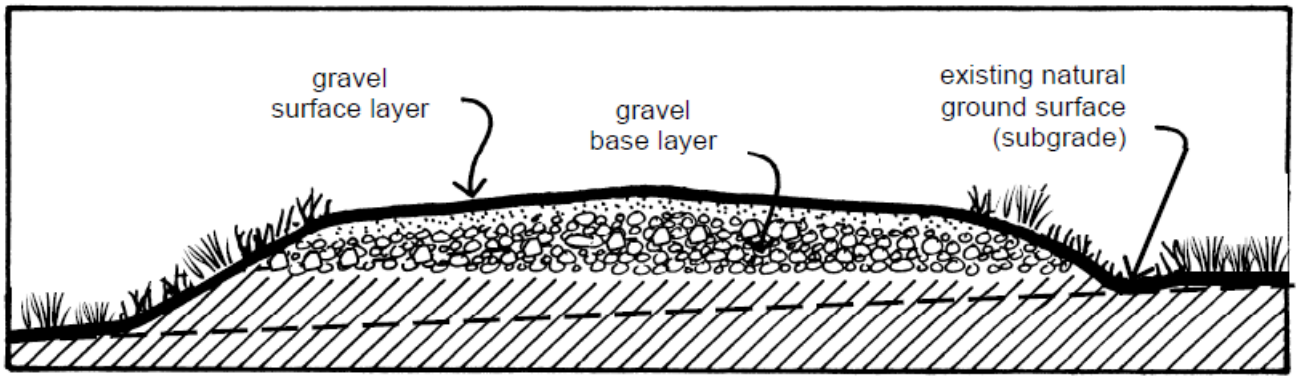


Figure 6. Well-constructed road: entire road built above original ground level.

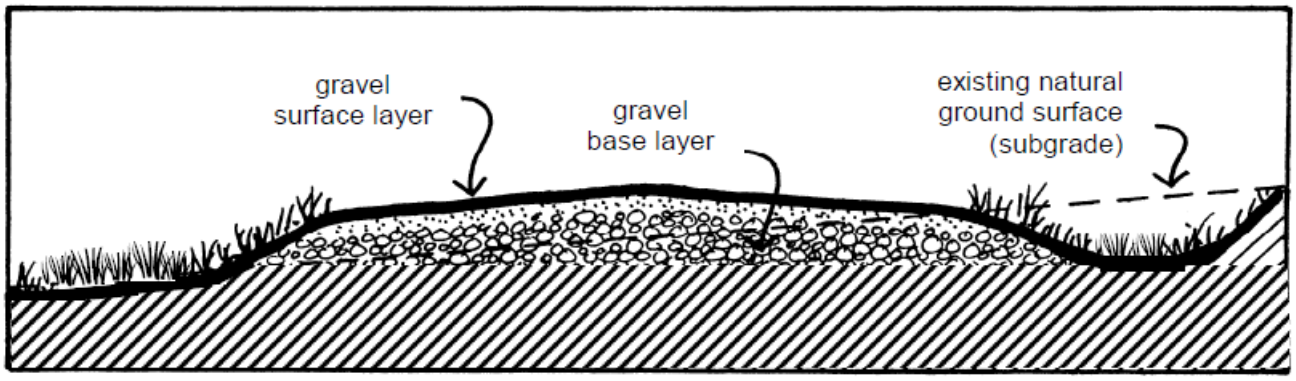


Figure 7. Well-constructed road: high point above original ground level.

