MILL POND NUTRIENT CONTROL MEASURES

FINAL REPORT

Project:

for the Durham, NH Mill Pond Study

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Acronym	Definition
ASCE	AMERICAN SOCIETY OF CIVIL ENGINEERS
BMP	STORMWATER BEST MANAGEMENT PRACTICE
CWA	CLEAN WATER ACT
DWRE	DIPLOMATE, WATER RESOURCES ENGINEER
EIC	EFFECTIVE IMPERVIOUS COVER
EPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EWRI	ENVIRONMENTAL WATER RESEARCH INSTITUE
EMC	EVENT MEAN CONCENTRATION
FCA	FINANCIAL CAPABILITY ANALYSES
FR	FEDERAL REGISTER
GIS	GEOGRAPHIC INFORMATION SYSTEMS
HRU	HYDROLOGIC RESPONSE UNIT
IA	IMPERVIOUS AREA
ICM	IMPERVIOUS COVER MODEL
LA	LOAD ALLOCATION
LID	LOW IMPACT DEVELOPMENT
LIDAR	LIGHT DETECTION AND RANGING
MSGP	MULTI-SECTOR GENERAL PERMIT
NCDC	NATIONAL CLIMATE DATA CENTER
NCP	NITROGEN CONTROL PLAN
NOI	NOTICE OF INTENT
NRCC	NORTHEAST REGIONAL CLIMATE CENTER
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
NPDES	NATIONAL POLLUTION DISCHARGE ELIMINATION PERMITS
NPS	NONPOINT SOURCE POLLUTION
PE	PROFESSIONAL ENGINEER
PLA	POLLUTANT LOADING ANALYSES
PLER	POLLUTANT LOAD EXPORT RATES
SWM	STORMWATER MANAGEMENT
SWMM	STORMWATER MANAGEMENT MODEL
SWPPP	STORMWATER POLLUTION PREVENTION PLAN
TMDL	TOTAL MAXIMUM DAILY LOAD
TN	TOTAL NITROGEN
TSS	TOTAL SUSPENDED SOLIDS
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
USGS	UNITED STATES GEOLOGICAL SURVEY
UWRCC	URBAN WATER RESOURCES RESEARCH COUNCIL
WLA	WASTE LOAD ALLOCATION
WQV	WATER QUALITY VOLUME

1. SUMMARY

The goal of the Mill Pond Nutrient Control study was to identify restorative actions that will be effective within the life expectancy of the dam and at the same time help address declining water quality in Mill Pond and NPDES permitting requirements. Aspects of this study are intended to be consistent (in part) with the 2017 MS4 permit. This includes source identification reporting, BMPs to be optimized for pollutant removal[1], retrofit inventory and priority ranking. The project included the following elements:

Watershed Assessment: A watershed assessment was conducted using existing GIS data layers including: LiDAR contour topographic data, land use/land cover, impervious surfaces, NRCS soil survey, roads, and infrastructure such as water, sewer, outfalls, catch basins, manholes, parcel boundaries. Nitrogen loads and target reductions were calculated for sources delivered to Mill Pond via stormwater and other non-point sources using approaches approved by EPA.

Nutrient Control Measures: A menu of lowest cost alternative of nitrogen control strategies was developed for non-point source reduction. Specifically, a list of potential nutrient control measures was developed through BMP optimization including non-point source loads from each subwatershed to identify target areas. This includes specific BMP type, BMP size, land use type, soil type, and total areas needed for management. Subcatchments were delineated and potential locations for nitrogen control strategies were identified including load reduction potential.

Implementation Plan and Schedule: A summary level implementation plan was developed for Mill Pond that identified target load reductions, estimated cost, future actions, and next steps. This includes planning level cost estimates for both capital cost and operations and maintenance to support the possibility for future SRF or other grant or loan financing. A range of draft implementation schedules were developed based on ranges from 15-25-year periods of implementation. These ranges included estimated annual costs and annual acreage required for effective impervious cover reduction. Guidance was provided for developing EPA approved implementation schedules. The plan describes measures and nitrogen load reduction estimates from implementation of nitrogen control strategies, for specific land uses and sources, down to the subwatershed level. The breakdown of sources and estimated potential load reductions at the subwatershed level will satisfies some MS4 requirements and will assist prioritization relative to other permitting needs.

Design Examples: 30% design examples were developed for 3 locations: Edgewood Road, Madbury Road, and Mill Pond Road. Design examples included BMP sizing based on the optimization results, BMP selection, pretreatment, and costing for total and unit cost.

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[1] Appendix H. Part I, 1.a Additional or Enhanced BMPs.i.2

2. Mill Pond Background and Regional Context

Like many coastal regions, population growth and development in Durham has contributed to an increase in impervious cover and has led to increased pollutant loads and stormwater runoff. As more impervious surface is added, flooding risks are elevated, and water quality is impacted. This has been especially evident in impacts to Mill Pond and the Mill Pond Dam with advancing eutrophication and historically high flood flows. Recent documented changes in climate have resulted in higher-intensity precipitation events, increased rainfall depth, and greater variations in storm duration and frequency which increase these risks and impacts.

Mill Pond is located on the Oyster River and is formed by a manmade dam, separating the river from the tidal zone. The entire Oyster River watershed encompasses roughly 13,700 acres (shown in Figure 1), roughly 4.6% of which is impervious. This study focused on a small portion of the watershed which contains the majority of the urban area that drains to Mill Pond.

In 2009, NHDES concluded that many sub-estuaries in the Great Bay Estuary were impaired by nitrogen, and the Great Bay was placed on the Clean Water Act (CWA) Sec. 303(d) list of impaired and threatened waters (NHDES, 2009). New and revised discharge permits in the watershed are now subject to additional nitrogen requirements including the National Pollutant Discharge Elimination System (NPDES) permits for wastewater treatment facilities, and Municipal Separate Storm Sewer Discharge (MS4) permits for stormwater.

The Town of Durham has been actively engaged in stormwater management and responsibilities for MS4 Phase II Stormwater regulations and nutrient management for the Great Bay. The town also participates in the Great Bay Pollution Tracking and Accounting Pilot Project (PTAPP), a collaborative effort between local communities in our region, regional planning commissions NHDES, and EPA, to enable regional coordination on nitrogen tracking and accounting for the Great Bay region.

A. Environmental Impacts from Growth

Monitoring and research conducted by various university, local, state and federal programs and projects have documented stresses in the Great Bay system. Prominent drivers of change include watershed modification and development resulting in increased impervious cover; increased nutrient and pollutant loading from a rapidly growing coastal population; and ecosystem instability and loss of diversity caused by invasive species, habitat destruction, disease, and others. Each stress drives additional physical, chemical, and biological pressures on the Great Bay system that effect the environmental, lifestyle, and economic benefits valued by local communities. Environmental indicators used by the Piscataqua Regions Estuaries Partnership to identify and track ecosystem health clearly illustrate an ecosystem in trouble. In the most recent State of Our Estuaries 2018 report (PREP, 2018), 14 of 24 indicators showed a declining or cautionary condition. Impervious cover, an indicator of development, shows a long-term increasing trend which is related to condition indicators including nutrient concentration, eelgrass, dissolved oxygen, and macroalgae that show either no improvement or continued quality decline.

B. 2017 NH Small MS4 Permit

Under the MS4 program, towns with urbanized areas as defined by the US Census are required to obtain permit coverage for their stormwater discharges. Durham is subject to the requirements of EPA's 2017 NH Small MS4 General Permit for stormwater discharges. EPA released a final permit in 2017 which contained new provisions for the 6 Minimum Measures (MM):

1) Public Education and Outreach
2) Public Participation/Involvement
3) Illicit Discharge Detection and Elimination
4) Construction Site Runoff Control
5) Post-Construction Runoff Control
6) Pollution Prevention/Good Housekeeping

The new 2017 permit includes new requirements to develop Nitrogen Source Identification Reports[2] for discharge to impaired water bodies. The reports will assess all significant discharges to determine if they could contribute to the waterbody impairment and identify BMPs and a schedule for implementation to address the impairments.

Aspects of this study for Nutrient Control Measures for Mill Pond are intended to be consistent (in part) with the 2017 MS4 permit. This includes source identification reporting, BMPs to be optimized for pollutant removal[3], retrofit inventory and priority ranking.

C. EPA Integrated Planning Framework and Watershed Based Planning

The town and UNH continue to discuss and further develop the comprehensive integrated watershed management plan for the Oyster River Watershed. This includes evaluating wastewater and stormwater funding strategies, and an analysis of nitrogen loading by the WWTP and other sources in the Oyster River Watershed. The June 2012 EPA memorandum, "Integrated Municipal Stormwater and Wastewater Planning Approach Framework" provides guidance for EPA, States and local governments to develop and implement effective integrated plans that satisfy the CWA. The framework outlines the overarching principles and essential elements of a successful integrated plan which includes:

- Maintaining existing regulatory standards that protect public health and water quality.
- Allowing a municipality to balance CWA requirements in a manner that addresses the most pressing public health and environmental protection issues first.
- The responsibility to develop an integrated plan rests on the municipality that chooses to pursue the approach. EPA and/or the State will determine appropriate actions, which may include developing requirements and schedules in enforceable documents.

[2] 2017 NH Small MS4 General Permit: Appendix H, Requirements Related to Discharges to Certain Water Quality Limited Waterbodies, I. Discharges to water quality limited waterbodies and their tributaries where nitrogen is the cause of the impairment, Part I, 1.b Nitrogen Source Identification Report

[3] Appendix H. Part I, 1.a Additional or Enhanced BMPs.i.2

- Innovative technologies, including green infrastructure, are important tools that can generate many benefits, and may be fundamental aspects of municipalities' plans for integrated solutions.

D. 2014 Mill Pond Assessment[4]

Mill Pond has become increasingly impacted by high nutrient concentrations, leading to eutrophication and other water-quality related issues. A number of recent studies have characterized the nutrient-related concerns in water bodies within the Oyster River watershed. A 2014 assessment focused on ponds in the vicinity of Durham, NH and included an assessment of Mill Pond in particular. The key findings of this study are summarized below.

Phosphorus is the primary limiting nutrient in most northern temperate lakes, hence algal growth is typically directly related to phosphorus concentrations. Total phosphorus concentrations in Mill Pond are high, ranging from 0.046 to 0.074 mg/l. Typically in New England lakes, phosphorus concentrations in excess of 0.020 mg/l are sufficient to regularly fuel algal blooms. The presence of soluble reactive phosphorus (readily available for plant growth) in relatively high concentrations on all sampling dates further indicates that there is more phosphorus in Mill Pond than the existing algal and plant community can use. Observed concentrations in College Brook (0.041 to 0.198 mg/l) are substantially higher than those observed in the Oyster River upstream of Mill Pond (0.029-0.054 mg/l) particularly after rain. Although flows are lower in College Brook than the Oyster River, reductions in phosphorus inputs to College Brook will be critical in the long term to reducing phosphorus concentrations in Mill Pond.

Nitrogen can also play a role in determining the type of algae present and the amount of algal growth in a water body since some cyanobacteria (blue-green algae) can fix nitrogen from the atmosphere. Similar to phosphorus, nitrogen concentrations in Mill Pond are high, however, the ratio of nitrogen to phosphorus observed in Mill Pond suggests that, at times, nitrogen as a plant nutrient is in shorter supply than phosphorus. At the concentrations currently observed, there is sufficient nitrogen and phosphorus to grow plants and algae in nuisance quantities. The management challenge is to reduce one or both of these nutrients to levels that will ultimately limit the amount of plant and algal growth that can occur in Mill Pond.

A nitrogen to phosphorus ratio of less than 10 generally suggests nitrogen limitation of algae growth while a ratio greater than 16 suggest phosphorus limitation. Between those numbers, either nitrogen or phosphorus availability may limit algal growth. An examination of water quality data collected in 2013 shows a total nitrogen to total phosphorus ratio ranging from 8.0 to 12.5 in Mill Pond. This range of ratios suggests that algal growth in Mill Pond is limited by phosphorus at times and nitrogen at times, making control of both nitrogen and phosphorus important.

It should be noted that concentrations of both phosphorus and nitrogen in Mill Pond are more than sufficient to grow algae and plants and in fact, light or flushing may be the limiting factor

[4] 2014 DKWRC, Durham Ponds Assessment and Plan. Prepared for VHB

for algal growth currently. Because neither light nor flushing can be changed substantially, reduction of nutrients to the point where they limit plant and algal growth is still the most promising management strategy. However, because nutrient concentrations are currently so high, reductions in plant and algal growth may not be seen until substantial reductions in nutrient loading occur.

The overall watershed of Mill Pond consists of a mixture of rural, agricultural, residential and urban land uses. Because of their abundance and relatively high nutrient export coefficients, the developed areas of the watershed tend to yield a large portion of the nutrient load to the ponds. The 2014 study found that nutrient loading from the watershed was overwhelmingly the largest source of phosphorus and nitrogen to Mill Pond, accounting for greater than 99% of the nutrient load. Thus, watershed management is the key to substantial improvements in the pond.

Current TP and TN loading and in-pond concentrations are more than sufficient to fuel algal blooms and encourage the growth of aquatic plants. In order to realize improvement in the appearance of the ponds, target reductions of 66% for phosphorus and 69% for nitrogen were calculated of the 2014 Plan. The study further notes that the best pathway to achieving these reduction targets is through installation of watershed BMPs to limit nutrient loading. While improvement may be seen with lesser reduction and reductions beyond these may result in further improvement in the ponds, these levels were chosen to provide a readily apparent improvement in water quality that might be achievable with very aggressive watershed management.

3. Watershed Assessment

Land use, impervious cover, and nitrogen loads were examined for the Mill Pond watershed. Detailed land use data from the NH Granit Statewide GIS Data Clearinghouse was used to assess impervious cover, watershed delineation, and pollutant loading. This included 2011 LiDAR for the Northeast (2m Resolution, 15cm Vertical Accuracy), and Impervious Surfaces in the Coastal Watershed of NH (High Resolution, 2010). Generalized land use data was fit into categories for which nitrogen pollutant load export rates are available. This information can be used for priority ranking to reduce discharges, and pollutant source identification reporting.

The study area represents the most highly urbanized portions of the Mill Pond watershed and is comprised of 2 distinct subwatersheds, the upper watershed area to the west (S1), and the lower area to the east and directly adjacent to Mill Pond (S2) as displayed in Figure 2. The total study area encompasses 1,208 acres, 21% of which is impervious cover. This area contributes an estimated 4,733 lbs of nitrogen annually. Table 1 details land use and pollutant load for subwatersheds 1 and 2. Figure 3 illustrates the dominant soil types within the watershed. The watershed land use is predominantly forest, residential, commercial, and agricultural as illustrated in Figure 4. The upper watershed, S1, is 1,177 acres and contributes an estimated 4,347 lbs of nitrogen annually. The lower watershed, S2, is 91 acres and contributes an estimated 386 lbs of nitrogen annually.

Figure 5 plots percent impervious cover versus area for Mill Pond watershed as a total, and for subwatersheds 1 and 2. This figure is used to determine the degree of impervious cover treatment to reduce effective impervious cover (EIC). EIC of 9% (10%-1% margin of safety) is the oft recommended management target shown to be protective of natural watershed function in urban areas.[5]

Impervious cover provides a common index between watershed planners, stormwater engineers, water quality regulators, and stream ecologists[6]. EIC is the area that is hydraulically connected to a receiving water by means of continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume (EPA 2011). Reduction of EIC can be achieved using low impact development (LID) BMPs that use filtration and or infiltration to treat a water quality volume[7]. For the purposes of this study EIC reduction is limited soley to LID treatment and does not refer to impervious cover disconnection such as directing downspouts to pervious areas. That is because the generalized impervious cover model (ICM) from which the 9% EIC is based upon, does not differentiate between the degree of IC connectivity. With this approach it is possible to track the reduction of EIC throughout a watershed as LID BMPs are implemented.

[5] The impervious cover model (ICM) quantifies stream integrity as a function of watershed impervious cover (Schueler et al. 2009). Numerous studies have identified 10-14% impervious cover as a threshold above which stream impairments become marked (Booth and Jackson 1997; CWP 2003; Deacon et al. 2005; Klein 1979; Schueler 1994; Schueler et al. 2009).

[6] Arnold and Gibbons 1996; Schueler et al. 2009

[7] Hlas, V., R. Roseen, et al. (2013). An Examination of the Reduction of Effective Impervious Cover and Ecosystem Watershed Response. Department of Civil Engineering. Durham, NH, University of New Hampshire Stormwater Center.

