Weston & Sampson[SM]

westonandsampson.com

55 Walkers Brook Drive, Suite 100
Reading, MA 01867
tel: 978.532.1900

CAPTAIN POND PHOSPHOROUS SOURCE IDENTIFICATION REPORT

MS4 GENERAL PERMIT COMPLIANCE

JUNE 2022

TOWN OF
Salem
NEW HAMPSHIRE

psir

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Captains Pond, located along the eastern boundary of Salem, NH, is impaired for phosphorus, chlorophyll-a, dissolved oxygen, and pH. A total maximum daily load (TMDL) for phosphorus in Captains Pond was issued after the effective date of the 2017 New Hampshire General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4 Permit), therefore the Town developed this Phosphorus Source Identification Report (PSIR) for Captains Pond to meet MS4 Permit requirements.

The Captains Pond watershed covers approximately 1,250 acres in Salem, NH, Atkinson, NH, and Haverhill, MA. The watershed is primarily forest, open space, and low-density residential land. There are 17 delineated catchment areas within the Captains Pond watershed that collect stormwater in Salem's MS4 and discharge to the waterbody via regulated outfalls. In accordance with MS4 Permit requirements, percent impervious area and directly connected impervious area was calculated for each catchment area using publicly available land use/land cover data and Hot Spot/Pollutant Loading data provided by the New Hampshire Department of Environmental Services (NHDES). The results of the impervious and directly connected impervious area calculations were used to calculate an estimated annual phosphorus loading for each catchment area.

The 17 catchment areas in the Captains Pond watershed were ranked based on estimated annual phosphorus loading and designated as High or Low Priority. Available dry and wet-weather sampling data, distance between the outfall and the receiving water, and other factors were also considered in the prioritization, however any catchment area estimated to contribute less than one pound per year of phosphorus to the waterbody was ranked "Low Priority". Parcels and areas within the right-of-way in each of the catchments designated as "High Priority" were evaluated for potential retrofit opportunities, including structural stormwater best management practices (BMPs) and the reduction of impervious area. A list of six potential retrofit opportunities in High Priority catchment areas is included in this report.

This report was completed in FY2022 in accordance with MS4 Permit requirements. In Permit Year 5 (FY2023), the Town will evaluate the feasibility of each of the retrofit opportunities included in this report and develop a schedule for implementation. The Town of Salem will complete construction of one "demonstration project" before the end of Permit Year 6, or by June 30, 2024.

1.0 REGULATORY SUMMARY AND PURPOSE

The 2017 New Hampshire MS4 Permit includes specific requirements for MS4 operators that discharge to impaired waterbodies where pollutants typically found in stormwater—specifically nutrients, solids, bacteria/pathogens, chloride, metals, and oil and grease—are the cause of the impairment and require the development of a Total Maximum Daily Load (TMDL). Additional requirements for phosphorus impairments include supplementary public education efforts, specific BMP design standards, increased street sweeping, and the development of a Phosphorus Source Identification Report for each waterbody with a phosphorus impairment.

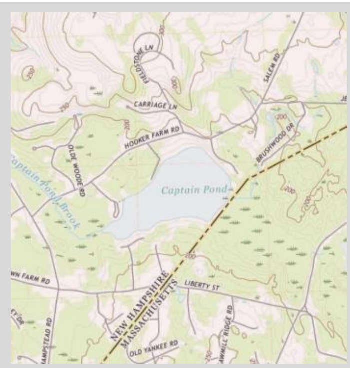
This Phosphorous Source Identification Report (PSIR) has been developed for Captains Pond in Salem, NH. In accordance with permit requirements, the report includes the following elements:

1. A calculation of the total MS4 areas draining to the water quality limited receiving water, incorporating updating mapping of the MS4 and catchment delineations;
2. All screening and monitoring results targeting the receiving water;
3. Impervious area and Directly Connected Impervious Area (DCIA) for the target catchment area(s);
4. Identification, delineation, and prioritization of potential catchments with high phosphorus loadings; and
5. Identification of potential retrofit opportunities or opportunities for the installation of structural BMPs during redevelopment, including the removal of impervious area.

The PSIR must be completed on or before the end of Permit Year 4 or June 30, 2022.

1.1 Waterbody Description

Captains Pond is an 87-acre great pond located in Salem, NH. The pond is near the eastern Salem town boundary, and significant portions of its 1,250-acre watershed are in Atkinson, NH and Haverhill, MA. Documentation of poor water quality in Captains Pond is available from as early as 1986, when samples collected during the summer months showed that "Captains Pond has experienced increasing pollution that contributes to faster eutrophication"[1]. It has since been listed on every available New Hampshire Surface Water Quality List, or Section 303(d) list, for some or all of the following impairments: chlorphyll-a, dissolved oxygen, total phosphorus, and pH.



Captains Pond Locus Map (USGS)

There are multiple swimming beaches at Captains Pond, including Camp Otter beach, Camp Hadar beach, and Camp Y-Wood beach. Camp Otter beach Captains was included in the New Hampshire Statewide Total Maximum Daily Load (TMDL) for Bacteria Impaired Waters, which was issued in September 2010, and the Bacteria Total Maximum Daily Load (TMDL) Report for Camp Hadar Beach on Captains Pond in Salem, NH was issued as a follow-up report in September 2016. The Total Maximum Daily Load for Phosphorus for Captains Pond, Salem, NH was finalized in September 2017, just after the effective date of the 2017 MS4 Permit. The Town of Salem is therefore not required to

[1] Town of Salem, NH. 1986 Water Quality Study.

meet MS4 Permit requirements for receiving waters with an approved TMDL for phosphorus until the permit is reissued.

2.0 LITERATURE REVIEW

A literature review and review of historic sampling data was conducted as part of this Phosphorus Source Identification Report.

2.1 Literature Review

Since water quality in Captains Pond has been an ongoing point of concern, various studies, reports, and remediation plans for the pond have previously been developed. Ongoing in-lake sampling has been conducted by the Volunteer Lake Assessment Program (VLAP). The following studies and reports were reviewed as part of the development of the PSIR:

- 1986 Water Quality Study for the Town of Salem, NH. Salem 208 Water Quality Commission.

- Total Maximum Daily Load for Phosphorus for Captains Pond, Salem, NH. New Hampshire Department of Environmental Services, September 2017.

- Volunteer Lake Assessment Program Individual Lake Reports – Captains Pond, Salem NH. 2019-2020.

- New Hampshire Lake Trend Report: Status and Trends of Water Quality Indicators. New Hampshire Department of Environmental Services, June 2020.

2.1.1 1986 Water Quality Study for the Town of Salem, NH

The Town of Salem, NH began collecting water quality data for its streams, lakes and ponds in 1976. The 1986 report, which is publicly available, references data collected in previous years and discusses observed trends in the overall health of surface waters in Salem. Nutrient pollution was already a concern for Captains Pond in 1986: "individually, Arlington Reservoir, Hedgehog Pond, and Captains Pond have worsened in terms of nutrient pollution since 1976, the first year of recent Salem lake data on record"[2]. Nutrient loading from non-point pollution sources was identified as the most serious threat to surface waters in this report, citing malfunctioning septic systems and stormwater runoff as the most likely sources within the watershed.

Phosphorus concentrations in Captains Pond were not monitored as part of the 1986 study, but in-lake samples were collected for dissolved oxygen, secchi disk transparency, pH, conductivity, total alkalinity, and fecal coliform/fecal strepcoccus. Captains Pond did not have the elevated bacteria levels it experiences today in 1986—"two samples were analyzed for fecal coliform bacteria and they yielded counts of 0 and 2 colonies/100 ml, both excellent sanitary counts"[3]. However, the bottom layer of the lake was "completely depleted of oxygen by late summer despite the abundance of aquatic vegetation", indicating excess nutrient loading in the lake[4].

The report included multiple recommendations for improving water quality in all surface waters in Salem. Many of these recommendations are consistent with current MS4 Permit requirements, including water quality monitoring, public education efforts, banning the sale of phosphorus-containing fertilizers and detergents, prohibiting waterfowl feeding, inspecting septic systems at

[2] 1986 Water Quality Report, 1.
[3] 1986 Water Quality Report, 42.
[4] 1986 Water Quality Report, 42.

seasonal homes or determining if seasonal homes have been converted to year-round use, and experimenting with different applications and materials for roadway deicing.

2.1.2 Total Maximum Daily Load for Phosphorus for Captains Pond, Salem NH

The TMDL for Captains Pond was published in September 2017, after the effective date of the 2017 MS4 Permit. The report discusses land use in the Captains Pond watershed, estimates phosphorus loading to the pond from different sources, and establishes the annual load requirement needed to reach an in-lake phosphorus concentration that supports recreational uses as well as aquatic life.

The TMDL splits the Captains Pond watershed into a “direct drainage” area and a “northeast watershed” area, shown in Figure 4. The majority of the “direct drainage” area is in Salem, with small portions in Atkinson and Haverhill, MA; the majority of the “northeast watershed” area is in Atkinson or Haverhill and consists of areas that discharge to streams or wetlands tributary to the pond. Deciduous forest, low-density residential urban land, public land, and wetland areas are listed as the predominant land uses in the overall watershed. A water budget calculated for Captains Pond determined that water sources include direct precipitation, runoff, and baseflow, with approximately 34% of the water in Captains Pond coming from watershed runoff.

The TMDL identified five distinct sources of phosphorus in Captains Pond: atmospheric deposition, internal loading, waterfowl, septic system inputs, and watershed load. The total annual phosphorus loading was estimated to be 124.9 kg/yr (275.4 lb/yr). Watershed load was split into load from the “direct drainage” area and the “northeast watershed” area. The watershed load contributes 47% of the annual phosphorus loading to Captains Pond. Waterfowl were determined to be the second highest contributors of phosphorus to Captains Pond, responsible for 34% of the annual load.

Establishing a target in-lake total phosphorus concentration of 12 μg/L, “the total maximum annual TP load that is expected to result in [the target concentration] was estimated to be 75.7 kg/year (166.9 lb/yr), which represents an approximate 39% reduction from existing conditions”[5]. The TMDL includes recommendations for reducing annual loading from different sources, including a waterfowl management program, structural stormwater BMP retrofits, wetland restoration or preservation, and the updating of land use ordinances to prohibit additional total phosphorus loading from new development projects. Continued lake monitoring and assessments were determined to be the best way to track progress towards meeting this phosphorus reduction goal.

2.1.3 VLAP Individual Lake Reports – Captains Pond

New Hampshire’s VLAP is a citizen-based network that collects water quality data at waterbodies throughout the state. NHDES utilizes data collected by VLAP to develop annual water quality report cards for each waterbody participating in the monitoring program. Each report card includes the following:

- Morphometric data,
- Watershed land use summary,
- Comparison of the year’s sampling results to the state standard for designated uses,

[5] New Hampshire Department of Environmental Services, 2017. *Total Maximum Daily Load for Phosphorus for Captain Pond, Salem NH.* Page 4-1.

- Water quality assessment at primary contact beaches,
- Observations for each sampling parameter monitored that year,
- Average water quality data for each parameter during that year, and
- Recommended interventions and an analysis of historical water quality trends.

Water quality report cards for Captains Pond from 2014 to 2020 were reviewed as part of the PSIR. Pond phosphorus levels, specifically in the epilimnion, were elevated and above the state median in both 2019 and 2020. A cyanobacterial bloom occurred in late June 2019 and excess algal growth was observed in June and July of 2019. No cyanobacterial blooms occurred in 2020. The report card cited above average rainfall, stormwater runoff, high water levels, and the presence of waterfowl as potential sources for elevated phosphorus concentrations in 2019. Similarly, drought caused the slightly improved water quality observed in 2020. The interventions recommended in the VLAP report were similar in 2019 and 2020—both reports proposed developing a watershed management plan, continuing waterfowl management activities, implementing stormwater best management practices, and educating shorefront property owners about individual impacts on water quality.

2.1.4 NH Lake Trend Report: Status and Trends of Water Quality Indicators

NHDES develops regular reports on water quality status and trends observed under its ongoing water quality monitoring efforts. The most recent statewide report, published in June of 2020, analyzes over ten years of monitoring data from 150 lakes and ponds across the state. The most recent data included in this report was collected in 2018. Statewide trends observed between 1991 and 2018 include an increase in total phosphorus concentrations in eutrophic waterbodies, a decrease in dissolved oxygen concentration in mesotrophic waterbodies, and an increase in the number of cyanobacteria advisories issued between 2003 and 2018. This report indicates that water quality has been consistent in Captains Pond—there was no trend in the long term (1991-2018) and no significant change in the short term (2014-2018) for any primary indicators, which include chlorophyll-a, pH, secchi depth, specific conductance, and total phosphorus.

2.2 Historic Sampling Data

Most available in-lake sampling data for Captains Pond was collected through the Volunteer Lake Assessment Program (VLAP), and was provided by NHDES to develop this report. Samples collected before 2000 were not considered, as nutrient data that is more than twenty years old is not considered to be indicative of current water quality trends.

Phosphorus samples are routinely collected at the inlet, outlet, and deep spot of Captains Pond, as well as at swimming beaches and other places of interest around the shoreline. The highest average phosphorus concentrations have been observed at the deep spot, outlet, and near stormwater outfalls from Plaisted Circle and Emilio Lane. A map of in-lake sampling locations, symbolized by average observed phosphorus concentration, is included in Figure 1. Corresponding average phosphorus concentrations for each sampling location are included in Table 1.

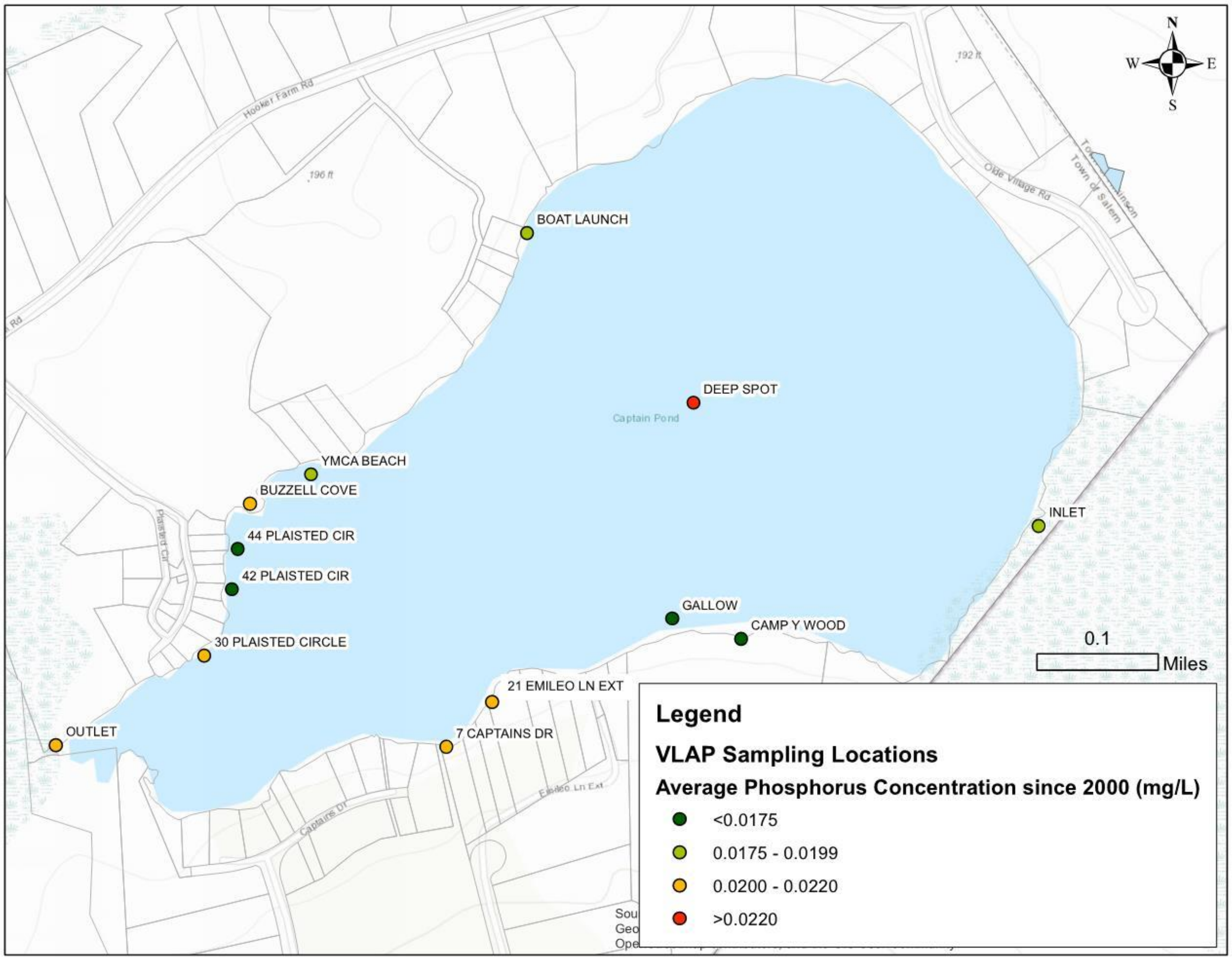


Figure 1: VLAP Phosphorus Sampling Locations

Table 1: Average Phosphorus Concentrations in Captains Pond, 2001-2021	
Sampling Location	Phosphorus Concentration (µg/L)
Deep Spot	103.8
30 Plaisted Circle	22.1
Outlet	21.9
21 Emileo Lane Ext	21.5
7 Captains Drive	20.4
Buzzell Cove	20.4
Boat Launch	19.4
YMCA Beach	19.2
Inlet	17.6
44 Plaisted Circle	17.0
Camp Y Wood	17.0
42 Plaisted Circle	16.8
Gallow	16.7

Phosphorus levels in Captains Pond have remained relatively stable across all sampling locations since 2000, with an elevated average concentration at the deep spot in 2015, 2016, and 2017. This trend is shown in Figure 2 and reflects noted observations in the 2015, 2016, and 2017 VLAP reports. Measurements at the deep spot are taken at three depths: the epilimnion (2 feet deep), metalimnion (4 feet deep), and hypolimnion (6 feet deep). As shown in Figure 3, elevated concentrations were primarily observed in the hypolimnion in 2015, 2016, and 2017. Phosphorus levels in the waterbody spiked after large storm events in each of those summers, and hypolimnetic phosphorus levels were "elevated" in each of those years. The hypolimnion has a consistently higher phosphorus concentration than the epilimnion, which is typical of stratified lakes in the warmer months. The 2016 VLAP report cites that low dissolved oxygen concentrations in the hypolimnion may cause phosphorus in the bottom sediment to be released into the water column, which could have impacted the sampling results.

