

2 – DRAINAGE STANDARDS

2.1 General

- A. Any activity subject to the Town of Concord Storm Water Regulations that will measurably change the ability of a ground surface area to absorb and/or infiltrate stormwater, will change existing surface drainage patterns or will change the rate or volume of stormwater discharging from a site will require the development of a *stormwater management plan*.
- B. All stormwater management plans and calculations shall be completed by a Professional Engineer licensed within the Commonwealth of Massachusetts.

2.2 Design

2.2.1 Criteria

- A. All projects requiring stormwater management review shall provide adequate stormwater management measures to ensure the rate and volume of stormwater discharge from a project do not exceed pre-development conditions.
- B. Post development conditions shall maintain natural drainage flow patterns to the maximum extent feasible.
- C. Storm drains, culverts, catch basins, manholes, retention/detention structures, water quality structures, permeable surfaces, Low Impact Development (LID) techniques and related best management practices (BMPs), shall be installed where necessary to provide adequate treatment and onsite infiltration or offsite disposal of surface water from all streets and adjacent land as shown on the proposed plans that require approval by the Town prior to construction.
- D. All stormwater designs and calculations shall be completed for the 2 year, 10 year, 25 year and 100 year frequency, Type III, NRCS 24 hour rainfall distribution.
- E. Hydraulic calculations shall utilize appropriate engineering methodologies to properly model project hydraulic conditions including: Soil Conservation Service (SCS) unit hydrograph method (TR-20), Storage-Indication method, or other approved method. The preferred method of delivery is a printout utilizing HydroCAD software.
- F. Storm drain capacity calculations shall be performed for all conveyance BMPs (i.e. drain pipe, grass swale, etc.). Capacity calculations shall be provided utilizing the rational method for a 100 year frequency storm event and Manning's equation for open channel flow.
- G. Proper operation and maintenance of the stormwater management system shall be considered when selecting, sizing and siting stormwater best management practices (BMPs) in the proposed design.

2.2.2 Massachusetts Stormwater Standards

- A. All projects that require stormwater review must meet the requirements set forth in the MADEP Stormwater Management Standards regardless of proximity to wetland resource areas.
- B. Redevelopment projects must meet the MADEP Stormwater Standards to the maximum extent practicable.

2.2.3 Stormwater Management Plan Contents:

- A. Existing Conditions Plan:
 - 1. Size and location of existing storm drainage facilities and conveyances.
 - 2. Existing utility locations (i.e. gas, water, sewer, electric, CATV, etc.)
 - 3. Existing utility easements
 - 4. Existing topography – Contours provided at 2' intervals with spot grades provided at critical divide locations. Slopes less than 1% shall have spot elevations every 25'.
 - 5. Delineation of resource areas and buffer areas, as defined by the Wetlands Protection Act and the Town of Concord Wetland Bylaw.
 - 6. Locations of soil test holes including depth to groundwater.
 - 7. Delineation of ground cover type (i.e. woods, grass, impervious areas)

- B. Proposed Conditions Plan:
 - 1. Size and location of proposed storm drainage facilities, BMPs and conveyance.
 - 2. Proposed topography – Contours provided at 2' intervals with spot grades provided at critical divide locations. Slopes less than 1% shall have spot elevations every 25'.
 - 3. Delineation of resource areas, as defined by the Wetlands Protection Act and the Town of Concord Wetland Bylaw.
 - 4. Locations of soil test holes in areas of proposed recharge areas
 - 5. Delineation of proposed ground cover type (i.e. woods, grass, impervious areas)

- C. Drainage Divide Plans: Plans depicting Pre Development and Post Development Sub-Watershed divides shall be provided at an appropriate scale. Plan data shall be overlaid on screened versions of the Existing Condition and Proposed Condition plans respectively and shall include:
 - 1. Sub-Watershed Areas with reference number/letter, quantified in square feet or acres and with individual ground cover types.
 - 2. Times of concentration path for each Sub Watershed Area.
 - 3. Drainage analysis points with reference number/letter

- D. Rational Method Divide Plan: Plan depicting catch basin Subcatchment divides shall be provided at an appropriate scale. Plan data shall be overlaid on screened version of the Proposed Condition plan and shall include:
 - 1. Subcatchment Areas with reference number/letter, quantified in square feet or acres and with individual cover types.
 - 2. Times of concentration path for each Subcatchment Area.
 - 3. Respective conveyance BMP clearly shown.