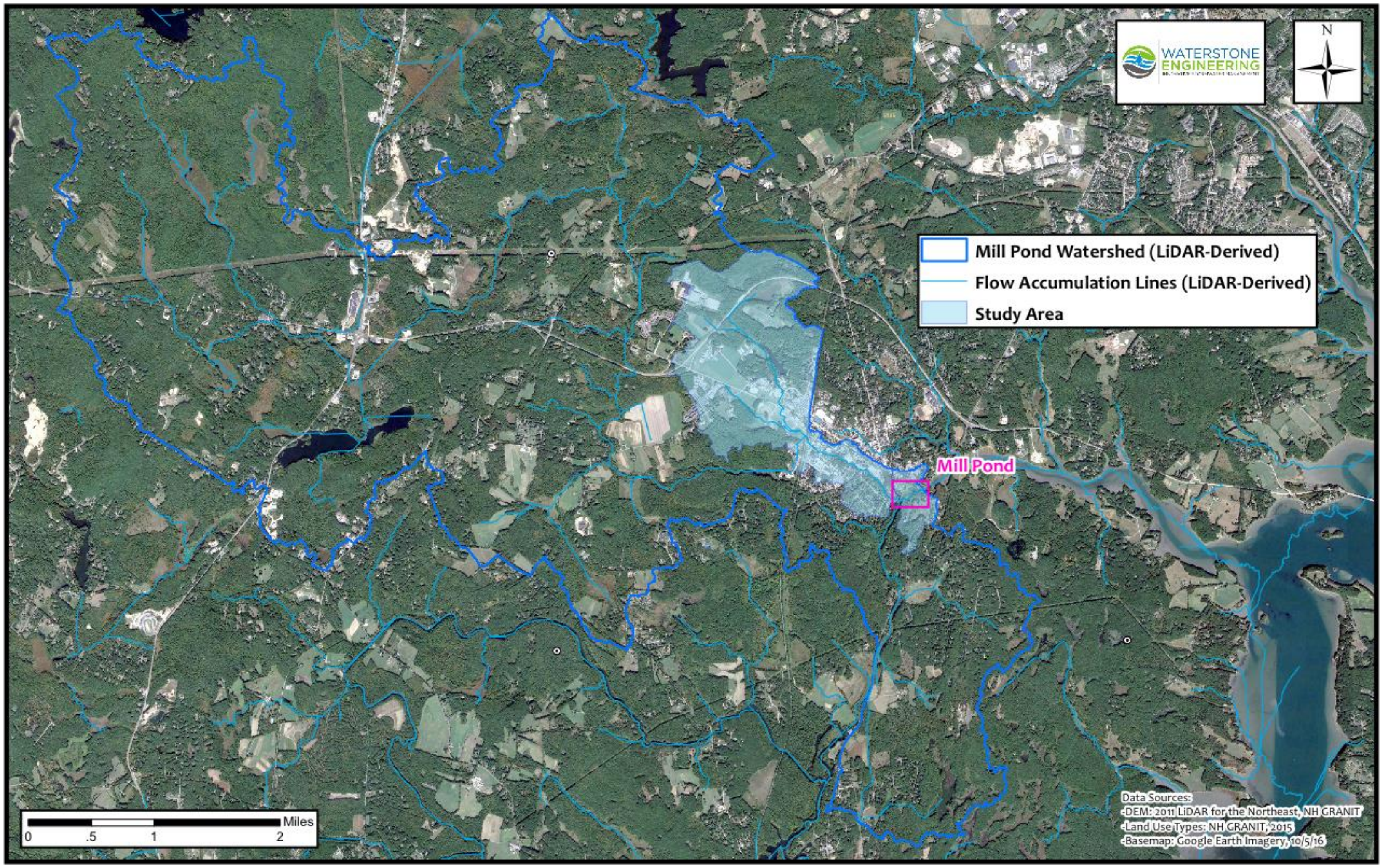

Figure 1 - Mill Pond Watershed Overview

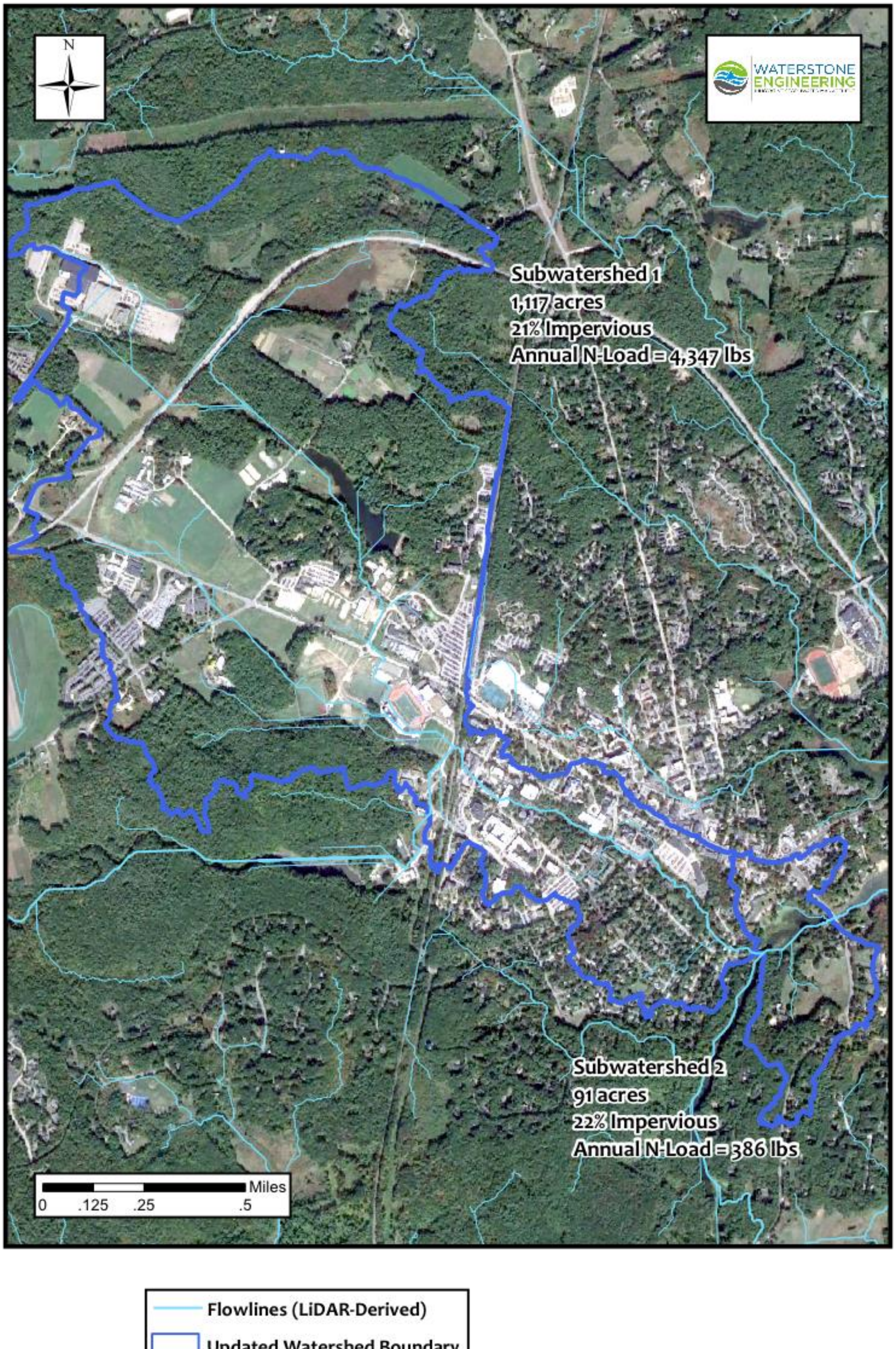

Figure 2: Study Area Subwatersheds

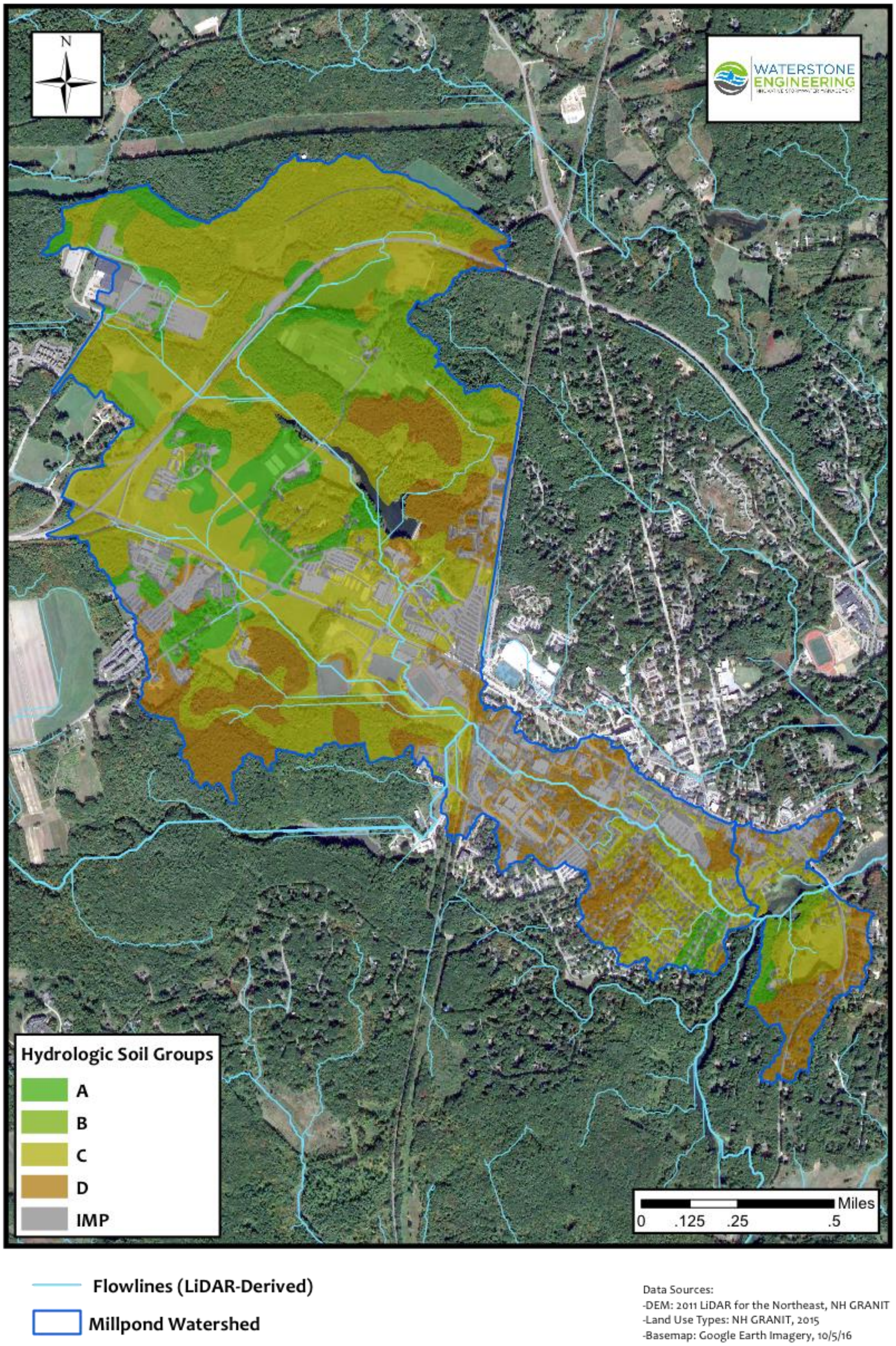

Figure 3 - Mill Pond Watershed Soils and Land Cover

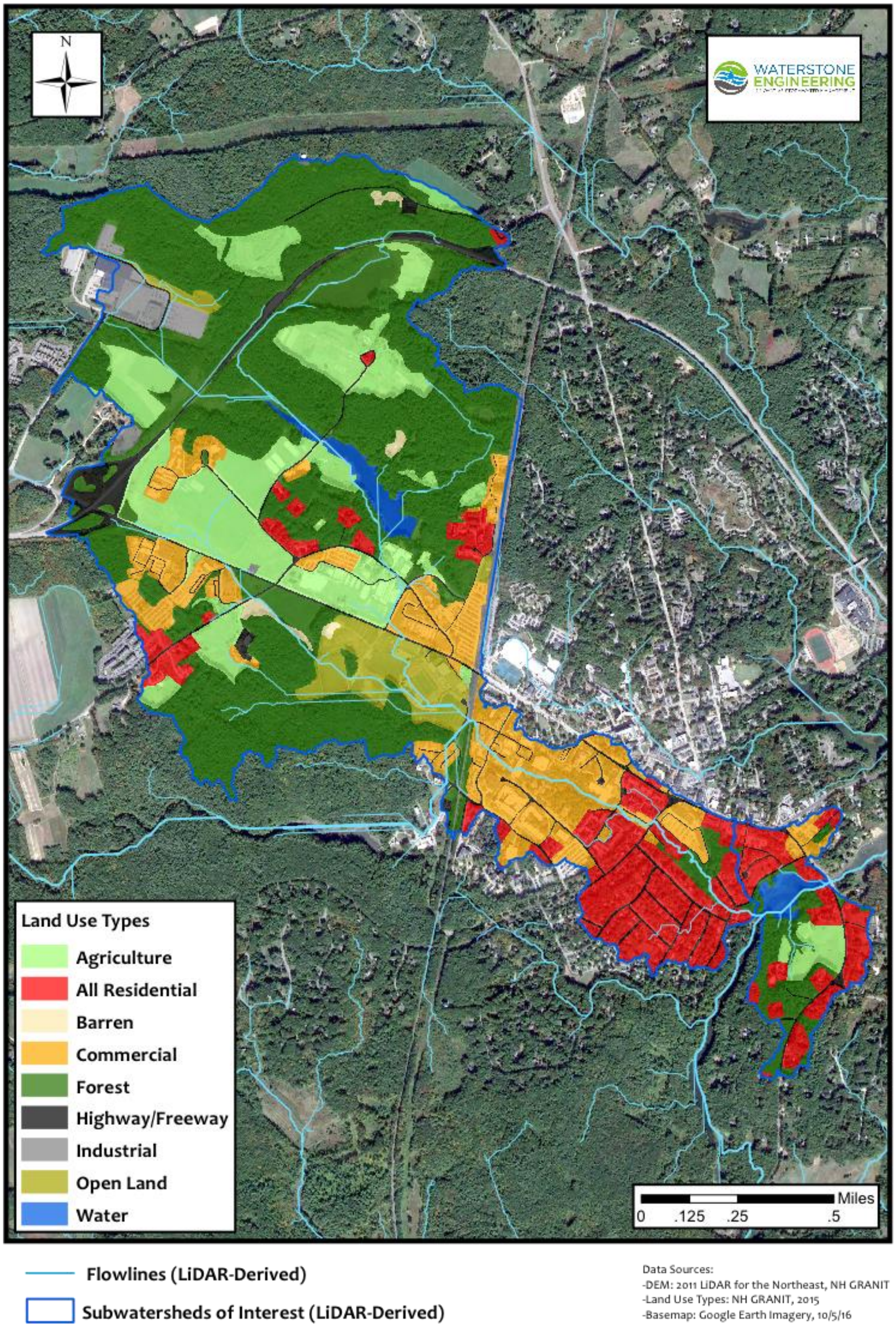

Figure 4 - Mill Pond Watershed Land Use

Table 1: Mill Pond Study Area Characteristics

Land Use Type	Hydrologic Soil Group	Subwatershed 1		Subwatershed 2		Entire Study Area	
		Area (acres)	Annual Nitrogen Export (lbs)*	Area (acres)	Annual Nitrogen Export (lbs)*	Area (acres)	Annual Nitrogen Export (lbs)*
Agriculture	-	0.5	1.4	0.0	0.0	0.5	1.4
	A	29.3	76.1	0.0	0.0	29.3	76.1
	B	40.0	104.1	0.1	0.1	40.1	104.3
	C	88.8	230.9	10.0	26.1	98.8	257.0
	D	8.2	21.2	0.7	1.8	8.8	23.0
	IMP	11.2	127.0	0.1	0.8	11.3	127.8
All Residential	-	0.0	0.0	0.3	0.6	0.3	0.6
	A	10.8	3.3	0.7	0.2	11.5	3.5
	B	0.4	0.5	1.0	1.2	1.4	1.6
	C	35.3	84.8	8.8	21.1	44.1	105.9
	D	29.3	105.5	16.0	57.5	45.3	163.0
	IMP	35.6	502.4	10.4	147.0	46.1	649.4
Barren	-	0.0	0.0	0.0	0.0	0.0	0.0
	A	0.5	0.2	0.0	0.0	0.5	0.2
	B	0.0	0.0	0.0	0.0	0.0	0.0
	C	5.8	13.8	0.0	0.0	5.8	13.8
	D	0.0	0.0	0.0	0.0	0.0	0.0
	IMP	0.0	0.3	0.0	0.0	0.0	0.3
Commercial	-	0.5	1.3	0.0	0.0	0.5	1.3
	A	7.2	2.2	0.0	0.0	7.2	2.2
	B	0.0	0.0	0.0	0.0	0.0	0.0
	C	12.4	29.9	0.5	1.3	13.0	31.2
	D	28.7	103.4	0.7	2.3	29.4	105.7
	IMP	98.9	1483.4	3.9	59.2	102.8	1542.6
Forest	-	1.7	0.8	0.8	0.4	2.5	1.2
	A	40.3	20.1	1.6	0.8	41.9	20.9
	B	68.3	34.2	5.3	2.7	73.6	36.8
	C	309.3	154.7	5.3	2.7	314.6	157.3
	D	93.8	46.9	11.6	5.8	105.4	52.7
	IMP	6.4	71.8	0.4	4.9	6.8	76.7
Highway/ Freeway	-	0.0	0.0	0.0	0.0	0.0	0.0
	A	0.1	0.0	0.0	0.0	0.1	0.0
	B	0.1	0.2	0.0	0.0	0.1	0.2
	C	12.5	30.0	0.0	0.0	12.5	30.0
	D	2.1	7.4	0.2	0.7	2.3	8.2
	IMP	45.9	481.6	4.6	48.7	50.5	530.3
Industrial	-	0.6	1.5	0.0	0.0	0.6	1.5
	A	1.6	0.5	0.0	0.0	1.6	0.5
	B	1.5	1.7	0.0	0.0	1.5	1.7
	C	5.0	12.0	0.0	0.0	5.0	12.0
	D	3.4	12.2	0.0	0.0	3.4	12.2
	IMP	18.5	276.8	0.0	0.0	18.5	276.8
Open Land	-	0.0	0.0	0.0	0.0	0.0	0.0
	A	1.2	0.4	0.0	0.0	1.2	0.4
	B	0.1	0.1	0.0	0.0	0.1	0.1
	C	25.3	60.6	0.0	0.0	25.3	60.6
	D	2.4	8.7	0.0	0.0	2.4	8.7
	IMP	20.6	233.0	0.0	0.0	20.6	233.1
Water	-	9.2	0.0	6.3	0.0	15.5	0.0
	A	0.1	0.0	0.0	0.0	0.1	0.0
	B	0.0	0.0	0.8	0.0	0.8	0.0
	C	3.8	0.0	0.5	0.0	4.3	0.0
	D	0.0	0.0	0.0	0.0	0.0	0.0
	IMP	0.0	0.0	0.0	0.0	0.0	0.0
Totals		**1,117**	**4,347**	**91**	**386**	**1,208**	**4,733**

*Based on EPA, 2017 PLERs

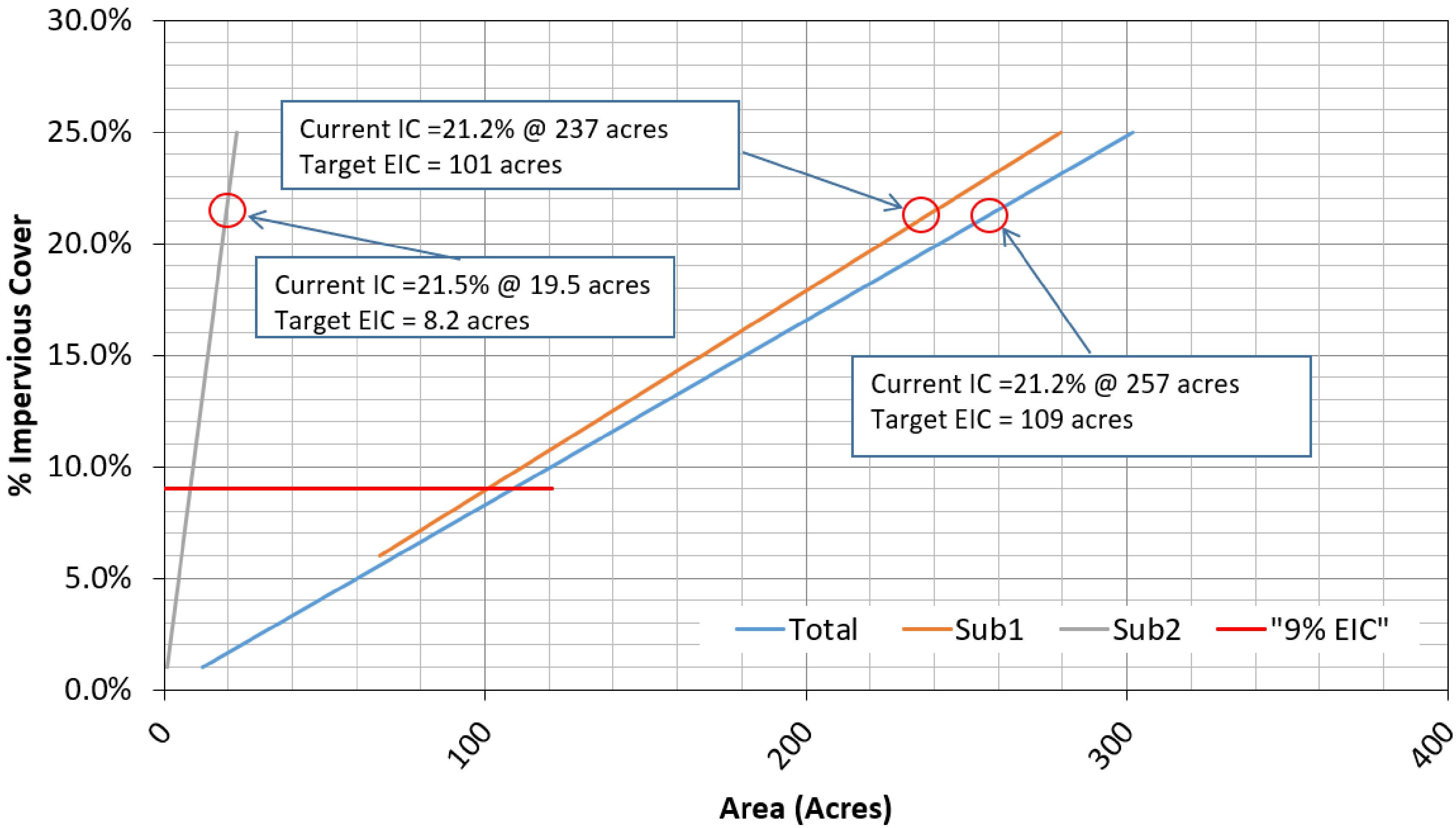

Figure 5 – Impervious Cover Percentage versus Area for Mill Pond Total, Subwatershed 1 and 2

4. NITROGEN SOURCE IDENTIFICATION REPORTING

This Mill Pond study included elements required in the new 2017 MS4 permit. Specifically this report would address requirements to develop Nitrogen Source Identification Reports[8] for discharge to impaired water bodies. The reports need to assess all significant discharges to determine if they could contribute to the waterbody impairment and identify BMPs and a schedule for implementation to address the impairments. This report addresses report elements 1, 3, 4, and 5 (partially) which include the following elements:

1. Calculation of total MS4 area draining to the water quality limited water segments or their tributaries, incorporating updated mapping of the MS4 and catchment delineations,
2. All screening and monitoring results targeting the receiving water segment(s)
3. Impervious area and DCIA for the target catchment
4. Identification, delineation and prioritization of potential catchments with high nitrogen loading
5. Identification of potential retrofit opportunities or opportunities for the installation of structural BMPs during redevelopment

It is important to note that the MS4 requirements need to be reviewed for completeness both for source identification reporting and other elements.

Figure 6 examines the lower S1 watershed, the subwatershed delineation, identification of nitrogen load, drainage infrastructure, and potential retrofit opportunities. Figure 7 is a heat map of nitrogen load that illustrates the areas of highest loading concern for prioritization of structural BMPs. Figure 8 illustrates for subwatershed 2 the delineation, identification of nitrogen load, drainage infrastructure, and potential retrofit opportunities in the immediate proximity to Mill Pond.

[8] 2017 NH Small MS4 General Permit: Appendix H, Requirements Related to Discharges to Certain Water Quality Limited Waterbodies, I. Discharges to water quality limited waterbodies and their tributaries where nitrogen is the cause of the impairment, Part I, 1.b Nitrogen Source Identification Report

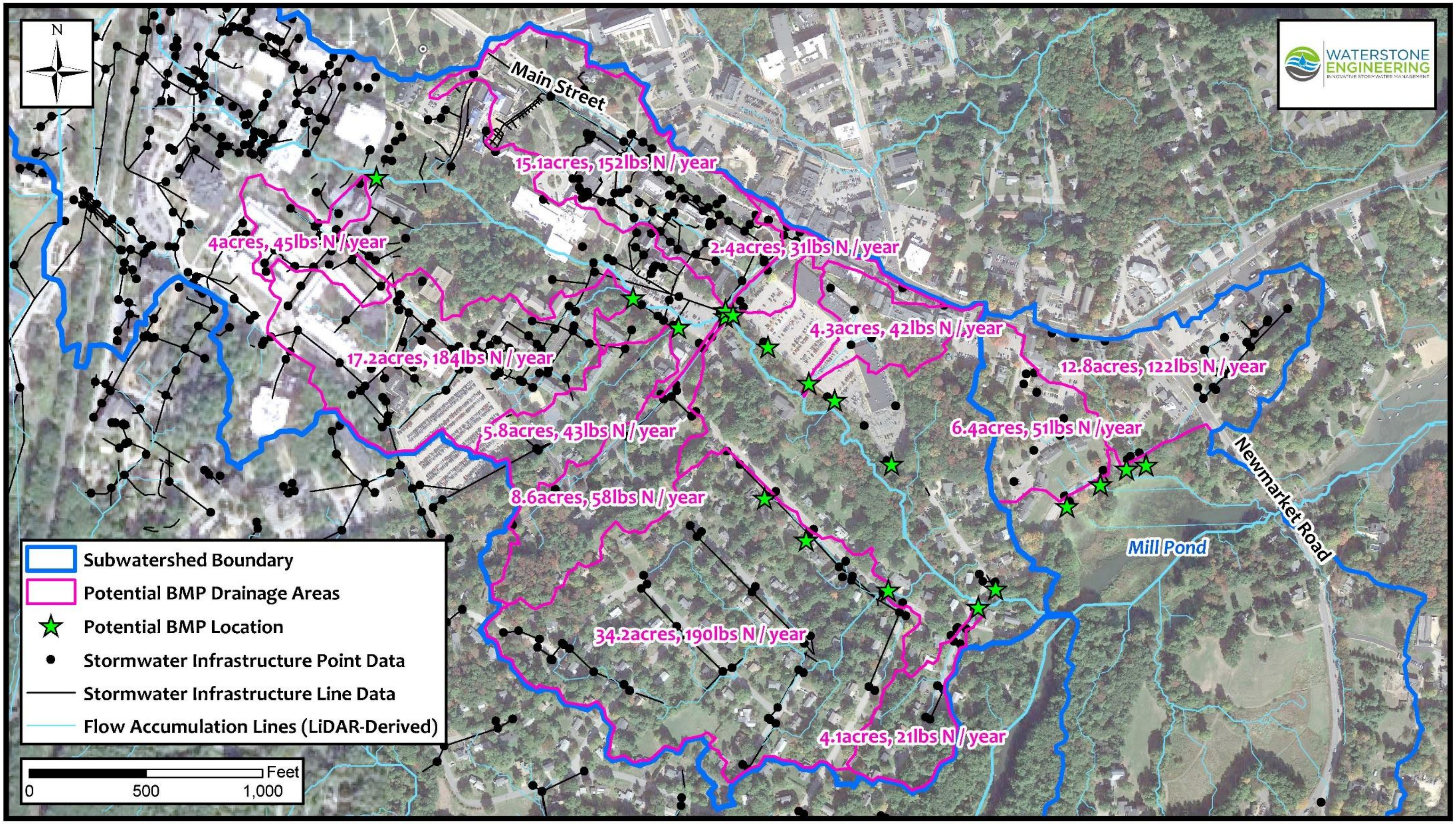

Figure 6 – Nitrogen Loading by Subwatershed S1 for Lower Mill Pond Watershed

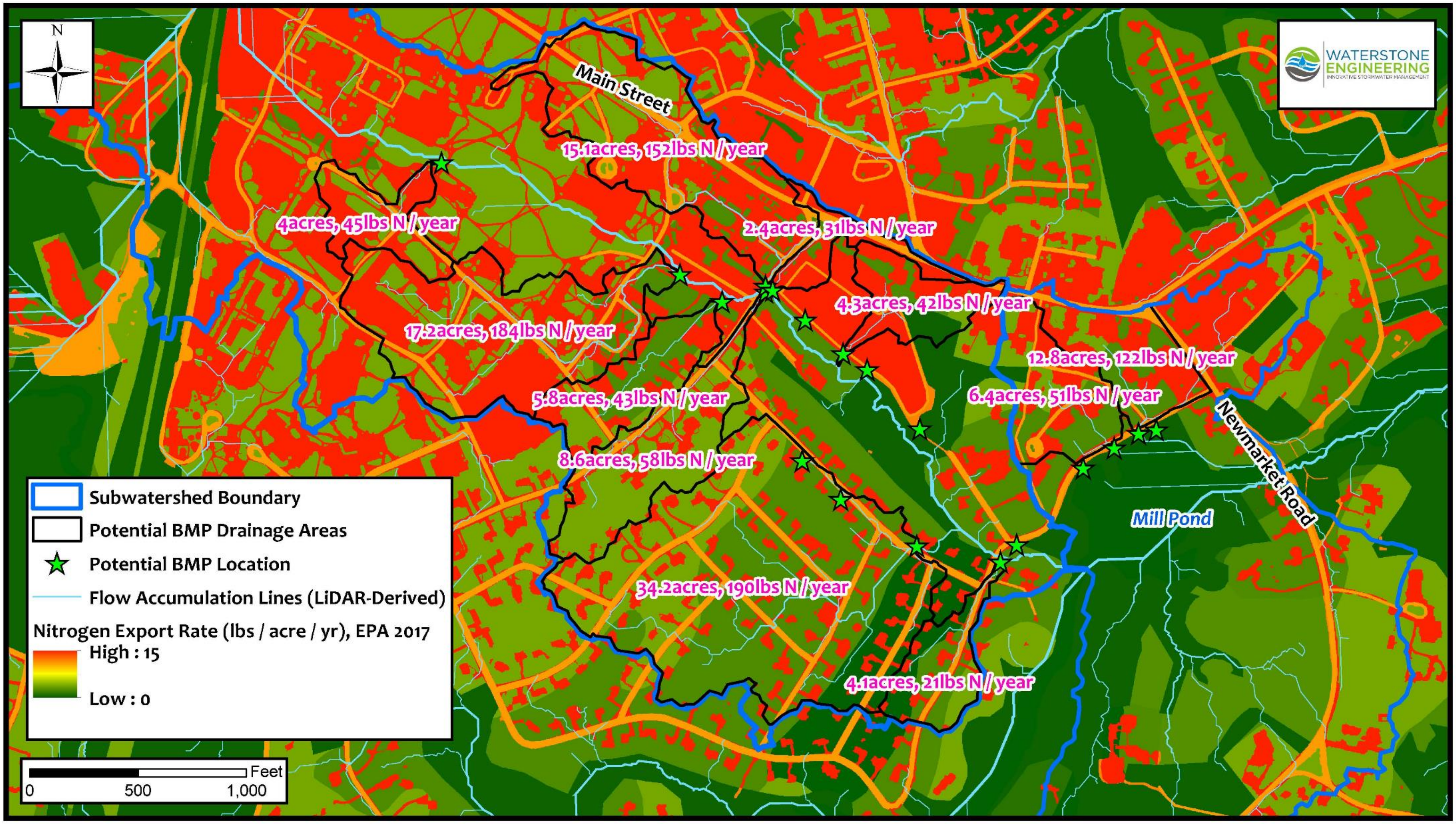

Figure 7 – Heat Map of Nitrogen Loading by Subwatershed S1 and Potential Retrofit Opportunities for Lower Mill Pond Watershed

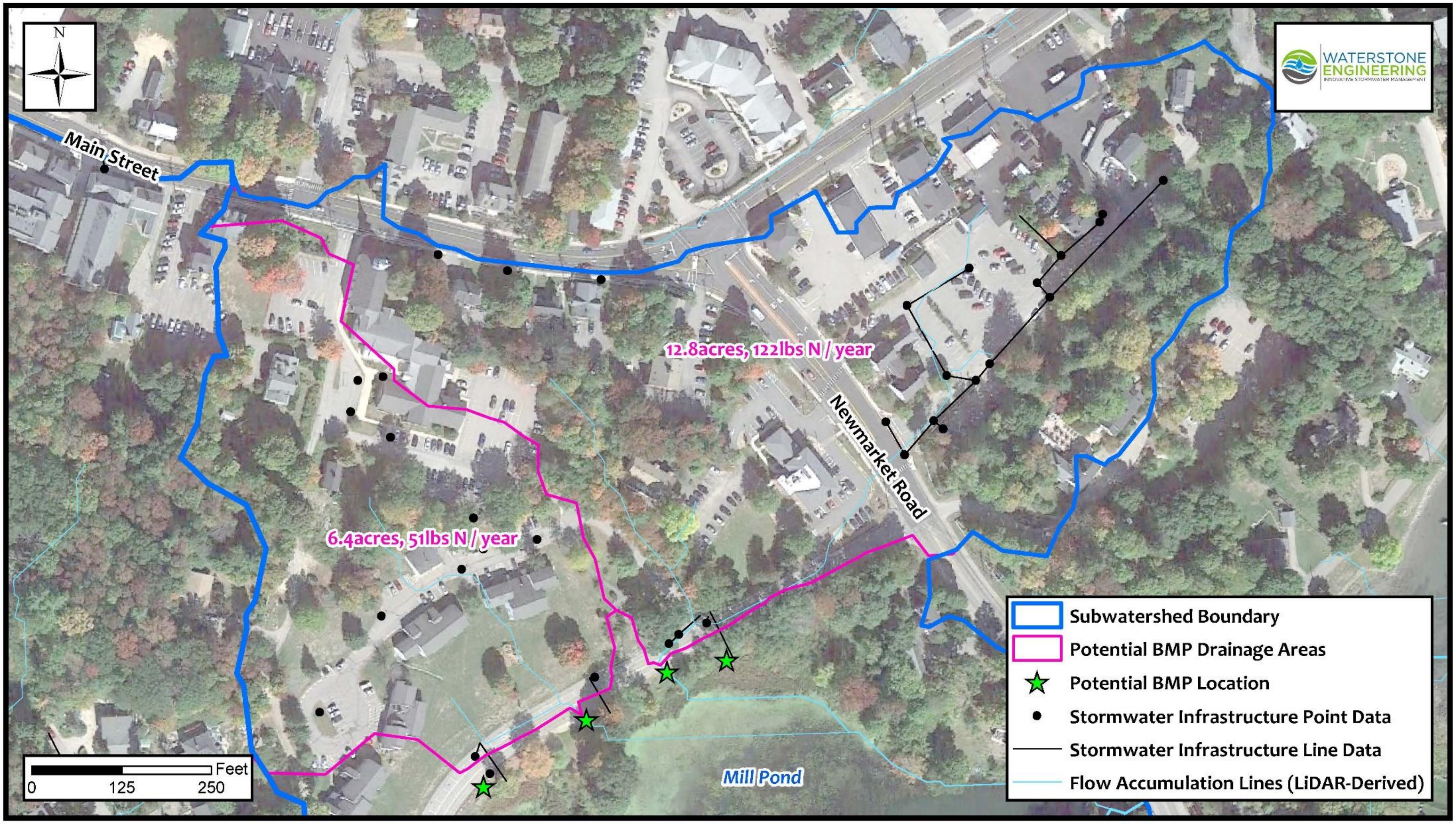

Figure 8 –Nitrogen Loading by Subwatershed 2 for Mill Pond Watershed

5. STORMWATER MANAGEMENT AND RETROFIT OPPORTUNITIES

BMPs for stormwater management and nitrogen controls include both structural and non-structural practices to reduce runoff volume from stormwater sources such as impervious surfaces (rooftops and parking lots), residential areas, commercial/industrial/institutional properties, roads, outdoor recreational spaces (i.e., parks), agricultural areas, and managed turf (i.e., golf courses, lawn). Common BMPs for nutrient controls include biofiltration (bioretention, raingardens, tree planters), gravel wetlands, infiltration practices (dry wells, and subsurface infiltration), and porous pavements. A wealth of BMP sources exists in the literature and locally at the UNH Stormwater Center. A list of practices can be found in the New Hampshire Stormwater Manual on the NHDES website.

6. BMP OPTIMIZATION FOR NITROGEN REMOVAL

The 2017 MS4 permit includes the requirement for BMPs to be optimized for pollutant removal[9]. Optimization is especially valuable for retrofitting and redevelopment because it involves sizing of a BMP to achieve the greatest performance for least cost. Results are influenced by pollutant type, soils, land use, BMP performance and cost, and application constraints (i.e. prohibiting certain BMPs for certain land uses). Optimization can occur at multiple scales. In its simplest sense optimization is done at the BMP level for sizing an individual system. At its most complex it can be used at the watershed-scale to determine a menu of lowest cost highest performance BMPs by type and size while factoring in multiple land uses, soils, performance, cost, and constraints.

The Mill Pond optimization study was conducted using a previously developed optimization model[10] developed in collaboration with and approved by EPA, and a related EPA optimization tool[11]. The model selects the most cost-effective management measures for a range of increasing runoff reduction. The optimization model runs repeatedly, changing the target volume reduction with each iteration. It evaluates the runoff control strategies based upon user defined constraints including available land for implementation, volume reduction capability based on capture depth of the BMP, and cost to implement the strategy. This model was first applied at the system level to develop a series of BMP performance curves. It was next applied at the land use scale to identify the most cost-effective options for each particular land use. For the Mill Pond analysis, the optimization tool was focused on the study area described in previous sections for the range of feasible runoff control measures, and the range of land uses.

[9] Appendix H. Part I, 1.a Additional or Enhanced BMPs.i.2
[10] Roseen, R., Watts, A., Bourdeau, R., Stacey, P., Sinnott, C., Walker, T., Thompson, D., Roberts, E., and Miller, S. (2015). Water Integration for Squamscott Exeter (WISE), Preliminary Integrated Plan, Final Technical Report. Portsmouth, NH, Geosyntec Consultants, University of New Hampshire, Rockingham Planning Commission, Great Bay National Estuarine Research Reserve, Consensus Building Institute.
[11] EPA (2015). Opti-Tool for Stormwater and Nutrient Management. Boston, MA, U.S. Environmental Protection Agency, Region 1, New England
Tetra Tech.