Figure 2: Historical In-Lake Phosphorus Concentrations at Captains Pond, 2001-2021

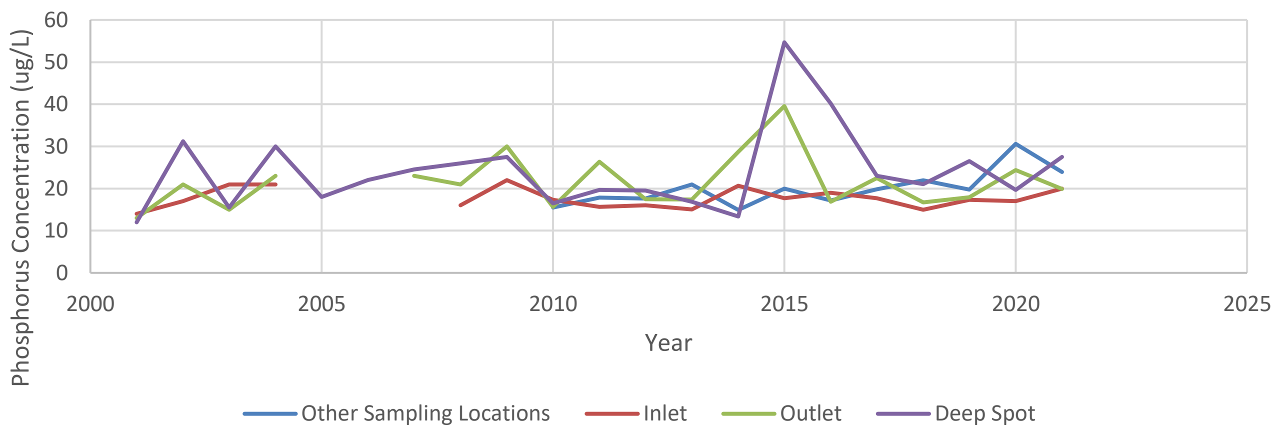
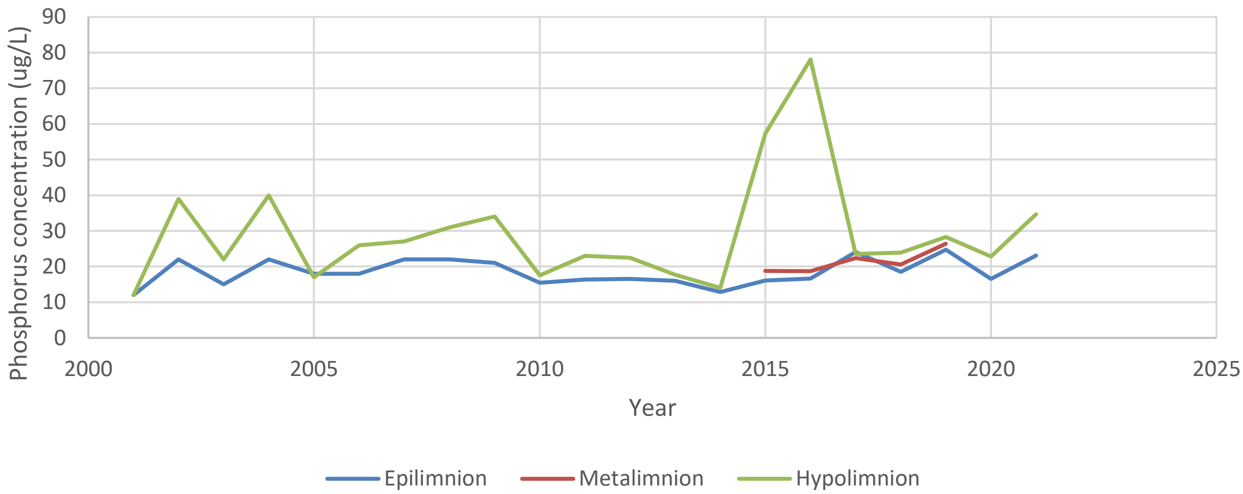


Figure 3: Historical Deep-Spot Phosphorus Concentrations at Captains Pond, 2001-2021



Dry and wet weather screening and sampling of stormwater outfalls, which is a better indicator of the quality of runoff entering the waterbody than in-lake sampling, has been conducted at each outfall discharging to Captains Pond as part of the Town's ongoing MS4 compliance efforts. Outfall sampling results are discussed in Section 4.5, below.

Document1

3.0 CAPTAINS POND TRIBUTARY AREA

Weston & Sampson used available GIS mapping and parcel data provided by NHDES to determine land use characteristics for the MS4 catchment areas tributary to Captains Pond and the greater Captains Pond watershed. The greater Captains Pond watershed is divided into a direct drainage area and the northeast drainage area—runoff from the direct drainage area discharges directly to Captains Pond, while runoff form the northeast drainage area discharges to the waterbody's tributary streams or wetlands. NHDES Hot Spot/Pollutant Loading data[6] was used to calculate percent impervious area and directly connected impervious area (DCIA) for catchments and parts of the watershed located in New Hampshire; impervious area data from MassGIS was used to calculate percent impervious cover and percent DCIA for the portions of the watershed located in Massachusetts. This section details the procedures for those calculations. Results are discussed as part of the pollutant loading analysis in Section 4.0.

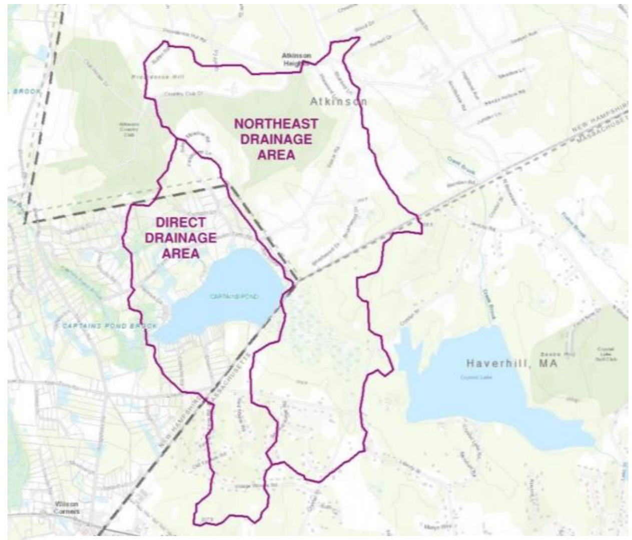


Figure 4 – Captain Pond Watershed Boundary

3.1 Available GIS Mapping

The Town's GIS includes extensive mapping of the drainage system tributary to Captains Pond, including catchment delineations, which were evaluated and modified as part of this report. There are currently five outfalls owned by the Town of Salem that discharge directly to Captains Pond, and eleven outfalls owned by the Town of Salem that discharge to a channel, wetland area, or overland upstream of the pond. The total drainage area tributary to Captains Pond is approximately 1,250 acres which extends into Salem, NH and Atkinson, NH, and Haverhill, MA. There is one mapped structural BMP in the drainage system tributary to Captains Pond, which is located at the end of Plaisted Circle and treats runoff from catchment CAP-0658-OF. A map showing the drainage infrastructure owned by Salem in the MS4 catchment areas is included in Appendix A.

Land use data for the properties within the Captains Pond watershed, as well as impervious area delineations for roads and other rights-of-way, was collected from the most recent (2015) land use data layer available on GRANIT. Land use data for the portion of the watershed in Massachusetts was collected from the MassGIS 2016 Land Cover/Land Use dataset. Table 2 and Figure 4 present a summary of land use in the Captains Pond watershed:

Table 2: Land Use in the Captains Pond Watershed		
Land Use	Acres	Percent of Overall Catchment Area
Agriculture	51.69	4.1%
Commercial	15.83	1.3%
Forest	267.87	21.4%

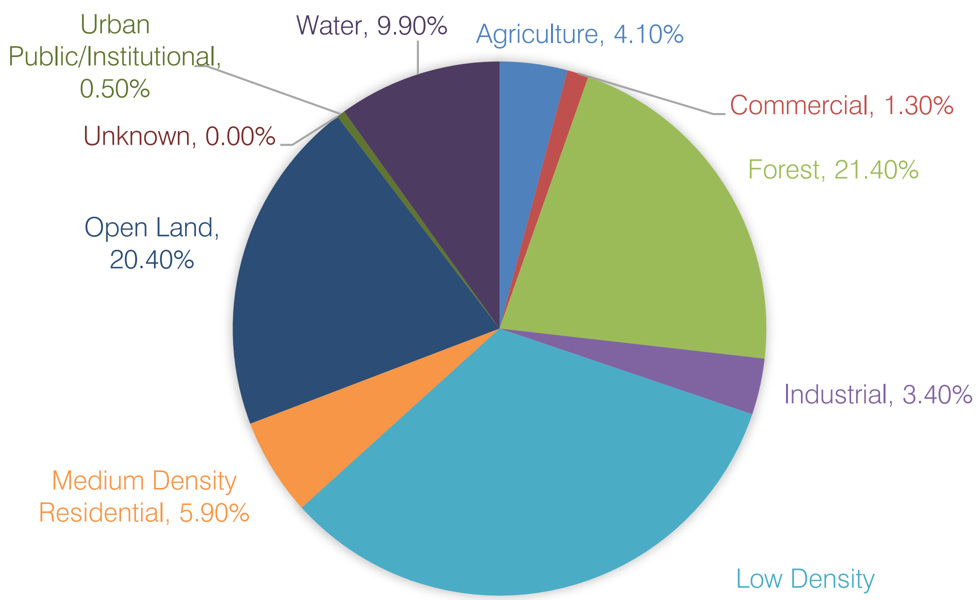
[6] New Hampshire Department of Environmental Services. *Pollutant Load Hot Spot Maps.* https://www4.des.state.nh.us/nh-ms4/?page_id=1798

Table 2: Land Use in the Captains Pond Watershed		
Land Use	Acres	Percent of Overall Catchment Area
Industrial*	43.29	3.4%
Low Density Residential	414.45	33.1%
Medium Density Residential	73.3	5.9%
Open Land	255.11	20.4%
Unknown	0.15	0.0%
Urban Public/Institutional**	6.37	0.5%
Water	123.54	9.9%
Grand Total	**1,251.6**	**100.00%**

*EPA considers all transportation uses, including roads, to be industrial uses.

**Urban Public/Institutional land use includes all publicly-owned land including schools, parks, and government buildings, as well as property that is exempt from taxation such as property owned by religious groups, housing/utility authorities, hospitals, museums, etc.

Figure 5: Land Use In The Captain Pond Watershed



3.2 Directly Connected Impervious Area

The land use and impervious area data were used to calculate the percent of Directly Connected Impervious Area (DCIA) for the MS4 catchment areas. For areas in New Hampshire, impervious area for each parcel was provided by NHDES in the Hot Spot/Pollutant Loading dataset and aggregated with impervious area data within the right-of-way to determine DCIA. It was assumed that the acreage of impervious area included in the NHDES Hot Spot/Pollutant Loading dataset for each parcel was the same as the DCIA on that parcel. For areas within Massachusetts where parcel-level impervious area data was not available, percent DCIA was calculated by applying the Sutherland Equation developed in the 1995 publication *Methodology for Estimating the Effective Impervious Area of Urban Watersheds*[7].

In order to properly use the Sutherland Equations, MassGIS land use codes were converted to EPA land use codes using the conversion methodology recommended by EPA. Once EPA land use codes are assigned, the amount and percent of impervious area can be applied to the Sutherland Equation to determine percent DCIA for each land use type. Table 3 lists the Sutherland Equations that are used for different land uses. It was determined that there is no directly connected impervious area in the portion of the Captains Pond watershed in Massachusetts.

Table 3: EPA Land Use Classes and Corresponding Sutherland Equations (Source: EPA)

EPA Code	Land Use	Watershed Selection Criteria	Sutherland Equation (where IA(%) > 1)
1	Commercial	Average: Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are directly connected.	DCIA%=0.1(IA%)^1.5
2	Industrial	Average: Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are directly connected.	DCIA%=0.1(IA%)^1.5
3	Low Density Residential	Somewhat connected: 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration	DCIA%=0.04(IA%)^1.7
4	Medium Density Residential	Average: Mostly storm sewered with curb and gutter, no dry wells or infiltration, residential rooftops not directly connected	DCIA%=0.1(IA%)^1.5
5	High Density Residential	Highly Connected: Same as above, but residential rooftops are connected	DCIA% = 0.4(IA%)^1.5
6	Urban Public/ Institutional	Average: Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are directly connected.	DCIA%=0.1(IA%)^1.5
7	Agriculture	Mostly Disconnected: Small Percentage of impervious area is storm sewered, or 70% or more infiltrated/disconnected	DCIA%=0.01(IA%)^2
8	Forest	Mostly Disconnected: Small Percentage of impervious area is storm sewered, or 70% or more infiltrated/disconnected	DCIA%=0.01(IA%)^2
9	Open Land	Average: Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are not directly connected.	DCIA%=0.1(IA%)^1.5
10	Water	n/a	n/a

[7] Sutherland, R.C., "Methodology for Estimating the Effective Impervious Area of Urban Watersheds", Watershed Protection Techniques, Vol. 2, No. 1, Fall 1995.

4.0 POLLUTANT LOADING ANALYSIS AND PRIORITIZATION OF CATCHMENTS WITH HIGHER POTENTIAL PHOSPHORUS LOADS

The 2017 MS4 Permit requires all Phosphorus Source Identification Reports to include the identification, delineation, and prioritization of potential catchments with high phosphorus loadings. The potential for a particular site or area to contribute phosphorus to stormwater varies based on land use, impervious coverage, directly connected impervious area, and soil type. Hydrologic soil group (HSG), or the soil's ability to infiltrate stormwater, is the most important soil characteristic for the purposes of this analysis. HSG is ranked from A to D, with type A soils more suited for infiltration, and type D soils more likely to contribute runoff. This section discusses the methodology and results of the pollutant loading analysis that was conducted for the catchment areas tributary to Captains Pond.

4.1 Phosphorus Load Export Rates

Land use, impervious coverage, directly connected impervious area, and HSG have been utilized by EPA as part of the MS4 Permit to develop Phosphorus Load Export Rates (PLERs) for different combinations of those attributes in close geographical areas where there is no considerable difference in average annual rainfall. Table 4 presents the PLERs that are included in Attachment 1 of Appendix F of the 2017 New Hampshire MS4 Permit. Low density residential land is the most prevalent land use in the catchment areas tributary to Captains Pond, followed by forest, open land, industrial, and agriculture.

Table 4: Phosphorus Load Export Rates (PLERs) by Land Use

Land Use Category	Land Surface Cover	PLER (lb/acre/year)
Commercial and Industrial	Directly Connected Impervious	1.78
	Pervious	*See Developed Pervious
Multi-Family and High Density Residential	Directly Connected Impervious	2.32
	Pervious	*See Developed Pervious
Medium Density Residential	Directly Connected Impervious	1.96
	Pervious	*See Developed Pervious
Low Density Residential	Directly Connected Impervious	1.52
	Pervious	*See Developed Pervious
Highway	Directly Connected Impervious	1.34
	Pervious	*See Developed Pervious
Forest	Directly Connected Impervious	1.52
	Pervious	0.13
Open Land	Directly Connected Impervious	1.52
	Pervious	*See Developed Pervious
Agriculture	Directly Connected Impervious	1.52
	Pervious	0.45
*Developed Pervious – HSG A	Pervious	0.03
*Developed Pervious – HSG B	Pervious	0.12
*Developed Pervious – HSG C	Pervious	0.21
*Developed Pervious – HSG C/D	Pervious	0.29
*Developed Pervious – HSG D	Pervious	0.37

4.2 NHDES Hot Spot/Pollutant Loading Data

NHDES completed a Geographic Information System (GIS) analysis for Salem, NH in 2019 using publicly available GIS layers that yielded nutrient loadings, including phosphorus, nitrogen, and suspended solids, associated with impervious coverage on each of the parcels in Salem[8]. For this report, the total phosphorus (TP) loads for parcels in Salem, NH and Atkinson, NH were utilized to complete a phosphorus loading analysis within the Captains Pond watershed. NHDES developed the TP value per parcel by coupling GIS layers for parcel boundaries, conservation areas, land use, and impervious cover with the pollutant load export rates found in Table 4 above.

4.3 Pollutant Loading Analysis Methodology

Since the Captains Pond watershed covers land in three separate municipalities and two states, the pollutant loading analysis was completed using two different data sources. Where available, the NHDES Hot Spot/Pollutant Loading data was used. The phosphorus loading data from NHDES was applied to all New Hampshire parcels within the watershed. The 2015 NH Land Use data from NHGranit was used to fill in the areas not accounted for by the parcel data, such as roads or other areas within the right-of-way. For the portion of the watershed located in Massachusetts, soils data from the United States Department of Agriculture (USDA) Natural Resource Conservation (NRCS) was combined with the 2016 Land Cover/Land Use dataset from MassGIS to create a combined land use/land cover grid for the pollutant loading calculations.

For parcels within 200 meters of Captains Pond, the TP values from the NHDES Hot Spot/Pollutant Loading data were summed together to calculate phosphorus load. Where any portion of a particular parcel was within the 200 meter buffer, the original TP value was used. For parcels further than 200 meters from Captains Pond, the TP values were adjusted by an attenuation factor of 0.24. The attenuation factor was calculated using the ratio of PLERs for disconnected and directly connected impervious surfaces in the same land use, and was used to account for the fact that not all runoff from impervious surfaces in the watershed will contribute phosphorus loading to the waterbody. The PLER for directly connected impervious area in a low-density residential area is 1.52 lb/acre/year; disconnected impervious area is assigned the PLER for pervious surfaces in soil group D, 0.37 lb/acre/year, in accordance with permit guidance. The attenuation factor is the ratio of the disconnected PLER to the PLER for DCIA, or 0.37/1.52 = 0.24. These adjusted values were summed together.

For the portion of Captains Pond's watershed that is located in Massachusetts, land use data and HSG was used to create a grid of unique land use and soil type combinations. This data was then correlated to the pollutant load export rates found in Table 4 to calculate the associated phosphorus loading rate. The portion of the Captains Pond watershed which is located in Massachusetts does not have any directly connected impervious area. Therefore, impervious area in Massachusetts was considered pervious coverage in HSG D to account for the fact that some runoff from the disconnected impervious surfaces will be infiltrated before it reaches Haverhill's MS4 or Captains Pond.

[8] New Hampshire Department of Environmental Services, 2021. *Pollutant Hot Spots – Priority Ranked Parcel Summary Report. Municipality: Salem, NH.* https://www4.des.state.nh.us/nh-ms4/?page_id=1798

4.4 Results

The methodology discussed in Section 4.3 was used to calculate an estimated phosphorus load for each MS4 catchment area. The parcel TP values provided by NHDES, attenuated parcel TP values, calculated TP values for areas in the right-of-way and estimated TP values for portions of the watershed in Massachusetts were summed by catchment area to estimate the phosphorus loading at each outfall. The results of the pollutant loading analysis are presented in Table 5. A map of the catchment areas is included in Appendix A.

Table 5: Results of Pollutant Loading Analysis

Catchment ID	Catchment Area (Ac.)	IA (Ac.)	IA (%)	Catchment P Load (lbs/year)
CAP-0227-OF	1.33	0.07	5.6	0.08
CAP-0228-OF	8.64	2.46	28.5	2.13
CAP-0229-OF	0.09	0.09	100.0	0.15
CAP-0230-OF	54.47	9.68	17.8	11.42
CAP-0244-OF	0.03	0.03	100.0	0.05
CAP-0246-OF	7.62	2.16	28.3	3.62
CAP-0517-OF	11.26	1.88	16.7	4.63
CAP-0609-OF	39.96	2.84	7.1	5.52
CAP-0612-OF	1.00	0.51	50.8	0.89
CAP-0658-OF	0.99	0.74	74.7	1.12
CAP-0678-OF	28.68	4.40	15.4	8.79
CAP-0679-OF	0.01	0.01	100.0	0.01
CAP-0689-OF	0.01	0.01	100.0	0.02
CAP-0690-OF	1.49	0.32	21.1	0.63
CAP-0801-OF	19.96	2.79	14.0	3.70
CAP-0802-OF	6.11	1.34	21.9	1.18
CAP-0993-OF	1.50	0.39	26.2	0.77
Total	**183.14**	**29.71**	**16.22**	**44.72**

*Since runoff generated from impervious surfaces in the areas that contribute overland flow to Captains Pond is not collected by a storm sewer, it was considered disconnected impervious area and modeled as pervious land in HSG D.