Proper grading and annual roadway shoulder maintenance:

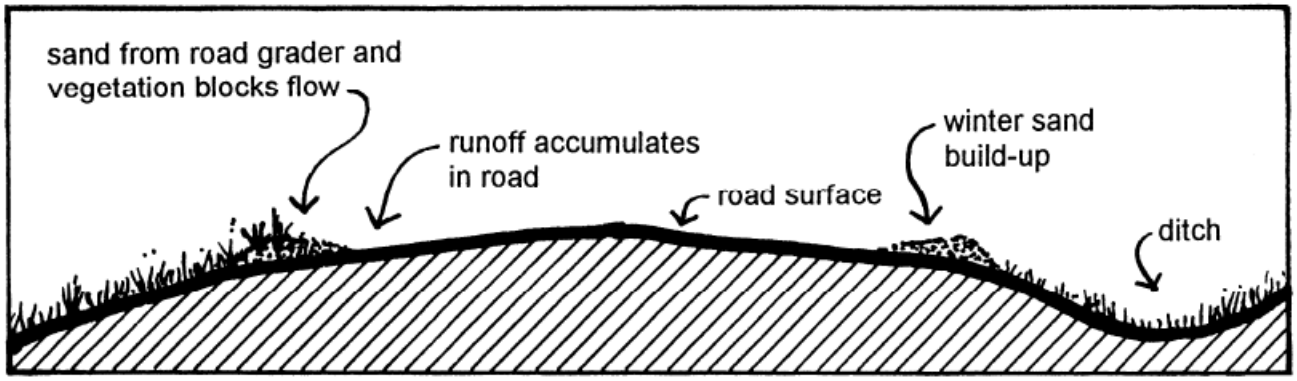


Figure 12. Sand and vegetation build-up prevents drainage to sides of road.

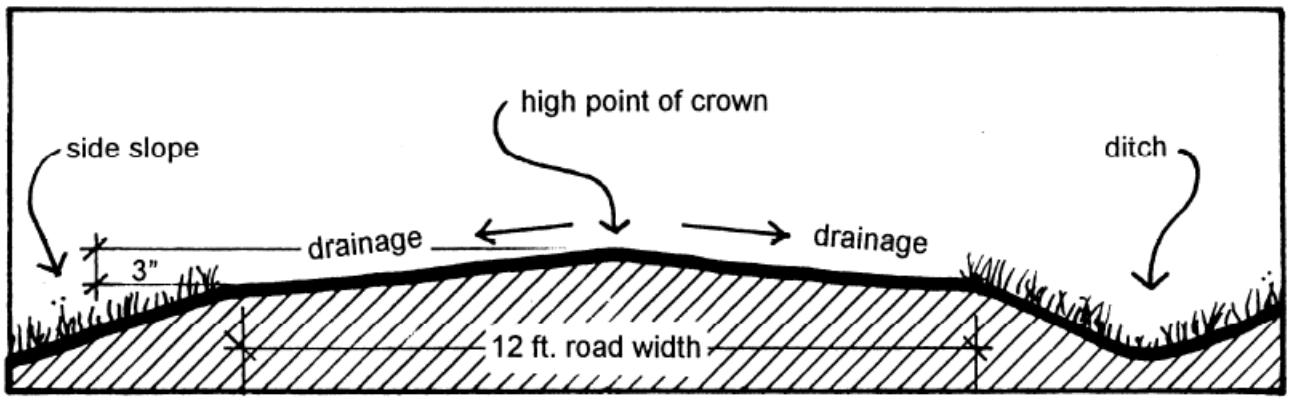


Figure 13. Crown profile: ½ " of crown per foot of road width (e.g., ½ " x ½ x 12' road = 3" crown).