A. BMP Optimization Examples at the BMP and Land Use Scale

Example 1 and Figure 9 below illustrates the process of how optimization of the size of a bioretention system can occur based on varying the capture depth of the water quality volume. Example 2 and Figure 10 illustrate how the optimization occurs at a land-use scale.

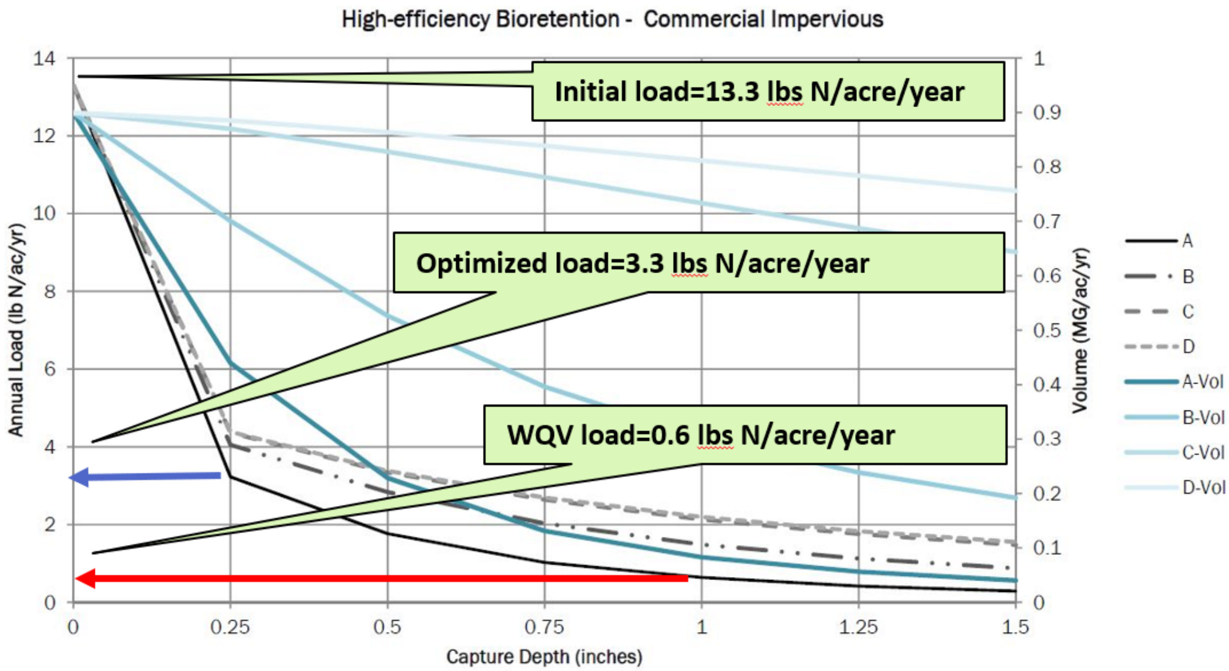

Figure 9 – BMP-Scale Optimization Example for Commercial Bioretention with Annual Exported Load and Volume based on Water Quality Volume (Aka Capture Depth)

Example 1: BMP optimization for bioretention at 0.25" and 1" water quality volumes

From the BMP performance curve for a high-performance bioretention we can see that for a type A soil, 4 systems designed to treat a 0.25" water quality volume in replace of one system to treat a 1" water quality volume would remove an additional 27 lbs of Nitrogen per year at nearly equivalent costs, or approximately 315% greater optimization. A single system treating a 1" water quality volume for 1 acre will remove approximately 12.7 lbs N/acre/year. Whereas 4 smaller systems across 4 acres designed to treat 0.25" water quality volume per acre will each remove 10 lbs N/acre/year for a total of 40 lbs N per year.

Example 2: BMP optimization for a range of nitrogen control measures for residential land use

Figure 10 is an example of an optimization for a residential land use which shows the cost to achieve reduction in relation to the nitrogen management practices ordered in terms of cost efficiency. This process enables the identification of the point at which cost effectiveness and pollutant reduction is greatest and the feasibility to implement cost effective and pollutant load reduction management practices begins to decline. In this example, 10,000 pounds of nitrogen can be reduced at a cost of about $7 million dollars ($700 per pound N reduced). In contrast, as cost efficiency begins to decline removal of 12,500 pounds costs an estimate $15 million dollars ($1,200 per pound N reduced), and 15,000 pounds is at a cost of nearly 44 million dollars ($2,930 per pound N reduced). This process demonstrates the cost efficiency of low-cost rooftop infiltration and small BMPs sized to capture the first-flush for nitrogen which results in the majority of pollutant mass being washed off from runoff in the beginning of a storm (0.25-0.5" WQV). Additional removal occurs at higher cost in more expensive systems.

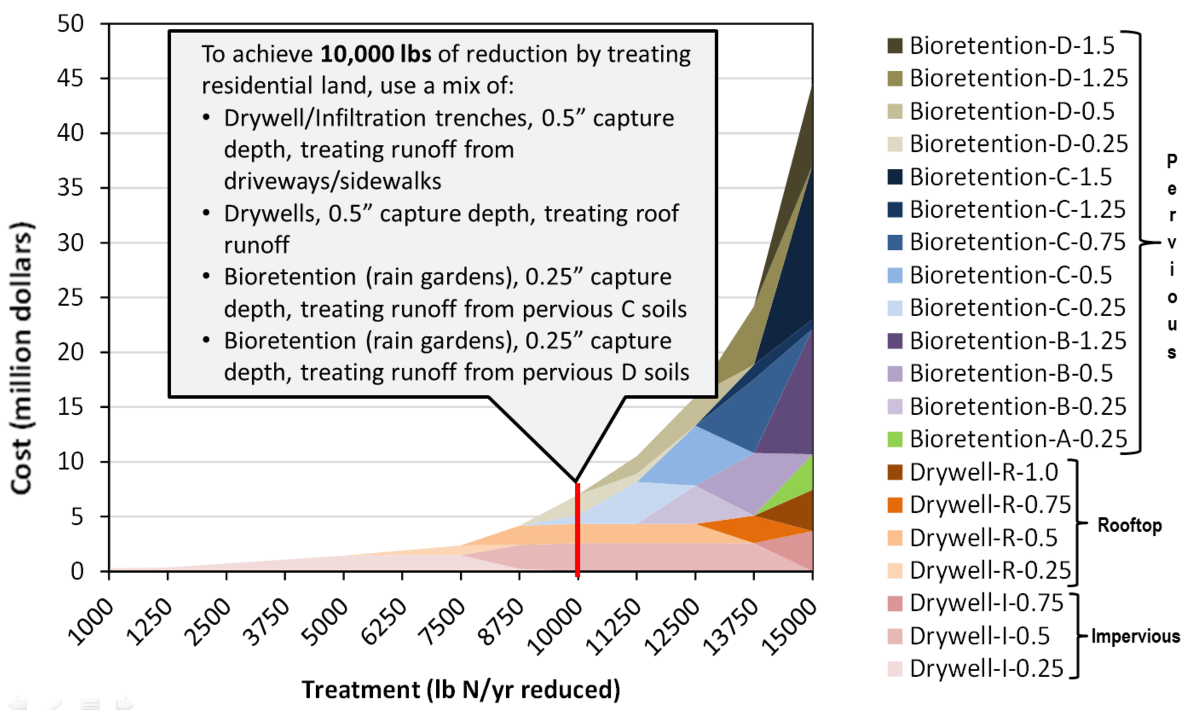

Figure 10 – Residential Land Use-Scale BMP Optimization Example

B. BMP Optimization and Effective Impervious Cover Reduction in the Mill Pond Watershed

The power of the optimization analysis lies in its ability to identify the most cost-effective BMP options for achieving a desired nitrogen load reduction based on the land use and land cover characteristics in the Mill Pond watershed. Figure 11 illustrates the treated area and nitrogen reduction by estimated cost as computed within the optimization analysis. For this study the level of reduction required to reduce effective impervious cover (EIC) in the watershed to 9% was used as the recommended target load reduction for the Mill Pond watershed. The analysis indicates that a target EIC of 9% will require managing runoff from 257 acres of impervious cover and would result in the reduction of 2,400 lb in annual nitrogen load, at an estimated cost of $1,762,000.

Table 2 shows the recommended order of implementation for each BMP/land use/land cover combination identified in the optimization analysis. Table 3 displays the menu of BMPs developed through optimization to manage 257 acres and achieving 2,400 lbs of N reduction. The table lists the acreage treated and runoff volume managed for each BMP and a planning level cost analysis.

Table 2 - Priority Implementation Schedule for BMPs from LO Analysis

Priority	Land Use	Land Cover	BMP	System Size
1	Commercial	Roof	Dry Well	0.25" WQV
1	Residential	Roof	Dry Well	0.50" WQV
3	Industrial	Roof	Dry Well	0.25" WQV
4	Industrial	Impervious	Gravel Wetland	0.25" WQV
5	Residential	Impervious	Raingarden	0.50" WQV
6	Outdoor	Impervious	Gravel Wetland	0.25" WQV
7	Commercial	Impervious	Gravel Wetland	0.25" WQV
8	Commercial	Impervious	HE Bioretention	0.25" WQV
9	Commercial	Impervious	Subsurface Infiltration	0.25" WQV
10	Road	Impervious	Gravel Wetland	0.25" WQV
11	Road	Impervious	Bioretention	0.25" WQV
12	Commercial	HSG D	Gravel Wetland	0.25" WQV

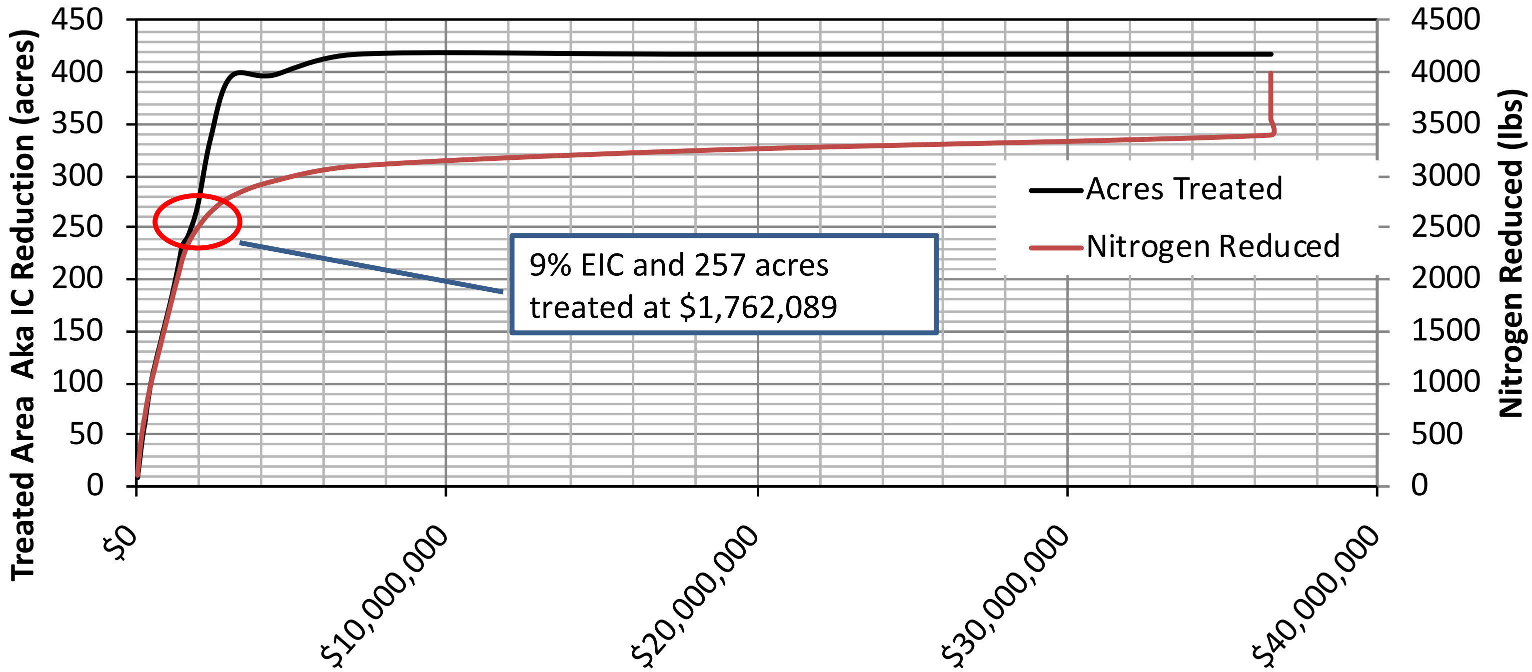

Figure 11 – Estimated BMP Cost by Linear Optimization by Drainage Area and Nitrogen Reduction

Table 3 - BMP Menu for Managing 257 acres and Achieving 2,400 lbs of N Reduction

Land Use	Land Cover	BMP	System Size	Treatment (lbs N/acre)	Recommended Acreage	Total Available Acreage	% Acreage Utilized	Construction Cost ($/acre)	Unit Cost ($/lb N)	Total N Load Reduction (lbs)	Total Cost
Industrial	Impervious	Gravel Wetland	0.25" WQV	10.65	12.0	11.99	100%	5900	$ 554	127.7	$ 70,767
Outdoor	Impervious	Gravel Wetland	0.25" WQV	7.66	20.6	20.62	100%	5900	$ 770	158.0	$ 121,686
Residential	Roof	Dry Well	0.5" WQV	11.32	18.9	18.88	100%	7000	$ 618	213.8	$ 132,182
Residential	Impervious	Raingarden	0.5" WQV	10.21	27.2	27.17	100%	7000	$ 686	277.4	$ 190,213
Commercial	Roof	Dry Well	0.25" WQV	13.09	20.6	20.57	100%	4000	$ 306	269.2	$ 82,272
Industrial	Roof	Dry Well	0.25" WQV	13.09	6.5	6.46	100%	4000	$ 306	84.5	$ 25,834
Road	Impervious	Gravel Wetland	0.25" WQV	8.52	41.9	50.5	83%	5900	$ 692	357.1	$ 247,313
Commercial	Impervious	Gravel Wetland	0.25" WQV	10.65	59.2	82.27	72%	5900	$ 554	630.9	$ 349,490
Commercial	HSG D	Gravel Wetland	0.25" WQV	3.06	20.5	29.37	70%	5900	$ 1,928	62.8	$ 121,050
Commercial	Impervious	HE Bioretention	0.25" WQV	9.21	16.5	82.27	20%	12255	$ 1,331	151.5	$ 201,648
Road	Impervious	Bioretention	0.25" WQV	4.79	8.6	50.5	17%	11400	$ 2,380	41.1	$ 97,875
Commercial	Impervious	Subsurface Infiltration	0.25" WQV	3.94	6.6	82.27	8%	18500	$ 4,695	25.9	$ 121,762
					259					**2,400**	**$ 1,762,089**

7. IMPLEMENTATION SCHEDULE

A. Scheduling and Cost Considerations for Mill Pond

Implementation schedules are a requirement for the new MS4. Typically, a requirement for EPA approval requires using established guidance for scheduling by performing a financial capability analyses (FCA) (EPA 2014). An FCA is conducted to evaluate the impact on residential rate payers using indicators including household income, existing rates and taxes, as well as allowing a flexibility of schedule to be responsive to circumstances unique to a community, while advancing the goal to protect clean water. A final schedule will provide metrics and milestones that must be tracked and accounted for and reported in the Annual Report on the Nitrogen Control Plan (NCP).

One of the critical elements to be considered with an extended implementation schedule is that a multi-5-yr permit cycle period would benefit from private sector redevelopment. It could be expected that as redevelopment occurs that enhanced stormwater management will be required due to revised municipal stormwater regulations. The revised stormwater regulations require management of nitrogen for new and redevelopment including municipal capital improvement projects that impact stormwater management. In many communities up to 50% of the improvements could occur in the private sector. Areas associated with management of NPS (non-point source) for municipally owned and managed land include parks, schools, roads, municipal offices, police and fire, public works facilities, and impervious areas in the urban center typically managed by the municipality. With this approach the total cost of NPS management is covered by the land uses that generate stormwater runoff, both municipal and private sector.

In absence of a financial capability analysis, a range of implementation periods was examined to determine the yearly rate for treated acres and the estimated cost to implement. The cost in this instance is total cost and does not differentiate between private and public sector. Table 4 illustrates implementation schedules ranging from 15 years (3 permit cycles), 17.1 acres per year at an annual cost of $117,500 to 25 years (5 permit cycles) and 10.3 acres per year at $70,500 annually.

Table 4 - Cost Options for EIC Reduction Implementation Schedules Ranging from 15-25 Yrs

Implementation Period (yrs)	Yearly Rate of Area Treated-Total (AC/YR)	Yearly Cost to Implement Total
15	17.1	$117,467
16	16.0	$110,125
17	15.1	$103,647
18	14.3	$97,889
19	13.5	$92,737
20	12.8	$88,100
21	12.2	$83,905
22	11.7	$80,091
23	11.2	$76,609
24	10.7	$73,417
25	10.3	$70,480

Assumptions: 257 acres treated for impervious cover reduction to achieve 9% EIC within the watershed; estimated cost to implement $1,762,000 in 2018 costs; estimated yearly cost to implement is average over period of time, it would be expected that early "low hanging fruit" installations would be less costly, and later installations more expensive.*

B. Guidance for Developing Implementation Schedules

Implementation scheduling approaches include guidance for CSO management, Integrated Planning, and MS4 implementation.

- Wastewater scheduling typically follows the FCA analysis. "Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development" (FCA Guidance) (EPA 832-B-97-004)
- Integrated planning is using similar info FCA Framework 2014. Financial Capability Assessment Framework for Municipal Clean Water Act Requirements (EPA, 2014)
- MS4 implementation for NH currently does not indicate a specific implementation schedule. No minimum period for an implementation schedule for Post Construction Stormwater Management (Minimum Measure 5) is required. We have heard from EPA in the public forum that an extended period of time will be allowable.
- Similarly, EPA Headquarters, and Region 1 Leadership spoke at the September 2013 NACWA Integrated Planning Workshop in Portsmouth, NH, that extended implementation periods similar to CSO implementation are conceivable in the range of 4 or more permit cycle period.

8. BMP Examples for Nutrient Control in Urban Areas

There are several best management practices that can be used in the municipal, commercial, industrial, and residential areas to manage runoff from roof tops, impervious surfaces and pervious surfaces. This includes dry wells, subsurface infiltration, gravel wetlands, porous pavements, biofiltration, and high efficiency bioretention.

Figure 12 - Stormwater Tree Planter Combined with Catch Basin

Figure 12 illustrates a tree planter installed as part of a road reconstruction and sewer improvements. The tree planter combines a tree well and catchbasin with an engineered soil that provides a growing medium and water quality filter. The planter was designed for considerations of low maintenance and winter maintenance in that it can be cleared easily by snow plow and sediment and debris removal is limited to a deep sump and cleaning by vactor truck. With the tree planter grate the sidewalk area is usable for pedestrian travel. Tree planters, bioretention, and other forms of infiltration or biofiltration can be combined with streetscapes for added functionality.

Figure 13: Parking Lot Bioretention

Figure 13 shows a bioswale with pretreatment systems located in a parking lot that could be applied in a road right-of-way. Figure 14 is an example of a streetscape and tree planter that could easily be combined for stormwater management. The streetscape has a combination of pedestrian considerations, areas for local business to use the sidewalks, and park benches, all of which could allow for use of some type of planter or infiltration below ground. Figure 15 shows large scale subsurface infiltration combined with an isolator row for pretreatment. The isolator row is a wrapped chamber that prevents clogging of the stone bed. A subsurface infiltration system such as this combined with a pretreatment design could be used effectively for flood control and nutrient reduction.

Figure 14: Streetscape with Street Trees Adaptable for Stormwater Management

Figure 15: Subsurface Infiltration with Stone Reservoir and Isolator Row Pretreatment Chamber

9. BMP Implementation Examples for Mill Pond

A. Design and Maintenance

Three BMPs examples were developed for various locations within Durham (See Appendix A). BMPs were each designed to a 30% level in order to demonstrate BMP sizing considering land use, soils, and calculating the nitrogen-reduction potential and cost for systems of this type. These BMPs are all relatively simple installations which make use of existing drainage infrastructure for overflow and bypass and as such no additional piping (beyond the BMPs) is proposed.

Roadside bioswales with pretreatment were designed for Edgewood Road (EW1) and Madbury Road (MR1) designed to manage the ¼" WQV from a road and residential neighborhood (Figure 16 and Figure 17). A third system on Mill Pond Road (MP1) with a combination of pretreatment and subsurface infiltration was designed to manage the ¼" WQV from road, residential, and commercial areas (Figure 18). A pollutant loading analysis was performed for each BMP to determine the associated nitrogen load reduction potential.

All BMPs were designed for low maintenance with an emphasis on pretreatment to reduce maintenance needs. The maintenance goal is to use existing staff and equipment for standard catch basin cleaning. The focus on pretreatment should provide easy-to-maintain shallow sumps for collection of sediment and trash with standard maintenance procedures using vactor trucks and requires no specialty equipment or training. The absence of a pre-filter may allow trash and debris to prematurely clog the biofilter media or infiltration bed. Trash and debris can require frequent maintenance for aesthetics in high loading land uses and reduce the infiltration rate of filtration media.

To ensure the effectiveness of BMPs, regular inspections and maintenance is necessary. Generally, inspection and maintenance falls into two categories: expected routine maintenance and non-routine (repair) maintenance. Routine maintenance is performed regularly to maintain both aesthetics and their good working order. Routine inspection and maintenance helps prevent potential nuisances (odors, mosquitoes, weeds, etc.), reduces the need for repair maintenance, and insures long term performance.

Under MS4 rules, owners and operators are responsible for implementing BMP inspection and maintenance programs and having penalties in place to deter infractions. The rules recommend that all stormwater BMPs should be inspected on a regular basis for continued effectiveness and structural integrity.

B. Pollutant Load Reduction

For each location and proposed BMP a pollutant loading analysis was performed in order to quantify the potential to reduce total nitrogen loading to Mill Pond. Nitrogen removal performance was based on values derived as part of the EPA, 2017 revision to the NH MS4 General Permit, using pollutant load export rates (PLERs), BMP types, drainage areas, land uses, and soil types. Results were compiled for BMPs sized to accommodate the ¼" water quality volume and are presented in Table 5.

Table 5 - Pollutant Load Analysis Results for Example BMPs on Edgewood Road (EW1), Madbury Road (MR1), and Mill Pond Road (MP1)

BMP ID	Soil Type at BMP	% Impervious Cover	Drainage Area (acres)	Annual TN Load (lbs)	Volume (ft3)	TN Captured (lbs)
EW1	A	37%	0.71	3.7	245	1.9
MR1	D	51%	1.58	13.4	730	6.9
MP1	C	57%	5.43	49.8	2,790	25.1
			7.73	**66.9**	**3,766**	**33.9**

Figure 16 – Edgewood Road BMP 'EW1' Detailed Location and Drainage Area

Figure 17 – Madbury Road BMP 'MR1' Detailed Location and Drainage Area

Figure 18 – Mill Pond Road BMP 'MP1' Detailed Location and Drainage Area

C. Planning Level Cost Estimates

30% design costing analysis were developed to quantify the total and unit costs (cost per pound of nitrogen removed) for the three example BMPs.

The planning-level cost estimates are based on scalable unit costs developed in prior studies[10] study and the drainage area characteristics for each BMP. Results were compiled for the ¼" water quality volume and are presented in Table 6. Cost estimates presented in this report are conservative and should be further evaluated as designs are finalized and when system size and material quantities are known. Tremendous cost saving opportunities exist when BMP retrofits are phased with road and utility improvements. For example, a bioretention system designed to treat 1 acre of runoff might cost an estimated $40,000. However, when paired with road improvements the costs may be reduced to $10,000 due to the shared costs of curbs, sidewalks, and roads.

Table 6: BMP Pollutant Removal and Cost Estimates for a 1/4" Water Quality Volume

BMP #	Capture Volume (ft^3)	TN Capture (lbs)	Total Cost ($)	Unit Cost ($/lb)
MP1	3,100	25	$100,500	$4,000
EW1	130	2	$13,200	$7,000
MR1	525	7	$29,200	$4,200

10. RECOMMENDATIONS

As part of future efforts, we recommend the following:

1. Further study to complete the Nitrogen Source Identification Reports for the remaining subwatersheds
2. Advancing BMP designs to 95% level such that they can be included in future capital improvement projects, SRF, and grant funded efforts.
3. Including a study and cost prioritization of non-structural BMPs such as street sweeping, leaf litter control, impervious surface disconnection, urban tree planting, urban fertilizer control, impervious cover removal, soil augmentation, and catch basin cleaning.

Implementation of the recommendations will help Durham address requirements of EPA's 2017 NH Small MS4 General Permit for stormwater discharges. In particular new requirements to develop a Nitrogen Source Identification Report; and new development and redevelopment stormwater management BMPs be optimized for nitrogen removal; retrofit inventory and priority ranking to reduce nitrogen discharges.

11. REFERENCES

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APPENDIX A: 30% DESIGN EXAMPLES FOR EDGEWOOD ROAD, MADBURY ROAD, MILL POND ROAD

30% BMP EXAMPLE DESIGNS
FOR MILL POND NUTRIENT CONTROL MEASURES

FOR THE DURHAM, NH MILL POND STUDY

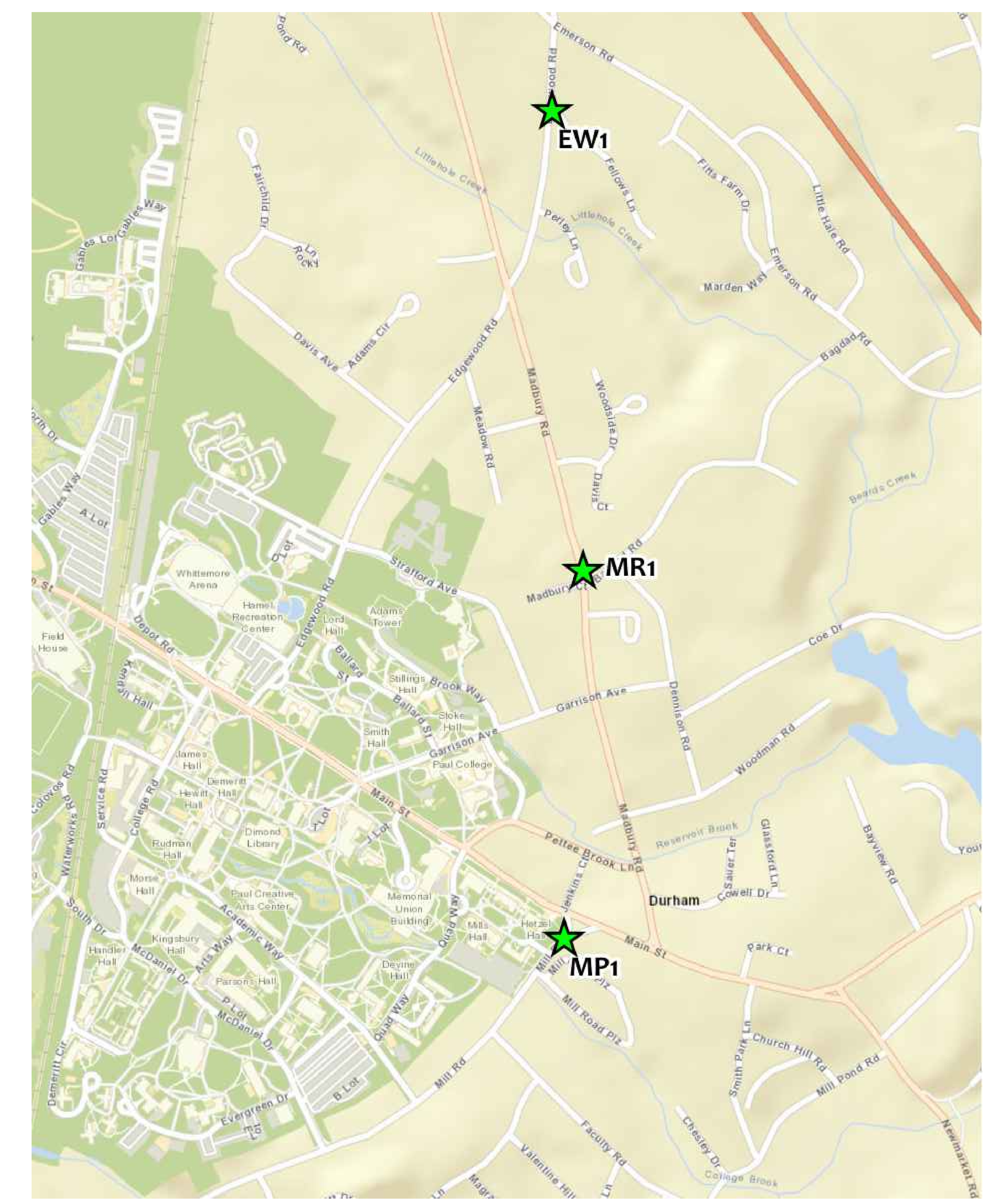
PREPARED FOR
TOWN OF DURHAM, NEW HAMPSHIRE

OWNER:
TOWN OF DURHAM
TODD I. SELIG
TOWN ADMINISTRATOR
APRIL TALON
TOWN ENGINEER
8 NEWMARKET ROAD
DURHAM, NH 03824

PREPARED BY:
ROBERT ROSEEN, PE, PHD, D.WRE
JAKE SAHL, MS
WATERSTONE ENGINEERING
STRATHAM, NH 03885

PROJECT MANAGER:
JEFFREY C. PROVOST, P.E.
WESTON & SAMPSON
PORTSMOUTH, NH 03801

DIG SAFE:
CONTACT DIG SAFE AT 811
HOURS PRIOR TO ANY CONSTRUCTION.