Table 5 confirms that catchments with more than one acre of impervious coverage have a higher potential to contribute phosphorus to stormwater runoff. Smaller catchments with fewer acres of IA have lower potential phosphorus loads.

Non-point source runoff is also a significant source of potential phosphorus loading to Captains Pond. Since there are many residential properties abutting the shores of the lake, runoff is generated from impervious area on those properties and discharges overland to the lake. Some of that runoff is likely infiltrated by lawns on the property, but what does reach the lake has a relatively high potential phosphorus load based on the amount of organic matter, such as leaf litter, grass clippings, fertilizer, soils, and dog waste that the runoff encounters. The presence of septic systems on properties adjacent to Captains Pond increases the potential phosphorus loading from non-point sources.

The results of the pollutant loading analysis is the basis for the catchment ranking discussed in Section 4.6.

4.5 Dry and Wet Weather Outfall Screening and Sampling

Dry and wet weather screening and sampling was conducted at each outfall discharging directly to Captains Pond between 2017 and 2022. The results of these sampling events were recorded in the Town's GIS and through individual sampling reports prepared by Weston & Sampson and FB Environmental. Dry-weather flow was observed at two of the five applicable outfalls and wet-weather flow was observed at all five applicable outfalls. Field tests kits were used to analyze samples for ammonia, chlorine, surfactants, temperature, salinity, and conductivity, and samples were sent to a laboratory for analysis for Escherichia coliform (E. coli), phosphorus, biological oxygen demand (BOD_5), and pH. The dry-weather and wet-weather sampling results for total phosphorus are presented in Table 6. A map showing outfall and catchment locations is included in Appendix A.

Table 6: Outfall Phosphorus Sampling Results			
Outfall ID	Address(1)	Wet Weather - Total Phosphorus (mg/L)	Dry Weather – Total Phosphorus (mg/L)
CAP-0246-OF	8 Olde Village Road	0.22	Dry
CAP-0517-OF	9 Captains Drive	0.25	<0.05
CAP-0658-OF	26 Plaisted Circle	0.21	Dry
CAP-0678-OF	21 Emileo Lane Ext.	0.23	Dry
CAP-0993-OF	3 Olde Village Road	<0.05	<0.05

(1) A map showing the location of each outfall is included in Appendix A

While there is no benchmark criteria for phosphorus concentrations in the New Hampshire Surface Water Quality Standards, 0.012 mg/L is the target phosphorus concentration outlined in the TMDL for Captains Pond, and has been adopted as a benchmark for outfall sampling. Four of the five outfalls sampled during wet-weather conditions exceeded that standard. None of the five outfalls sampled during dry-weather conditions exceeded benchmark criteria.

4.6 Catchment Ranking Matrix

The pollutant loading analysis was performed to develop a priority ranking of the MS4 catchment areas tributary to Captains Pond for BMP retrofit. Catchments with the highest potential phosphorus load were considered highest priority. Potential phosphorus load for each catchment area includes loading from private parcels and loading from areas within the municipal right-of-way, as discussed in Section 4.3. There are no municipally-owned parcels within the Captains Pond watershed. Since observed phosphorus concentrations in stormwater discharges can vary depending on the time of year the sampling is conducted, the size of the storm event, and other factors, the sample phosphorus concentrations were not considered when ranking the catchment areas. Other data collected during outfall inspections, such as whether or not the outfall was flowing during wet-weather and distance from the outfall to Captains Pond, were considered.

Catchments contributing less than one pound per year of phosphorus were determined to be lower priority. Catchment CAP-0658-OF had benchmark exceedances for phosphorus during wet weather but it is a relatively small catchment with a small phosphorus load (0.33 lbs/yr). This catchment already contains a rain garden which provides some storage and treatment for stormwater runoff from the street and was listed as low priority. The area that contributes overland flow to Captains Pond was not ranked, as it is not considered a delineated catchment area under the MS4 Permit. The catchment ranking is presented in Table 7. A figure highlighting the High Priority catchments is included in Appendix B.

Table 7: Captains Pond Catchment Priority Ranking by Phosphorus Loading

Rank	Catchment ID	Catchment P Load (lbs/year)	Wet Weather Sampling Results (mg/L)	Catchment Designation
1	CAP-0230-OF	11.42	-	High Priority
2	CAP-0678-OF	8.79	0.23	High Priority
3	CAP-0609-OF	5.52	-	High Priority
4	CAP-0517-OF	4.63	0.25	High Priority
5	CAP-0801-OF	3.70	-	High Priority
6	CAP-0246-OF	3.62	0.22	High Priority
7	CAP-0228-OF	2.13	-	High Priority
8	CAP-0802-OF	1.18	-	High Priority
9	CAP-0658-OF	1.120	0.21	High Priority
10	CAP-0993-OF	0.77	<0.05	High Priority
11	CAP-0612-OF	0.89	-	Low Priority
12	CAP-0690-OF	0.63	-	Low Priority
13	CAP-0229-OF	0.15	-	Low Priority
14	CAP-0227-OF	0.08	-	Low Priority
15	CAP-0244-OF	0.05	-	Low Priority
16	CAP-0689-OF	0.02	-	Low Priority
17	CAP-0679-OF	0.01	-	Low Priority

4.6.1 Catchment Summaries

The characteristics of each High Priority catchment area tributary to Captains Pond as they relate to potential phosphorus loading are summarized below:

1.1.1. Catchment CAP-0230-OF

Catchment CAP-0230-OF covers 37.23 acres along Carriage Lane, north of Captains Pond. CAP-0230-OF discharges to an open channel tributary to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 17.8% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.2. Catchment CAP-0678-OF

Catchment CAP-0678-OF covers 10.09 acres along Emileo Lane and Emileo Lane Extension, south of Captains Pond. CAP-0678-OF discharges to an open channel which discharges directly to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 15.4% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B/D. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.3. Catchment CAP-0609-OF

Catchment CAP-0609-OF covers 3.06 acres along Hooker Farm Road, north of Captains Pond. CAP-0609-OF discharges to a wooded area adjacent to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 7.1% impervious. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.4. Catchment CAP-0517-OF

Catchment CAP-0517-OF covers 13.70 acres along Captains Drive and Captains Road, south of Captains Pond. CAP-0517-OF discharges directly to the southeast corner of Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 16.7% impervious. The soils in this catchment are hydrologic soil group (HSG) C. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.5. Catchment CAP-0801-OF

Catchment CAP-0801-OF covers 10.60 acres along Hooker Farm Road, north of Captains Pond. CAP-0801-OF discharges to an open channel which eventually discharges to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 14.0% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.6. Catchment CAP-0246-OF

Catchment CAP-0246-OF covers 2.42 acres along Olde Village Road, east of Captains Pond. CAP-0246-OF discharges to wetlands adjacent to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 28.3% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.7. Catchment CAP-0228-OF

Catchment CAP-0228-OF covers 13.56 acres along Fieldstone Lane, north of Captains Pond. CAP-0228-OF discharges to a wooded area north of Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 28.5% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.8. Catchment CAP-0802-OF

Catchment CAP-0802-OF covers 3.22 acres along Hooker Farm Road, north of Captains Pond. CAP-0802-OF discharges to a wooded area adjacent to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 21.9% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.9. Catchment CAP-0658-OF

Catchment CAP-0658-OF covers 0.29 acres along Plaisted Circle, west of Captains Pond. The Town recently constructed a bioretention area which captures flow from the drainage system prior to discharging directly to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 74.8% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) D. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways.

1.1.10. Catchments CAP-0993-OF

Catchment CAP-0993-OF covers 0.87 acres along Olde Village Road, east of Captains Pond. The outfall discharges directly to Captains Pond. The most predominant land use in this catchment is low density residential; the catchment is 26.2% impervious coverage. The soils in this catchment are hydrologic soil group (HSG) B. There is no municipally-owned property in this catchment area outside of the right-of-way. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, groundwater seepage from septic systems, and other sediment and debris that may accumulate on roadways

5.0 BEST MANAGEMENT PRACTICE (BMP) RETROFIT OPPORTUNITIES

In addition to a community-wide BMP retrofit inventory, the 2017 MS4 Permit requires permittees with discharges to a phosphorus-impaired waterbody to identify potential retrofit opportunities in the sub-catchments tributary to those receiving waters as part of the PSIR. Retrofit opportunities may include the installation of structural BMPs during redevelopment or the removal of impervious area.

5.1 Potential Retrofit Sites

The following factors were considered when identifying potential retrofit sites in the MS4 catchments tributary to Captains Pond: parcel size, parcel ownership, parcel ranking in the Treatment Priority analysis conducted by NHDES in the Hot Spot/Pollutant Loading dataset, soil type, vicinity to the shoreline, and available open space. The treatment priority analysis conducted by NHDES in the Hot Spot/Pollutant Loading dataset ranks parcels in Salem based on the amount of impervious area and associated phosphorus loading on that parcel, assigning a higher weight to municipally-owned parcels. Areas within the right-of-way were also considered for impervious area disconnection and/or reduction. There are no municipally owned parcels within the Captains Pond watershed, therefore all proposed projects are either on private property within the limits of an assumed easement, or within the right-of-way. Projects within the right-of-way are intended to be considered in conjunction with the Town's existing schedule for roadway and sidewalk improvements in the area. Due to the lack of municipally-owned property in the watershed and improvements already completed by the Town of Salem, potential retrofit locations were not identified in every High Priority catchment area. The potential retrofit projects were ranked by assigning weights to the factors discussed above, including property ownership, soil type, existing drainage infrastructure, opportunities for public engagement, and others. The identified locations for potential BMP retrofit, listed in alphabetical order, are included in Table 8 and discussed in more detail below. The matrix used to rank the retrofit projects is included in Appendix C.

Table 8: Potential Retrofit Projects in the Captains Pond Watershed

Project Rank	Site Address	Property Owner	Parcel Size (Ac.)	Percent Impervious Coverage	NHDES Treatment Priority Ranking	Soil Type	Existing Parcel Use	Catchment ID and Rank	
1	52 Olde Village Road ROW	Town of Salem	-	-	-	B	ROW	CAP-0993-OF	10
2	Emileo Lane Cul-de-Sac	Town of Salem	-	-	-	B/D	ROW	CAP-0678-OF	2
3	Camp Hadar (92 Hooker Farm Road)	Jewish Community Center	13.03	5.4%	663 (2nd in Watershed)	B	Camp/ Recreation	N/A-overland	N/A

Table 8: Potential Retrofit Projects in the Captains Pond Watershed									
Project Rank	Site Address	Property Owner	Parcel Size (Ac.)	Percent Impervious Coverage	NHDES Treatment Priority Ranking	Soil Type	Existing Parcel Use	Catchment ID and Rank	
4	Camp Otter (66 Hooker Farm Road)	Greater Lawrence YMCA	12.10	5.4%	688 (4th in Watershed)	B	Camp/ Recreation	N/A - overland	N/A
5	8 Olde Village Road	Privately Owned	0.92	27.2%	2754	B	Residential	CAP-0246-OF	6
6	110 Hooker Farm Road	Captain's Village Development Corp.	5.28	2.8%	6169	C	Open Space	CAP-0801-OF, CAP-0230-OF	5, 1

5.1.1 52 Olde Village Road Right-of-Way

Runoff tributary to CAP-0993-OF is collected by two catch basins near 52 Olde Village Road before discharging directly to Captains Pond. The Town should consider retrofitting these catch basins with a suitable infiltration practice, such as infiltration trenches, leaching catch basins, or a green infrastructure practice if room allows within the right-of-way. Cut sheets for infiltration trenches and leaching catch basins are included in Appendix C. Even a small infiltration practice in this area will reduce stormwater volumes discharging to Captains Pond, therefore reducing the catchment's annual phosphorus loading. Olde Village Road is scheduled for reconstruction within the next 5 years as part of the Town's Road Program.

5.1.2 Emileo Lane Cul-de-Sac

The main storm drain tributary to CAP-0678-OF crosses directly under the cul-de-sac at the end of Emileo Lane before continuing under Emileo Lane Extension and discharging to a channel near the Captains Pond shoreline. A center island could be installed at this cul-de-sac, which could intercept some of the stormwater runoff from the upstream portion of the catchment. This island should incorporate a green infrastructure practice like bioretention, and could provide treatment for surface runoff from the surrounding roadway as well as storage or infiltration of runoff already in the drainage system. If filtration or infiltration of stormwater is not feasible at this location, then a vegetated island should still be considered to reduce impervious coverage in the catchment. Emileo Lane is scheduled for reconstruction within the next 5 years as part of the Town's Road Program.

5.1.3 Camp Hadar & Camp Otter

Camp Hadar and Camp Otter were among the highest-ranked parcels within the Captains Pond watershed on the treatment priority ranking developed by NHDES for Salem[9]. The Town could work with the JCC, YMCA, and staff from both camps to identify areas where runoff from impervious surfaces on both camp properties can be treated on-site. This may include surface runoff from the

[9] New Hampshire Department of Environmental Services, 2021. *Pollutant Hot Spots – Priority Ranked Parcel Summary Report. Municipality: Salem, NH.* https://www4.des.state.nh.us/nh-ms4/?page_id=1798

driveways and parking area, or roof runoff from the cabins and other buildings at the camps. If groundwater conditions are favorable, bioretention areas could be installed to capture surface runoff, or stormwater planter boxes could be used to capture roof runoff. The camps offer opportunities for public engagement and partnership with a non-governmental organization—the BMPs could tie into any existing programming relating to science or the environment at the camps and increase awareness among campers about the importance of improving and maintaining water quality. BMPs at either of these sites may also help mitigate elevated bacteria concentrations often observed after rain events, which causes the water at both swimming beaches to exceed state standards for swimming. Cut sheets for bioretention areas and stormwater planter boxes are included in Appendix C.

5.1.4 8 Olde Village Road

The outfall at 8 Olde Village Road (CAP-OF-0246) discharges to a wetland area between the houses at 8 and 10 Olde Village Road. The outfall is difficult to locate as the wetland area is overgrown and piles of yard waste were observed in the area during sampling events. Natural wetlands, when in good condition, provide nutrient removal to stormwater discharges. The Town could perform a condition assessment of this wetland area and, if necessary, perform some wetland restoration to ensure that phosphorus removal is maximized. While the site is not suitable for a structural BMP, performing any necessary maintenance should effectively treat discharges from CAP-OF-0246. The Town will need to determine if an easement exists at this location before proceeding with this retrofit option.

5.1.5 Drainage Channels at 110 Hooker Farm Road

Runoff from catchments CAP-0801-OF and CAP-0230-OF discharge to two drainage channels, which run across the property at 110 Hooker Farm Road. CAP-0801-OF discharges to a channel in the center of the property; CAP-0230-OF discharges to a channel that runs along the driveway near the eastern property line. While the Town does not have existing drainage easements for those channels, they could perform a condition assessment of the channels and determine what, if any, pollutant removal can be attributed to the channels in their existing condition. One or both existing channels could be retrofitted with green infrastructure practices, such as a water quality swale or bioretention system, to maximize pollutant removal from stormwater prior to discharging to Captains Pond. Cut sheets for water quality swales and bioretention systems are included in Appendix C. Any improvements of the drainage channels at this site must be coordinated with the Captain's Village Development Corporation, who likely have plans to redevelop the site. Since no easement exists, the Town should consider recommending green infrastructure retrofits to the drainage channels when reviewing a proposed redevelopment plan for the site. Any development at this site must meet the standards outlined in the Town's stormwater bylaw, which is in the process of being updated to meet MS4 Permit requirements.

5.1.6 Continuous Opportunities for Impervious Area Reduction and Green Infrastructure

In addition to the projects discussed above, the Town of Salem should continue to evaluate streets in the Captains Pond watershed for opportunities to reduce impervious coverage or incorporate green streets practices as part of their routine roadway improvement efforts. Green streets practices include the use of bioretention areas, tree trenches, infiltration trenches, and similar practices to manage stormwater as close to the source as possible. These practices effectively disconnect upstream sections of the catchment area from the drainage system, reducing runoff volumes and associated pollutant loads at the outfall. The average phosphorous loading per acre of impervious area in the Captains Pond watershed is 1.51 lb/acre/year—every square foot of impervious area removed or disconnected from the MS4 through the use of green infrastructure reduces the annual phosphorus load to Captains Pond by 0.0000346 lb. By continuing to identify and implement opportunities for green infrastructure within the watershed, the Town of Salem can make progress towards meeting the waste load allocation for phosphorus determined in the Captains Pond TMDL.

5.2 Completed Retrofit Projects

The Town has completed some stormwater retrofit projects in the Captains Pond watershed in conjunction with its roadway improvement program. These projects are summarized in Table 9 and discussed in more detail below. This section should be updated as the Town completes stormwater retrofit projects in the watershed.

Table 9: Completed Retrofit Projects in Captains Pond Watershed

Site Address	Property Owner	Parcel Size (Ac.)	NHDES Treatment Priority Ranking	Soil Type	Existing Parcel Use	Catchment ID	Catchment Rank
Captains Drive Drainage Improvements (Bioretention)	Town of Salem	-	-	-	ROW	CAP-0517-OF	4
Plaisted Circle ROW Improvements	Town of Salem	-	-	-	ROW	CAP-0658-OF	9

5.2.1 Captains Drive Drainage Improvements (Bioretention)

The Town completed a roadway project at Captains Drive in 2018, which included updates to the drainage system and the installation of a bioretention area immediately downstream of outfall CAP-0517-OF. The bioretention area receives flow from the entire 11.26-acre catchment area, of which 1.88 acres is impervious area, and provides 0.39 lb/yr of phosphorous removal, or 9.2% of the catchment's total load. As-built drawings for the Captains Drive improvements are included in Appendix C.

5.2.2 Plaisted Circle Right-of-Way Improvements

The Town completed a roadway project at Plaisted Circle in 2020, which included the removal of two direct stormwater discharges to Captains Pond and the rerouting of all stormwater from the roadway to a wetland area between #28 Plaisted Circle and the Captains Pond shoreline. Natural wetlands provide stormwater storage and nutrient removal when in good condition. The Town should continue to inspect the new outfall and wetland area at Plaisted Circle, and perform maintenance as needed to ensure the system continues to function as designed. As-built drawings for the Plaisted Circle improvements are included in Appendix C.

5.3 Implementation

The Town of Salem will begin addressing the findings of this Phosphorus Source Identification Report in Permit Year 5 (FY2023). The Town must first evaluate each potential retrofit opportunity identified in the previous section through the following actions:

- Determine a planned retrofit date for each potential retrofit site identified in Section 5.1 based on the next planned infrastructure, resurfacing, or redevelopment activity planned for the site.

- Determine an estimated cost for each potential retrofit project discussed in Section 5.1.
- Determine the engineering and regulatory feasibility of implementing each potential retrofit project.

A list of planned BMP retrofit projects and schedule for their implementation will be included in the Town's Year 5 MS4 Annual Report.

In Permit Year 6 (FY2024), the Town will plan and install one of the retrofit projects identified in Section 5.1 as a demonstration project in the Captains Pond watershed. The remainder of the retrofit projects, where implementation is feasible from an engineering and permitting perspective, will be installed according to the schedule included in the Year 5 annual report. Future availability of funding will also be considered in developing the schedule. Salem will track any structural BMPs installed in the watershed and calculate the estimate phosphorus removal attributable to those BMPs consistent with Attachment 3 to Appendix F of the MS4 Permit. The BMP type, area treated, design storage volume, and estimated phosphorus removed in pounds per year by each BMP will be included in the Town's future MS4 annual reports.