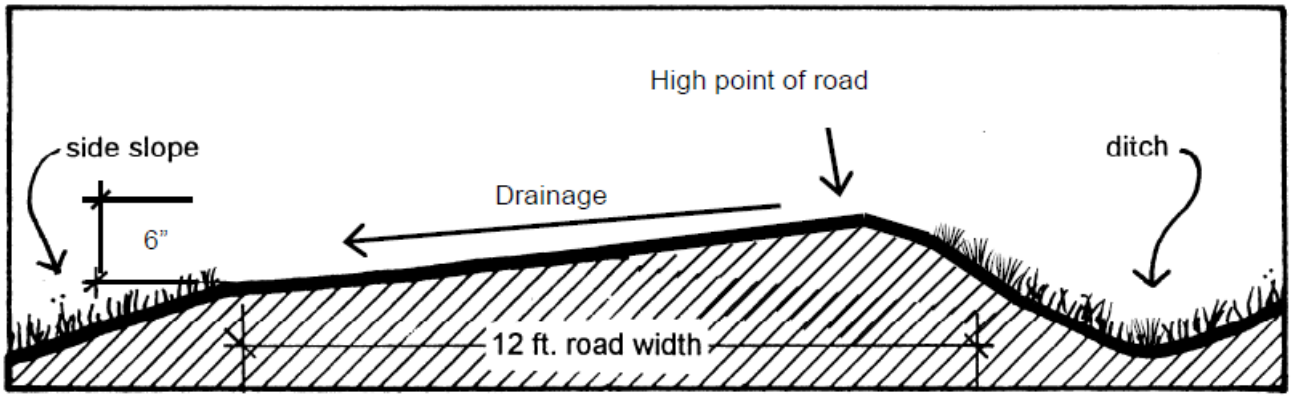


Figure 14. Super-elevation profile: ½ " of super-elevation per foot of road width (e.g., ½ " x 12' road = 6" crown).

Using proper roadway drainage features and surface water conveyance systems will help prevent erosion, minimize the need for future repairs and reduce repetitive maintenance requirements:

DRAINAGE DITCHES:

SLOPE VALUE EQUIVALENTS		
Ratio	**Percent Slope**	**Degrees**
1:1	100% slope	45°
1.5:1	67% slope	34°
2:1	50% slope	27°
4:1	25% slope	14°

Figure 18. Slope value equivalents

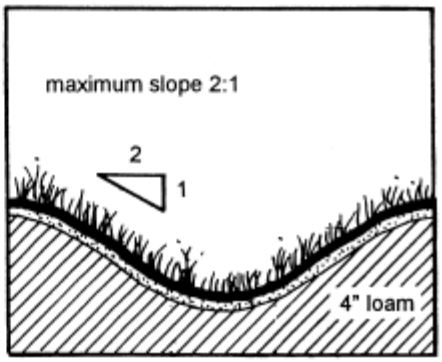


Figure 19. Parabolic (U-shaped) ditch, grass-lined.

Steepness of slope can be a difficult concept to understand. It is easiest to visualize slope as the long side of a triangle with horizontal "run" and vertical "rise" being the other two sides (see diagram below). Slope expressed as a ratio is "run" : (to) "rise." To express slope as a percentage, simply divide rise by run and multiply by 100: (rise/run) x 100.