LOCATION MAP
NOT TO SCALE

NOTES: UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS, AND THEREFORE THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS PRESENTLY NOT KNOWN. ANYONE USING UTILITY INFORMATION AND DATA PROVIDED HEREIN SHALL CALL DIG SAFE AT 811 SEVENTY TWO (72) HOURS, 3 BUSINESS DAYS IN ADVANCE TO VERIFY THE LOCATION OF UTILITIES PRIOR TO START OF CONSTRUCTION.

This Drawing shall not be used for Construction unless Signed and Sealed For Construction.

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
9 GRETA'S WAY
STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS
FOR THE DURHAM, NH MILL POND STUDY
MILL POND
NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY: RR
DRAFTED BY: JS
CHECKED BY: RR

COVER SHEET AND VICINITY MAPS

JOB #: 171006
SCALE: AS SHOWN
CONTRACT #: N/A
SHEET #: 1

G1

LEGEND - EXISTING

(EXISTING - PHASE 1)

SMH	SEWER MANHOLE
DMH	DRAINAGE MANHOLE
	GRATED INLET
CB	CATCH BASIN
CBCI	CATCH BASIN WITH CURB INLET
TMH	TELEPHONE MANHOLE
	TELEPHONE POLE
	UTILITY POLE
	LIGHT POLE
	SPOT LIGHT
EMH	ELECTRIC MANHOLE
	SURVEY MONUMENT
	PULL BOX
	WHEELCHAIR RAMP (WCR)
	BOLLARD
	SIGN
	VERTICAL BENCHMARK
	SHRUB
	TREE
	CURB STOP
SG	SEWER GATE
	FIRE HYDRANT
WMH	WATER MANHOLE
WG	WATER GATE

	CONTOUR MAJOR
	CONTOUR MINOR
W	WATER LINE
G	GAS MAIN
T	UNDERGROUND TELEPHONE OR ELECTRIC
D	STORM DRAINAGE PIPE
	OVERHEAD ELECTRIC
	FENCE
	TREE LINE
	PROPERTY LINE OR RIGHT-OF-WAY
VS	SANITARY VACUUM SEWER
S	SANITARY GRAVITY SEWER
FM	SANITARY SEWER FORCE MAIN
	STONE WALL
	RETAINING WALL
GC	GRANITE CURB
VP1 OR VP2	VALVE PIT TYPE 1 OR TYPE2
SBT OR DBT	SINGLE OR DUAL BUFFER TANK

LEGEND - EXISTING

(EXISTING - SURVEYED AREAS)

	ABUTTERS LINE (PER TOWN OF EXETER GIS)
	STOCKADE FENCE
v	PICKET FENCE
<>	POST & RAIL FENCE
	CHAIN LINK FENCE
OHW	OVERHEAD WIRES
	SEWER LINE
D	DRAIN LINE
G	GAS LINE
W	WATER LINE
100	MAJOR CONTOUR LINE
98	MINOR CONTOUR LINE
	TREE LINE
	SHRUB LINE
	UTILITY POLE
	UTILITY POLE & GUY WIRE
	SIGN
	GRANITE BOUND FOUND
	IRON PIPE/ROD FOUND
	POST
	FIRE HYDRANT
WV	WATER GATE VALVE
WSO	WATER SHUTOFF VALVE
GV	GAS GATE VALVE
GSO	GAS SHUTOFF VALVE
GM	GAS METER
	MAIL BOX
	CATCH BASIN (ROUND)
	CATCH BASIN
	DRAIN MANHOLE
	MANHOLE
	ELECTRIC MANHOLE
	TELEPHONE MANHOLE
	WATER MANHOLE
	SEWER MANHOLE
	BOULDER

	TREE STUMP
	CONIFEROUS TREE
	DECIDUOUS TREE
	CONIFEROUS SHRUB
	DECIDUOUS BUSH
	BORING
	PEDESTRIAN MAT
	CONCRETE
	LANDSCAPED AREA
	CRUSHED STONE
	BRICK
TYP.	TYPICAL
EP	EDGE OF PAVEMENT
SWL	SINGLE WHITE LINE
SYL	SINGLE YELLOW LINE
DYL	DOUBLE YELLOW LINE
CONC.	CONCRETE
VGC	VERTICAL GRANITE CURB
SGC	SLOPED GRANITE CURB
CC	CONCRETE CURB
BB	BITUMINOUS BERM
TM63/L19	TAX MAP & LOT NUMBER

MATERIAL LEGEND

- INFILTRATION CHAMBER
- BRICK SIDEWALK WITH PATTERN TO MATCH EXISTING
- CONCRETE SIDEWALK
- CONCRETE PAVING
- GRASS
- STANDARD "HMA" PAVEMENT
- BIORETENTION SWALE
- TREE PLANTER
- ROW - INFILTRATION GRASSED
- ROW INFILTRATION - TREE TRENCH

DRAWING LIST

LEGEND - PROPOSED

(ALL PHASES)

1+00	ROADWAY BASELINE
	EDGE OF POROUS PAVEMENT
	GRANITE CURBING
	CAPE COD BERM
	LIMIT OF STONE RESERVOIR TRENCH
	EDGE TRANSITION DETAIL
S	REMOVE AND RESET PARKING METER
D	REMOVE AND RESET PARKING METER
D	HDPE DRAIN PIPE
	HDPE CAP
	CATCH BASIN
	CATCH BASIN WITH TIP DOWN DETAIL
	DRAIN MANHOLE

UTILITY OPERATING AUTHORITIES	
DRAIN/SEWER/WATER	TOWN OF DURHAM
TELEPHONE	
ELECTRIC	

DRAINAGE NOTES:

1. ALL DRAINAGE PIPING SHALL BE 12" INSIDE DIAMETER CORRUGATED HDPE TYPE N-12 PIPE MANUFACTURED BY ADS OR EQUAL SUITABLE FOR H-20 LOADING AT MINIMUM BURIED DEPTH OF 24" UNLESS OTHERWISE NOTED. PIPE SHALL BE SUPPLIED IN 20 FT LENGTHS. JOINTS SHALL BE SOIL TIGHT PUSH ON JOINTS.
2. FINAL LOCATION OF ALL DRAINAGE STRUCTURES TO BE COORDINATED WITH RESIDENT PROJECT REPRESENTATIVE PRIOR TO STARTING WORK.
3. PIPE SHALL BE SLOPED AT A MINIMUM OF 1.0% UNLESS OTHERWISE NOTED.
4. CONTRACTOR IS RESPONSIBLE FOR VERIFYING ALL UTILITIES PRIOR TO EXCAVATION, INCLUDING UTILITIES NOT MARKED BY DIG-SAFE (811), NOT SHOWN ON THE SURVEY, OR NOT MARKED BY THE TOWN. CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL DAMAGES IF AN UNDERGROUND UTILITY IS DAMAGED DURING THE COURSE OF CONSTRUCTION.
5. IN THE EVENT THAT ANY UTILITY, UNDERGROUND OR OVERHEAD, IS DAMAGED DURING CONSTRUCTION, CONTRACTOR SHALL IMMEDIATELY NOTIFY ENGINEER AND THE APPROPRIATE UTILITY COMPANY.
6. ALL CONNECTIONS BETWEEN PRECAST CONCRETE SECTIONS SHALL BE SEALED WITH NON-SHRINK GROUT.
7. CATCH BASINS, INLETS & INFILTRATION BEDS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE STATE DEPARTMENT OF TRANSPORTATION AND ENVIRONMENTAL SERVICES UNLESS OTHERWISE NOTED.
8. ALL PRECAST CONCRETE STRUCTURES SHALL BE RATED FOR AASHTO/H-20 LOADING.
9. ALL MATERIALS USED AND CONSTRUCTION METHODS EMPLOYED ARE TO BE IN ACCORDANCE WITH THE LATEST FEDERAL, STATE AND TOWN REGULATIONS.
10. CONTRACTOR IS RESPONSIBLE FOR DETERMINING DEPTH OF GROUNDWATER AND FOR ALL COSTS ASSOCIATED WITH DEWATERING NECESSARY TO INSTALL STRUCTURES OR PIPING.
11. 13. ANY UNSUITABLE MATERIAL ENCOUNTERED DURING EXCAVATION (ORGANICS, PEAT, ETC.) FOR DRAINAGE STRUCTURES SHALL BE DISPOSED OF BY THE CONTRACTOR AT THEIR EXPENSE. CONTRACTOR IS RESPONSIBLE FOR PROVIDING SUITABLE CLEAN BACKFILL FOR BACKFILL AND COMPACTION.
12. 14. ALL GATE BOXES, PULL BOXES, CATCH BASIN GRATES AND OTHER UTILITY COVERS SHALL BE RAISED AS NEEDED TO BE FLUSH WITH THE TEMPORARY AND FINAL PAVING IF APPLICABLE.

GENERAL NOTES:

1. THIS PROJECT HAS BEEN FINANCED BY A DES COASTAL PROGRAM PLANNING GRANT.
2. THE LOCATIONS OF THE BUILDINGS AND PROPERTY LINES WERE TAKEN FROM TOWN SUPPLIED GIS FILES AND SUPPLEMENTED BY THE FIELD SURVEY, REFERENCED BELOW, PERFORMED BY DOUCET LAND SURVEYORS, INC.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING FINAL LOCATION AND DEPTH OF ALL UTILITIES.
4. THE CONTRACTOR SHALL CONTACT UTILITY COMPANIES WHEN EXCAVATING IN THE VICINITY OF EXISTING UTILITIES. CONTRACTOR SHALL BE RESPONSIBLE FOR THE REPAIR OF ANY EXISTING UTILITIES DAMAGED DUE TO HIS OPERATION.
5. THE CONTRACTOR SHALL STRUCTURALLY SUPPORT AND/OR PROTECT WATER MAIN, GAS, STORM SEWER, SANITARY SEWER OR ANY OTHER EXISTING UTILITIES WHERE NECESSARY IN ACCORDANCE WITH UTILITY OWNER'S REQUIREMENT WHEN EXCAVATING ADJACENT TO OR CROSSING THAT UTILITY.
6. CONTRACTOR SHALL NOTIFY ENGINEER IMMEDIATELY OF ANY INTERFERENCE WITH EXISTING UTILITIES AND THE NEW UTILITIES. IF NEW WORK NEEDS TO BE MOVED OR RELOCATED DUE TO A FIELD CHANGE (EXISTING UTILITIES, TREES, OWNER REQUEST, ETC.) COST FOR RELOCATION SHALL BE INCLUDED IN THE INDIVIDUAL BID ITEM BASED ON THE QUANTITY OF ACTUAL MATERIAL INSTALLED.
7. CONTRACTOR SHALL BE RESPONSIBLE FOR SUPPORT OF ALL EXCAVATIONS, AS REQUIRED, INCLUDING SHEETING OR BRACING, OR OTHER METHOD APPROVED BY ENGINEER.
8. ALL EXISTING ITEMS, INCLUDING BUT NOT LIMITED TO LANDSCAPING, CURBING AND SIDEWALKS DAMAGED BY THE CONTRACTOR SHALL BE RESTORED TO ORIGINAL CONDITIONS AT THE CONTRACTORS EXPENSE.
9. WHEN THE CONTRACTOR DISTURBS AN AREA WITHIN 5' OF A UTILITY POLE, THE CONTRACTOR SHALL SUPPORT THAT POLE IN ACCORDANCE WITH UTILITY OWNER'S REQUIREMENTS AT NO ADDITIONAL COST TO THE OWNER.
10. LIMIT OF WORK SHALL BE WITHIN THE PUBLIC RIGHT OF WAY OR AS SHOWN ON THE DRAWINGS.
11. PROPOSED CONDITIONS SHOWN HEAVY. EXISTING CONDITIONS SHOWN LIGHT.
12. ALL PAVEMENT TO BE SAW-CUT.
13. NOT ALL OVERHEAD WIRES AND POWER LINES ARE SHOWN ON THE DRAWINGS. THE CONTRACTOR SHALL FIELD VERIFY LOCATIONS BEFORE CONSTRUCTION COMMENCES.
14. FOR CLARITY PROFILES DO NOT SHOW UTILITIES.
15. PRIOR TO SUBMITTING HIS/HER BID THE CONTRACTOR SHALL VISIT THE SITE TO IDENTIFY AND DOCUMENT WHAT EXISTING CONDITIONS ARE PRESENT ALONG THE STREETSCAPE CORRIDOR AS THESE WILL BE IMPORTANT FOR THE SATISFACTORY COMPLETION OF THE PROJECT.
16. NEW SITE GRADES AND ELEVATIONS SHALL BE ESTABLISHED FROM THE ACTUAL EXISTING ELEVATIONS THAT BORDER EACH SECTION OF THE WORK ZONE. THESE ELEVATIONS MAY BE AT STEP BASES, WALK SURFACES, AND EXISTING EARTH AND GARDEN AREAS.
17. THE RECONSTRUCTED STREET PAVEMENT SHALL BE GRADED SO THAT SURFACE DRAINAGE PITCHES TO THE NEW DRAINS. INLETS TO BE SET AT A DESIRED GRADE OF 2 PERCENT, WITH A MINIMUM GRADE OF 1 PERCENT. IN SOME AREAS THE SURFACE GRADE OF THE STREET MAY EXCEED 2 PERCENT BUT SHALL NOT EXCEED 3 PERCENT ON A CROSS PITCH ACROSS THE STREET PAVEMENT.
18. NEW DRAIN INLETS SHALL HAVE THEIR RIM ELEVATIONS SET TO WORK WITH THE REBUILT STREET GRADES.
19. AT ALL TIMES THE CONTRACTOR SHALL MAINTAIN A SMOOTH CURB LINE THAT FUNCTIONS WITH THE SIDEWALK AND STREET GRADES AND IS WITHOUT SHARP BREAKS, HUMMOCKS, AND HOLLOWS. THE FINAL SURFACE OF THE SIDEWALK SHALL HAVE AN EVEN GRADIENT ALONG THE LINE OF THE STREETSCAPE AS WELL AS FROM SIDE TO SIDE AND SHALL FUNCTION WITH A STREET PAVEMENT THAT HAS THE SAME CHARACTER.

This Drawing shall not be used for Construction unless Signed and Sealed For Construction.

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
9 GRETA'S WAY
STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY

MILL POND NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

LEGENDS, NOTES AND DRAWING INDEX

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	2

G2

LIST OF ABBREVIATIONS - PROPOSED

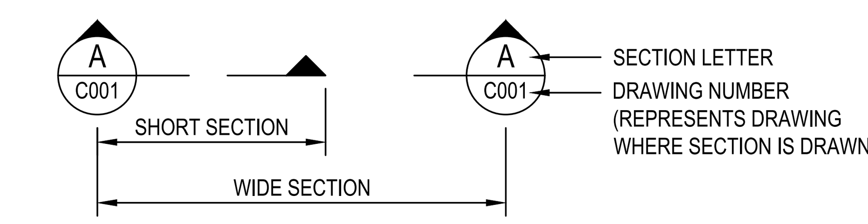
AB	ANCHOR BOLT
AC	ASBESTOS CEMENT
ACOUS	ACOUSTICAL (SOUND DEADENING)
ACTL	ACOUSTIC TILE
ADD'L	ADDITIONAL
ADJ	ADJUSTABLE
AFF	ABOVE FINISHED FLOOR
AGGR	AGGREGATE
ALLOW	ALLOWANCE
ALT	ALTERNATE
ALUM	ALUMINUM
APPROX	APPROXIMATE
ARCH	ARCHITECT OR ARCHITECTURAL
AS	AUTOMATED SAMPLER
ASB	ASBESTOS
ASPH	ASPHALT
ASSY	ASSEMBLY
AST	ASPHALT TILE
ATPB	ASPHALT TREATED PERMEABLE BASE
BCV	BUTTERFLY CONTROL VALVE
BF	BLIND FLANGE
BIT	BITUMINOUS
BL or ℄	BUILDING LINE
BLDG	BUILDING
BLK	BLOCK
BM	BENCH MARK\ BEAM
BO	BOARD
BOF	BOTTOM OF FOOTING
BOT or B	BOTTOM
BP	BASE PLATE
BRG	BEARING
BRK	BRICK
BRZ	BRONZE
BTW	BETWEEN
BU	BUILT UP
CABN	CABINET
CB	CATCH BASIN
CC	CENTER TO CENTER
CEM	CEMENT
CER	CERAMIC
CF	CUBIC FEET
CFM	CUBIC FEET PER MINUTE
CI	CAST IRON
CIP	CAST IRON PIPE
CIRC	CIRCLE, CIRCULAR or CIRCUMFERENCE
℄	CENTER LINE
CL2	CHLORINE
CL or CLR	CLEAR
CLG	CEILING
CLKG	CAULKING
CLF	CHAIN LINK FENCE
CL JT	CONTROL JOINT
CMH	CHEMICAL MANHOLE
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CS JT	CONSTRUCTION JOINT
CO	CLEANOUT
COL	COLUMN, COLOR
COMBN	COMBINATION
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
CONT	CONTINUOUS
CONTR	CONTRACTOR
COND	CONDUIT
COR	CORRIDOR
COORD	COORDINATE
CP	CONCRETE PLANK
CPLG	COUPLING
CPVC	CHLORINATED POLYVINYL CHLORIDE
CRF	CHEMICAL RESISTANT FINISH
CRS	COURSE
CT	CERAMIC TILE
CTR	CONTRACT
CTRD	CENTERED
CTS	COPPER TUBE SIZE
CU	COPPER
CU IN	CUBIC INCH
CV	CHECK VALVE
CW	COLD WATER/ CIRCULAR WASHER
CY	CUBIC YARD
DJ	DOUBLE JOINT
DL	DEAD LOAD
DET	DETAIL
DIA, Ø	DIAMETER
DIAG	DIAGONAL
DEFL	DEFLECTION
DIM	DIMENSION
DIST	DISTRIBUTION, DISTANCE
DI	DUCTILE IRON
DOZ	DOZEN
DN	DOWN
DR	DOOR
DWG	DRAWING
DWL	DOWEL
DH	DECK HYDRANT
DMH	DRAINAGE MANHOLE
E	EAST

EA	EACH
EF	EACH FACE
EJ	EXPANSION JOINT
EW	EACH WAY
ECC	ECCENTRIC
EFF	EFFLUENT
EL or ELEV	ELEVATION
ELB	ELBOW
ELEC	ELECTRIC
ENAM	ENAMEL
ENG	ENGINE
ENGR	ENGINEER
ENT	ENTRANCE
EQUIP	EQUIPMENT
EQ or EQUIV	EQUAL or EQUIVALENT
EX, EXIST	EXISTING
EXC	EXCAVATE
EXH	EXHAUST
EXP	EXPANSION
EXT	EXTERIOR
EXTEND OPER	EXTENDED OPERATOR
EXTR	EXTRUDE
FA	FLANGE ADAPTER
FC	FOOT CANDLE/ FLUSHING CONNECTION
FD	FLOOR DRAIN/ FIRE DOOR
FE	FIRE EXTINGUISHER
FF	FAR FACE/ FINISHED FLOOR
FG	FIBERGLASS
FAB	FABRICATE
FND	FOUNDATION
FIN	FINISH
FIN RAD	FIN RADIATOR
FITG	FITTING
FIX	FIXTURE
FL	FLASHING/ FLANGE
FLX CON	FLEXIBLE CONTAINMENT TUBE
FLG	FLOORING
FLR	FLOOR
FLOUR	FLUORESCENT
FOC	FACE OR COLUMN
FPRF	FIREPROOF
FRP	FIBERGLASS REINFORCED PLASTIC
FS	FOOTING STEP
FST	FINAL SETTLING TANK
FT	FEET
FTG	FOOTING
FURR	FURRING/ FURRED
F&C	FRAME AND COVER
F&G	FRAME AND GRATING
GC	GENERAL CONTRACTOR
GI	GALVANIZED IRON
GPM	GALLONS PER MINUTE
GV	GATE VALVE
GWF	GLAZED WALL FINISH
GA	GAUGE
GAL	GALLON
GALV	GALVANIZED
GEN	GENERATOR
GL	GLASS
GR	GRADE
GRAN	GRANITE
GRTG	GRATING
GYP	GYPSUM
GYP BD	GYPSUM BOARD
GMU	GLAZED MASONRY UNIT
HVAC	HEATING and VENTILATION
HD	HEAVY DUTY
HDPE	HIGH DENSITY POLYETHYLENE
HDBD	HARDBOARD
H EXCH	HEAT EXCHANGER
HWL	HIGH WATER LEVEL
HDWR	HARDWARE
HGT or HT	HEIGHT
HM	HOLLOW METAL
HMA	HOT MIX ASPHALT
H or HORIZ	HORIZONTAL
HP	HORSEPOWER
H PT	HIGH POINT
HTR	HEATER
HSC	HYDRAULIC SYSTEM CENTER
HYD	HYDRANT
I	IRON
'I'	INLET
IF	INSIDE FACE
ID	INSIDE DIAMETER
INCIN	INCINERATOR
INCL	INCLUDE
INSUL	INSULATION
INT	INTERIOR
INV	INVERT
IPS	INTERNAL PIPE SIZE
ISO	ISOLATION
I/O	INPUT/ OUTPUT
JCT	JUNCTION
JST	JOIST

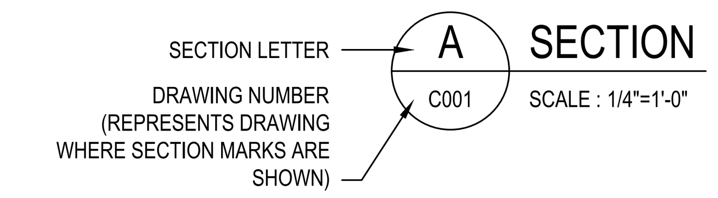
JT	JOINT
JAN CLO	JANITOR'S CLOSET
K	1,000 POUNDS (1 KIP)
KC	KEENE'S CEMENT
KGF	KNIFE GATE VALVE
L	ANGLE
LE	LEFT END
LF	LINEAR FEET
LL	LIVE LOAD
LLV/ (H)	LONG LEG VERT./ (HOR.)
LWL	LOW WATER LEVEL
LAM	LAMINATE
LAV	LAVATORY
LT WT	LIGHTWEIGHT
LG	LENGTH/ LONG
L PT	LOW POINT
LT	LIGHT
LV	LOUVER
M	MOTOR
MCC	MOTOR CONTROL CENTER
MGD	MILLION GALLONS PER DAY
MH	MANHOLE
MJ	MECHANICAL JOINT
MO	MASONRY OPENING
MAS	MASONRY
MATL	MATERIAL
MAX	MAXIMUM
MECH	MECHANICAL
MEMB	MEMBRANE
MTL	METAL
MEZZ	MEZZANINE
MFR	MANUFACTURER
MIN	MINIMUM
MIR	MIRROR
MISC	MISCELLANEOUS
MMH	METHANOL MANHOLE
MTD	MOUNTING
MULT	MULTIPLE
N	NORTH
NF	NEAR FACE
NIC	NOT IN CONTRACT
NPT	NATIONAL PIPE THREAD
NTS	NOT TO SCALE
No. or #	NUMBER
NOM	NOMINAL
NAT	NATURAL
NS	NO SMOKING
OF	OVERFLOW STRUCTURE
OC	ON CENTER
OD	OUTSIDE DIAMETER
OF	OUTSIDE FACE
OT	OPEN TRUSS
OPNG	OPENING
OPP	OPPOSITE
ORIG	ORIGINAL
OPER	OPERABLE
P&ID	PROCESS INSTRUMENTATION DIAGRAM
PCF	POUNDS PER CUBIC FOOT
PRV	PRESSURE RELIEF VALVE
PSF	POUNDS PER SQUARE FOOT
PV	PLUG VALVE
PSI	POUNDS PER SQUARE INCH
POLY, PE	POLYETHYLENE
PAR	PARALLEL
PARTN	PARTITION
PAT	PATTERN
PAVT	PAVEMENT
PC	PIECE
PDC	POWER DISTRIBUTION CENTER
PERF	PERFORATED
PERP	PERPENDICULAR
PIV	PINCH VALVE
℞	PLATE/ PROPERTY LINE
PLAST	PLASTER
PLAS LAM	PLACTIS LAMINATE
PLBG	PLUMBING
PLE	PLANT EFFLUENT
PLR	PILASTER
PLYWD	PLYWOOD
PNL	PANEL
POR	PORCELAIN
PR	PAIR
PREFAB	PREFABRICATED
PROP	PROPOSED
PT	POINT/ PAINT
PVC	POLYVINYL CHLORIDE
QT	QUARRY TILE
QTY	QUANTITY
R	RISER, REACTION, RADIUS
RD	ROOF DRAIN\ ROAD
RO	ROUGH OPENING
ROB	RUN OF BANK
RAD	RADIUS/ RADIATOR
RE	RIGHT END