6.0 REFERENCES

1. Salem 208 Water Quality Commission. "1986 Water Quality Study for the Town of Salem, NH", 1986.

2. New Hampshire Department of Environmental Services. "Total Maximum Daily Load for Phosphorus for Captains Pond, Salem, NH", September 2017.

3. New Hampshire Department of Environmental Services. "Volunteer Lake Assessment Program Individual Lake Reports – Captains Pond, Salem NH", 2019.

4. New Hampshire Department of Environmental Services. "Volunteer Lake Assessment Program Individual Lake Reports – Captains Pond, Salem NH", 2020.

5. New Hampshire Department of Environmental Services. "New Hampshire Lake Trend Report: Status and Trends of Water Quality Indicators", June 2020.

6. Sutherland, R.C., "Methodology for Estimating the Effective Impervious Area of Urban Watersheds", Watershed Protection Techniques, Vol. 2, No. 1, Fall 1995.

7. United States Environmental Protection Agency., "Methodology to Calculate Baseline Estimates of Impervious Area and Directly Connected Impervious Area for Massachusetts Communities". March 2010. https://www3.epa.gov/region1/npdes/stormwater/ma/IA-DCIA-Calculation-Methodology.pdf

8. Obropta, C.C. & Del Monaco, N. "Reducing Directly Connected Impervious Areas with Green Stormwater Infrastructure". *Journal of Sustainable Water in the Built Environment.* 2018. https://ascelibrary.org/doi/pdf/10.1061/JSWBAY.0000833

9. New Hampshire Department of Environmental Services. "Pollutant Hot Spots – Priority Ranked Parcel Summary Report. Municipality: Salem, NH", 2021. https://www4.des.state.nh.us/nh-ms4/?page_id=1798

APPENDIX A

Captains Pond Catchment Area Map

APPENDIX A

TOWN OF SALEM, NEW HAMPSHIRE
PHOSPHORUS SOURCE IDENTIFICATION REPORT

CAPTAIN POND CATCHMENT AREAS

MAY 2022 SCALE: NOTED

Weston & Sampson

APPENDIX B

Catchment Prioritization Map

APPENDIX B

TOWN OF SALEM, NEW HAMPSHIRE
PHOSPHORUS SOURCE IDENTIFICATION REPORT

CAPTAIN POND
CATCHMENT PRIORITIZATION

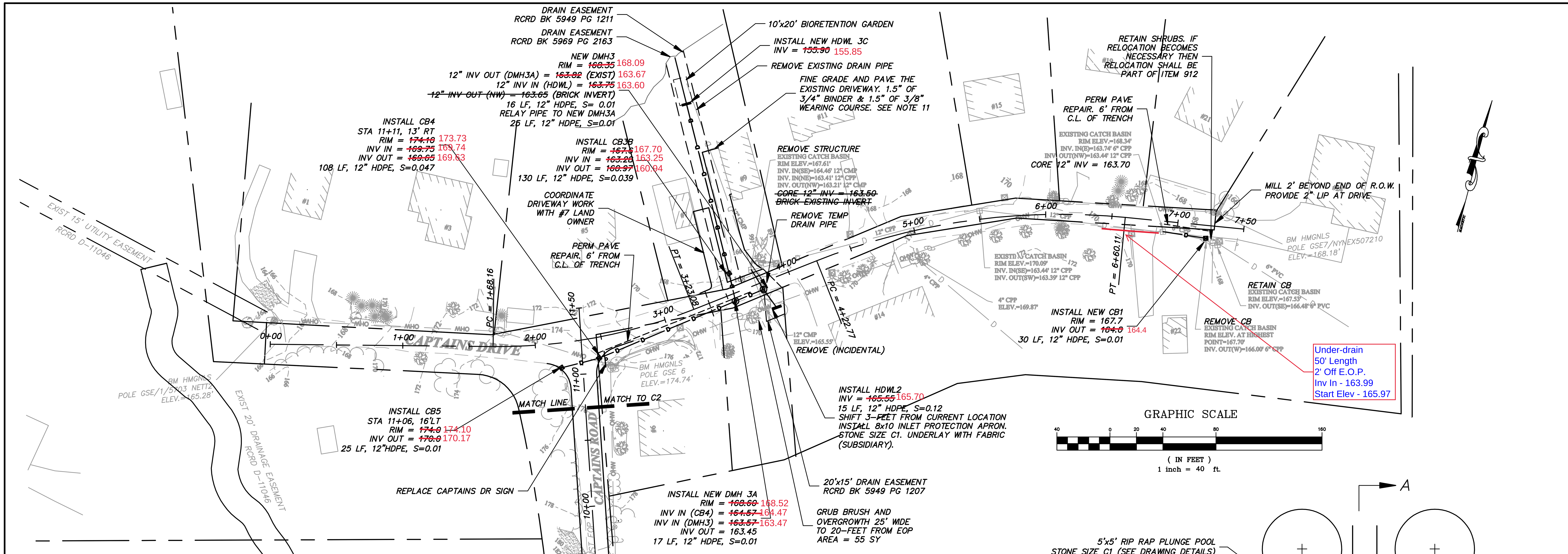
MAY 2022 SCALE: NOTED

Weston & Sampson

APPENDIX C

Retrofit Project Ranking Matrix, BMP Retrofit Cut Sheets, Examples, and Working Designs

Captain Pond Phosphorus Source Identification Report - Retrofit Project Ranking Matrix														
	Impervious Cover (IC) Area Score	Is the site easy to access for maintenance purposes?	Are site conditions, including soils, geology, depth to water table, site slopes, site elevation, and proximity to surrounding aquifers appropriate for a stormwater BMP? (expand this column as necessary in Year 5 when conducting feasibility assessments)	Is the proximity to subsurface infrastructure including sanitary sewers and septic systems appropriate for a stormwater BMP?	What is the risk to public safety?	Capital Improvements Plan (CIP) for storm and/or sanitary sewer infrastructure and paving projects - Is the BMP area located within an area scheduled for construction?	What is the current storm sewer level of service?	Is the site appropriate for public use?	Is there an opportunity for public education at the site?	Is there an opportunity for general public education?	Would a stormwater infiltration BMP be appropriate in this area?	Are drainage easements or other permissions needed to install and maintain the BMP?		
Retrofit Project	0-2 Acres IC = 5 2.1-5 Acres IC = 10 5.1-10 Acres IC = 15 10.1-20 Acres IC = 20 20.1+ Acres IC = 25	Yes = 10 Possibly = 5 No = 0	Yes = 10 Possibly/Unknown= 5 No= 0	Yes = 10 Possibly/Unknown = 5 No = 0	Low Risk = 10 Medium Risk = 5 High Risk = 0	<1 year = 15 1-3 years = 10 >3 = 5 Not scheduled or in CIP = 0	Stormwater collection system present = 10 Stormwater collection system nearby = 5 No stormwater collection system present = 0	Yes = 10 Possibly = 5 No = 0	Yes = 10 Possibly = 5 No = 0	Yes = 10 Possibly = 5 No = 0	Yes = 10 Possibly = 5 No = 0	Yes = 0 Possibly = 5 No = 10	Score	Rank
52 Olde Village Road ROW	5	10	5	5	10	5	10	5	5	5	10	10	85	1
Emileo Lane Cul-de-Sac	5	10	5	5	5	5	10	5	5	5	10	10	80	2
Camp Hadar (92 Hooker Farm Road)	5	5	5	5	5	0	0	10	10	5	5	0	55	3
Camp Otter (66 Hooker Farm Road)	5	5	5	5	5	0	0	10	10	5	5	0	55	4
8 Olde Village Road	5	5	5	5	10	0	5	0	0	5	0	5	45	5
110 Hooker Farm Road	5	5	5	5	10	0	5	0	0	5	5	0	45	6



CAPTAINS RD AND CAPTAINS DR NOTES:

1. THE INTENT OF THIS PLAN IS TO PROVIDE ROADWAY IMPROVEMENTS FOR CAPTAINS ROAD AND CAPTAINS DRIVE AS PART OF THE 2018 ROADWAY IMPROVEMENT PROJECT – CAPTAINS RD, CAPATAINS DRIVE, BONNANO RD, COBURN ST, PACHECO DR, WITCH HAZEL RD, HARRIS RD, DOIRON RD.
– WORK ON CAPTAINS ROAD WILL INVOLVE RECLAMATION ACTIVITIES, EXCAVATION, FINE GRADING, AND REPAVE OF THE EXISTING ROADWAY. MINOR DRAINAGE IMPROVMENTS WILL BE INCORPORATED INTO THE PROJECT
– WORK ON CAPTAINS DRIVE WILL BE MILL AND OVERLAY WORK. MINOR DRAINAGE IMPROVEMENTS OF THE EXISTING INFRASTRUCTURE WILL ALSO BE INCORPORATED INTO THE PROJECT.

2. REFER TO DRAWING D5 FOR PROJECT GENERAL NOTES.

3. MILLING NOTE: CAPTAINS DRIVE SHALL BE MILLED FULL WIDTH FOR THE ENTIRE LENGTH. MILLING ACTIVITIES SHALL NOT EXTEND INTO DRIVEWAYS UNLESS OTHERWISE STATED OR DIRECTED. DEPENDING ON FIELD CONDITIONS NOTE THAT IT MAY BE NECESSARY TO MILL PORTIONS OF DOWN-GRADIENT DRIVEWAYS IN ORDER TO CONSTRUCT A "LIP" AT THE EOP.

4. RECLAIM NOTE: CAPTAINS ROAD WILL BE RECLAIM IN-PLACE FOR FULL WIDTH OF ROAD TO A DEPTH OF 10" FOR THE ENTIRE LENGTH OF THE ROAD. BOX WIDENING SHALL BE PROVIDED AS NOTED ON THE PLAN.

5. GRADING INTENT: IT IS THE INTENT OF THIS PLAN FOR THE CONTRACTOR TO
- SHAPE THE RECLAIM IN PLACE SUCH THAT MINIMAL IMPACTS TO DRIVEWAYS OCCURS. THE 10" RECLAIM SECTION SHALL NOT BE REDUCED TO LESS THAN 8" THICKNESS DURING FINE GRADE OPERATIONS.
- THE CONTRACTOR SHALL ESTABLISH FIELD CONTROL AND COORDINATE WITH THE ENGINEER FOR ANY MINOR ADJUSTMENTS.

6. LANDSCAPE NOTE: ALL DISTURBED LANDSCAPE AREAS ADJACENT TO THE WORK (INCLUDING LANDSCAPE AREAS AROUND MAILBOXES) SHALL BE RESTORED AND CONSIDERED PART OF ITEM 912. LOAM AND SEED (ITEM 646.512) SHALL BE RE-ESTABLISHED TO WORK LIMIT. WORK LIMIT IS GENERALLY DEFINED AS 3-FEET FROM NEW EOP EXCEPT WHERE ADDITIONAL GRADING IS DIRECTED. DISTURBED BARK MULCH AREAS SHALL BE RESTORED AND PAID AS ITEM 646.512. UNDERLAY MUCH WITH FABRIC IF PRESENT IN EXISTING CONDITION (INCIDENTAL).

7. DRIVEWAY NOTE: IT IS THE INTENT OF THIS PLAN TO PROVIDE RECONSTRUCTED DRIVEWAY APRONS 5-FEET (OR AS OTHERWISE NOTED) FROM THE NEW EDGE OF PAVEMENT. IN SOME CASES DRIVEWAY APRONS MAY NEED TO EXTEND FURTHER TO OBTAIN POSITIVE DRAINAGE AND/OR BETTER TRANSITION GRADES. SEE DRIVEWAY DETAIL ON SHEET D1.

8. TREE TRIMMING: TREE TRIMMING AND PRUNING (ITEM 201.321) SHALL BE AS SHOWN ON THE PLANS AND WHERE DIRECTED BASED ON FIELD CONDITIONS.

9. GRUBBING NOTE: IN GENERAL, GRUBBING THE SHOULDERS AS SHOWN ON THE PLAN SHALL BE INCLUSIVE OF SMALL TREE REMOVAL. NOT ALL SHOULDER WORK SHALL BE CONSIDERED GRUB. ONLY THOSE AREAS SPECIFICALLY IDENTIFIED AS GRUB SHALL BE PAID.

10. PAVED DRIVEWAY FOR #7 CAPTAINS DRIVEWAY SHALL BE COORDINATED WITH LAND OWNER. SIZE, LAYOUT, AND LOCATION AS SHOWN IS GENERAL IN NATURE. FINAL LAYOUT TO BE APPROVED BY THE ENGINEER PRIOR TO THE WORK BEING COMPLETED.

11. PAVED DRIVEWAY FOR #9 CAPTAINS DRIVEWAY SHALL BE 12-FEET WIDE IN GENERAL AND MIMIC THE LAYOUT OF THE EXISTING DRIVEWAY.

AS BUILD DRAWN BY EJ PAVING CO INC

DATED: 10/1/2019

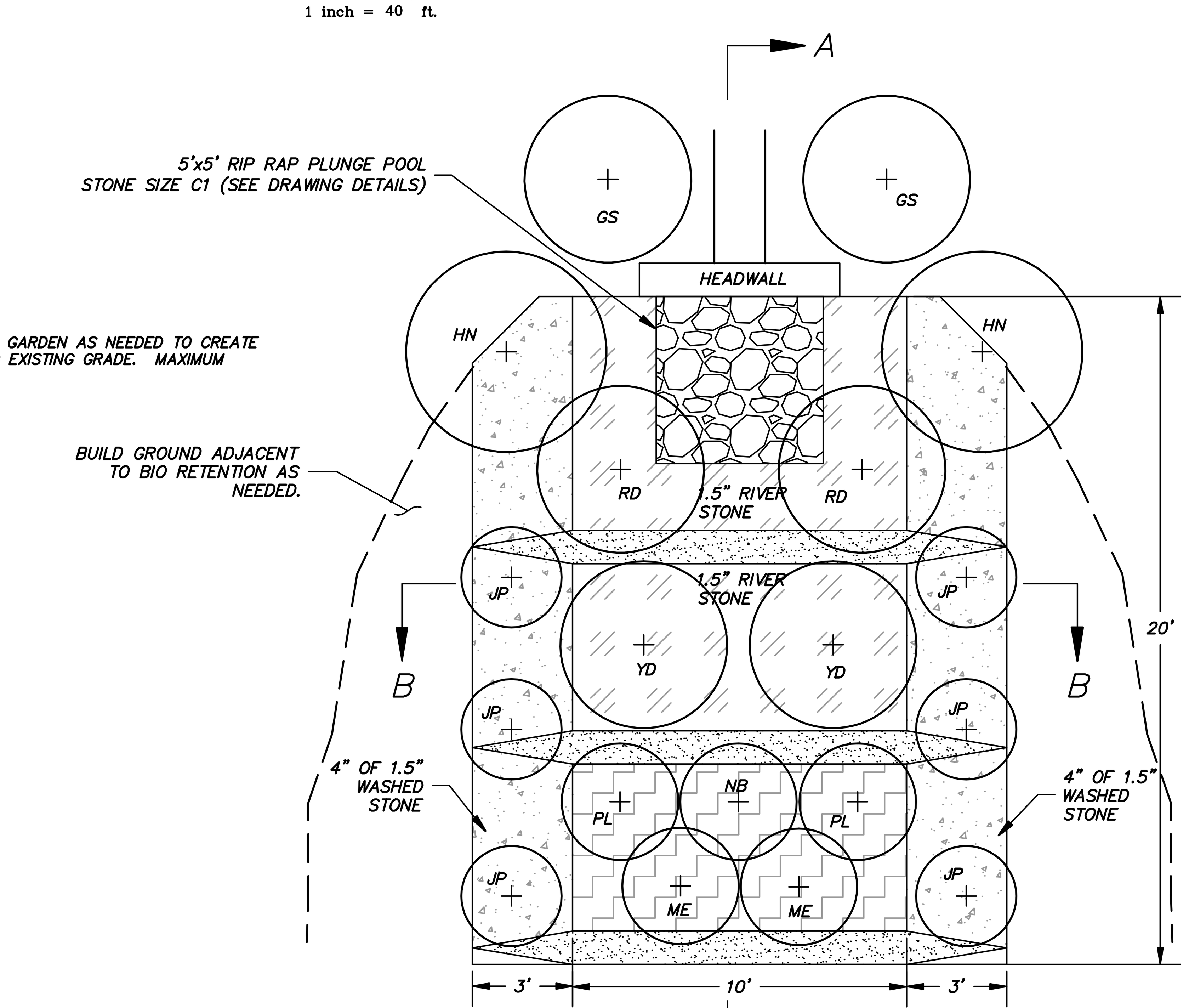
BIORETENTION NOTES:

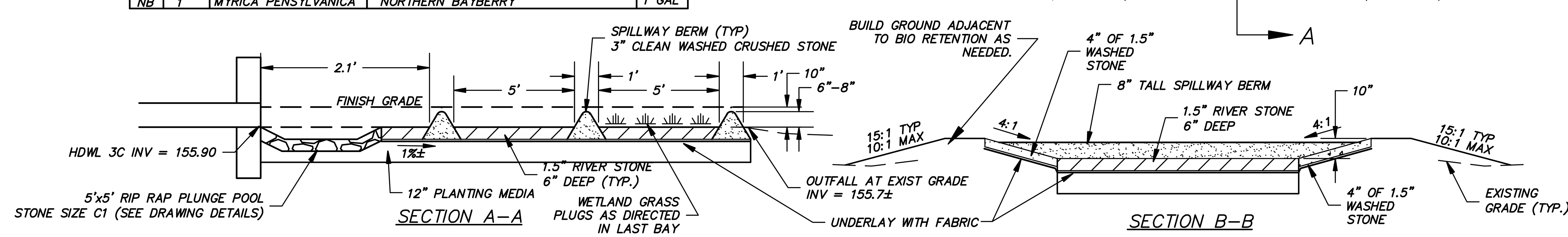
1. BUILD GROUND ADJACENT GROUND TO BIORETENTION GARDEN AS NEEDED TO CREATE BOWLED AREA AS DETAILED. FAN AS NEEDED BACK TO EXISTING GRADE. MAXIMUM SLOPE 10:1.