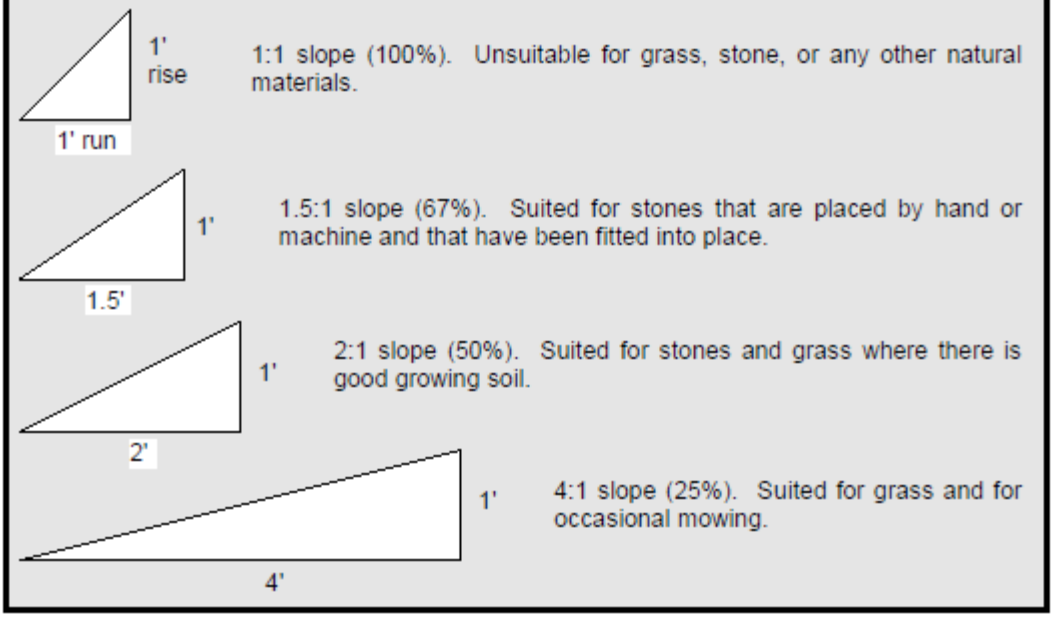


Figure 20. Slope

Figure 22. Plant grass to control erosion in ditches with less than 5% pitch

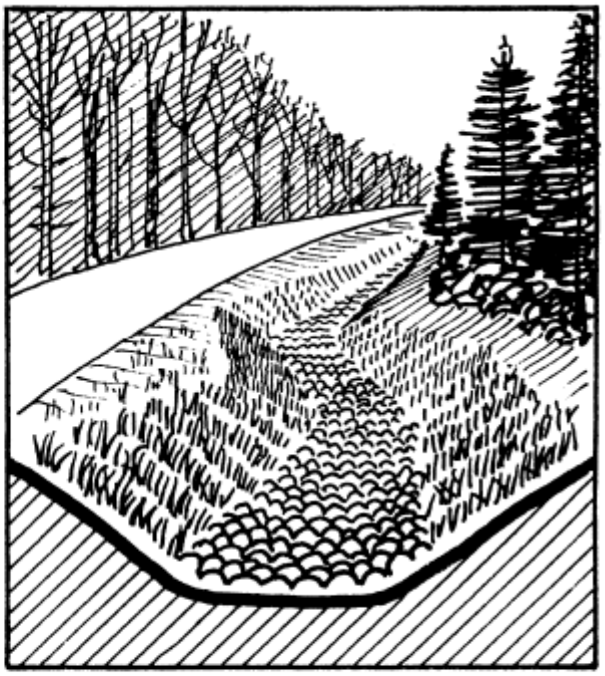


Figure 23. Grass and stone to control erosion for ditches with more than 5% pitch

PROPER CROSS CULVERT PLACEMENT AND INSTALLATION:

ANGLE

Culverts should be set at an angle 30 -35 degrees downslope from a line perpendicular to the road's centerline. Setting culverts on an angle improves their hydraulic efficiency and lessens the chance of erosion at the inlet. Culverts installed in a natural drainage channel (e.g., streams) should be installed at the same angle as the channel.

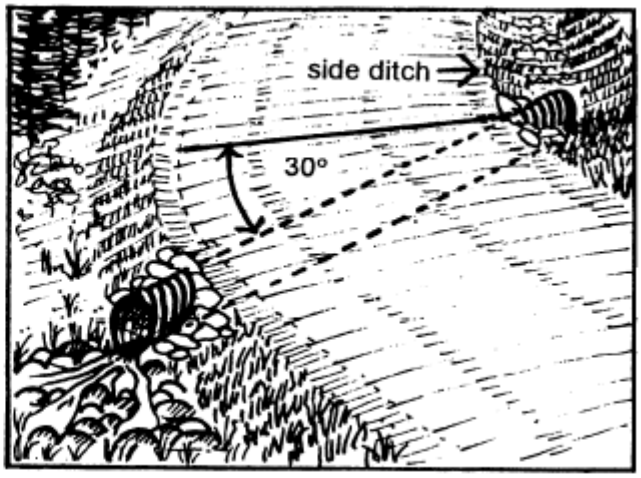


Figure 29. Set culvert at 30° downslope.