REC	RECESS/ RECORD
RECIR	RECIRCULATION
RED	REDUCER
REF	REFERENCE/ REFRIGERATOR
RCP	REINFORCED CONCRETE PIPE
REG	REGISTER
REINF	REINFORCING
REM	REMOVE
REP	REPAIR
REQ'D	REQUIRED
REV	REIVISE
RF	ROOF
RFG	ROOFING
RL	ROOF LEADER
RM	ROOM
RUBB	RUBBER
RES FLR	RESILIENT FLOORING
S	SOUTH
'S'	SUCTION
SCC	SYSTEM CONTROL CENTER
SF	SQUARE FOOR
SJ	STEEL JOINT
SP	STOP PLATE
SS	STAINLESS STEEL
SWD	SIDE WATER DEPTH
SADL	SADDLE
SCH	SCHEDULE
SECT	SECTION
SEL	SELECTION
SH	SHEET
SIM	SIMILAR
SMP	SUMP PUMP
SOI	SPRAYED ON INSULATION
SPEC	SPECIFICATION
SQ	SQUARE
ST	STREET
STAT	STATION
STL	STEEL
STL JST	STEEL JOIST
STOR	STORAGE
STD	STANDARD
STIRR	STIRRUPS
STRUC	STRUCTURAL or STRUCTURE
SUR	SURFACE
SUS	SUSPENDED/ SUSPENSION
SYM	SYMMETRICAL
SYP	SOUTHERN YELLOW PINE
SCP	STRUCTURAL CLAY PIPE
SV	SOLENOID VALVE
T	TILE, TREAD or TOP
TDH	TOTAL DYNAMIC HEAD
T/B	TOP OF BERM
T/D	TOP OF DECK
T/FTG	TOP OF FOOTING
T/G	TOP OF GROUT
T/GRTG	TOP OF GRATING
T/MAS	TOP OF MASONARY
T/S	TOP OF SLAB
T/STL	TOP OF STEEL
T/W	TOP OF WALL
THK	THICK
T&B	TOP AND BOTTOM
T&G	TONGUE AND GROOVE
TEL	TELEPHONE
TEMP	TEMPERATURE
TR	TOILET ROOM
TOL	TOLERANCE
TRANS	TRANSFORMER
TK	TANK
TYP	TYPICAL
UNO	UNLESS NOTED OTHERWISE
UR	URINAL
UV	ULTRAVIOLET
V	VINYL or VERTICAL
VAT	VINYL ASBESTOS TILE
VT	VITRIFIED TILE
VERT	VERTICAL
VS	VACUUM SEWER
W	WATER
W/	WITH
WAS	WAS LINE
WI	WROUGHT IRON
WG	WEIR GATE
WL	WATER LEVEL
WO	WINDOW OPENING
W/O	WITHOUT
WS	WATER SURFACE
WWF	WELDED WIRE FABRIC
WC	WATER CLOSET
WD	WOOD
WP	WORKING POINT
WS	WATERSTOP
WT	WEIGHT
W ST	WELDED STEEL PIPE
WV	WATER VALVE
WH	WALL HYDRANT
WP	WORKING POINT

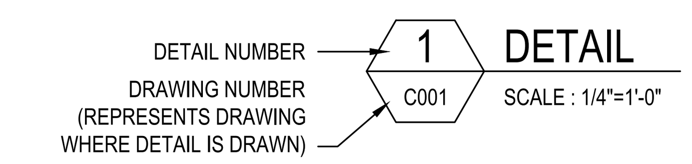
TYPICAL SECTION MARKS (FOR PLANS)



TYPICAL SECTION SUB-TITLE (FOR SECTIONS)



TYPICAL DETAIL MARKS



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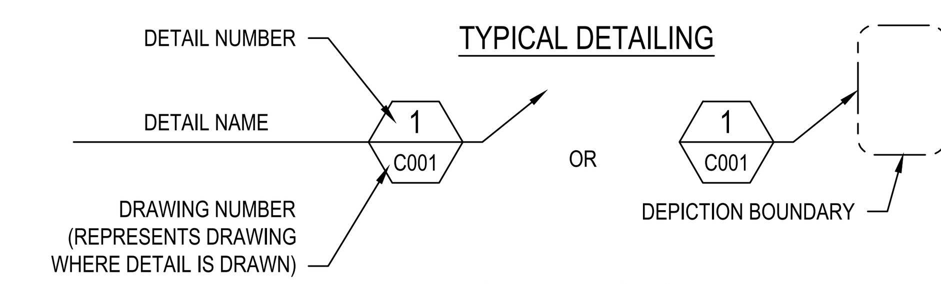
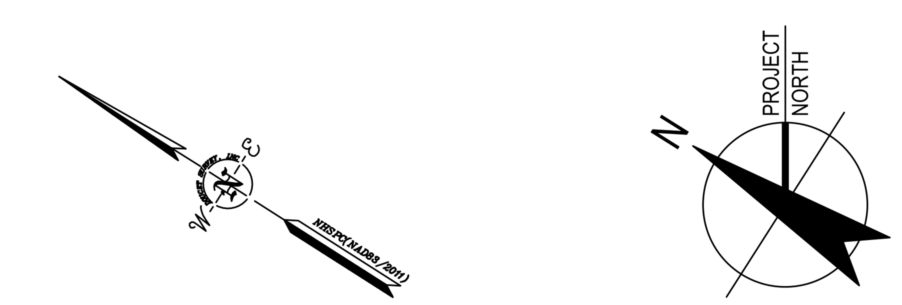


NORTH ARROWS



CIVIL DRAWINGS ONLY SHOW SURVEY NORTH

ALL DRAWINGS SHOW PROJECT/SURVEY NORTH

PROPOSED LEGEND

PROPOSED GRAPHICS; EQUIPMENT, STRUCTURES, ETC., ARE SHOWN AS BOLD LINEWORK AND IN THIS TEXT FORMAT.

EXISTING GRAPHICS; EQUIPMENT, CONDITIONS STRUCTURES, ETC. ARE SHOWN AS LIGHT LINEWORK AND IN THIS TEXT FORMAT.

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NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
9 GRETA'S WAY
STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY

MILL POND NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

ABBREVIATIONS AND LEGENDS

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	3

G3

BMP ID	SOIL CLASS (NRCS)	SOIL TYPE (NRCS)	HYDROLOGIC SOIL GROUP (NRCS)	HYDRAULIC CONDUCTIVITY (SSSNNE)
EW1	GLOUCESTER	VERY STONY FINE SANDY LOAM	A	6.0 IN/HR

MATERIAL LEGEND

- INFILTRATION CHAMBER
- BRICK SIDEWALK WITH PATTERN TO MATCH EXISTING
- CONCRETE SIDEWALK
- CONCRETE PAVING
- GRASS
- STANDARD "HMA" PAVEMENT
- BIORETENTION SWALE
- TREE PLANTER
- ROW - INFILTRATION GRASSED
- ROW INFILTRATION - TREE TRENCH

LEGEND - EXISTING

(EXISTING - SURVEYED AREAS)

- ABUTTERS LINE (PER TOWN OF EXETER GIS)
- STOCKADE FENCE
- PICKET FENCE
- POST & RAIL FENCE
- CHAIN LINK FENCE
- OHW OVERHEAD WIRES
- SEWER LINE
- D DRAIN LINE
- G GAS LINE
- W WATER LINE
- 100 MAJOR CONTOUR LINE
- 98 MINOR CONTOUR LINE
- TREE LINE
- SHRUB LINE
- UTILITY POLE
- UTILITY POLE & GUY WIRE
- SIGN
- GRANITE BOUND FOUND
- IRON PIPE/ROD FOUND
- POST
- FIRE HYDRANT
- WV WATER GATE VALVE
- WS WATER SHUTOFF VALVE
- GV GAS GATE VALVE
- GS GAS SHUTOFF VALVE
- GM GAS METER
- MAIL BOX
- CATCH BASIN (ROUND)
- CATCH BASIN
- DRAIN MANHOLE
- MANHOLE
- ELECTRIC MANHOLE
- TELEPHONE MANHOLE
- WATER MANHOLE
- SEWER MANHOLE
- BOULDER
- TREE STUMP
- CONIFEROUS TREE
- DECIDUOUS TREE
- CONIFEROUS SHRUB
- DECIDUOUS BUSH
- BORING
- PEDESTRIAN MAT
- CONCRETE
- LANDSCAPED AREA
- CRUSHED STONE
- BRICK
- TYP. TYPICAL
- EP EDGE OF PAVEMENT
- SWL SINGLE WHITE LINE
- SYL SINGLE YELLOW LINE
- DYL DOUBLE YELLOW LINE
- CONC. CONCRETE
- VGC VERTICAL GRANITE CURB
- SGC SLOPED GRANITE CURB
- CC CONCRETE CURB
- BB BITUMINOUS BERM
- TM63/L19 TAX MAP & LOT NUMBER
- FLOW LINES (ASSUMED)

NOTE:
ALL ELECTRIC, GAS, TEL. WATER, SEWER AND DRAIN SERVICES ARE SHOWN IN SCHEMATIC FASHION, THEIR LOCATIONS ARE NOT PRECISE OR NECESSARILY ACCURATE. NO WORK WHATSOEVER SHALL BE UNDERTAKEN ON THIS SITE USING THIS PLAN TO LOCATE THE ABOVE SERVICES. CONSULT WITH THE PROPER AUTHORITIES CONCERNED WITH THE SUBJECT SERVICE LOCATIONS FOR INFORMATION REGARDING SUCH. CALL DIG-SAFE AT 811.

DATA SOURCES:
BACKGROUND: GOOGLE EARTH IMAGERY, 2017
TOPOGRAPHIC DATA: 2011 LIDAR FOR THE NORTHEAST

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NO	DATE	DESCRIPTION	CKD
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WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
9 GRETA'S WAY
STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY

MILL POND NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

EDGEWOOD ROAD BMP - EW1

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	4

C1

BMP ID	SOIL CLASS (NRCS)	SOIL TYPE (NRCS)	HYDROLOGIC SOIL GROUP (NRCS)	HYDRAULIC CONDUCTIVITY (SSSNNE)
MR1	HOLLIS-CHARLTON	FINE SANDY LOAMS	A	0.6 IN/HR

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
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STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY

MILL POND NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

MADBURY ROAD
BMP - MR1

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	5

C2

BMP ID	SOIL CLASS (NRCS)	SOIL TYPE (NRCS)	HYDROLOGIC SOIL GROUP (NRCS)	HYDRAULIC CONDUCTIVITY (SSSNNE)
MP1	SUFFIELD	SILT LOAM	C	0-0.2 IN/HR

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
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STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY

MILL POND NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
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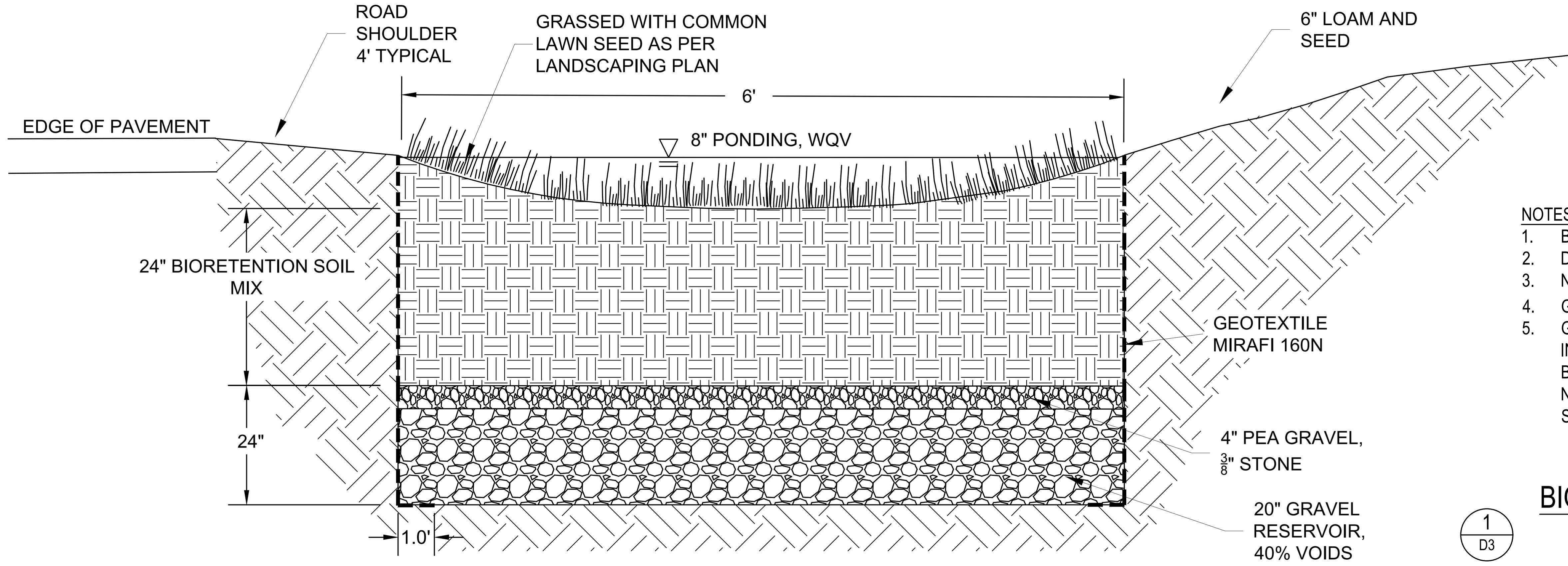
CHECKED BY:	RR

MILL POND ROAD BMP - MP1

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	6

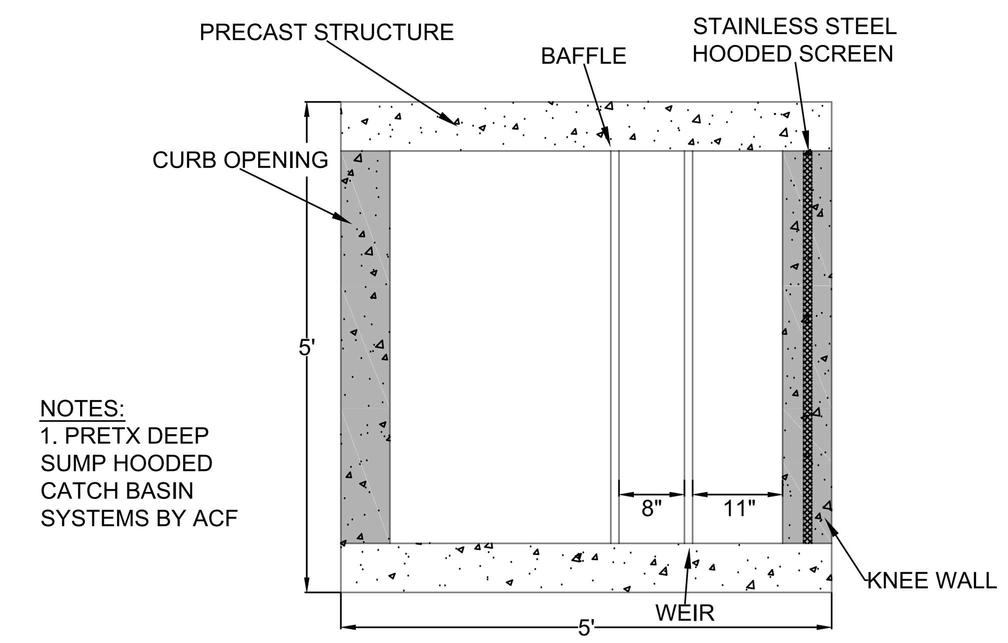
C3



NOTES:
1. BIORETENTION SOIL MIX SHALL CONSIST OF 40% LOAM, 60% SAND.
2. DO NOT COMPACT SUBGRADE AT BOTTOM OF EXCAVATION.
3. NO BIORETENTION SOIL MIX SHALL BE PLACED UNTIL AFTER ENGINEERING APPROVAL AND INSPECTION OF SUBGRADE.
4. GRAVEL RESERVOIR SHALL BE ½" TO 3" STONE WITH 40% VOIDS, ALTERNATIVES ACCEPTABLE UPON APPROVAL.
5. GRASS SEED MIX SHALL BE NEW ENGLAND NATIVE WARM SEASON GRASS MIX WITH A BLEND OF COOL SEASON GRASSES INCLUDED AS A "STARTER" SEED FOR EROSION CONTROL. SPECIES: LITTLE BLUESTEM (SCHIZACHYRIUM SCOPARIUM), BIG BLUESTEM (ANDROPOGON GERARDII), VIRGINIA WILD RYE (ELYMUS VIRGINICUS), INDIAN GRASS (SORGHASTRUM NUTANS), RED FESCUE (FESTUCA RUBRA), SWITCH GRASS (PANICUM VIRGATUM), APPLICATION RATE: 23 LBS/ACRE | 1900 SQ FT/LB

1/D3 BIOSWALE SYSTEM - TYPICAL B-B' CROSS-SECTION

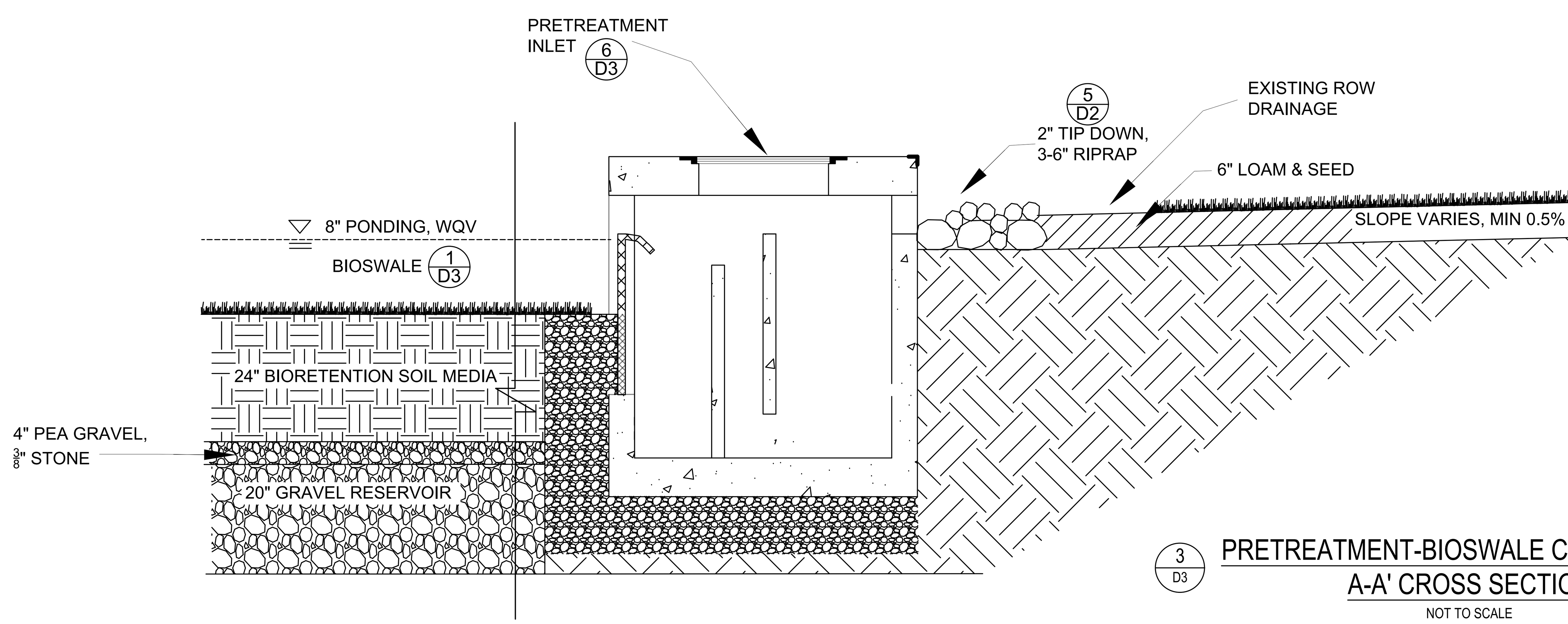
NOT TO SCALE



NOTES:
1. PRETX DEEP SUMP HOODED CATCH BASIN SYSTEMS BY ACF

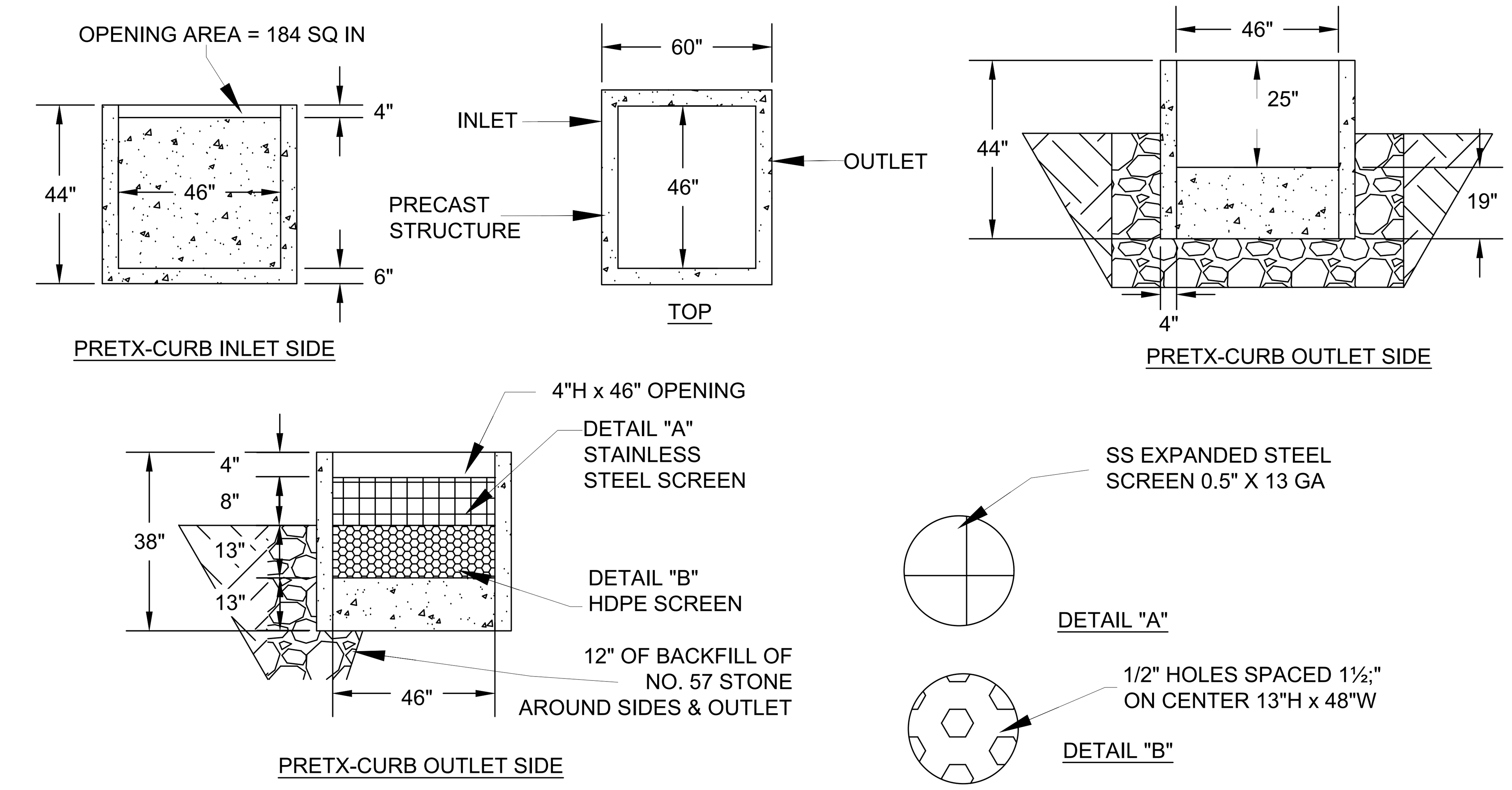
2/D3 PRETREATMENT CATCH BASIN PLAN VIEW

NOT TO SCALE



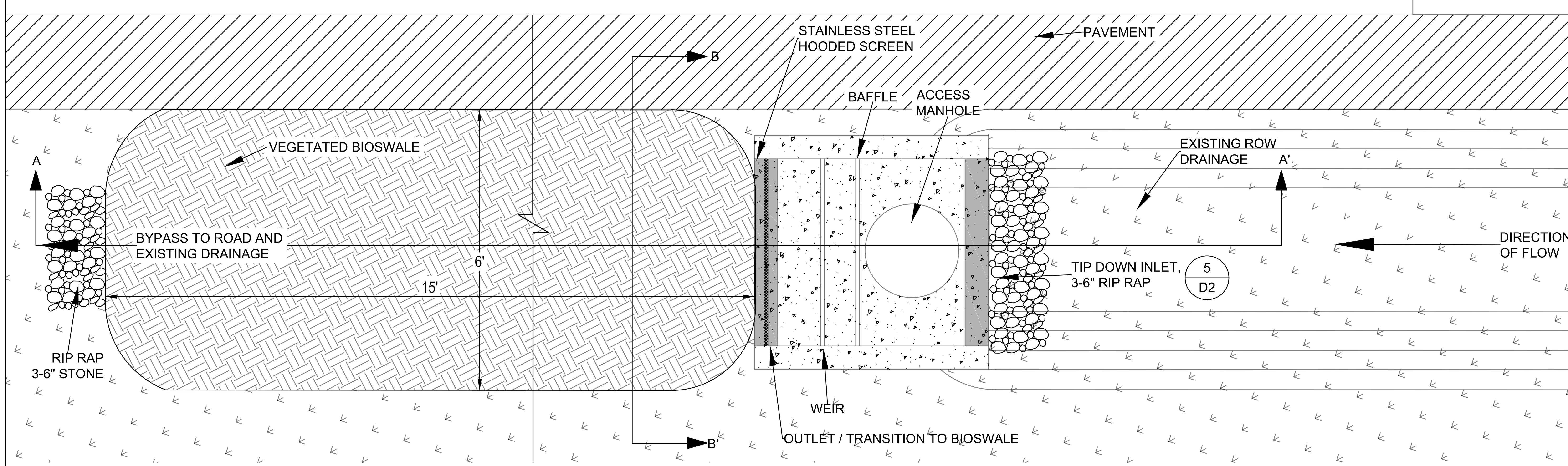
3/D3 PRETREATMENT-BIOSWALE COMBINATION A-A' CROSS SECTION

NOT TO SCALE



5/D3 PRETX CURB DETAILS

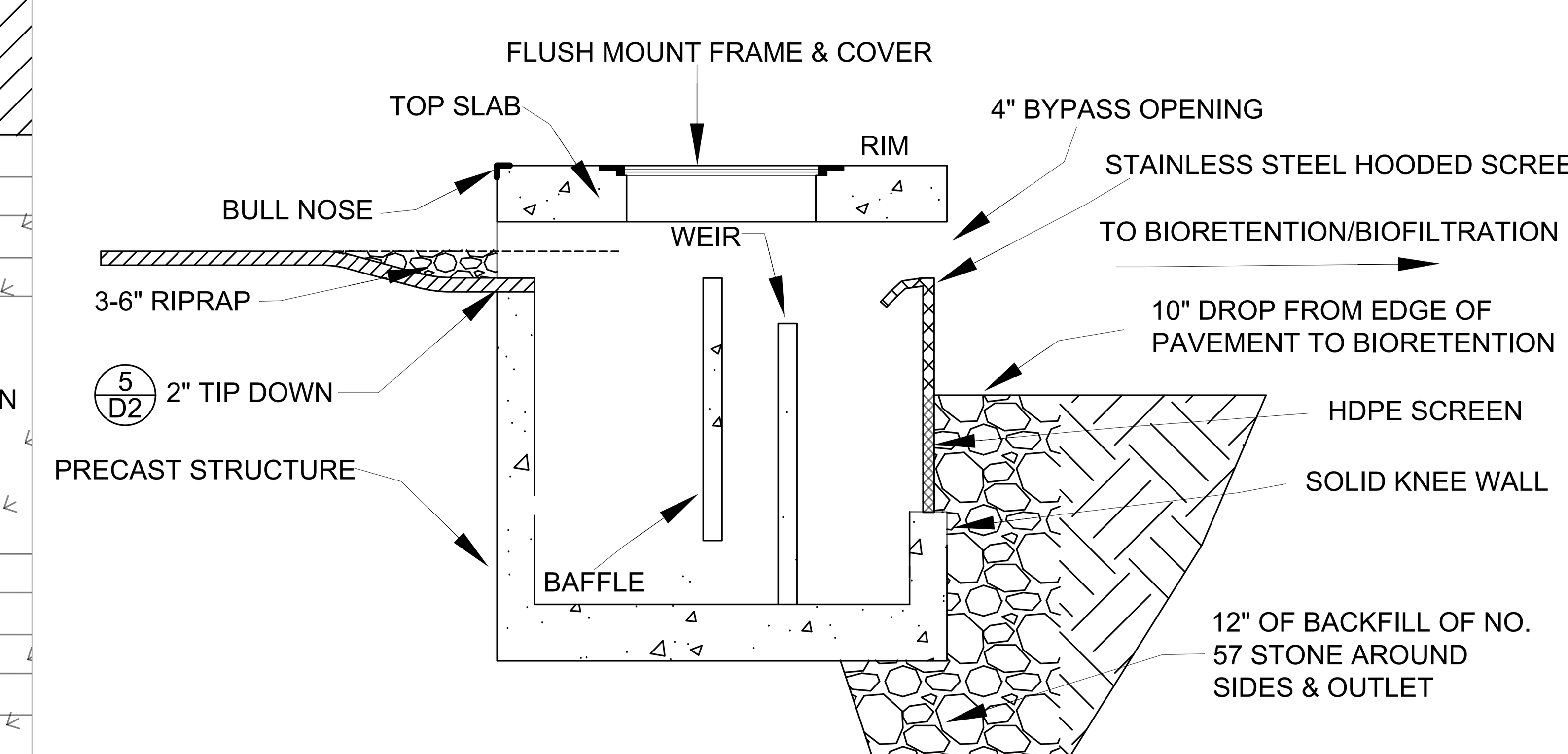
NOT TO SCALE



4/D3 PRETREATMENT CATCH BASIN OUTLET TO BIORETENTION CONFIGURATION

NOT TO SCALE

NOTES:
1. SEE DRAINAGE PLAN FOR STRUCTURE ELEVATION AND INVERTS, PIPE TYPE, LENGTH AND SLOPE, AND BIORETENTION AREA DIMENSIONS.