BIO-RETENTION AREA FILTER MEDIA

COMPONENT MATERIAL	% MIXTURE BY VOLUME	GRADATION OF MATERIAL	
		SIEVE NO.	% PASSING
ASTM C-33 CONC. SAND	50 TO 55		
LOAMY SAND TOPSOIL, WITH FINES AS INDICATED	20 TO 30	200	15 TO 20
MODERATELY FINE SHREDDED BARK OR WOOD FIBER MULCH, WITH FINES AS INDICATE	20 TO 30	200	<5

KEY	QTY	BOTANICAL NAME	COMMON NAME	SIZE
GS	2	SPIRAEA GOLDMOUND	GOLD SPIREA	3 GAL
JP	6	JUNIPERUS BLUE STAR	BLUE STAR JUNIPER	2 GAL
RD	2	CORNUS A IVORY HALO	RED TWIG DOGWOOD	3 GAL
HN	2	SALIX HAKURO NISHIKI	HAKURO NISHIKI – DAPPLED WILLOW	3 GAL
PL	3	PRUNUS MARITIMA	BEACH PLUM	1 GAL
ME	2	IVA FRUTESCENS	MARSH ELDER	1 GAL
YD	2	CORUNS A BUDS YELLOW	YELLOW TWIG DOGWOOD	3 GAL
NB	1	MYRICA PENSYLVANICA	NORTHERN BAYBERRY	1 GAL





NO.	DATE	REVISION
2	10/4/18	ADD BIORETENTION AREA
1	7/9/18	REVISED DRAINAGE

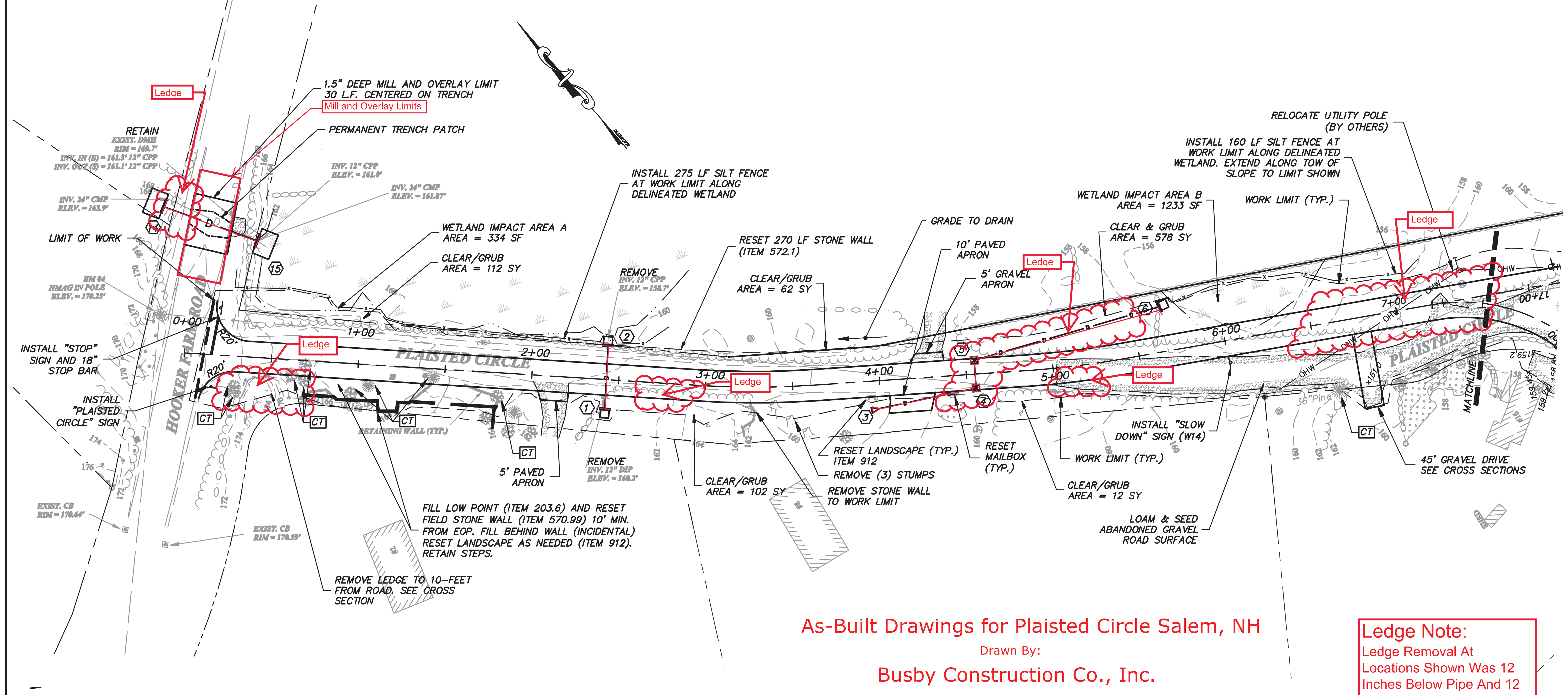
DRAWN: JAD | DESIGNED: JAD | CHECKED: DH | APPROVED: DH

OWNER:
TOWN OF SALEM
33 GEREMONTY DRIVE
SALEM, NH 03079

2018 ROADWAY IMPROVEMENT PROGRAM
NEIGHBORHOOD RECONSTRUCTION PROJECT
SALEM, NH 03079
ASSESSORS MAP 60

CAPTAINS DRIVE
GENERAL PLAN

DATE: DEC 2017
SCALE: 1"=40'(H)
SHEET: C1
PLAN NO. 2 OF 14



1. CONSTRUCT HDWL 1
STA 2+43, 17'RT
INVERT = ~~160.0~~ 159.99
36 LF, 12" RCP, S=0.027
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

2. CONSTRUCT HDWL 2
STA 2+43, 19'LT
INVERT = ~~159.03~~ 158.97
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

3. CONSTRUCT FES3 (HDPE)
STA 4+00, 16'RT
INVERT = ~~157.72~~ 157.68
54 LF, 12" RCP, S=0.017

4. CONSTRUCT CB4 Top of Precast - 158.77
4" F&G, 6" FLAT TOP W/O SHIP LAP
STA 4+55, 8'RT
RIM = ~~159.08~~ 159.06
INV IN = ~~156.80~~ 156.82
INV OUT = ~~156.70~~ 156.72
INSTALL POLY-LINER
12 LF, 12" RCP, S=0.005

5. CONSTRUCT CB5 Top of Precast - 158.47
4" F&G, 6" FLAT TOP W/O SHIP LAP
STA 4+55, 8'LT
RIM = ~~159.08~~ 159.06
INV IN = ~~156.64~~ 156.48
INV OUT = ~~156.54~~ 156.38
INSTALL POLY-LINER
108 LF, 12" HDPE, S=0.005

6. CONSTRUCT HDWL 6
STA 5+65, 25'LT
INVERT = ~~156.0~~ 155.81
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

14. CONSTRUCT HDWL 14
ADJUST LOCATION AS SHOWN
INVERT = ~~163.9~~ 164.33
58 LF, 24" RCP, S=0.034
CONSTRUCT 10x15 RIP RAP APRON
STONE SIZE C1/C2
UNDERLAY WITH FABRIC (SUBSIDIARY)

15. CONSTRUCT HDWL 15
RETAIN EXISTING LOCATION
INVERT = ~~161.9~~ 161.93
CONSTRUCT 10x15 RIP RAP APRON
STONE SIZE C1/C2
UNDERLAY WITH FABRIC (SUBSIDIARY)

CT – TREE REMOVAL

PLAISTED CIRCLE NOTES:

1. THE INTENT OF THIS PLAN IS TO PROVIDE ROADWAY IMPROVEMENTS FOR PLAISTED CIRCLE AS PART OF THE 2020 ROADWAY IMPROVEMENT PROJECT. THE WORK WILL INVOLVE FULL BOX ROAD BED EXCAVATION AND GRAVEL, FINE GRADING, AND REPAVE OF THE ROADWAY. SUPPLEMENTAL DRAINAGE IMPROVEMENTS WILL ALSO BE INCORPORATED INTO THE PROJECT.

2. REFER TO DRAWING D4 FOR PROJECT GENERAL NOTES.

3. GRADING INTENT: IT IS THE INTENT OF THIS PLAN FOR THE CONTRACTOR TO
- SHAPE THE GRAVELS SUCH THAT MINIMAL IMPACTS TO DRIVEWAYS OCCURS.
- THE CONTRACTOR SHALL ESTABLISH FIELD CONTROL AND COORDINATE WITH THE ENGINEER FOR ANY MINOR ADJUSTMENTS.

4. LANDSCAPE NOTE: ALL DISTURBED LANDSCAPE AREAS ADJACENT TO THE WORK (INCLUDING LANDSCAPE AREAS AROUND MAILBOXES) SHALL BE RESTORED AND CONSIDERED PART OF ITEM 912. LOAM AND SEED (ITEM 646.512) SHALL BE RE-ESTABLISHED TO WORK LIMIT. DISTURBED BARK MULCH AREAS SHALL BE RESTORED AND PAID AS ITEM 646.512. UNDERLAY MUCH WITH FABRIC IF PRESENT IN EXISTING CONDITION (INCIDENTAL).

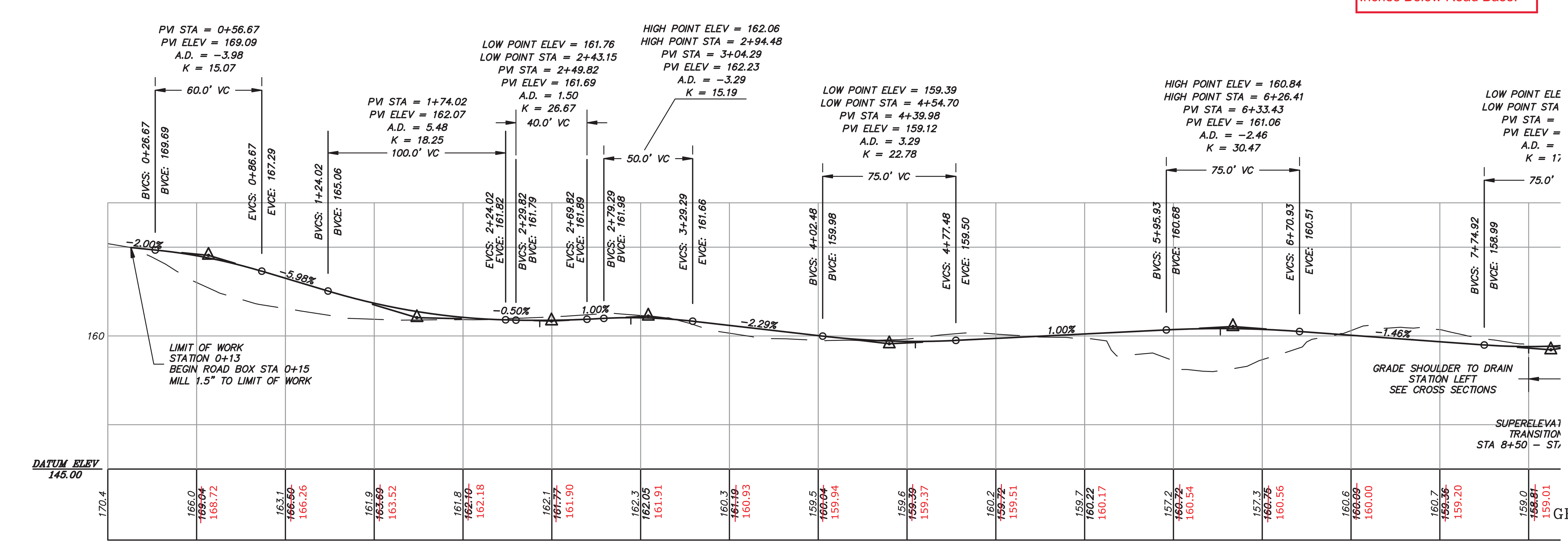
5. TREE TRIMMING: TREE TRIMMING AND PRUNING (ITEM 201.321) SHALL BE AS SHOWN ON THE PLANS AND WHERE DIRECTED BASED ON FIELD CONDITIONS.

6. DRIVEWAY NOTE: IT IS THE INTENT OF THIS PLAN TO PROVIDE RECONSTRUCTED DRIVEWAY APRONS 5-FEET (OR AS OTHERWISE NOTED) FROM THE NEW EDGE OF PAVEMENT. IN SOME CASES DRIVEWAY APRONS MAY NEED TO EXTEND FURTHER TO OBTAIN POSITIVE DRAINAGE AND/OR BETTER TRANSITION GRADES. SEE DRIVEWAY DETAIL ON SHEET D1.

7. COMMON EXCAVATION QUANTITY: WHERE LEDGE IS PRESENT IN THE EXCAVATION AREA THE EXCAVATION QUANTITY SHALL BE REDUCED BY THE AMOUNT OF LEDGE REMOVED. OVER EXCAVATION OF LEDGE AS SHOWN ON THE DETAIL SHALL BE BACKFILLED WITH STRUCTURAL FILL (ITEM 508).

8. FIELD STONE WALL RESET: FIELD STONE WALL SHALL BE RESET 10-FEET FROM EOP

9. MONUMENT RESET NOTE: ALL MONUMENTS IMPACTED BY ROAD CONSTRUCTION SHALL BE RESET UNLESS OTHERWISE SHOWN TO BE "RETAINED".



GRAPHIC SCALE
(IN FEET)
1 inch = 8 ft.

GRAPHIC SCALE
(IN FEET)
1 inch = 40 ft.

WETLAND IMPACT SUMMARY

LOCATION	TEMPORARY	PERMANANT	TOTAL
AREA A	0 SF	334 SF	334 SF
AREA B	0 SF	1,233 SF	1,233 SF
TOTAL	0 SF	1567 SF	1,567 SF

TOWN OF SALEM
33 GEREMONTY DRIVE
SALEM, NH 03079

OWNER:

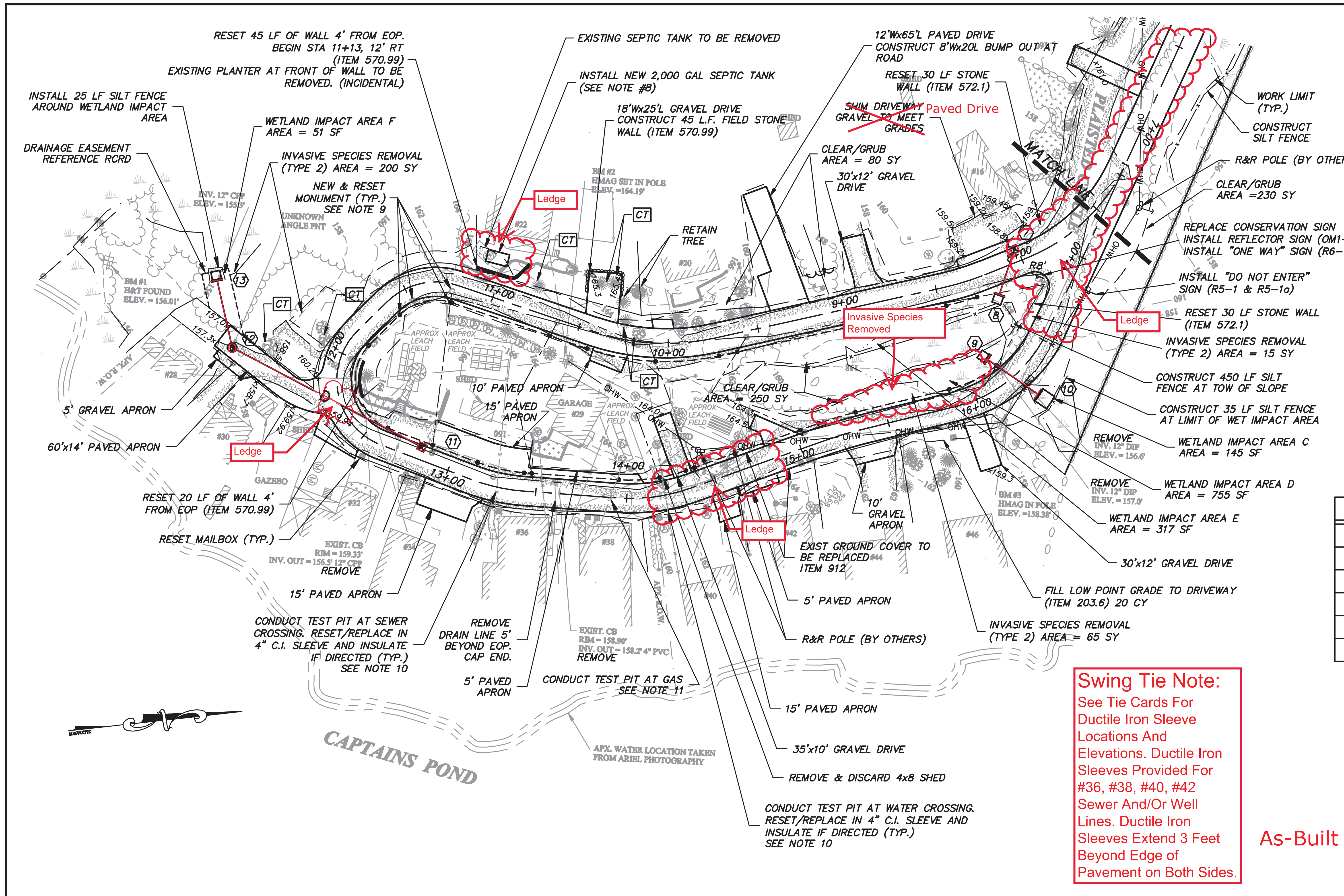
2020 ROADWAY IMPROVEMENT PROGRAM
NEIGHBORHOOD RECONSTRUCTION PROJECT
SALEM, NH 03079
ASSESSORS MAP 51

PLAISTED CIRCLE
PLAN & PROFILE

NO.	DATE	REVISION
-	-	-

DRAWN: JAD | DESIGNED: JAD | CHECKED: DH | APPROVED: DH

DATE: DEC 2019 | SCALE: 1"=40'(H) 1"=8'(V) | SHEET: C1 | PLAN NO. 2 OF 15



Swing Tie Note:

See Tie Cards For Ductile Iron Sleeve Locations And Elevations. Ductile Iron Sleeves Provided For #36, #38, #40, #42 Sewer And/Or Well Lines. Ductile Iron Sleeves Extend 3 Feet Beyond Edge of Pavement on Both Sides.

(7) CONSTRUCT DIDB7 (ROUND) Top of Precast - 158.09
STA 8+02, 7'RT
RIM = ~~158.58~~ 158.75
INV OUT = ~~157.08~~ 157.06
INSTALL POLY-LINER
26 LF, 10" DIP, S=0.005

(8) CONSTRUCT HDWL 8
STA 8+19, 13'LT
INVERT = ~~156.95~~ 156.95
36 LF, 12" RCP, S=0.027
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

(9) CONSTRUCT HDWL 9
STA 16+18, 16'LT
INVERT = ~~156.77~~ 156.70
34 LF, 12" RCP, S=0.005
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

(10) CONSTRUCT HDWL 2
STA 16+27, 16'RT
INVERT = ~~156.6~~ 156.48
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

(11) CONSTRUCT CB3 Top of Precast - 157.78
4" F&G
STA 12+93, 8'LT
RIM = ~~158.78~~ 158.67
INV OUT = ~~155.9~~ 155.77
INSTALL POLY-LINER
124 LF, 12" HDPE, S=0.005

(12) CONSTRUCT DMH12 Top of Precast - 157.06
4" F&C, 6" FLAT TOP W/O SHIP LAP
RIM = ~~157.30~~ 157.41
INV IN = ~~155.28~~ 155.22
INV OUT = ~~155.18~~ 155.12
INSTALL POLY-LINER
35 LF, 12" HDPE, S=0.005

(13) CONSTRUCT FES13 (HDPE)
INVERT = ~~155.0~~ 154.94
CONSTRUCT 5x5 RIP RAP APRON
STONE SIZE C1
UNDERLAY WITH FABRIC (SUBSIDIARY)

CT – TREE REMOVAL

WETLAND IMPACT SUMMARY

LOCATION	TEMPORARY	PERMENANT	TOTAL
AREA C	45 SF	100 SF	145 SF
AREA D	0 SF	755 SF	755 SF
AREA E	0 SF	317 SF	317 SF
AREA F	51 SF	0 SF	51 SF
TOTAL	96 SF	1,172 SF	1,268 SF

Ledge Note:

Ledge Removal At Locations Shown Was 12 Inches Below Pipe And 12 Inches Below Road Base.