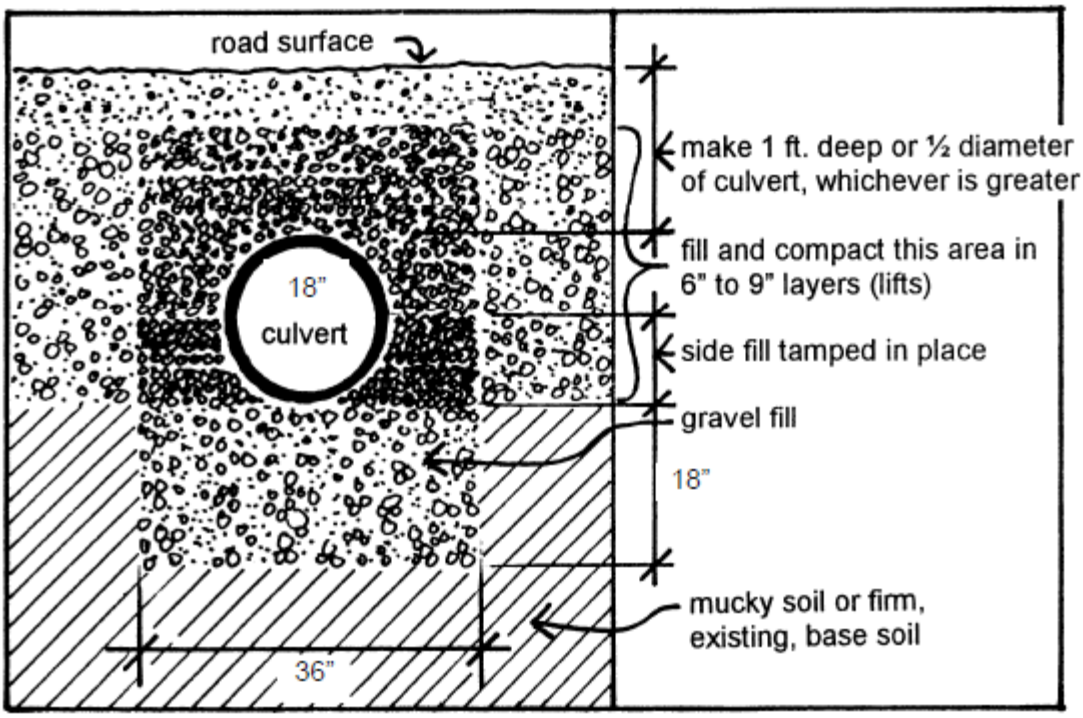


Figure 30. Culvert Installation

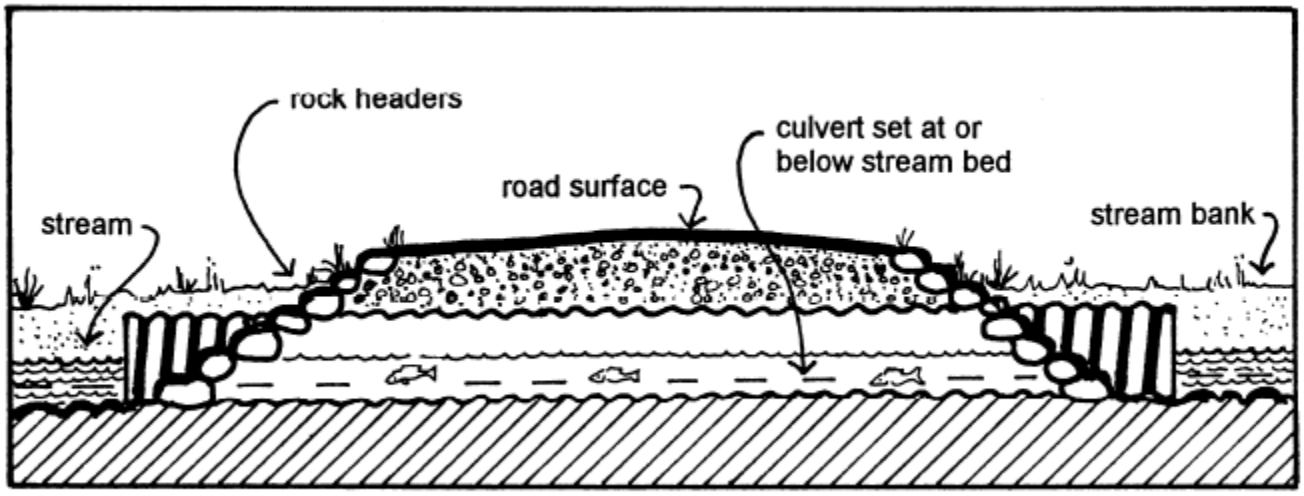


Figure 31. Culvert installed in a stream to allow fish passage.

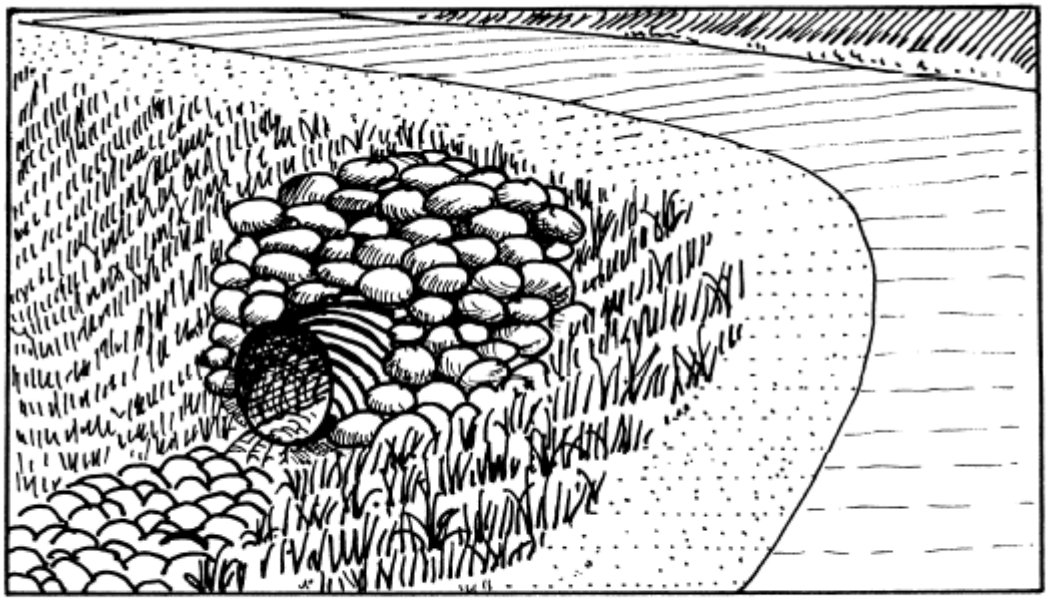


Figure 32. Rock headers on culvert outlet: headers (on 2:1 slope) at both ends prevent erosion.

Typical gravel road BMPs consist of constructing stabilized areas to safely pass surface water flows; store stormwater to promote setting of sediments and nutrients; and reduce runoff velocities at carefully selected locations. Some of the BMPs include:

STONE FORD CROSSINGS:

Figure 37. Stone ford crossing over low-lying channel: suitable only on limited use camp roads.

WATER BARS OR BROAD BASED "DIPS":