NOTES:
1. PRETX DEEP SUMP HOODED CATCH BASIN SYSTEMS BY ACF ARE A PRE-FILTER AND CRITICAL MAINTENANCE DEVICE THAT EXTENDS THE OPERATING LIFE AND REDUCES THE MAINTENANCE BURDEN OF BIORETENTION SYSTEMS, RAIN GARDENS, AND BIOSWALES BY FILTERING OUT SEDIMENT, TRASH AND DEBRIS AT THE INLET.

6/D3 PRETREATMENT CATCH BASIN INLET DETAIL

NOT TO SCALE

This Drawing shall not be used for Construction unless Signed and Sealed For Construction.

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
INNOVATIVE STORMWATER MANAGEMENT
9 GRETA'S WAY
STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY

MILL POND NUTRIENT CONTROL MEASURES

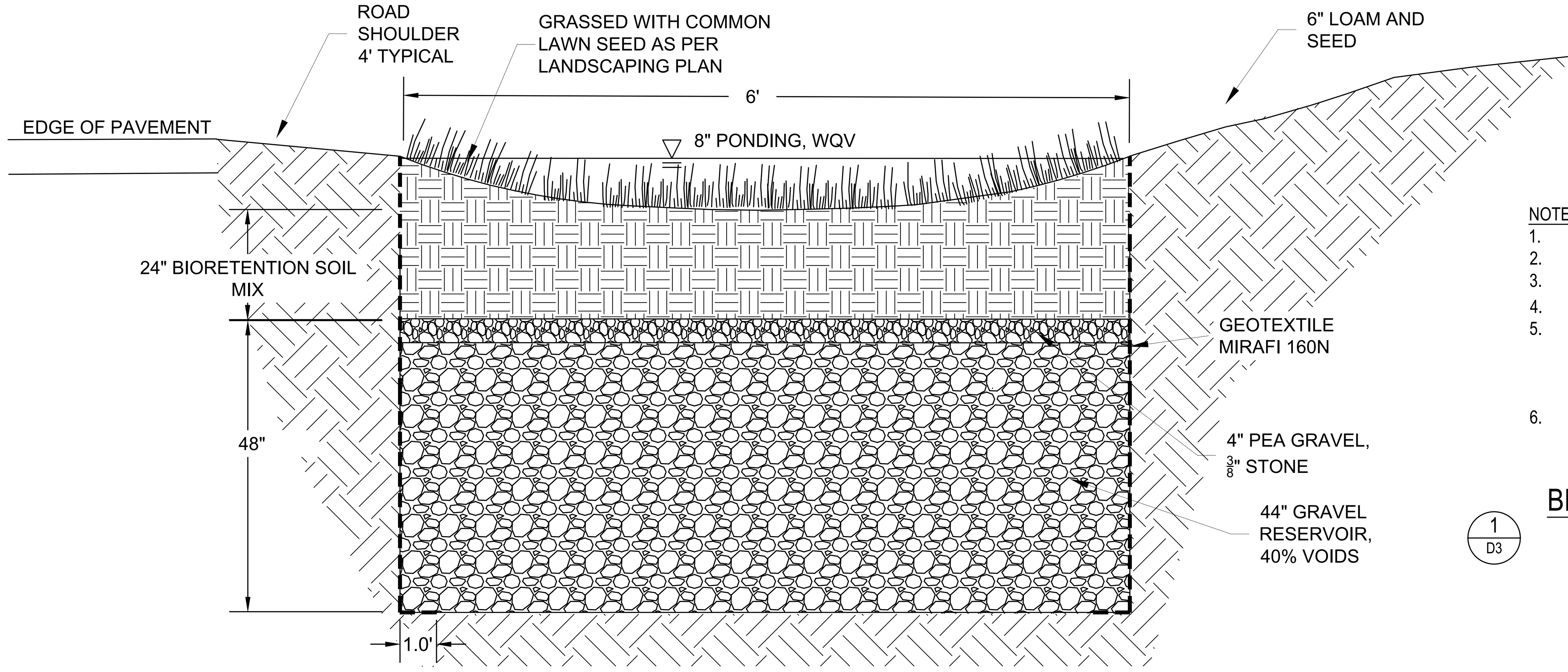
PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

DRAINAGE DETAILS

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	7

D1

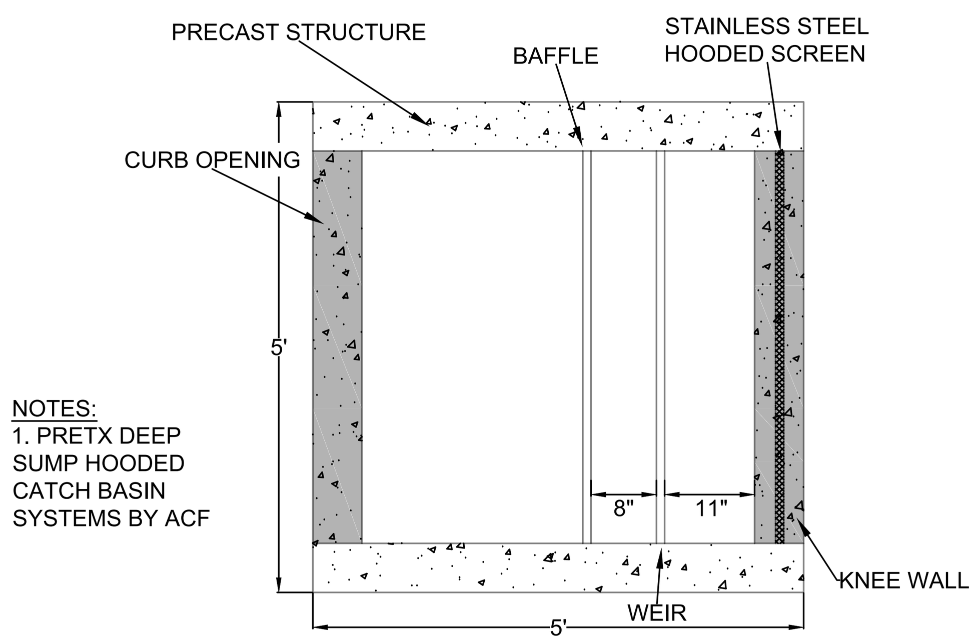


NOTES:

1. BIORETENTION SOIL MIX SHALL CONSIST OF 40% LOAM, 60% SAND.
2. DO NOT COMPACT SUBGRADE AT BOTTOM OF EXCAVATION.
3. NO BIORETENTION SOIL MIX SHALL BE PLACED UNTIL AFTER ENGINEERING APPROVAL AND INSPECTION OF SUBGRADE.
4. GRAVEL RESERVOIR SHALL BE ¾" TO 3" STONE WITH 40% VOIDS, ALTERNATIVES ACCEPTABLE UPON APPROVAL.
5. GRASS SEED MIX SHALL BE NEW ENGLAND NATIVE WARM SEASON GRASS MIX WITH A BLEND OF COOL SEASON GRASSES INCLUDED AS A "STARTER" SEED FOR EROSION CONTROL. SPECIES: LITTLE BLUESTEM (SCHIZACHYRIUM SCOPARIUM), BIG BLUESTEM (ANDROPOGON GERARDII), VIRGINIA WILD RYE (ELYMUS VIRGINICUS), INDIAN GRASS (SORGHASTRUM NUTANS), RED FESCUE (FESTUCA RUBRA), SWITCH GRASS (PANICUM VIRGATUM).
6. APPLICATION RATE: 23 LBS/ACRE | 1900 SQ FT/LB.

1 / D3 — BIOSWALE SYSTEM - TYPICAL B-B' CROSS-SECTION

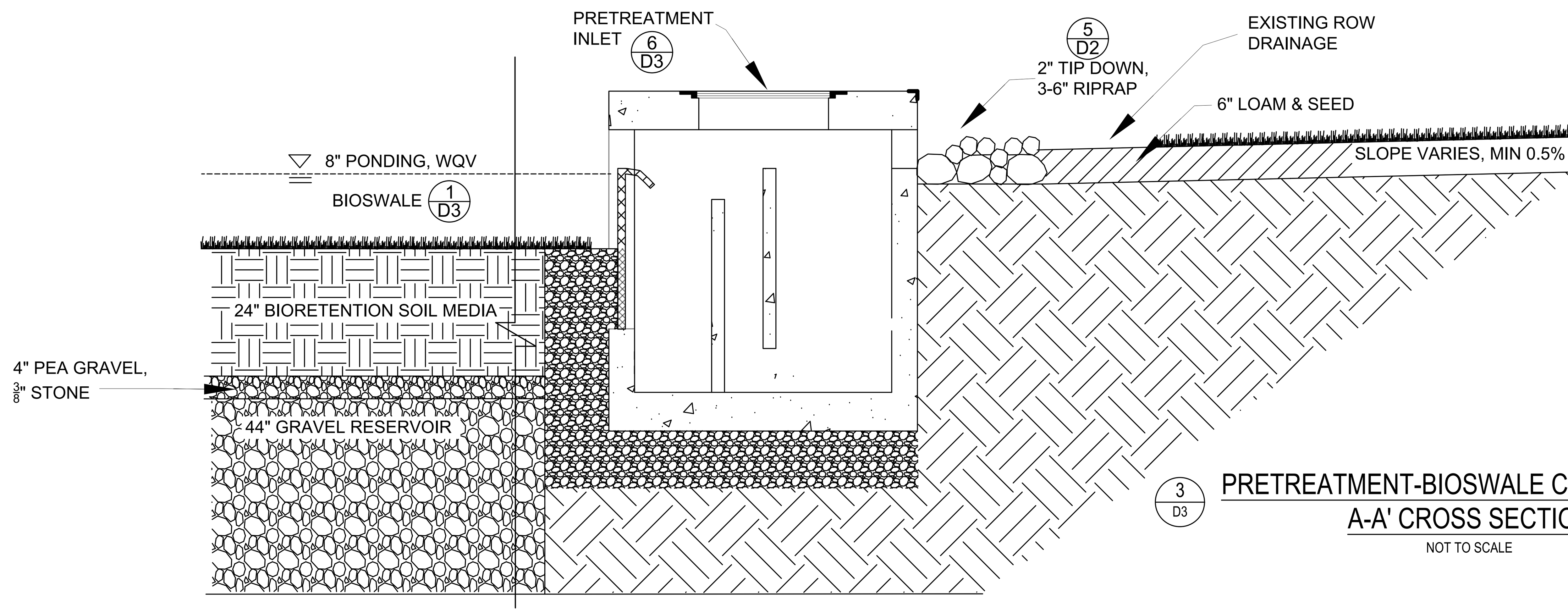
NOT TO SCALE



NOTES:
1. PRETX DEEP SUMP HOODED CATCH BASIN SYSTEMS BY ACF

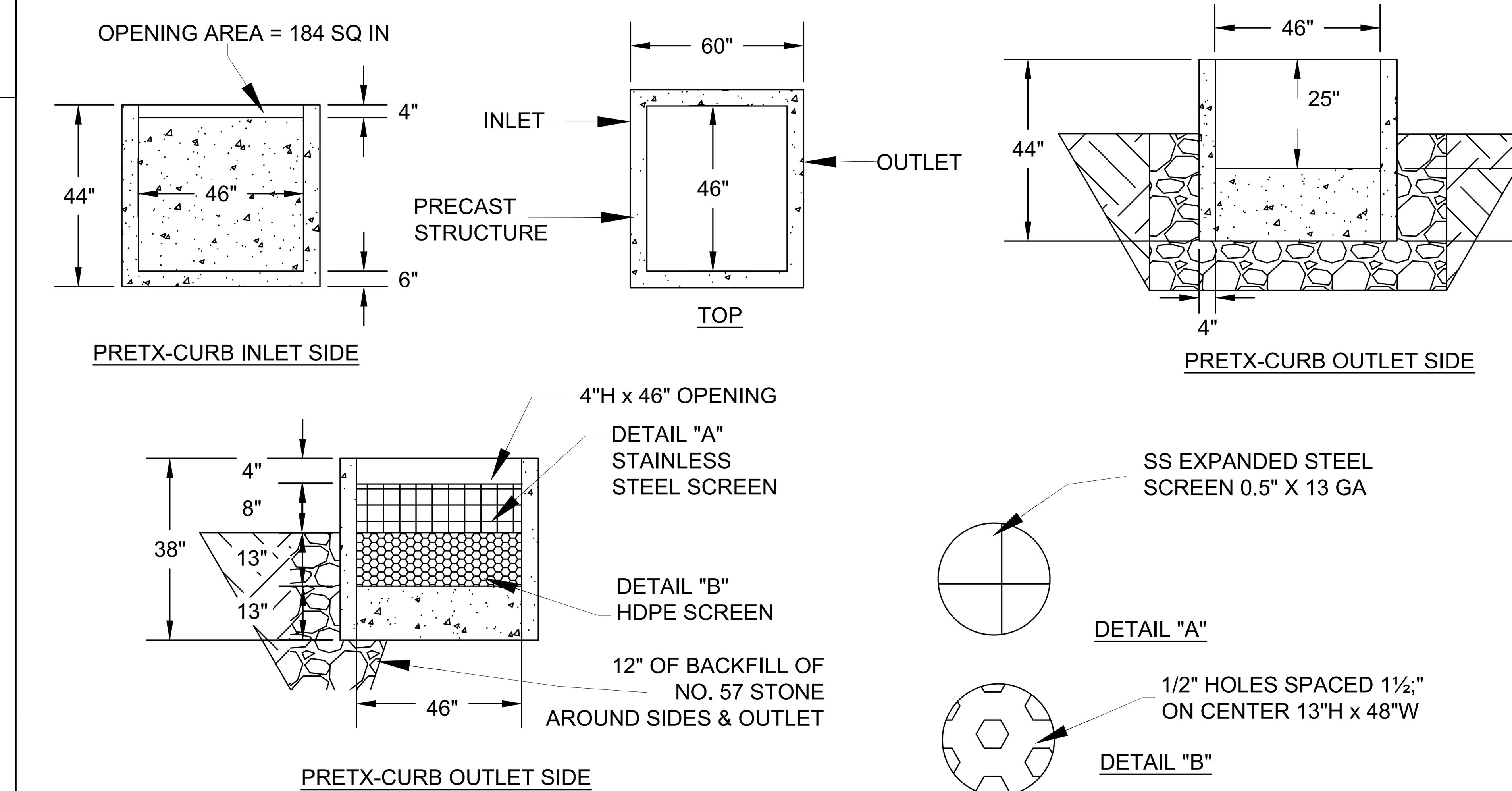
2 / D3 — PRETREATMENT CATCH BASIN PLAN VIEW

NOT TO SCALE



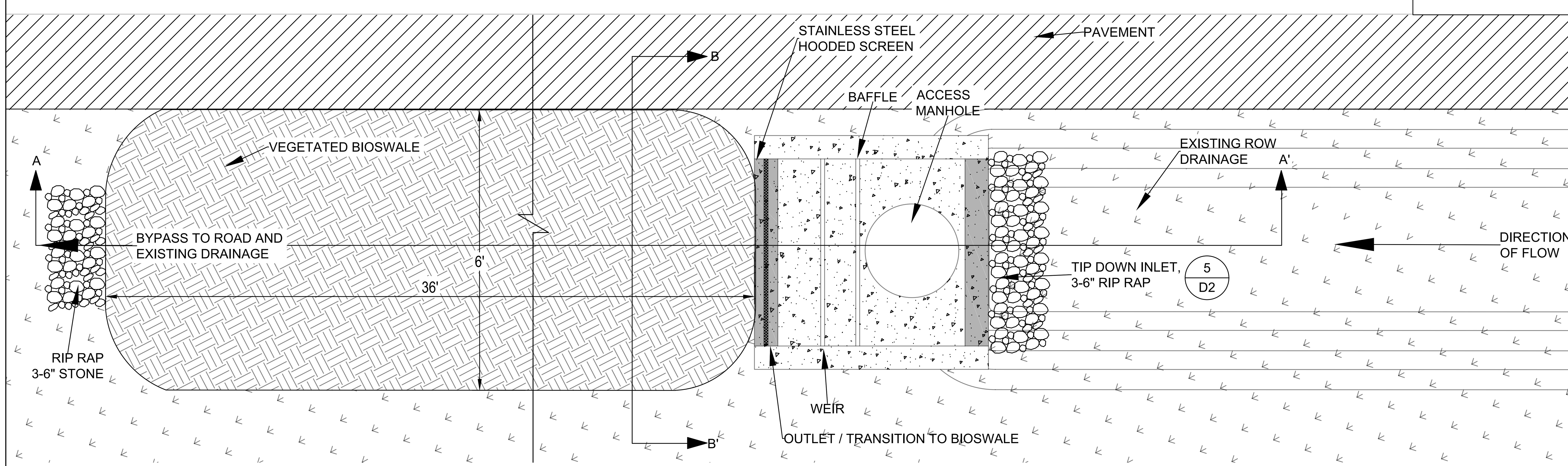
3 / D3 — PRETREATMENT-BIOSWALE COMBINATION A-A' CROSS SECTION

NOT TO SCALE



5 / D3 — PRETX CURB DETAILS

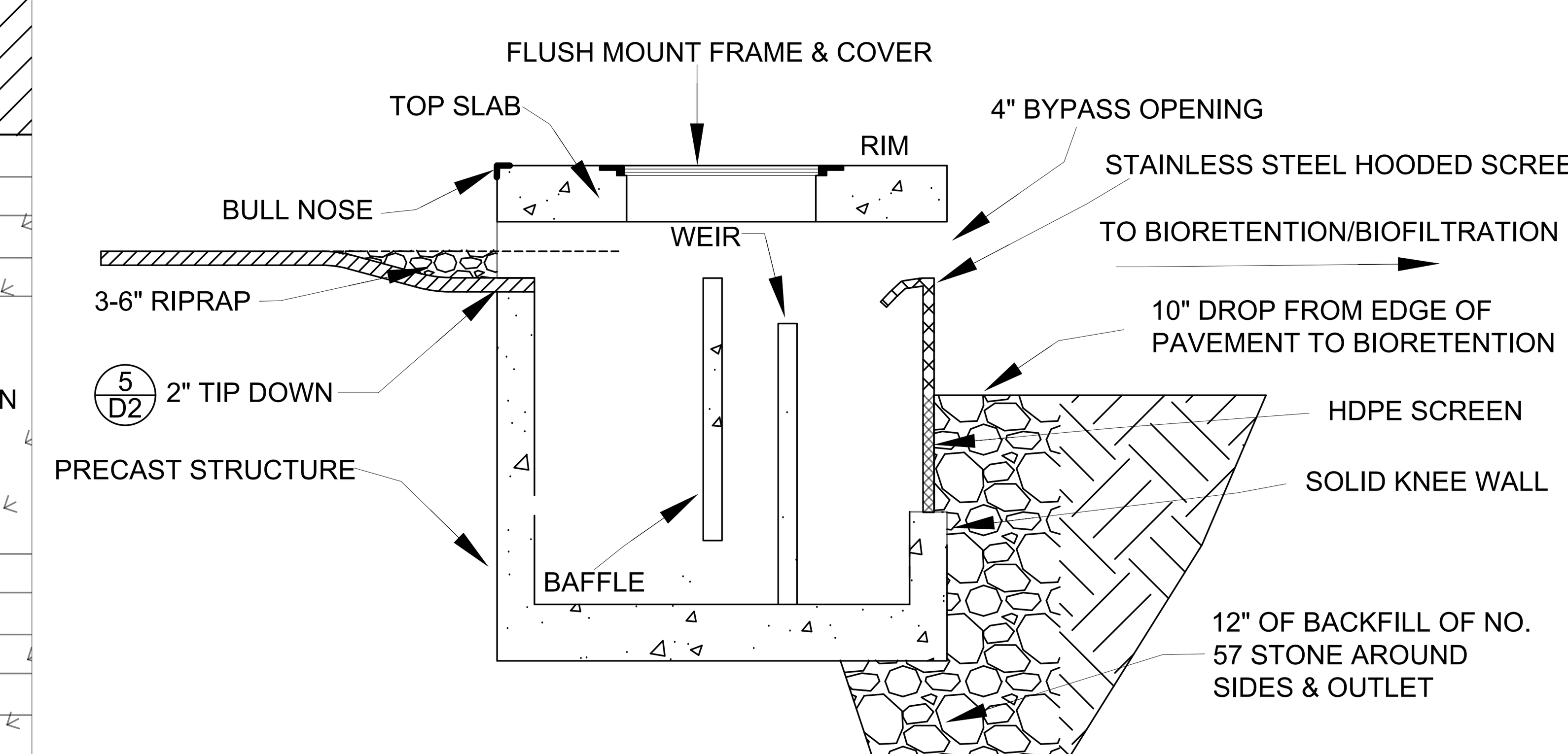
NOT TO SCALE



4 / D3 — PRETREATMENT CATCH BASIN OUTLET TO BIORETENTION CONFIGURATION

NOT TO SCALE

NOTES:
1. SEE DRAINAGE PLAN FOR STRUCTURE ELEVATION AND INVERTS, PIPE TYPE, LENGTH AND SLOPE, AND BIORETENTION AREA DIMENSIONS.



NOTES:
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6 / D3 — PRETREATMENT CATCH BASIN INLET DETAIL

NOT TO SCALE

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

WATERSTONE ENGINEERING
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9 GRETA'S WAY
STRATHAM, NH 03885
(p) 603.686.2488

30% BMP EXAMPLE DESIGNS
FOR THE DURHAM, NH MILL POND STUDY
MILL POND
NUTRIENT CONTROL MEASURES

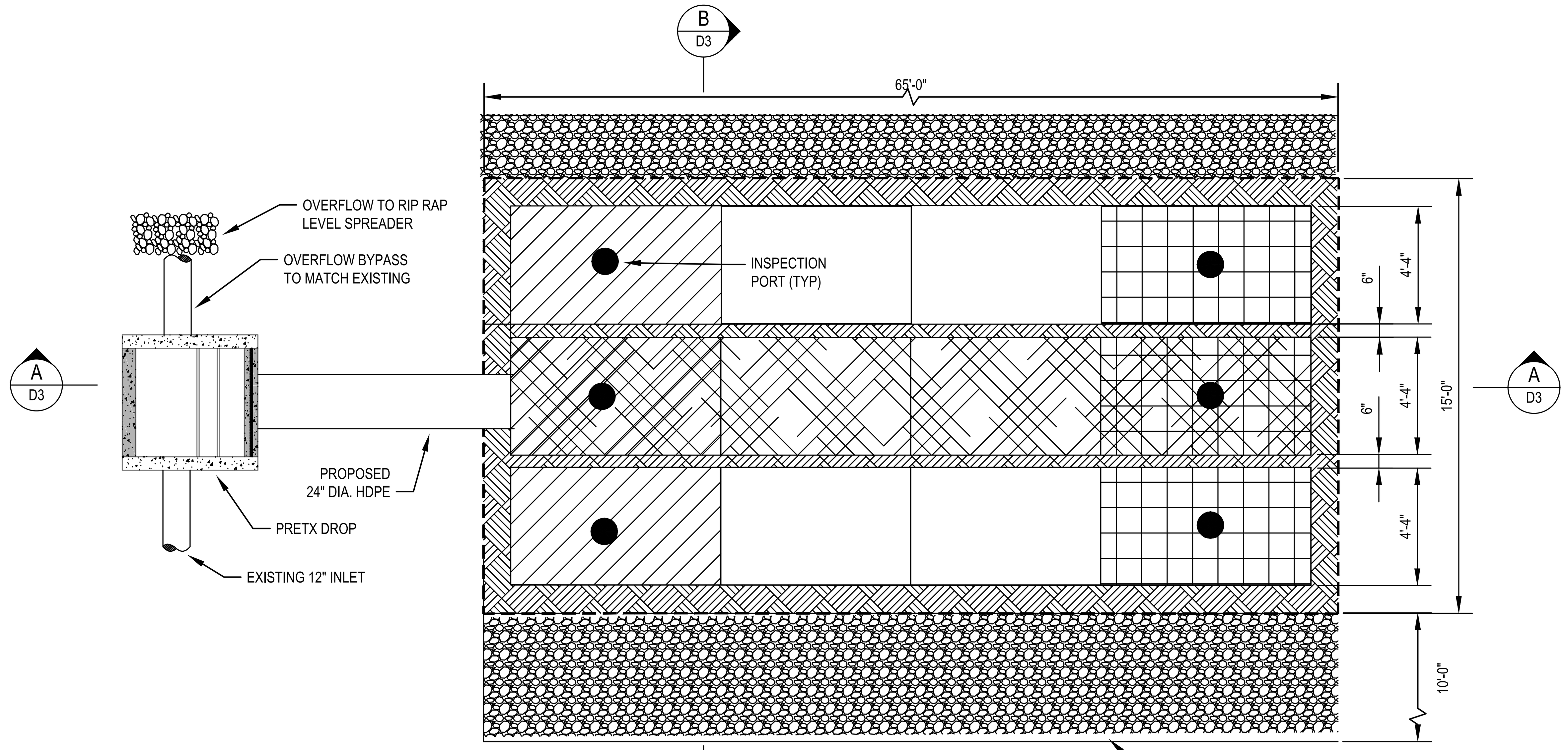
PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