PLAISTED CIRCLE NOTES:

1. THE INTENT OF THIS PLAN IS TO PROVIDE ROADWAY IMPROVEMENTS FOR PLAISTED CIRCLE AS PART OF THE 2020 ROADWAY IMPROVEMENT PROJECT. THE WORK WILL INVOLVE FULL BOX ROAD BED EXCAVATION AND GRAVEL, FINE GRADING, AND REPAVE OF THE ROADWAY. SUPPLEMENTAL DRAINAGE IMPROVEMENTS WILL ALSO BE INCORPORATED INTO THE PROJECT.

2. REFER TO DRAWING D4 FOR PROJECT GENERAL NOTES.

3. GRADING INTENT: IT IS THE INTENT OF THIS PLAN FOR THE CONTRACTOR TO
- SHAPE THE GRAVELS SUCH THAT MINIMAL IMPACTS TO DRIVEWAYS OCCURS.
- THE CONTRACTOR SHALL ESTABLISH FIELD CONTROL AND COORDINATE WITH THE ENGINEER FOR ANY MINOR ADJUSTMENTS.

4. LANDSCAPE NOTE: ALL DISTURBED LANDSCAPE AREAS ADJACENT TO THE WORK (INCLUDING LANDSCAPE AREAS AROUND MAILBOXES) SHALL BE RESTORED AND CONSIDERED PART OF ITEM 912. LOAM AND SEED (ITEM 646.512) SHALL BE RE-ESTABLISHED TO WORK LIMIT. DISTURBED BARK MULCH AREAS SHALL BE RESTORED AND PAID AS ITEM 646.512. UNDERLAY MUCH WITH FABRIC IF PRESENT IN EXISTING CONDITION (INCIDENTAL).

5. TREE TRIMMING: TREE TRIMMING AND PRUNING (ITEM 201.321) SHALL BE AS SHOWN ON THE PLANS AND WHERE DIRECTED BASED ON FIELD CONDITIONS.

6. DRIVEWAY NOTE: IT IS THE INTENT OF THIS PLAN TO PROVIDE RECONSTRUCTED DRIVEWAY APRONS 5-FEET (OR AS OTHERWISE NOTED) FROM THE NEW EDGE OF PAVEMENT. IN SOME CASES DRIVEWAY APRONS MAY NEED TO EXTEND FURTHER TO OBTAIN POSITIVE DRAINAGE AND/OR BETTER TRANSITION GRADES. SEE DRIVEWAY DETAIL ON SHEET D1.

7. COMMON EXCAVATION QUANTITY: WHERE LEDGE IS PRESENT IN THE EXCAVATION AREA THE EXCAVATION QUANTITY SHALL BE REDUCED BY THE AMOUNT OF LEDGE REMOVED. OVER EXCAVATION OF LEDGE AS SHOWN ON THE DETAIL SHALL BE BACKFILLED WITH STRUCTURAL FILL (ITEM 508).

8. SEPTIC TANK INSTALLATION: REFERENCE NHDES SEPTIC APPROVAL CA2019112637. MATCH EXISTING INVERT. PLUMB ADDITIONAL PIPE AS NEEDED TO MAINTAIN 1% PIPE SLOPE TO TANK. ANY LEDGE REMOVAL REQUIRED FOR TANK INSTALLATION SHALL BE PAID UNDER ITEM 206.2. WALL RESET PAID UNDER ITEM 570.9. ALL OTHER WORK ASSOCIATED WITH INSTALLATION OF TANK SHALL BE INCIDENTAL TO THE ITEM.

9. MONUMENT NOTE: ALL MONUMENTS IMPACTED BY ROAD CONSTRUCTION SHALL BE RESET UNLESS OTHERWISE SHOWN TO BE "RETAINED". NEW ROADWAY EASEMENT LIMITS SHALL HAVE NEW MONUMENTS SET ACCORDING TO THE PLAN. REFERENCE RCRD PLAN # D-42192.

10. SEWER SERVICE NOTE: THERE ARE FOUR SEPARATE SEPTIC FORCE MAINS UNDER THE ROAD. DEPTH OF THE FORCE MAINS ARE UNKNOWN. CONTRACTOR SHALL CONDUCT TEST PITS TO LOCATE. CONTRACTOR MAY BE DIRECTED TO RELAY FORCE MAIN LOCATED UNDER THE ROAD INSIDE 4" D.I.P AND INSULATE. INSULATION SHALL BE INCIDENTAL.

11. GAS SERVICE NOTE: STA 13+90. RESET TO 30" DEEP IF TOO SHALLOW. COORDINATE INSPECTION WITH GAS COMPANY

As-Built Drawings for Plaisted Circle Salem, NH

Drawn By:

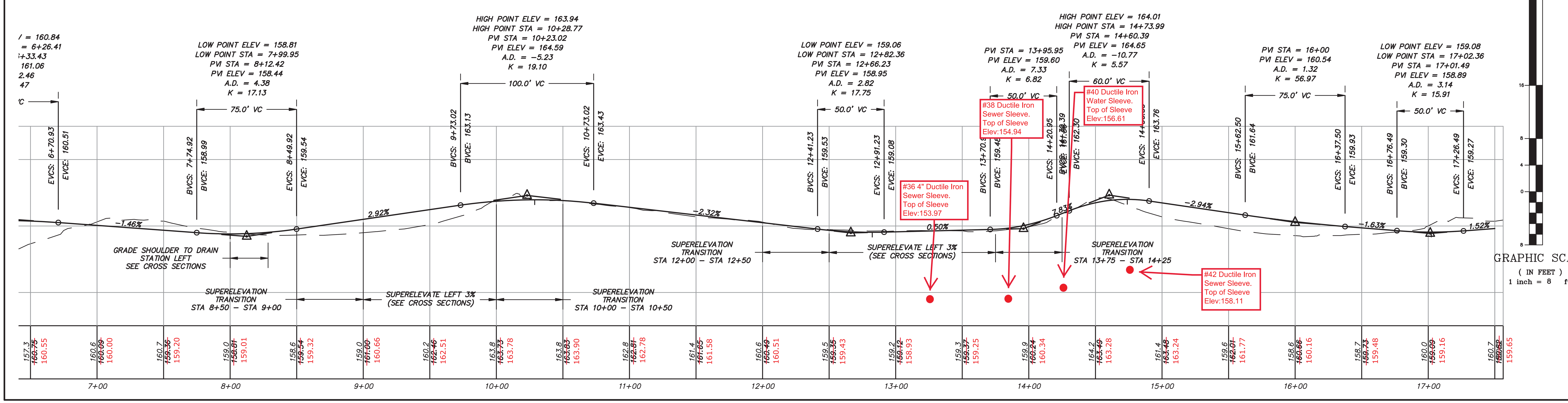
Busby Construction Co., Inc.

12.22.2020

GRAPHIC SCALE

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.



OWNER:

TOWN OF SALEM
33 CEREMONY DRIVE
SALEM, NH 03079

2020 ROADWAY IMPROVEMENT PROGRAM
NEIGHBORHOOD RECONSTRUCTION PROJECT
SALEM, NH 03079
ASSESSORS MAP 51

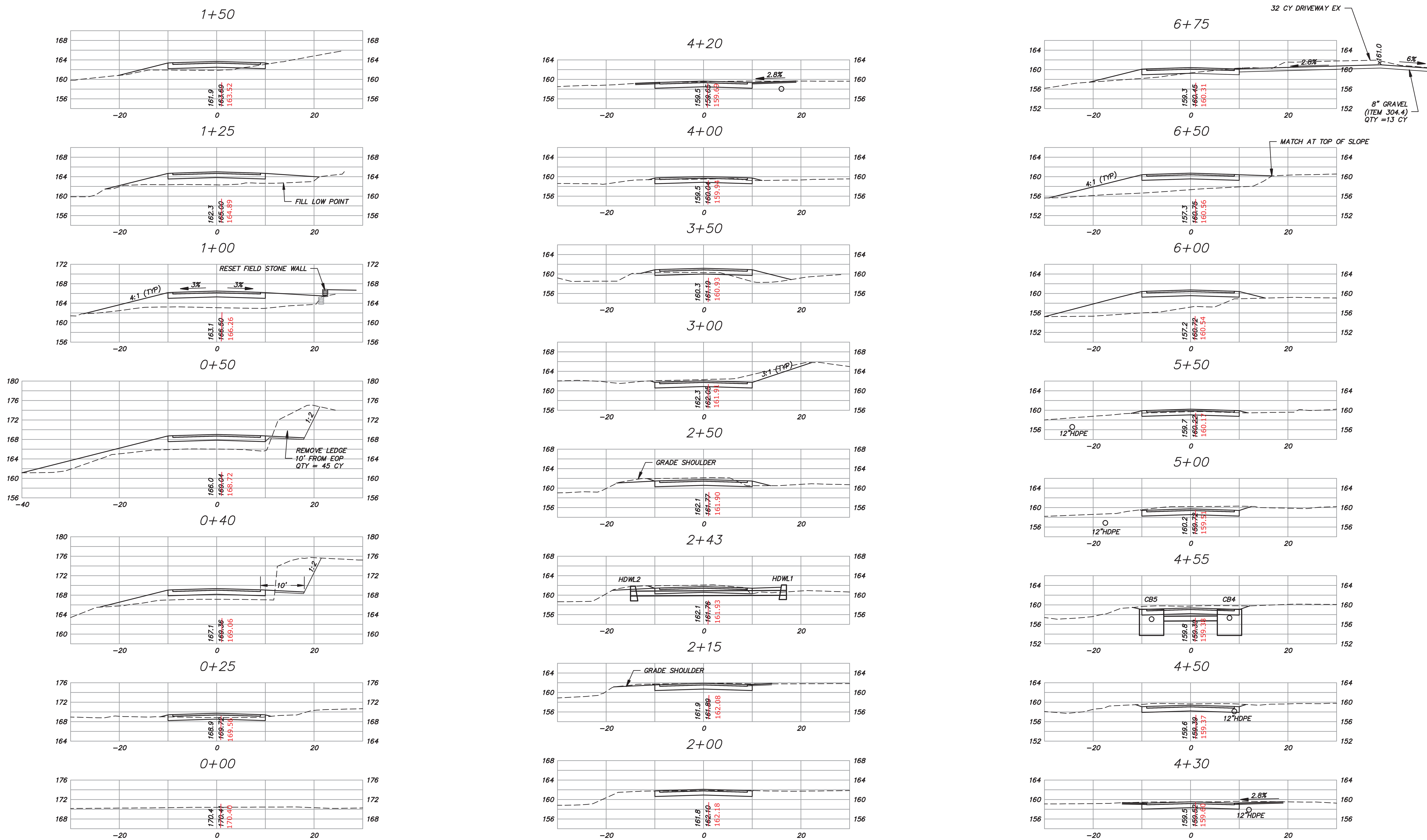
PLAISTED CIRCLE
PLAN & PROFILE

NO.	DATE	REVISION
–	–	–

DRAWN: JAD | DESIGNED: JAD | CHECKED: DH | APPROVED: DH

SCALE: 1"=40'(H) 1"=8'(V) | DATE: DEC 2019 | PLAN NO. 3 OF 15 | SHEET: C2

Z:\Projects\2020 Road Program\Neighborhoods\dwg\Plaisted MD 071519.dwg 12/18/2019 10:39:29 AM EST



As-Built Drawings for Plaisted Circle Salem, NH
Drawn By:
Busby Construction Co., Inc.
12.22.2020

GRAPHIC SCALE
(IN FEET)
1 inch = 10 ft.

NO.	DATE	REVISION
-	-	-

DRAWN: JAD
DESIGNED: JAD
CHECKED: DH
APPROVED: DH

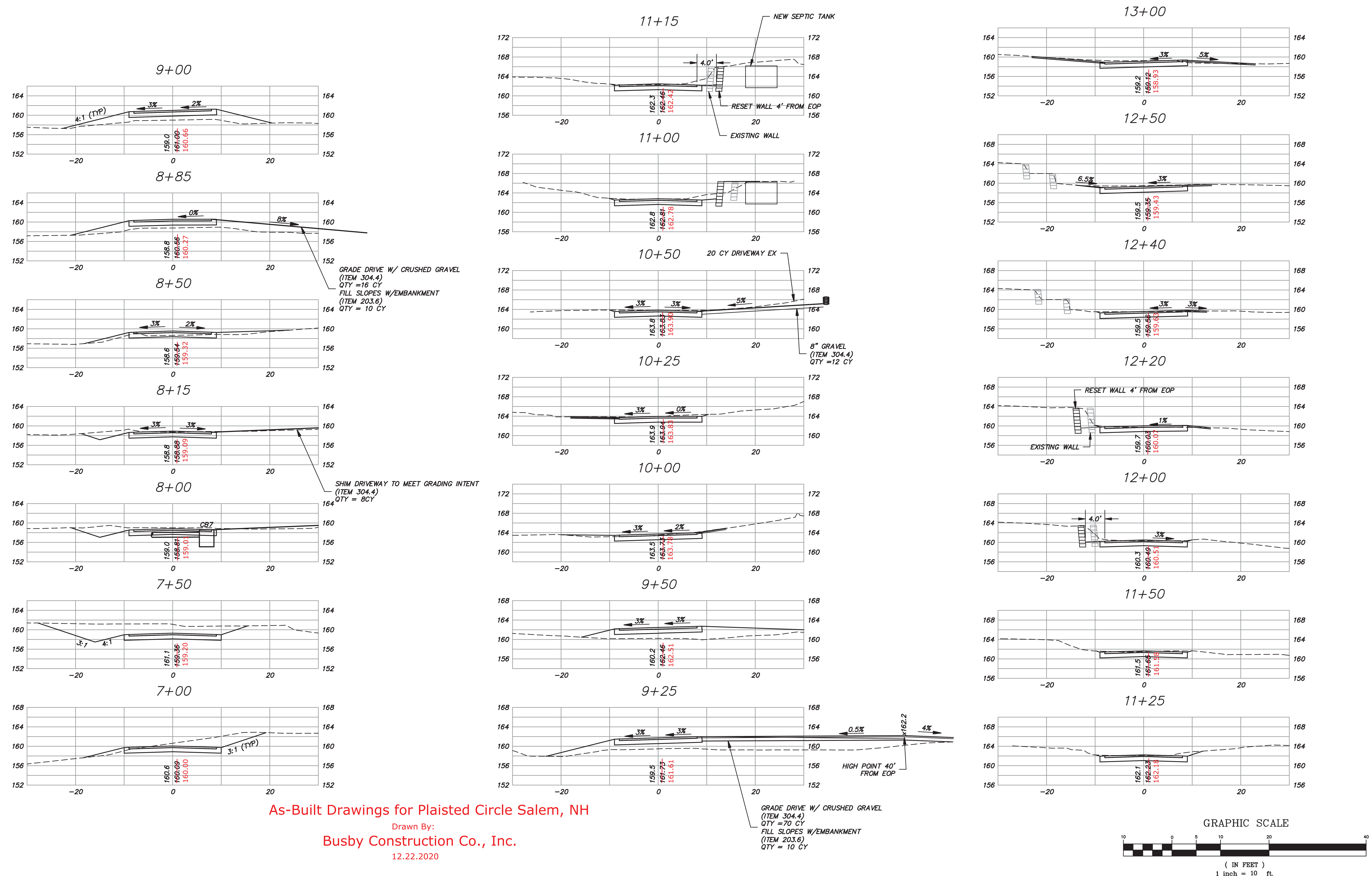
OWNER:
TOWN OF SALEM
33 GEREMONTY DRIVE
SALEM, NH 03079

2020 ROADWAY IMPROVEMENT PROGRAM
PLAISTED CIRCLE
SALEM, NH 03079
ASSESSORS MAP 51

CROSS SECTIONS

SCALE: 1"=10'
PLAN NO. 5 OF 15
DATE: DEC 2019
SHEET: X1

Z:\Projects\2020 Road Program\Neighborhoods\dwg\Plaisted MD 071519.dwg 12/18/2019 10:39:29 AM EST



As-Built Drawings for Plaisted Circle Salem, NH

Drawn By:

Busby Construction Co., Inc.

12.22.2020

NO.	DATE	REVISION
–	–	–

DRAWN: JAD
DESIGNED: JAD
CHECKED: DH
APPROVED: DH

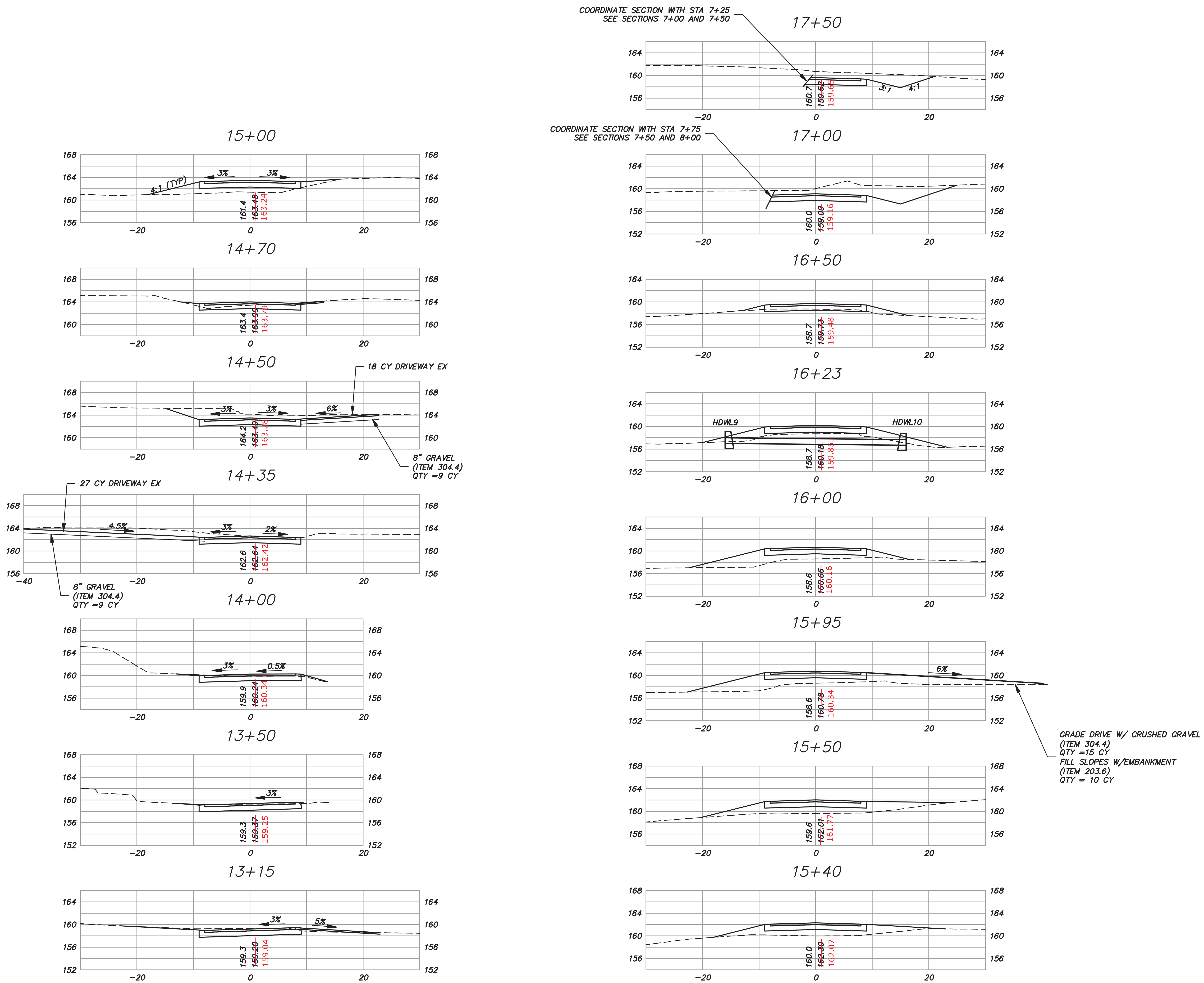
OWNER:
TOWN OF SALEM
33 GEREMONTY DRIVE
SALEM, NH 03079

2020 ROADWAY IMPROVEMENT PROGRAM
PLAISTED CIRCLE
SALEM, NH 03079
ASSESSORS MAP 51

CROSS SECTIONS

DATE: DEC 2019
SCALE: 1"=10'
PLAN NO. 6 OF 15
SHEET: X2

Z:\Projects\2020 Road Program\Neighborhoods\dwg\Plaisted MD 071519.dwg 12/18/2019 10:39:29 AM EST



As-Built Drawings for Plaisted Circle Salem, NH

Drawn By:

Busby Construction Co., Inc.