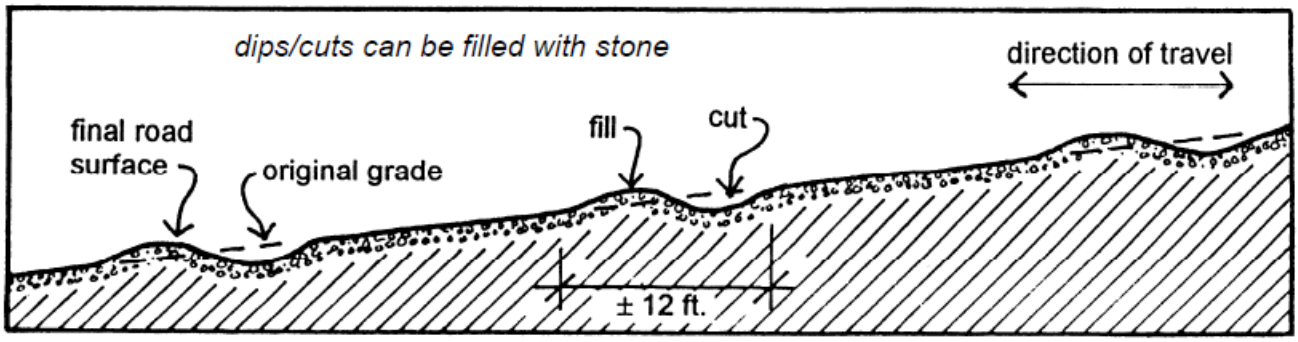


Figure 38. Water Bars

RUBBER RAZORS TO REDUCE VELOCITIES:

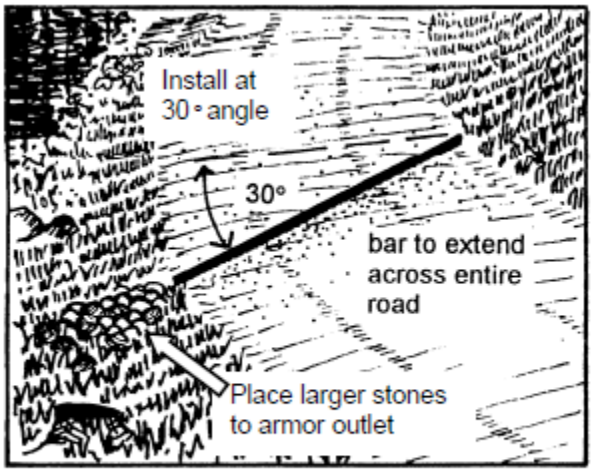


Figure 40. Set Rubber Bar at 30° downslope.

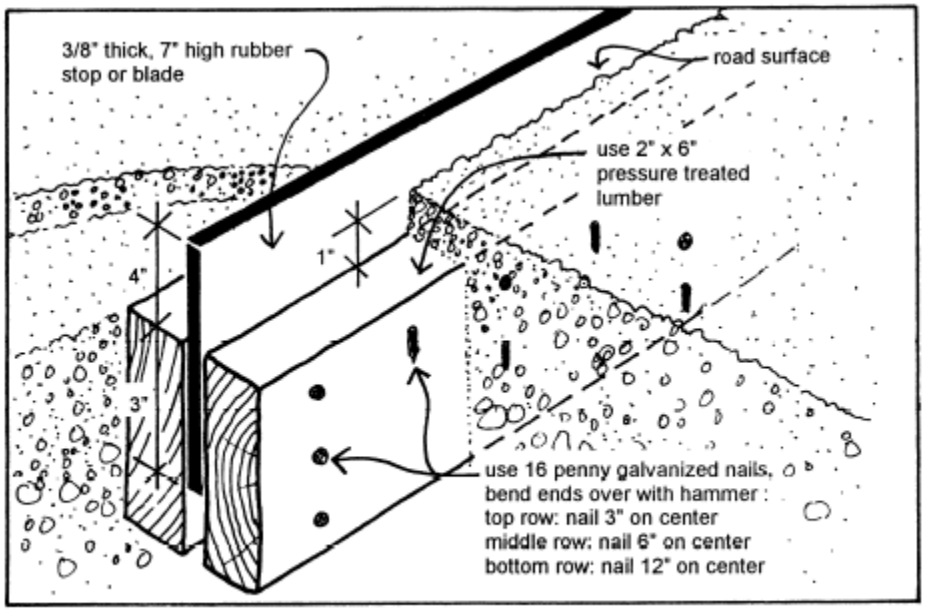


Figure 41. Rubber Bar Construction

OPEN TOP BOX CULVERTS:

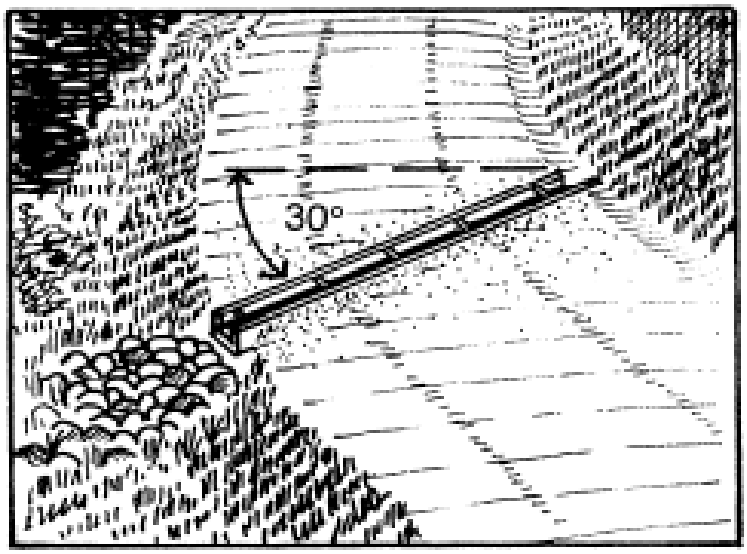


Figure 43. Open-top culvert set 30° downslope.

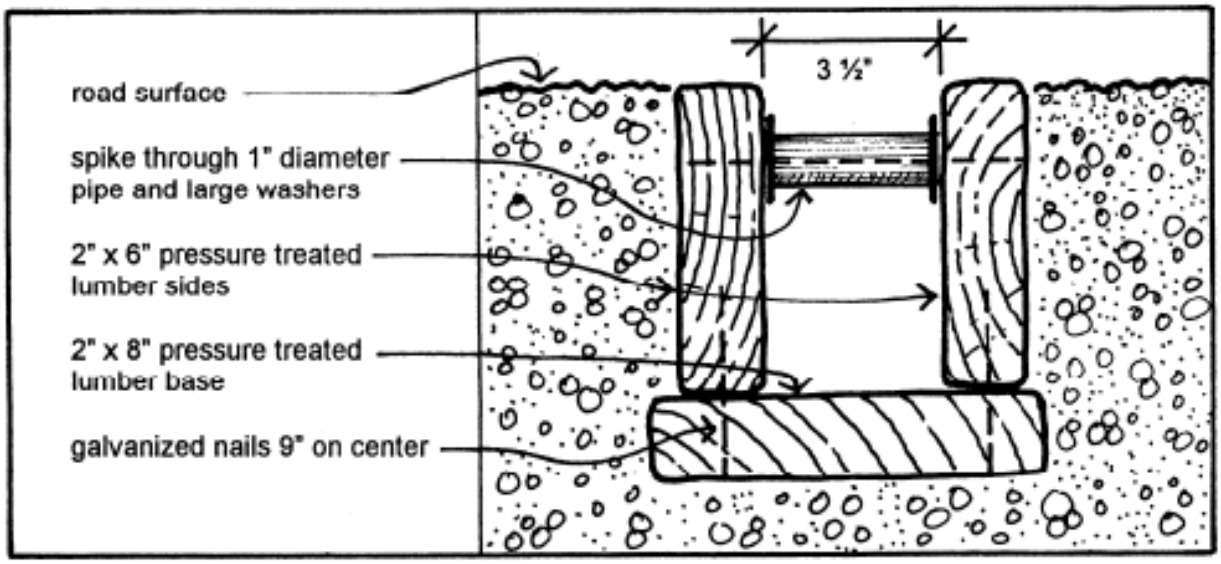


Figure 42. Open Top (Box) Culvert

In general, good gravel road maintenance requires due diligence and common sense: "when in doubt, armor it!"