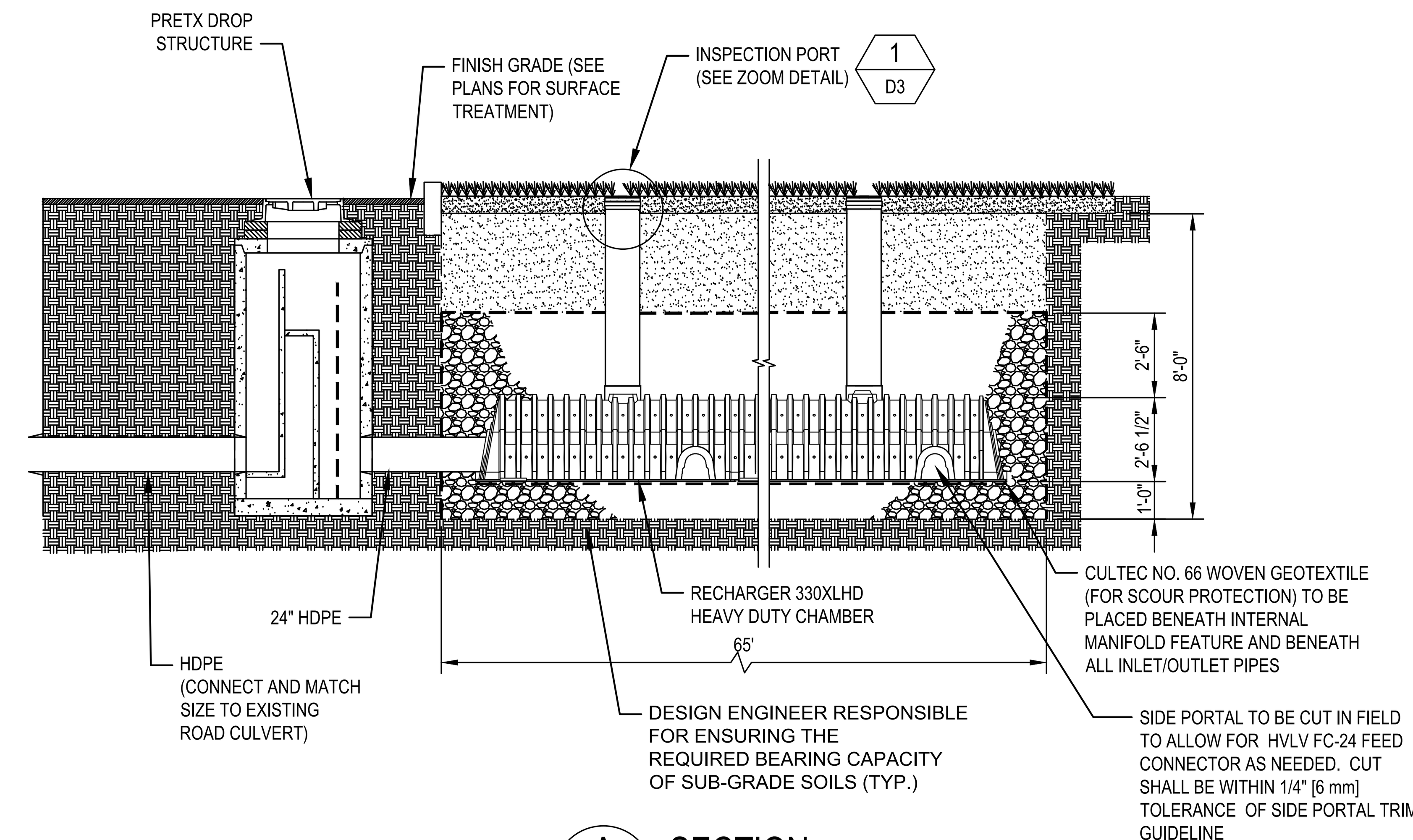
MADBURY ROAD BMP - MR1

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	8

D2

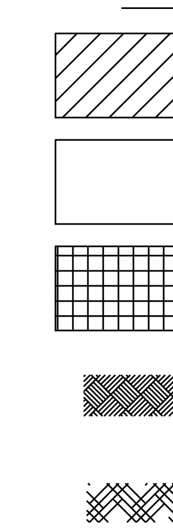


PLAN
CULTEC RECHARGER® 330
STORMWATER MANAGEMENT SYSTEM
NOT TO SCALE



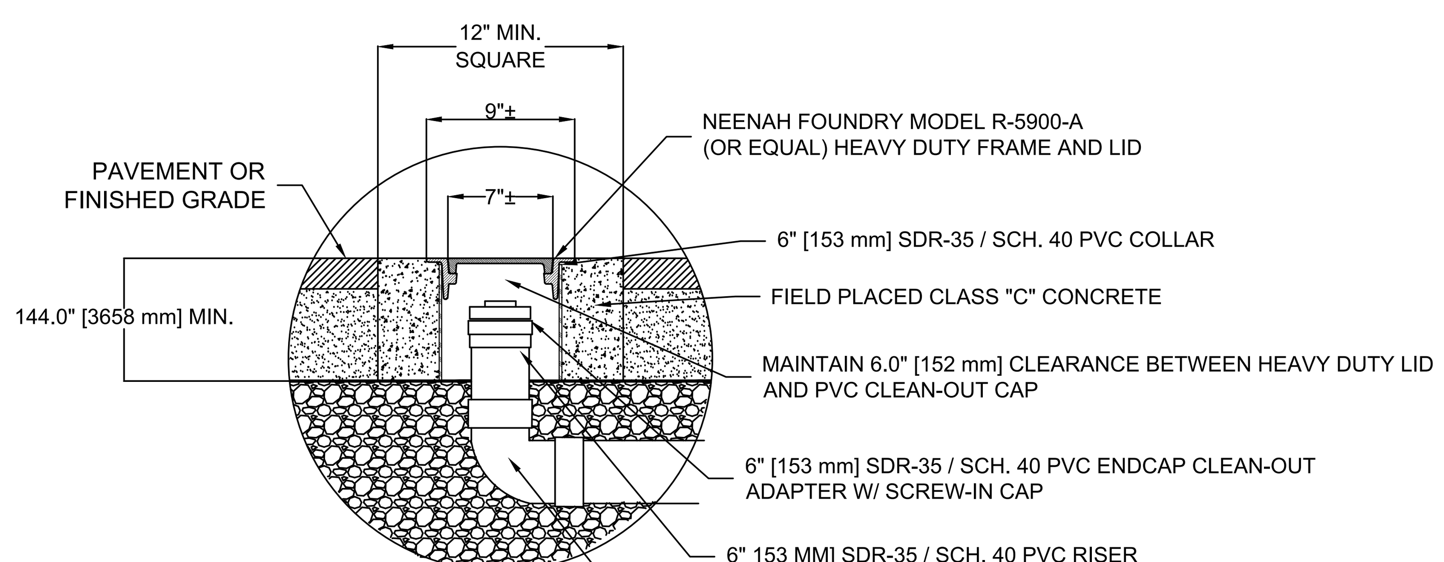
A
D3
SECTION
SCALE : NOT TO SCALE

CULTEC RECHARGER® 330 XLHD LEGEND



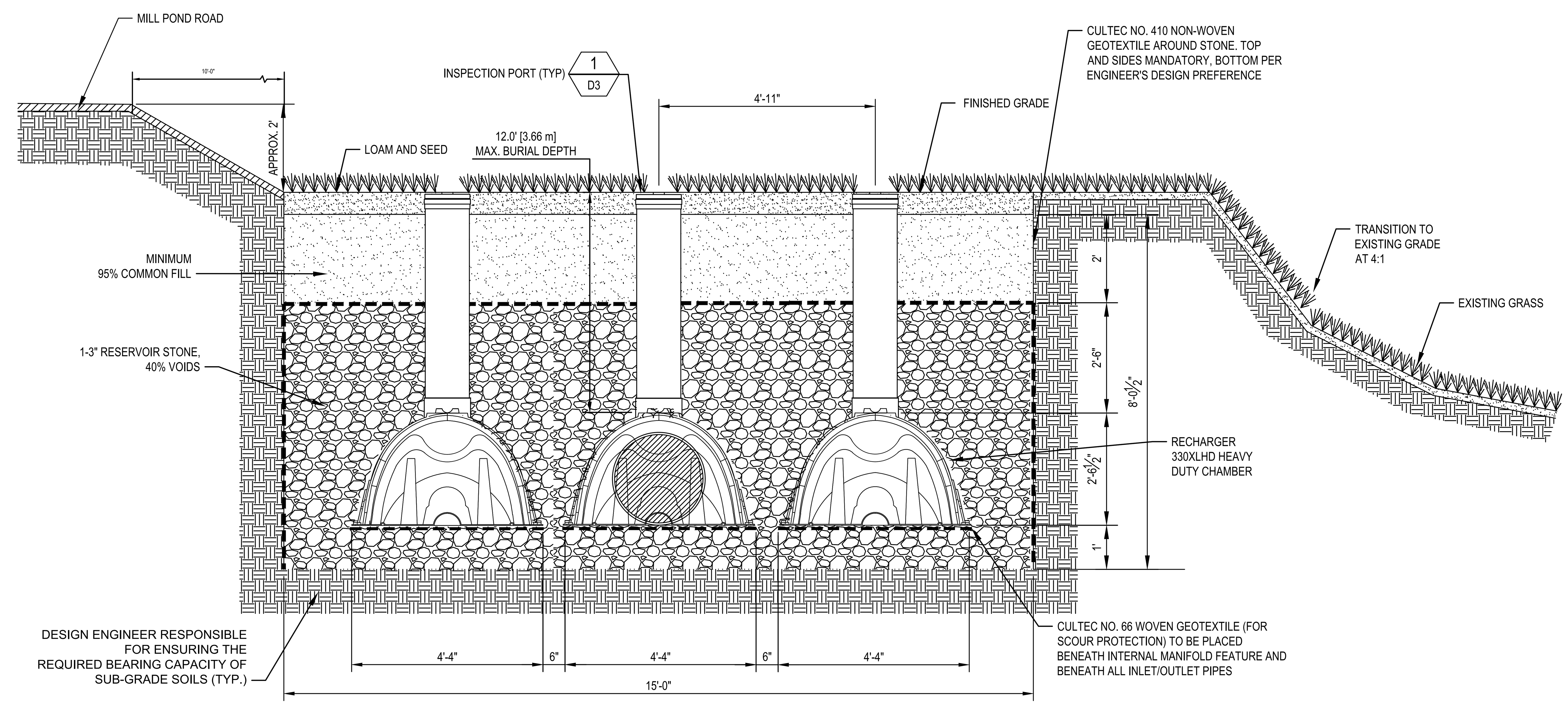
RECHARGER 330XLSHD STARTER
RECHARGER 330XLIHD INTERMEDIATE
RECHARGER 330XLEHD END
CULTEC NO. 66 WOVEN GEOTEXTILE
CULTEC NO. 410 NON-WOVEN GEOTEXTILE

TEST PITS
TEST PITS MUST BE CONDUCTED AT EACH LOCATION TO VERIFY SOILS AND SEASONAL HIGH WATER TABLE



1
D3
INSPECTION PORT DETAIL
NOT TO SCALE

MATERIALS LIST		
(SEE COVER SHEET FOR COMBINED PROJECT MATERIALS LIST)		
RECHARGER 330XLSHD STARTER		PIECES
RECHARGER 330XLIHD INTERMEDIATE		PIECES
RECHARGER 330XLEHD END		PIECES
CULTEC NO. 66 WOVEN GEOTEXTILE 7.5' x 300'		LINEAL FEET
SEPARATOR ROW MATERIALS LIST		
CULTEC NO. 410 NON-WOVEN GEOTEXTILE 7.5' x 300' (TO WRAP SEPARATOR ROW)		SQ. YDS
CULTEC NO. 66 WOVEN GEOTEXTILE 7.5' x 300' (BENEATH SEPARATOR ROW)		ROLLS



B
D3
SECTION
SCALE : NOT TO SCALE

NOTES:
1. ALL ELECTRIC, GAS, TEL. WATER, SEWER AND DRAIN SERVICES ARE SHOWN IN SCHEMATIC FASHION, THEIR LOCATIONS ARE NOT PRECISE OR NECESSARILY ACCURATE. NO WORK WHATSOEVER SHALL BE UNDERTAKEN ON THIS SITE USING THIS PLAN TO LOCATE THE ABOVE SERVICES. CONSULT WITH THE PROPER AUTHORITIES CONCERNED WITH THE SUBJECT SERVICE LOCATIONS FOR INFORMATION REGARDING SUCH. CALL DIG-SAFE AT 811.
2. UNDERGROUND UTILITIES SHOWN ARE APPROXIMATE. EXACT LOCATIONS OF EXISTING UNDERGROUND UTILITIES SHALL BE DETERMINED BY THE CONTRACTOR IN THE FIELD PRIOR TO CONSTRUCTION.

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

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(p) 603.686.2488

30% BMP EXAMPLE DESIGNS FOR THE DURHAM, NH MILL POND STUDY
MILL POND NUTRIENT CONTROL MEASURES

PREPARED FOR:
TOWN OF DURHAM
8 NEWMARKET ROAD
DURHAM, NH 03824

DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

MILL POND ROAD BMP - MP1

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	9

D3

PRETX SPECIFICATIONS

A. GENERAL

1. PRETX SYSTEMS ARE A PRE-FILTER AND CRITICAL MAINTENANCE DEVICE THAT EXTENDS THE OPERATING LIFE AND REDUCES THE MAINTENANCE BURDEN OF BIORETENTION SYSTEMS, RAIN GARDENS, BIOSWALES AND OTHER TYPES OF SURFACE BEST MANAGEMENT PRACTICES BY FILTERING OUT SEDIMENT, TRASH AND DEBRIS AT THE INLET.

B. PRODUCTS

1. PRETX IS AVAILABLE IN 3 MODELS THAT MANAGE MOST BIORETENTIOIN INLET CONFIGURATIONS: CURB, DROP, AND INLINE.
2. PRETX-CURB IS FOR EDGE OF PAVEMENT RUNOFF AT A CURB CUT IN LIEU OF A STONE SPREADER.
3. PRETX-DROP IS FOR USE AS A DROP INLET CONFIGURATION ALONG A CURB LINE AND WOULD BE INSTALLED WITH A STANDARD DROP INLET GRATE.
4. PRETX-INLINE IS FOR USE WITH SUBSURFACE INLET AND OUTLET PIPE.
5. PRETX IS SIZED TO PRETREAT WATER QUALITY FLOWS AND BYPASS LARGER FLOWS THAT HAVE MINIMAL TRASH AND DEBRIS. PRETX CAN BE USED BOTH IN RETROFIT OR NEW INSTALLATIONS.
6. ACCEPTABLE SYSTEM SUPPLIER:
   CONVERGENT WATER TECHNOLOGIES, INC. OR ITS AUTHORIZED VALUE-ADDED RESELLER
   (800) 711-5428
   WWW.CONVERGENTWATER.COM

C. SUBMITTALS

1. SUBMIT PROPOSED LAYOUT DRAWINGS. DRAWINGS SHALL INCLUDE TYPICAL SECTION DETAILS ANNOTED WITH SYSTEM ELEVATIONS (E.G., RIM, PIPE INVERTS, OUTSIDE BOTTOM OF STRUCTURE, ETC.).
2. SUBMIT MATERIAL CERTIFICATES FOR FRAMES AND COVERS
3. ANY PROPOSED EQUAL ALTERNATE PRODUCT SUBSTITUION TO THIS SPECIFICATON MUST BE SUBMITTED FOR REVIEW AND APPROVED PRIOR TO BID OPENING.

D. EXECUTION

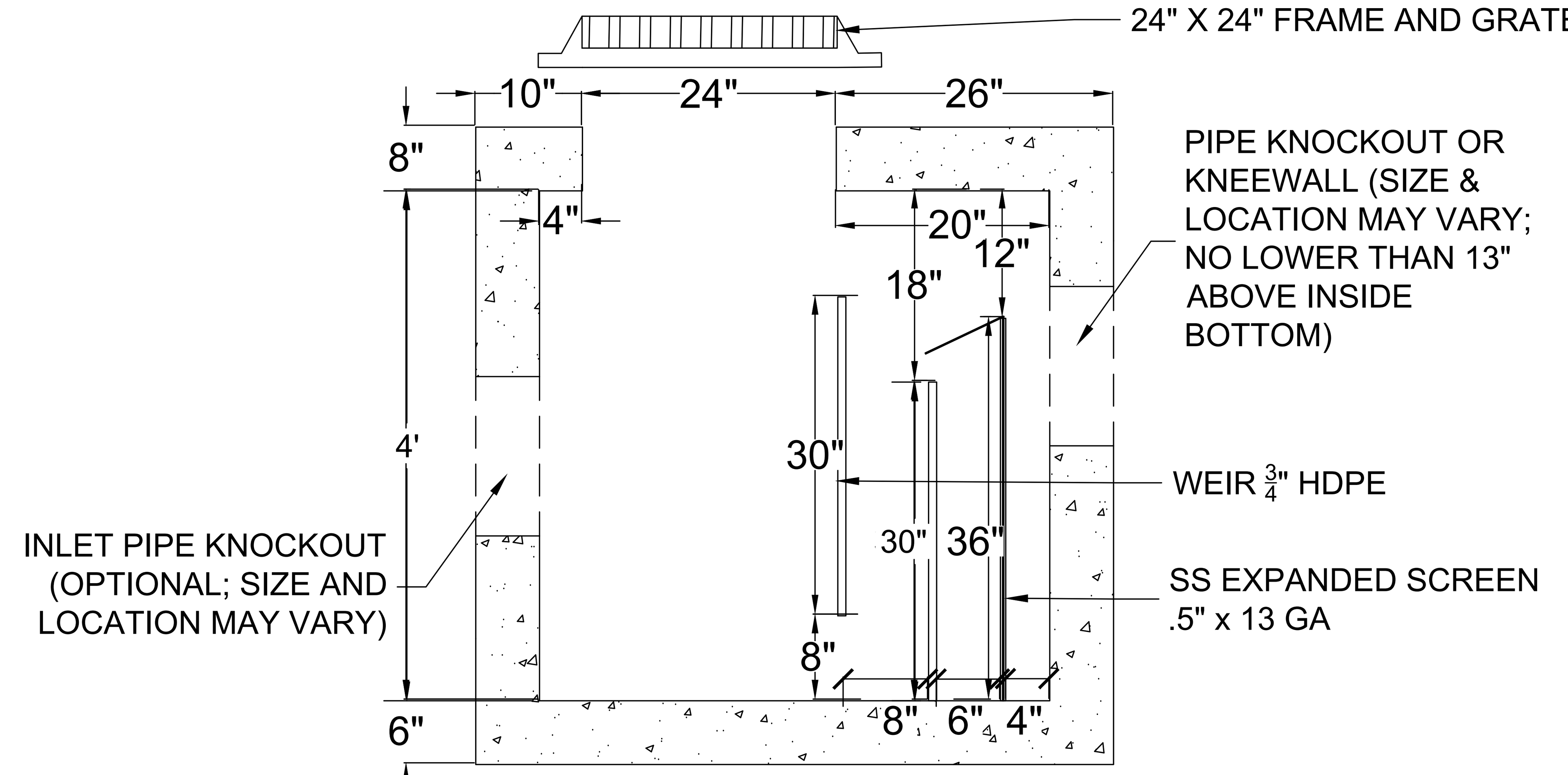
1. All PUBLIC STORM DRAINAGE SYSTEMS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE LATEST EDITION OF THE STATE DEPARTMENT OF TRANSPORTATION STANDARDS AND SPECIFICATIONS AND ACCORDING TO LOCAL MUNICIPAL REQ UIREME NTS.
2. All STORM DRAINAGE SYSTEM CONSTRUCTION IS SUBJECT TO INSPECTION AND APPROVAL BY THE PROJECT ENGINEER.
3. THE CONTRACTOR SHALL NOTIFYTHE PROJECT ENGINEER A MINIMUM OF TWO FULL BUSINESS DAYS PRIOR TO THE START OF CONSTRUCTIO N.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONTACTING AND OBTAINING APPROVAL FROM DIG-SAFE AND DETERMINING THE LOCATION OF All UNDERGROUND UTILITIES PRIOR TO THE START OF CONSTRUCTION/ EXCAVATI ON AND SHALL NOTIFY THE PROJECT ENGINEER OF ANY POTENTIAL CONFLICTS.
5. TO PROTECT STORMWATER FLOW CONTROL AND QUALITY TREATMENT FACILITIES FROM SEDIMENTATION, THEY SHALL BE CONNECTED TO THE STORM CONVEYANCE SYSTEM ONLY AFTER ALL SITE WORK, ROAD CONSTRUCTION, UTILITY WORK AND LANDSCAPING ARE IN PLACE IN ALL AREAS ABOVE AND UPSTREAM OF THE FACILITY.
6. THE EXISTING STORM SEWER SYSTEM SHALL STAY ISOLATED FROM THE NEW SYSTEM UNTIL THE NEW SYSTEM IS CLEANED, AND APPROVED FOR USE. THERE SHALL BE NO DEBRIS IN THE LINES OR FURTHER CLEANING Will BE REQUIRED PRIOR TO ACCEPTANCE.
7. PROVIDE A 1.5" MINIMUM GAP BETWEEN THE KNOCKOUT WALL AND THE OUTSIDE OF THE PIPE. AFTER THE PIPE IS INSTALLED, FILL THE GAP WITH JOINT MORTAR
8. THE OPENING SHALL BE MEASURED ATTHE TOP OF THE PRECAST BASE SECTION.
9. All PICKUP HOLES SHALL BE GROUTED FULL AFTER THE BASIN HAS BEEN PLACED.
10. STANDARD CURB INLETS AND TIPDOWNS SHALL BE PRECAST CONCRETE OR ASPHALT.
11. PIPE ENDS SHALL BE FLUSH WITH THE INNER WALL OR 1" MAXIMUM INTRUSION. MASONRY, CINDER BLOCKS, OR SIMILIAR MATERIALS MA Y BE USED TO ADJUST THE RISERS TO GRADE PRIOR TO GROUTING.
12. GROUTING SHALL BE SUFFICIENTTO PREVENT LEAKS BETWEEN THE PRECAST COMPONENTS OF THE COMPLETED STRUCTURE & SHALL BE PERFORMED INSIDE, BETWEEN & OUTSIDE OF All RISERS, JOINTS & PIPE PENETRATIONS.
13. MANHOLES TO BE CONSTRUCTED IN ACCORDANCE WITH AASHTO M-199 UNLESS OTHERWISE SHOWN ON PLANS OR NOTED IN THE STANDARD SPECIFICATIONS.
14. All REINFORCED CAST IN PLACE CONCRETE SHALL BE CLASS 4000. All PRECAST CONCRETE SHALL BE CLASS 4000.
15. RECAST BASES SHALL BE FURNISHED WITH CUTOUTS OR KNOCKOUTS. KNOCKOUTS SHALL HAVE A WALL THICKNESS OF 2" MINIMUM.
16. MATING SURFACES OF MANHOLE RINGS AND COVERSSHALL BE FINISHED TO ASSURE NON-ROCKING FIT WITH ANY COVER POSITIONS.

E. CONSTRUCTION AND SEQUENCING

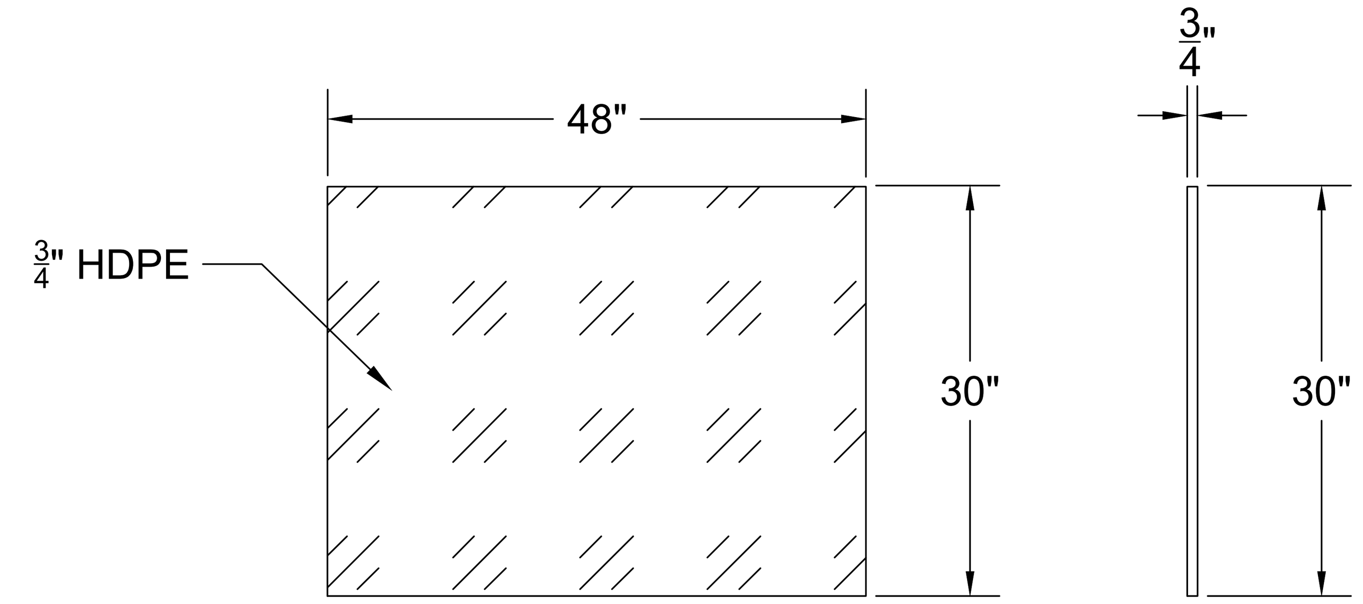
1. EXAMINATION
   A. VERIFY LAYOUT AND ORIENTATION OF PRE-TX SYSTEM AREA INCLUDING EDGE OF PAVEMENT, TIP DOWN, CURBS AND SIDEWALK, BIOFILTRATION SYSTEM, AND CONNECTIONS.
   B. VERIFY EXCAVATION BASE IS READY TO RECEIVE WORK AND EXCAVATIONS, DIMENSIONS, AND ELEVATIONS ARE AS INDICATED ON DRAWINGS.
2. PREPARATION
   A. CALL DIG SAFE AND RECEIVE APPROVAL BEFORE PERFORMING WORK.
   B. REQUEST UNDERGROUND UTILITIES TO BE LOCATED AND MARKED WITHIN AND SURROUNDING CONSTRUCTION AREAS.
   C. IDENTIFY REQUIRED LINES, LEVELS, CONTOURS, AND DATUM.
   D. CLEAR AND GRUB THE PROPOSED PRE-TX SYSTEM AREA.
3. EXCAVATION AND INSTALLATION
   A. THE FOLLOWING CONSTRUCTION SEQUENCE IS TO BE USED AS A GENERAL GUIDELINE. COORDINATE WITH THE OWNER, AND ENGINEERS FOR REVIEW AND APPROVAL PRIOR TO CONSTRUCTION.
   B. INSTALL TEMPORARY EROSION AND SEDIMENT CONTROLS TO DIVERT STORM WATER AWAY FROM THE PRE-TX SYSTEM AREA.
   C. EXCAVATE TO THE BOTTOM INVERT OF THE SYSTEM.
   D. TO MINIMIZE COMPACTION OF ADJACENT BIOFILTRATION SYSTEMS, WORK EXCAVATORS OR BACKHOES FROM THE SIDES TO EXCAVATE THE PRE-TX SYSTEM AREA TO ITS APPROPRIATE DESIGN DEPTH AND DIMENSIONS.
   E. ROUGH GRADE THE PRE-TX SYSTEM AREA DURING GENERAL CONSTRUCTION. EXCAVATE THE PRE-TX SYSTEM FACILITIES TO WITHIN 1 FOOT OF STRUCTURE BOTTOM .
   F. PLACE 1 FOOT BED OF COARSE STONE TO ELEVATION OF BASE OF STRUCTURE.
   G. ESTABLISH ELEVATIONS FOR ADJACENT CURBS, EDGE OF PAVEMENT AND TIP DOWN, SIDEWALK, PIPE INVERTS FOR INLETS AND OUTLETS AS INDICATED ON DRAWINGS.
4. INSTALLATION
   A. PLACE THE PRECAST SYSTEM TO NECESSARY ELEVATION.
   B. VERIFY ELEVATIONS FOR ADJACENT CURBS, EDGE OF PAVEMENT, PAVEMENT GRADING FOR INLET GRATE FOR PRETX-DROP, SIDEWALK, PIPE INVERTS FOR INLETS AND OUTLETS, OUTLET INVERT FOR KNEE WALL.
   C. FOR PRETX-SURFACE:
      a. VERIFY ELEVATIONS FOR ADJACENT CURBS.
      b. VERIFY EDGE OF PAVEMENT TIP DOWN PAVEMENT GRADING FOR INLET GRATE.
      c. VERIFY CURB ELEVATION IN RELATION TO PAVEMENT AND TIP DOWN.
      d. VERIFY OUTLET INVERT FOR KNEE WALL IN RELATION TO FILTER MEDIA.
   D. FOR PRETX-DROP:
      a. VERIFY ALL INLET PIPES ENTER THE STRUCTURE UPSTREAM OF BAFFLE.
      b. VERIFY FRAME AND GRATE OFFSET ON INLET SIDE AND UPSTREAM OF BAFFLE.
      c. VERIFY CURB LOCATION WITH RESPECT TO FRAME AND GRATE ORIENTATION.
   E. INSTALL BAFFLES, WEIR, AND SCREENS AS INDICATED ON DRAWINGS.
   F. VERIFY MAINTENANCE ACCESS THROUGH GRATE OR COVER AND CLEARANCE FOR VACTOR.
   G. INSTALL TOP OF STRUCTURE LEVEL WITH ADJACENT CURB OR SIDEWALK AS PER MANUFACTURERS SPECIFICATIONS. ENGINEER FIELD VISIT REQUIRED PRIOR TO BACKFILLING.
5. BACKFILLING
   A. BACKFILL WITH APPROVED SOIL AND STONE TO THE DESIGN GRADE AS SPECIFIED IN THE DRAWINGS.
   B. BACKFILL WITH 12” OF NO. 57 STONE AROUND REAR, LEFT, AND RIGHT SIDES TO LEVEL WITH TOP OF HDPE SCREEN.
   C. BACKFILL WITH BIORETENTION SOIL MIX BEYOND STONE BACKFILL TO EQUAL ELEVATION OF THE TOP OF HDPE SCREEN.
   D. DO NOT BACKFILL SOIL OR STONE AGAINST STAINLESS SCREEN.
   E. DO NOT COMPACT ADJACENT FILTRATION SYSTEM SOIL WITH MECHANICAL EQUIPMENT.
   F. STABILIZE All REMAINING DISTURBED AREAS AND SIDE SLOPES WITH SEEDING, HYDROSEEDING, AND/ ORinformEROSION CONTROL BLANKETS AS INDICATED ON DRAWINGS.
6. CLEAN UP
   A. AFTER COMPLETION OF THE WORK, REMOVE AND PROPERLY DISPOSE ALL DEBRIS, CONSTRUCTION MATERIA LS, RUBBISH, EXCESS SOIL, ETC., FROM THE PROJECT SITE. REPAIR PROMPTL Y ANY IDENTIFIED DEFICIENCIES AND LEAVE THE PROJECT SITE IN A CLEAN AND SATISFACTORY CONDITION.