12.22.2020

GRAPHIC SCALE

(IN FEET)
1 inch = 10 ft.

NO. | DATE | REVISION

DRAWN: JAD | DESIGNED: JAD | CHECKED: DH | APPROVED: DH

OWNER:

TOWN OF SALEM
33 GEREMONTY DRIVE
SALEM, NH 03079

2020 ROADWAY IMPROVEMENT PROGRAM
PLAISTED CIRCLE
SALEM, NH 03079
ASSESSORS MAP 51

CROSS SECTIONS

SCALE: 1"=10'

PLAN NO. 7 OF 15

DATE: DEC 2019

SHEET: X3

Z:\Projects\2020 Road Program\Neighborhoods\dwg\Plaisted MD 071519.dwg 12/18/2019 10:39:29 AM EST

3a. Infiltration Trench

An infiltration trench is a stone-filled excavation used to temporarily store runoff and allow it to infiltrate into surrounding, natural soil. Typically, runoff enters the trench as overland flow after pretreatment through a filter strip or vegetated buffer. An infiltration trench is suitable for treating runoff from small drainage areas (less than 10 acres). Installations around the perimeter of parking lots, between residential lots, and along roads are most common. Infiltration trenches can also be incorporated along the center of a vegetated swale to increase its infiltration ability.

An infiltration drip edge is constructed similar to an infiltration trench, except that a drip edge intercepts only roof runoff, and does not require pretreatment.

Design Considerations

- Pretreatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent infiltration BMPs.
    - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
    - After the basin is excavated to the final design elevation, the floor should be deeply tilled with a rotary tiller or disc harrow to restore infiltration rates, followed by a pass with a leveling drag.
    - Do not place infiltration systems into service until the contributing areas have been fully stabilized.
- For any fill required for system construction, use clean, washed, well-sorted aggregate for infiltration media; the porosity of material provided for construction should be verified against the porosity specified by design.

- Drip edges are not recommended adjacent to buildings with foundation drains, as the intercepted runoff may adversely affect performance of the foundation drainage system. Also, if there is a foundation sub-drain beneath the drip edge trench, the sub-drain will likely prevent infiltration from occurring, by intercepting the flow and conveying it to discharge along with other foundation drainage.
- For more guidance on installing monitoring wells, see: Sprecher, S.W. 2008. Installing monitoring wells in soils (Version 1.0). National Soil Survey Center, NRCS, USDA, Lincoln, NE.

Maintenance Requirements

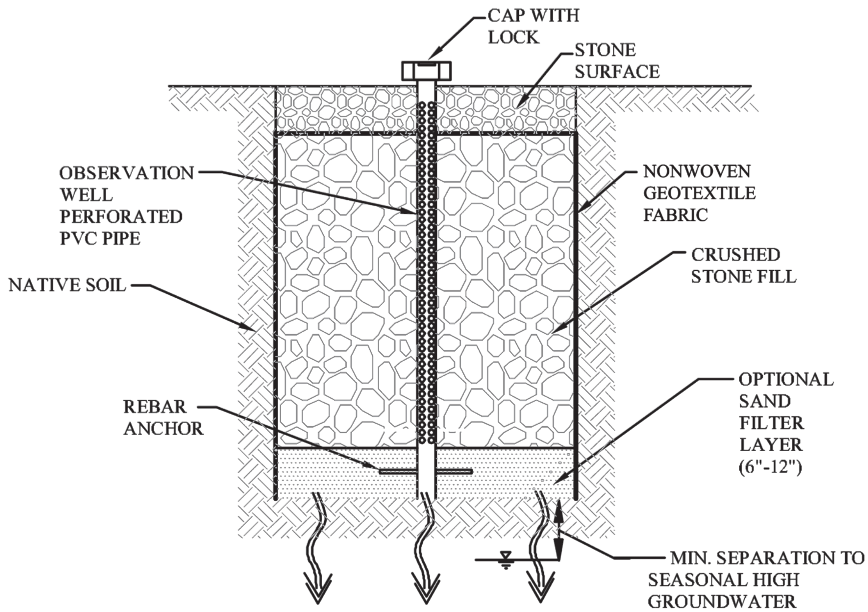
- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pretreatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- If an infiltration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

Design References

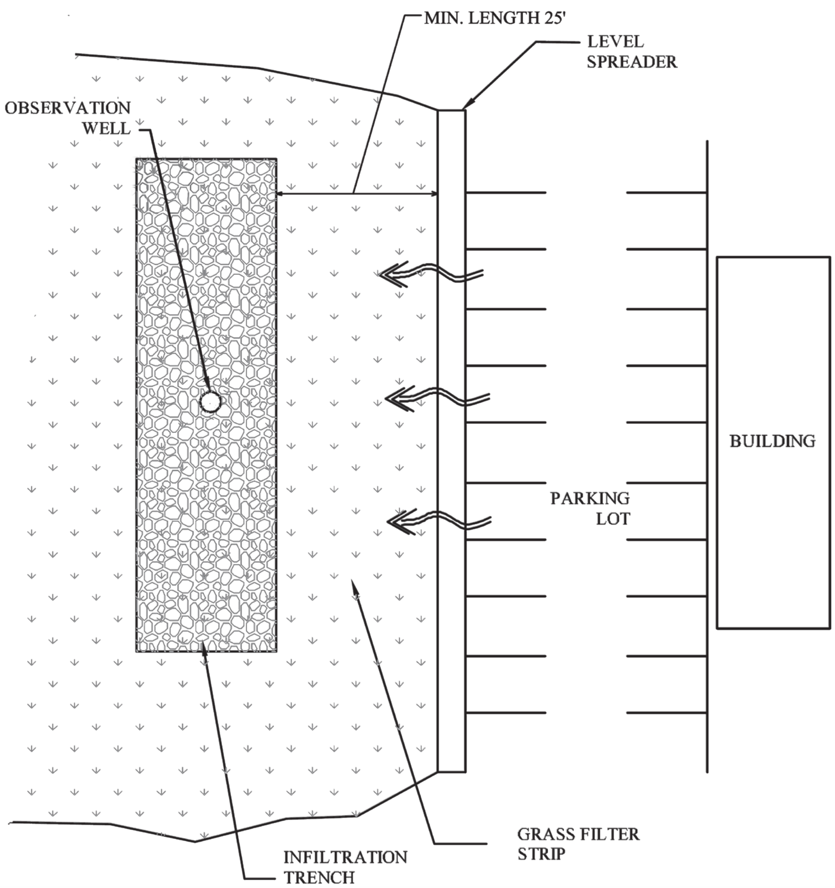
- Schueler (1987)
- Schueler, et al. (1992)
- Ferguson (1994)
- Sprecher (2008)

Example Design

Section



Planview



Design Criteria

Design Parameter	Criteria
Pretreatment	Required (see Section 4-4)
BMP Volume	≥ the larger of WQV or GRV, depending on purpose of BMP excluding sediment forebay capacity, if present, and exclude infiltration occurring during the design event
Minimum trench depth	4 feet
Maximum trench depth	10 feet
Design Infiltration Rate	See Section 2-4 for a discussion on selecting a design infiltration rate
Drain Time	< 72 hours for complete drainage of the water quality volume
Depth to Bedrock and Seasonal High Water Table Elevation	≥ 3 feet from bottom of BMP, except: ≥ 4 feet if within groundwater or water supply intake protection area ≥ 1 foot if runoff has been treated prior to entering the BMP
Overflow Discharge Capacity	10-year, 24-hour storm
Observation Well	Required along trench centerline
Infiltration Media Material	Clean, washed, uniform (well-sorted) aggregate Diameter 1.5 to 3 inches Porosity = 40%

3D. Dry Well & Leaching Basin

Dry wells are essentially small subsurface leaching basins. It consists of a small pit filled with stone, or a small structure surrounded by stone, used to temporarily store and infiltrate runoff from a very limited contributing area. Runoff enters the structure through an inflow pipe, inlet grate, or through surface infiltration. The runoff is stored in the structure and/or void spaces in the stone fill. Properly sited and designed dry wells provide treatment of runoff as pollutants become bound to the soils under and adjacent to the well, as the water percolates into the ground. The infiltrated stormwater contributes to recharge of the groundwater table.

Dry wells are well-suited to receive roof runoff via building gutter and downspout systems. With the small size and manageable cost of these BMPs, they are particularly suited for use in subdivisions and for single-family homes. When used for roof drainage, pretreatment of runoff is not typically required.

Leaching basins are dry wells used in well drained soils for the discharge of roadway or parking area runoff. In this case, pretreatment is required prior to discharge to the leaching basin. A typical arrangement is to use a deep sump, hooded catch basin in combination with a leaching basin.

Dry wells, leaching basins, and similar devices should meet the design criteria applicable to subsurface infiltration basins.

Design Considerations

- Pretreatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent infiltration BMPs.
    - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
    - Do not place infiltration systems into service until the contributing areas have been fully stabilized.

Maintenance Requirements

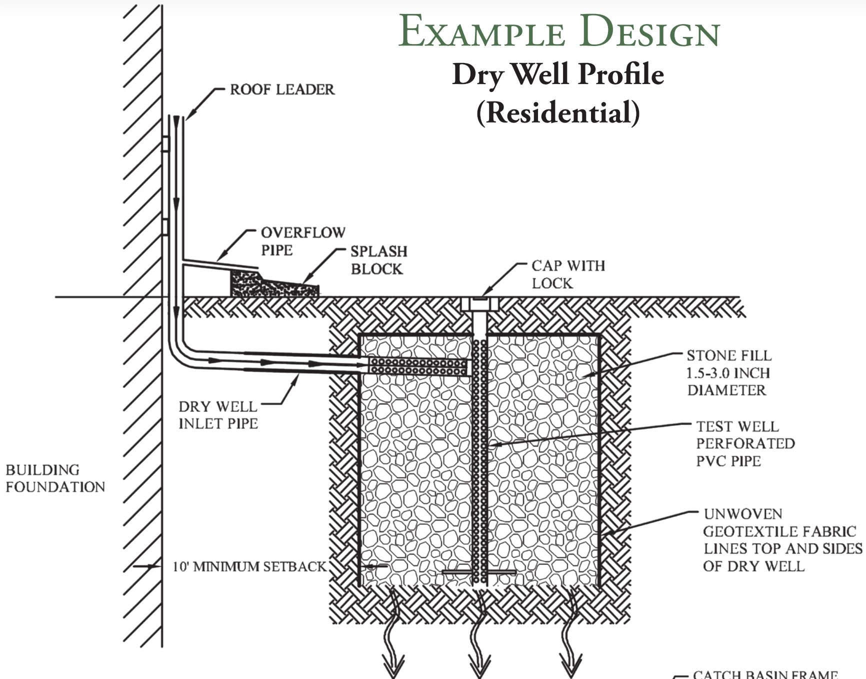
- Removal of debris from inlet and outlet structures
- Removal of accumulated sediment
- Inspection and repair of outlet structures and appurtenances
- Inspection of infiltration components at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- If an infiltration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

Design Criteria

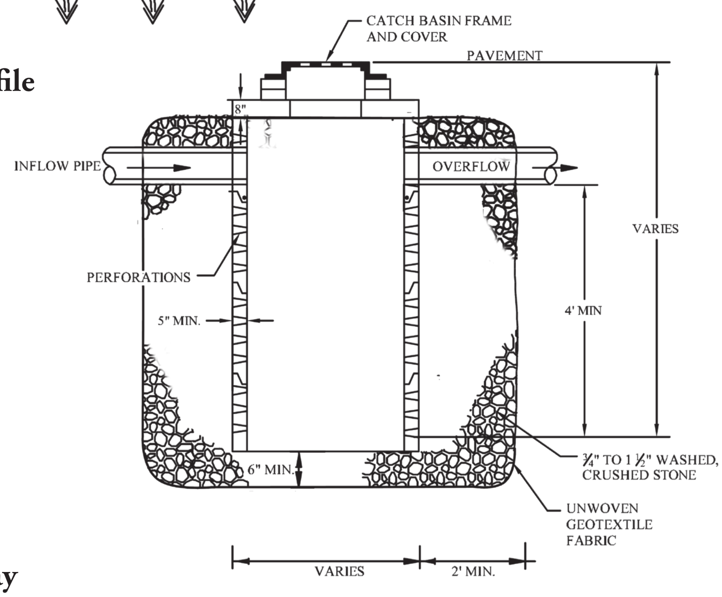
Design Parameter	Criteria
Pretreatment	Required (see Section 4-4)
BMP Volume	≥ the larger of WQV or GRV, depending on purpose of BMP excluding sediment forebay capacity, if present, and exclude infiltration occurring during the design event
Design Infiltration Rate	See Section 2-4 for a discussion on selecting a design infiltration rate
Drain Time	< 72 hours for complete drainage of the water quality volume
Depth to Bedrock and to Seasonal High Water Table Elevation	≥ 3 feet from bottom of BMP, except: ≥ 4 feet if within groundwater or water supply intake protection area ≥ 1 foot if runoff has been treated prior to entering the BMP

Example Design

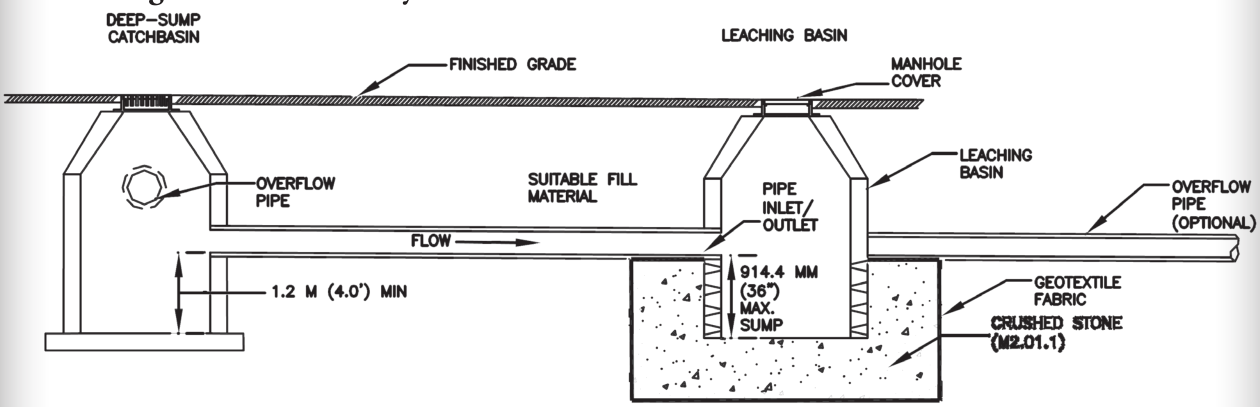
Dry Well Profile (Residential)



Leaching Basin Profile



Leaching Basin for Roadway



Source: MassHighway (2004)

5. TREATMENT SWALES

General Description

Treatment swales are designed to promote sedimentation by providing a minimum hydraulic residence time within the channel under design flow conditions (Water Quality Flow). This BMP may also provide some infiltration, vegetative filtration, and vegetative uptake. Conventional grass channels and ditches are primarily designed for conveyance. Treatment swales, in contrast, are designed for hydraulic residence time and shallow depths under water quality flow conditions. As a result, treatment swales provide higher pollutant removal efficiencies. Pollutants are removed through sedimentation, adsorption, biological uptake, and microbial breakdown.

Treatment swales also differ from practices such as underdrained swales (for example, “dry swales” and “bioretention swales”), which are essentially filtration practices, and “wet swales,” which are similar in function to pocket ponds.

General Requirements Applicable to Treatment Swales

- Swales are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued
- Swales are prohibited in groundwater protection areas receiving stormwater from a high-load area unless an impermeable liner is provided
- Swale shape should be trapezoidal or parabolic
- Swale must have ≥ 85% vegetated growth prior to receiving runoff
- Bottom of swale must be above seasonal high water table

Design Considerations

- Flow-Through Swales must be designed so that the flow travels the full length to receive adequate treatment. For this reason, flow must be directed to the inlet end of the swale, rather than the swale collecting water continuously along its length.
- All channels should be designed for capacity and stability. A channel is designed for capacity when it can carry the maximum specified design flow within the design depth of the channel (allowing for recommended freeboard). A channel is designed for stability when the channel lining (vegetation, riprap, or other material) will not be eroded under maximum design flow velocities. Analyses of these conditions must account for both the type of lining and its condition (for example, capacity analysis for a grassed channel must consider the

resistance of the maximum height of grass, while the stability analysis must consider the grass under its shortest, mowed condition).

- Vegetation should be selected based on site soils conditions, planned mowing requirements (height, frequency), and design flow velocities.
- The roughness coefficient, n, varies with the type of vegetative cover and flow depth. At very shallow depths, where the vegetation height is equal to or greater than the flow depth, the n value should be approximately 0.15. This value is appropriate for flow depths up to 4 inches typically. For higher flow rates and flow depths, the n value decreases to a minimum of 0.03 for grass channels at a depth of approximately 12 inches. The n value must be adjusted for varying flow depths between 4" and 12" (see chart below).

Maintenance Requirements

- Inspect annually for erosion, sediment accumulation, vegetation loss, and presence of invasive species.
- Perform periodic mowing; frequency depends on location and type of grass. Do not cut shorter than Water Quality Flow depth (maximum 4-inches)
- Remove debris and accumulated sediment, based on inspection.
- Repair eroded areas, remove invasive species and dead vegetation, and reseed with applicable grass mix as warranted by inspection.