F. PRECAST AND STRUCTURE ALIGNMENT

1. ALIGNMENT
   A. INLET SIDE AND LOCATION OFFSET GRATE TO BE ALIGNED WITH CURB.
   B. GRATE AND INLINE PIPES MUST ENTER UPSTREAM OF BAFFLE.
2. STANDARD HEAVY DUTY FRAME AND GRATE 24" X 24"
3. PICK WEIGHT APPROX.: TOP SLAB = 1,850 LBS BASE = 7,178 LBS
4. CONCRETE: 4,000 PSI MINIMUM AFTER 28 DAYS HS-20 DESIGN LOADING PER AASHTO HS-20-44 ASTM C478 SPEC FOR PRECAST REINFORCED CONCRETE MH SECTIONS
5. BAFFLES: B1 - $\frac{3}{4}$" HDPE
   B2 - $\frac{3}{4}$" HDPE
   B3 - .5" X 13 GA EXPANDED SS SHEET



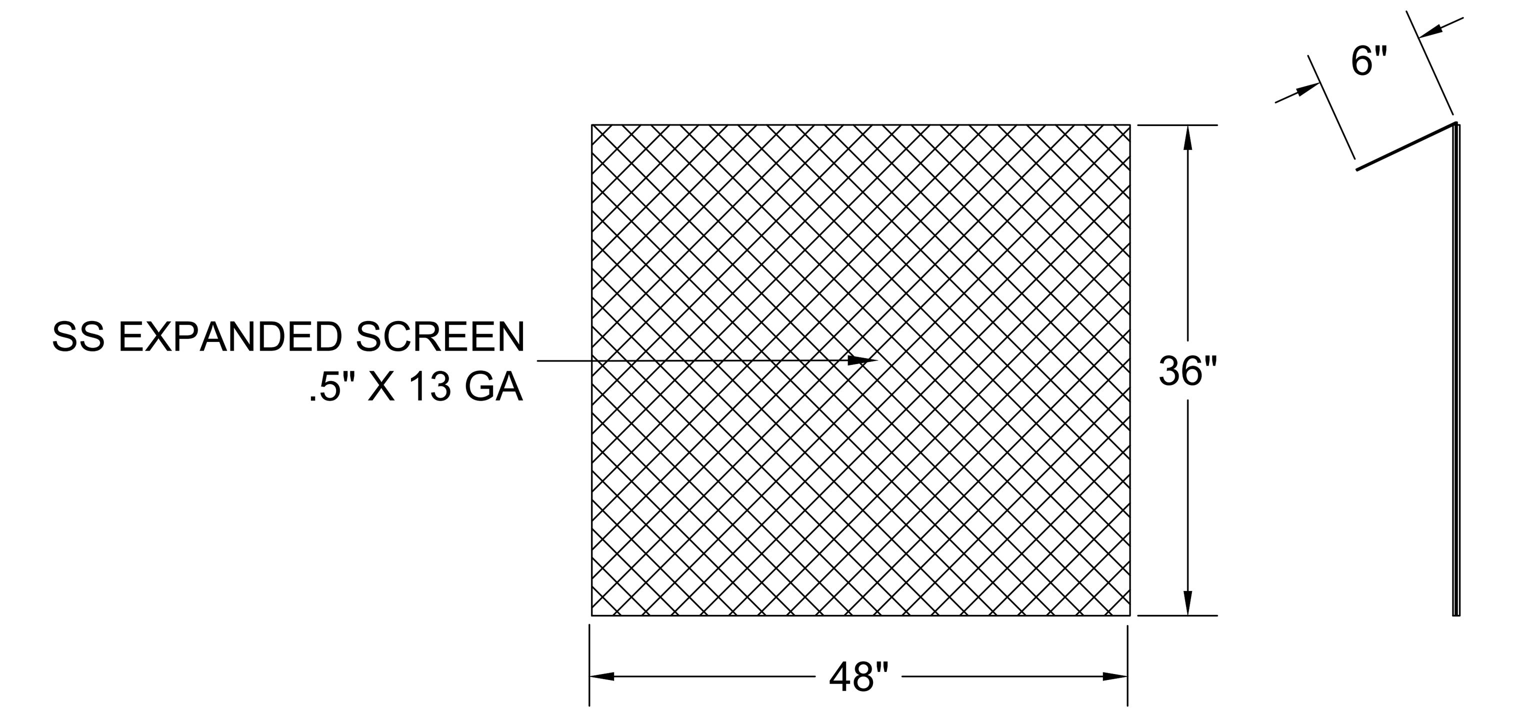
CROSS SECTION A-A



FRONT VIEW

SIDE VIEW

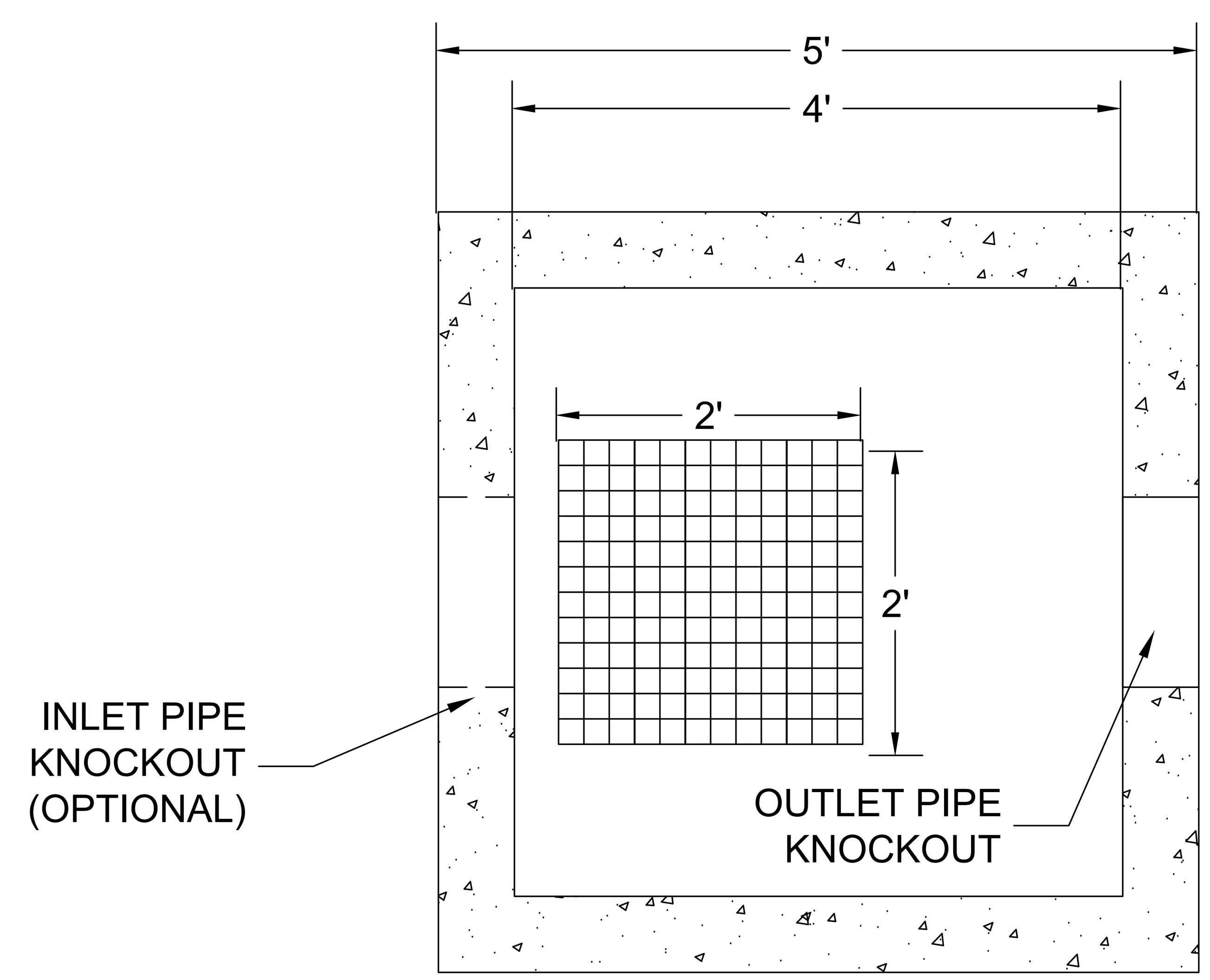
BAFFLE 1 & 2



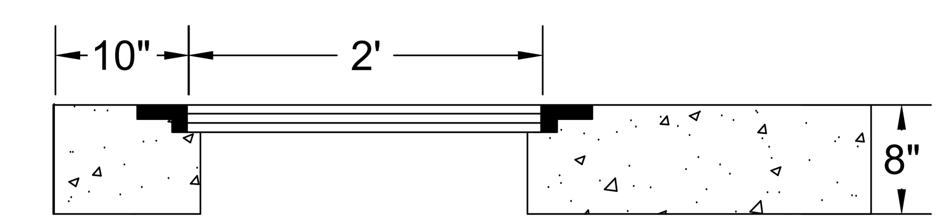
FRONT VIEW

SIDE VIEW

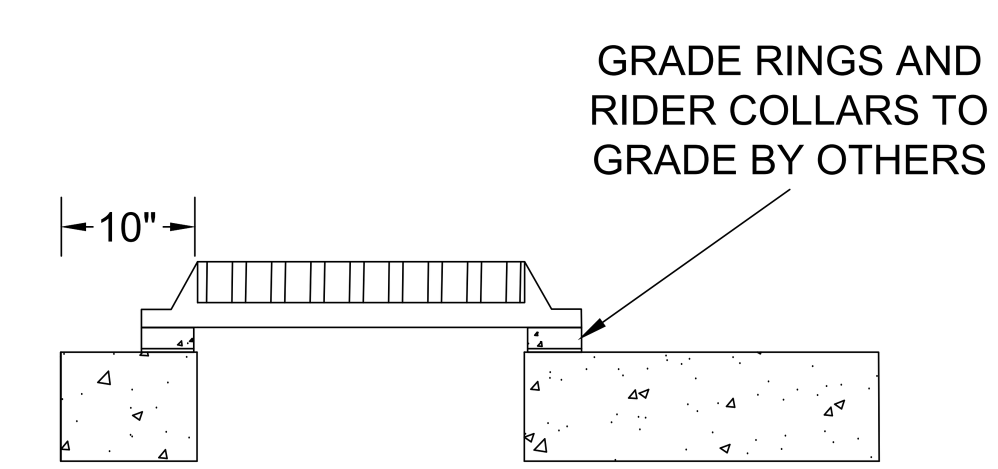
BAFFLE 3



PLAN VIEW



FLUSH MOUNT COVER



ALT. DETAIL - RAISED FRAME AND COVER

TOP SLAB

This Drawing shall not be used for Construction unless Signed and Sealed For Construction.

NO	DATE	DESCRIPTION	CKD
1	11/7/18	30% DESIGNS	RR

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DESIGNED BY:	RR
DRAFTED BY:	JS
CHECKED BY:	RR

PRETREATMENT DETAILS

JOB #:	171006
SCALE:	AS SHOWN
CONTRACT #:	N/A
SHEET #:	10

D4

APPENDIX B: POLLUTANT LOAD AND COSTING METHODOLOGY

Pollutant Loading and BMP Costing Analysis

A planning level pollutant loading and BMP costing analysis was performed for each of the 7 potential BMPs identified for the Lincoln Street watershed. The soil type, BMP type, and land use type for each BMP is shown in Table 1 - BMP type, soil, and land use summary. These were used in conjunction with performance curves from the WISE, 2015[1] analysis to determine expected runoff and nitrogen load reductions associated with each BMP.

These curves and associated pollutant load reduction estimates are shown in Section C.1, below.

Estimates for the cost per acre of drainage area for each BMP type from the WISE, 2015[1] analysis were used to estimate the total and unit costs associated with the nitrogen load reductions for each BMP. The numbers used for these estimates are shown in Section C.2, below.

Table 1 - BMP type, soil, and land use summary

BMP Location	Soil Type	Proposed BMP Type
1	A	Subsurface Infiltration
2	A	Subsurface Infiltration
3.1	A	Bioretention
3.2	A	Bioretention
3.3 - 3.6	A	Bioretention
4	A	Subsurface infiltration
5	A	Subsurface infiltration
6	C	Bioretention
7	A	Subsurface Infiltration

[1] Roseen, R., Watts, A., Bourdeau, R., Stacey, P., Sinnott, C., Walker, T., Thompson, D., Roberts, E., and Miller, S. (2015). Water Integration for Squamscott Exeter (WISE), Preliminary Integrated Plan, Final Technical Report. Portsmouth, NH, Geosyntec Consultants, University of New Hampshire, Rockingham Planning Commission, Great Bay National Estuarine Research Reserve, Consensus Building Institute.

C.1 Pollutant Loading Analysis

Pollutant Loading Calculation Example

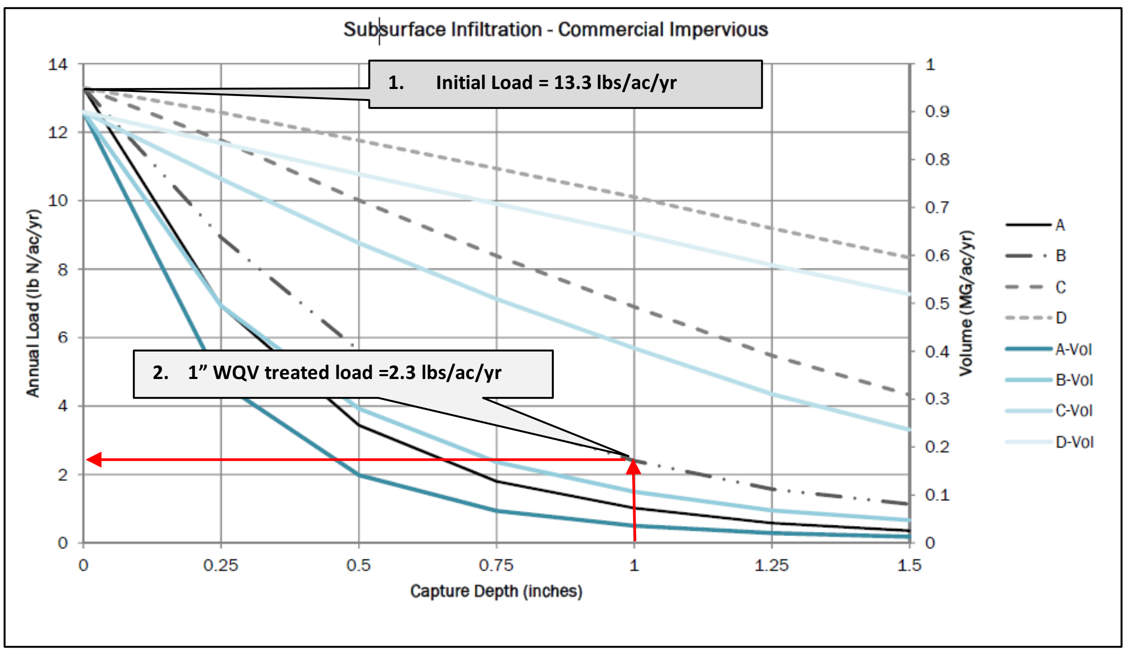
The following example and accompanying figures explain the approach taken for the pollutant loading and volume reduction analysis performed in this study with a BMP of the following characteristics:

- subsurface infiltration system,
- 1” water quality volume,
- type B soil,
- commercial land use,

From the BMP performance curve for a subsurface infiltration system pollutant removal and volume reduction are determined as follows:

1. **Determine initial load.** Where the BMP curve for nitrogen (black curves) crosses the left hand vertical axis (capture depth=0) determine the initial TN load based on commercial land use = 13.3 lbs/ac/yr.
2. **Determine treated load.** Locate performance curve for soil type B for the capture volume. A system treating a 1” water quality volume for 1 acre will have a treated load of 2.3 lbs/ac/yr.

Example 1: BMP optimization for pollutant load with subsurface infiltration at 1” water quality volume

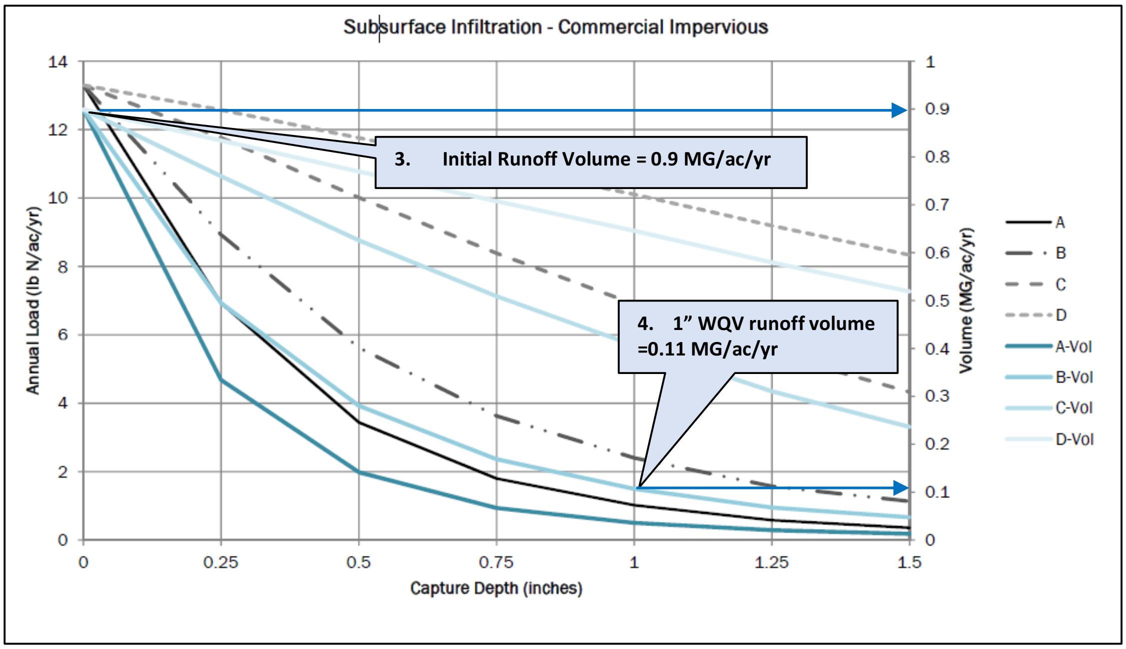


3. **Determine load removed.** An initial load of 13.3 lbs/ac/yr and a treated load of 2.3 lbs/ac/yr removes 11 lbs/ac/yr or 83% annual TN reduction.

$$\frac{\text{Treated Load}}{\text{Initial Load}} = \frac{11}{13.3} = 83\% \text{ TN reduction annually}$$

4. **Determine initial runoff volume.** Where the BMP curve for volume (blue curves) crosses the left hand vertical axis (capture depth=0) determine the initial runoff volume based on the right hand axis for commercial land use = 0.9 million gallons/ac/yr.
5. **Determine treated runoff volume.** Locate performance curve for soil type B for the capture volume. A system treating a 1" water quality volume for 1 acre will have a runoff volume = 0.11 million gallons/ac/yr.

Example 2: BMP optimization for volume with subsurface infiltration at 1" water quality volume



6. **Determine volume removed.** An initial runoff volume of 0.9 MG/ac/yr and a treated runoff volume of 0.11 MG/ac/yr removes 0.79 MG/ac/yr or 88% annual runoff reduction.

$$\frac{\text{Treated Runoff Volume}}{\text{Initial Runoff Volume}} = \frac{0.11}{0.9} = 88\% \text{ runoff volume reduction annually}$$

The complete methods can be found in the BMP Decision Support System (BMPDSS)(EPA 2010)[2] and WISE Project (Roseen et al 2015)[1]. This approach was developed in cooperation with EPA Region 1 to support an Integrated Planning and Permitting framework for watershed scale nitrogen management for the Exeter-Squamscott Watershed.

[2] EPA and I. Tetra Tech (2010). Stormwater Best Management Practices (BMP) Performance Analysis. United States Environmental Protection Agency – Region 1, Boston, MA.

The following tables display the actual numbers used to calculate pollutant load reductions in this analysis, applying the methodology outlined above in Examples 1 and 2. The associated BMP performance curves can be found in WISE, 2015[1], pages 92-180.

Table 2 - Performance estimates for BMP 6

BMP	Drainage Area (acres)	Annual N Load (lbs)	1/4" Volume Reduction (ft^3)	1/2" Volume Reduction (ft^3)	1/4" N Reduction (lbs)	1/2" N Reduction (lbs)
6	1.73	27.27	1,569	3,138	5	6

Table 3 - Performance estimates for BMP 3

BMP	Drainage Area (acres)	Annual N Load (lbs)	1/4" Volume Reduction (ft^3)	1/2" Volume Reduction (ft^3)	1/4" N Reduction (lbs)	1/2" N Reduction (lbs)
3	12.33	104.64	11,192	22,384	65	84

Table 4 - Performance estimates for BMPs 1, 2, 4, 5, and 7

BMP	Drainage Area (acres)	Annual N Load (lbs)	1/4" Volume Reduction (ft^3)	1/2" Volume Reduction (ft^3)	1/4" N Reduction (lbs)	1/2" N Reduction (lbs)
1	11.15	76.6	10,116	20,232	42	62
2	24.56	157.6	22,291	44,582	84	120
4	38.63	252.2	35,059	70,119	114	174
5	17.85	113.7	16,199	32,397	59	86
7	24.79	152.3	22,498	44,997	77	113

C.2 COSTING ANALYSIS

The WISE, 2015[3] study developed estimates for the cost of sizing a variety of stormwater capture systems to manage different size storm events. Table 5 - BMP cost estimates developed for WISE, 2015 shows the estimated per-acre costs for bioretention and subsurface infiltration systems designed to manage the 0.25” and 0.5” storm events.

In order to calculate the total cost of a BMP using this table, it is necessary to multiply the drainage area by the cost shown in Table 5 - BMP cost estimates developed for WISE, 2015. The unit cost ($ per pound of nutrient load reduction) can then be derived by dividing the total cost by the total expected annual nutrient load reduction.

Table 5 - BMP cost estimates developed for WISE, 2015

Structural Treatment Practice	Capitol Cost Range Based on Capture Depth of 1-acre drainage area ($)					
	0.25 in.			0.5 in.		
	LOW	HIGH	FINAL	LOW	HIGH	FINAL
Bioretention with Underdrain (No Pretreatment)[1]	$2,759	$40,000	$11,400	$5,518	$60,000	$18,300
Subsurface Infiltration	$18,000	$35,000	$18,500	$25,000	$45,000	$28,000

1. Pretreatment not required for direct runoff from impervious surfaces (i.e., roof tops and parking lots).

[3] Roseen, R., Watts, A., Bourdeau, R., Stacey, P., Sinnott, C., Walker, T., Thompson, D., Roberts, E., and Miller, S. (2015). Water Integration for Squamscott Exeter (WISE), Preliminary Integrated Plan, Final Technical Report. Portsmouth, NH, Geosyntec Consultants, University of New Hampshire, Rockingham Planning Commission, Great Bay National Estuarine Research Reserve, Consensus Building Institute.

BMP Cost Calculation Example

The following example explains the approach taken for the costing analysis performed in this study using BMP 1, which has the the following relevant characteristics:

- subsurface infiltration system,
- 0.25" water quality volume,
- 11.1 acre drainage area
- 42 lbs annual Nitrogen load reduction when sized for 0.25" water quality volume (from Pollutant Loading Analysis)

1. Reference Table 5 to determine the capital cost per-acre for a subsurface infiltration system sized to capture the 0.25" water quality volume. For this analysis, we use the 'Final' estimate rather than the 'High' or 'Low' estimates, yielding a per-acre cost of $18,500.

2. Multiply the per-acre cost by the BMP drainage area. For BMP 1, the drainage area is 11.1 acres:

[11.15 acres] x [$18,500 / acre] = $206,221

3. Divide the total cost from Step 2 by the annual Nitrogen Load reduction potential to derive the unit cost for the BMP:

[$206,206] / [42 lbs N] = $4,905 / lb N

Table 6 – Lincoln Street costing analysis results, shows the results of this analysis applied to the Lincoln Street watershed.

Table 6 – Lincoln Street costing analysis results

		1/4" WQV System		1/2" WQV System	
BMP Location	Drainage Area (acres)	Total Cost	Unit Cost ($/lb)	Total Cost	Unit Cost ($/lb)
1	11.1	$206,221	$4,900	$312,118	$5,000
2	24.6	$454,414	$5,400	$687,761	$5,700
3.1	6.9	$78,509	$2,200	$126,028	$2,700
3.2	4.2	$47,512	$2,500	$76,270	$3,100
3.3 - 3.6	1.3	$14,569	$1,400	$23,388	$1,800
4	38.6	$714,710	$6,300	$1,081,724	$6,200
5	17.9	$330,222	$5,600	$499,796	$5,800
6	1.7	$19,713	$3,800	$31,644	$5,000
7	24.8	$458,646	$5,900	$694,167	$6,100