Design References

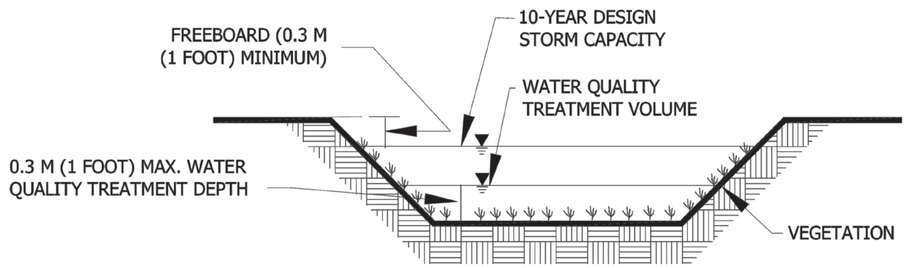
- Minton (2005)

Design Criteria

Design Parameter	Criteria
Minimum Length	≥ 100 feet (not including portions in a roadside ditch)
Bottom Width	4 to 8 feet (widths up to 16 feet are allowable with dividing berm/structure such that neither channel width exceeds 8 feet)
Longitudinal Slope	0.5% to 2% without check dams 2% to 5% with check dams
Maximum Side Slopes	3:1
Flow Depth	4 inches maximum at the WQF
Hydraulic Residence Time	> 10 minutes during the WQF
Design Discharge Capacity	10-year, 24-hour storm without overtopping

Example Design

Section



Adapted from MassHighway (2004)

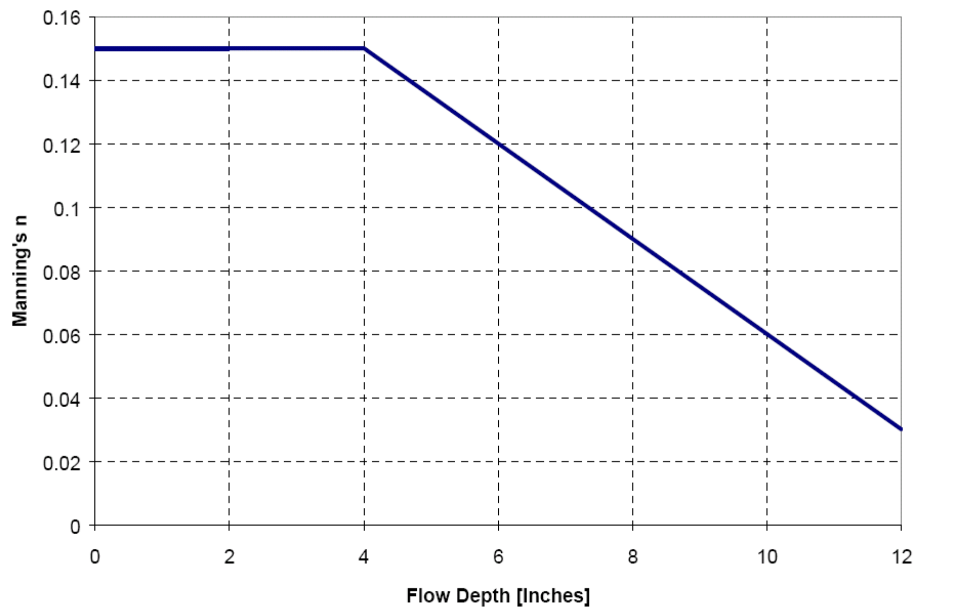


Figure 4-3. Manning's n Value with Varying Flow Depth (Source: Claytor and Schueler, 1986)

4c. Bioretention System

A bioretention system (sometimes referred to as a “rain garden”) is a type of filtration BMP designed to collect and filter moderate amounts of stormwater runoff using conditioned planting soil beds, gravel beds and vegetation within shallow depressions. The bioretention system may be designed with an underdrain, to collect treated water and convey it to discharge, or it may be designed to infiltrate the treated water directly to the subsoil. Bioretention cells are capable of reducing sediment, nutrients, oil and grease, and trace metals. Bioretention systems should be sited in close proximity to the origin of the stormwater runoff to be treated.

The major difference between bioretention systems and other filtration systems is the use of vegetation. A typical surface sand filter is designed to be maintained with no vegetation, whereas a bioretention cell is planted with a variety of shrubs and perennials whose roots assist with pollutant uptake. The use of vegetation allows these systems to blend in with other landscaping features.

Design Considerations

- Bioretention areas should be located close to the source of runoff.
- Bioretention areas are particularly adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.
- Bioretention areas can also be used to meet recharge objectives, where allowed by land use and receiving water characteristics.
- Do not place bioretention systems into service until the BMP has been planted and its contributing areas have been fully stabilized.
- Where ultimate discharge from the bioretention area is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to the bioretention area during any stage of construction.
    - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.

Maintenance Requirements

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pretreatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- Trash and debris should be removed at each inspection.
- At least once annually, system should be inspected for drawdown time. If bioretention system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore filtration function or infiltration function (as applicable), including but not limited to removal of accumulated sediments or reconstruction of the filter media.
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal and replacement of dead or diseased vegetation, and removal of invasive species.

Design References

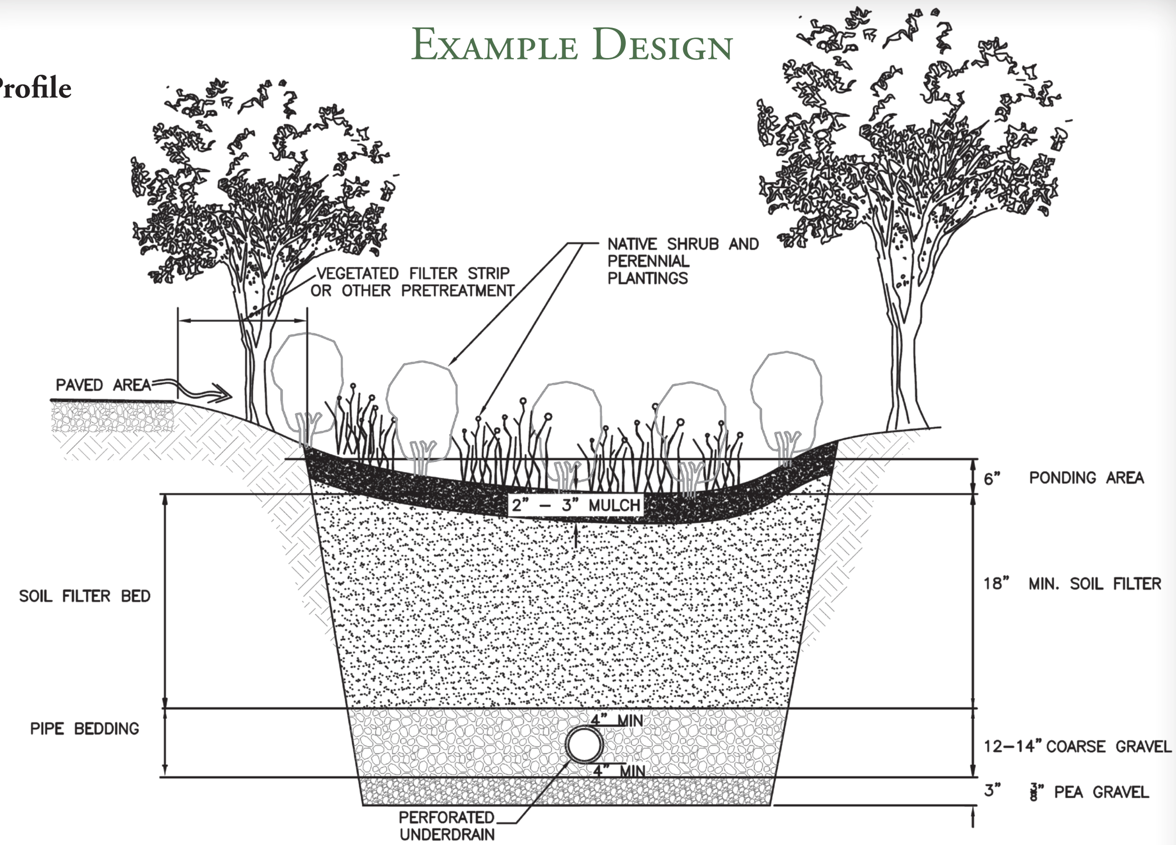
- UNH Stormwater Center
- EPA (1999a)

Table 4-4. Bioretention Filter Media

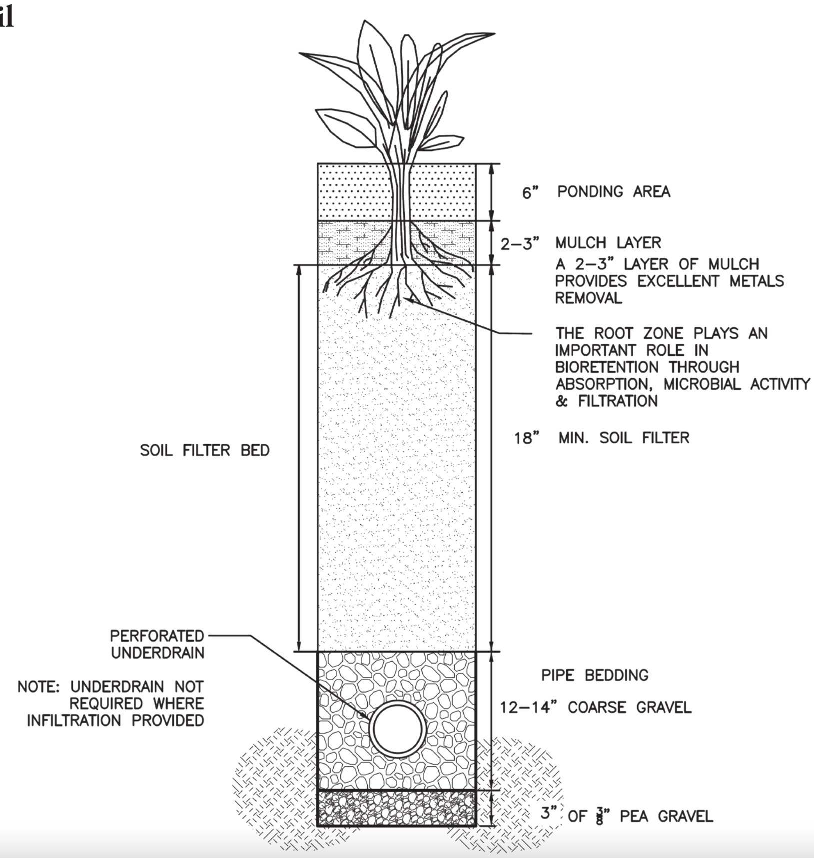
Component Material	Percent of Mixture by Volume	Gradation of Material	
		Sieve No.	Percent by Weight Passing Standard Sieve
Filter Media Option A			
ASTM C-33 concrete sand	50 to 55		
Loamy sand topsoil, with fines as indicated	20 to 30	200	15 to 25
Moderately fine shredded bark or wood fiber mulch, with fines as indicated	20 to 30	200	< 5
Filter Media Option B			
Moderately fine shredded bark or wood fiber mulch, with fines as indicated	20 to 30	200	< 5
Loamy coarse sand	70 to 80	10	85 to 100
		20	70 to 100
		60	15 to 40
		200	8 to 15

Example Design

Profile



Column Detail



Design Criteria

Design Parameter	Criteria
Bioretention Volume	≥ WQV (including storage area above filter and filter media voids)
Watershed	< 5 acres of contributing drainage area
Depth of Filter Media	18 – 24 inches
Filter Media	See Table 4-4
Drain Time	< 72 hours for complete drainage
Underdrain (where required)	≥ 6-inch diameter perforated PVC or HDPE set in 1- to 2-inch diameter stone or gravel free of fines and organic material
Depth to Bedrock and Seasonal High Water Table Elevation	If not providing an impermeable liner: ≥ 1 foot below the bottom of the filter course material. If within groundwater or water supply intake protection area the practice should also have: • 1 foot of separation from the bottom of the *practice* to the SHWT or • 1 foot of separation from the bottom of the filter course material *and* twice the depth of the filter course material recommended.
Overflow Discharge Capacity	10-year, 24-hour storm
Maximum Side Slopes	2:1
Surface Covering	2 to 3 inches well-aged shredded bark mulch (uniform in color, free of foreign and plant material)
Planting Design	Only native, non-invasive species Random and natural plant layout No woody vegetation near inflow locations Only facultative wetland species directly over the filter media Provide trees or large shrubs along perimeter Establish a tree canopy with an understory of shrubs and herbaceous plants Vegetation should be drought tolerant

4d. Tree Box Filter

The Tree Box Filter is essentially a small bioretention system, combining the function of a curb-side drainage inlet with the water quality treatment functions of a vegetated soil media. It consists of an open bottom or closed bottom concrete box or barrel filled with a porous soil media. An underdrain system, consisting of a perforated pipe bedded in crushed gravel, is provided beneath the soil media. A tree is planted in the soil media. Stormwater is directed from surrounding impervious surfaces through the top of the soil media.

If the device has an open bottom, the stormwater percolates through the media into the underlying ground. If the filtered stormwater exceeds the infiltration capacity of the underlying natural soil, the excess will be intercepted by the underdrain, where it may be directed to a storm drain, other device, or surface water discharge.

Where a closed bottom box filter is used, such as where necessary to protect groundwater resources, the filter is isolated from the underlying soil. In this case, all of the stormwater that passes through the soil media filter will be intercepted by the underdrain and conveyed to a suitable outlet.

Design Considerations

- Tree box filters should be carefully integrated into the design of parking areas and streets, to provide a sufficient number of units in suitable locations for capturing the required Water Quality Volume. Generally, these systems are sized and spaced similarly to catch basin inlets.
- Tree box filters are particularly adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.
- Do not use tree box filters to treat runoff from high-load areas (see the discussion of high load areas in Section 3-1 of this manual).
- Tree box filters can be used to meet recharge objectives, where underlying soils are suitable and where allowed by land use and receiving water characteristics.
- Do not place tree box filters into service until the BMP has been planted and its contributing areas have been fully stabilized.
- Where ultimate discharge from the tree box filter is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to the tree box filter during any stage of construction.
    - Do not traffic or compact exposed soil surface within the area of the filter with construction equipment. Perform excavation for the construction of this BMP with equipment positioned outside the limits of the system.

Maintenance Requirements

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 inches in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Trash and debris should be removed at each inspection.
- If inspection indicates that the system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the tree box filter to determine measures required to restore filtration function or infiltration function (as applicable), including but not limited to removal of accumulated sediments or reconstruction of the filter media.
- The tree should be inspected at least annually, and maintained in healthy condition, including pruning. A dead or diseased tree, or a tree in stressed condition because of the constricted root space in the filter, should be removed and replaced. Filter media should be replaced when the tree is replaced.

Design References

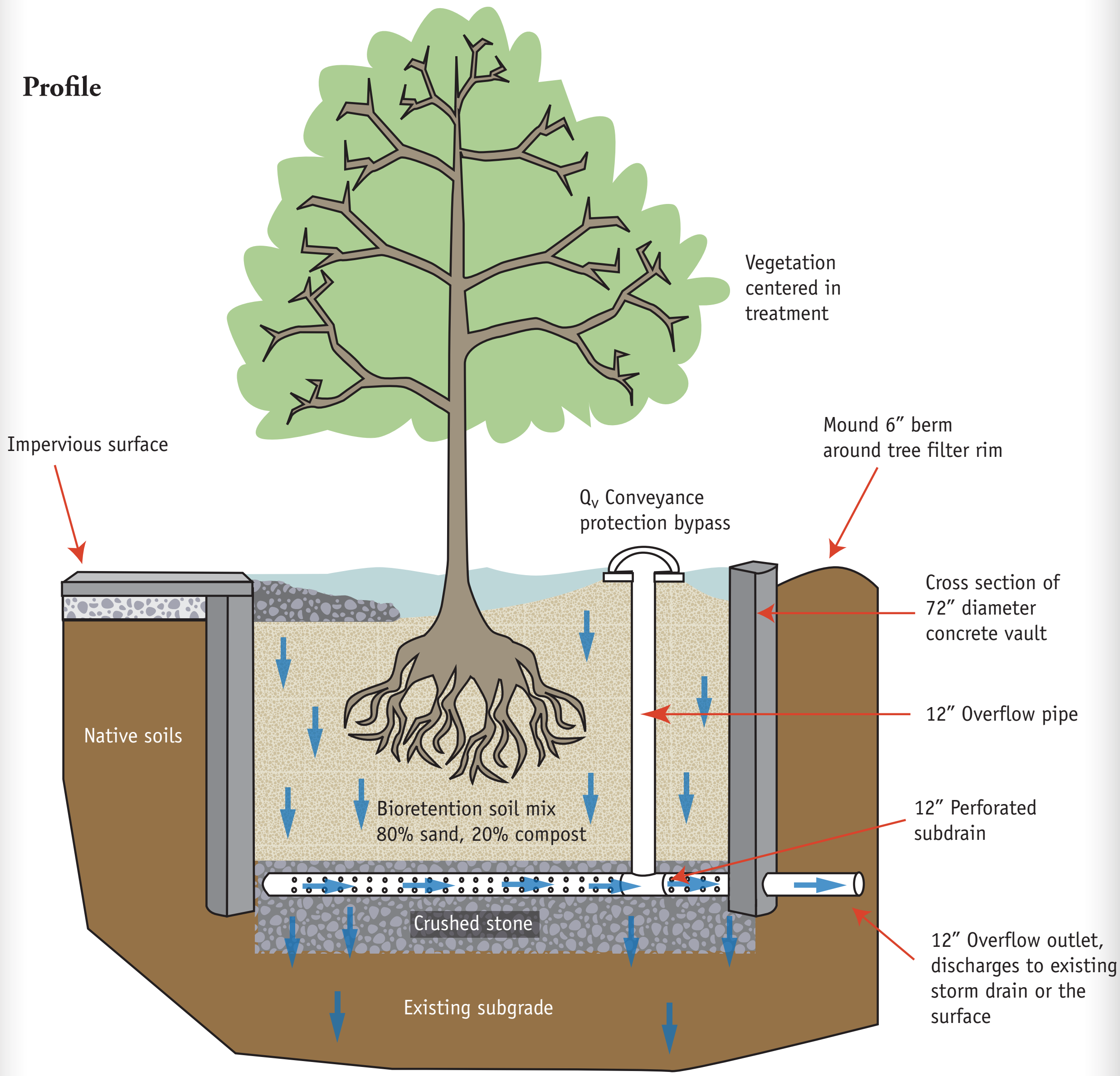
- UNH Stormwater Center (2007a)

Table 4-5. Tree Box Filter Media

Component Material	Percent of Mixture by Volume	Required Material Characteristics
Sand	80	ASTM C-33 concrete sand
Organic material, ***composted*** bark mulch recommended	20	< 5 % passing #200 Sieve
General requirements applicable to the mixture	1. Soil mix should be uniform, free of stones, stumps, roots, or similar materials larger than 2 inches. 2. Soil pH should be between 5.5 and 6.5	

Example Design

Profile



Source: UNH Stormwater Center (2007a)

Design Criteria

Design Parameter	Criteria
Pretreatment	Pretreatment not required. However, tree box filters should not be used for high-load areas.
Tree Box Filter Volume	≥ WQV (including storage area above filter and filter media voids)
Depth of Filter Media	36 inches, minimum
Filter Media	See Table 4-5
Drain Time	< 72 hours for complete drainage
Underdrain (where required)	≥ 6-inch diameter perforated PVC or HDPE set in 1- to 2-inch diameter stone or gravel free of fines and organic material
Depth to Bedrock and Seasonal High Water Table Elevation	If not providing an impermeable liner (or vault with integral bottom): ≥ 1 foot below the bottom of the filter course material. If within groundwater or water supply intake protection area the practice should also have: • 1 foot of separation from the bottom of the practice to the SHWT or • 1’ of separation from the bottom of the filter course material and twice the depth of the filter course material recommended.
Overflow Discharge Capacity	10-year, 24-hour storm
Planting Design	Vegetation selected for these systems should consist of native, drought-tolerant and salt-tolerant species. Plants with aggressive root growth may clog the sub-drain, and therefore may not be suitable for this type of system.