- E. Stormwater Calculations and Report: Supporting calculations developed and stamped by a Professional Engineer licensed within the Commonwealth of Massachusetts certifying that the *Stormwater Management Plan* has been prepared in accordance with the criteria established within the Massachusetts Stormwater Standards, Town regulations and requirements as well as these Standards. The report shall include:
 - 1. *Drainage Design Narrative*: Brief written description of Sub-Watersheds depicted on the Drainage Divide Plans. Description shall explain how and where stormwater will be controlled on-site including all assumptions utilized within the hydraulic model. The Narrative shall also clearly describe the location of drainage analysis points utilized in the design. The Narrative shall also include a summary table which clearly compares pre-development and post-development runoff rates and volumes at each analysis point.

2. *Hydrologic and hydraulic design:* Calculations for pre-development and post-development conditions shall be modeled as for the design storms as specified in these Standards. The calculations shall be a HydroCAD printout, hand calculations or other approved delivery method. The calculations shall clearly illustrate:
 - a. Description of the design storm frequency, intensity and duration used in the calculations as required by these regulations.
 - b. Time of concentration utilized for each Sub-Watershed Area.
 - c. Soil Runoff Curve Number (CN) based on land use and soil hydrologic group for each Sub-Watershed Area.
 - d. Peak runoff rates and total runoff volumes for each Sub-Watershed area and analysis point.
 - e. Infiltrative BMP design information including: infiltration capacity of soils based on test hole results and Rawls Tables.
 - f. Any additional documentation of sources for computation methods and field test results.
 - g. When appropriate, downstream tail water conditions, shall be evaluated within the hydraulic model.

3. *MA Stormwater Standards Calculations:* Supporting narratives and calculations to demonstrate how the drainage system will meet the Massachusetts Department of Environmental Protection (DEP) Stormwater Management Standards. The plans shall include details and descriptions of erosion control and stormwater management during construction. Section 4 - Erosion Control of these Standards provides additional guidance on the Erosion and Sedimentation Control Plan contents.

4. *Conveyance Design:* Calculations shall be provided to determine the required capacity for all proposed stormwater conveyances utilizing the rational method for the design storm outlined within these standards. All stormwater conveyances shall be sized utilizing Manning's equation. Calculations shall clearly show in a tabulated form:

Required Capacity (Rational Method):

 - a. Area (A) of each subcatchment
 - b. Curve number (C) for each subcatchment
 - c. Time of concentration for each subcatchment
 - d. Design storm intensity (I) for each subcatchment
 - e. Required design flow rate (Qr) for each subcatchment

Conveyance Sizing (Manning's Equation):

 - f. Stormwater conveyance type, size, etc.
 - g. Stormwater conveyance Manning's equation roughness coefficient (use C=0.013 for concrete pipe)
 - h. Design capacity (Qd) for each stormwater conveyance
 - i. Pipe velocity (V) utilizing the Rational Method required design flow (Qr) and stormwater conveyance design.

5. *Infiltrative BMP Design:* Calculations and supporting documentation shall be provided to clearly demonstrate:
 - a. Soils information from test pits performed within the footprint of the proposed stormwater management facilities, including but not limited to soil descriptions, depth to seasonal high groundwater, depth to bedrock, and percolation rates. Soils information will be based on deep holes and percolation tests logged by a Massachusetts Registered Soil Evaluator and witnessed by the Town.
 - b. All infiltrative BMPs shall include drawdown calculations demonstrating that stormwater for all design storms will be completely infiltrated within 72 hours.

- c. All infiltrative BMPs shall have proper pretreatment. Pretreatment BMPs must be sized for prescribed water quality volume. (i.e. include forebay sizing calculations).
6. *Long-term Operation and Maintenance Plan (LTO&M)*: All Stormwater Management Plans shall include for review a document/manual which shall clearly outline the long term maintenance responsibilities for all BMPs included within the plan. BMP maintenance responsibilities should be consistent with guidance provided within the MADEP Stormwater Manual. The LTO&M Plan shall include at a minimum:
- a. Responsible party for continuing LTO&M.
 - b. Annual maintenance cost for the plan.
 - c. The person(s)/entity responsible for financing maintenance and emergency repairs.
 - d. A plan outlining location of and access points to all BMPs proposed. The plan shall also depict/describe the woody and herbaceous vegetative stabilization utilized within the stormwater design.
 - e. A chart outlining the type of and frequency of maintenance work required for all stormwater BMPs proposed on site, including any landscaping required.

2.2.4 Structural Best Management Practices

A. General:

1. All structural Best Management Practices shall be designed in accordance with these standards as well as applicable sections from the *Massachusetts Stormwater Management Standards* and the *Massachusetts Stormwater Handbook* (Massachusetts Department of Environmental Protection, January 2008 et seq.).
2. Where appropriate, the Town of Concord encourages the use of Low Impact Development techniques.

B. Bioretention Areas/Rain Gardens:

1. Bioretention areas shall be designed to have a maximum ponding depth of 18”.
2. Bioretention areas shall be designed without filter fabric unless it is being utilized for treatment only.
3. Bioretention areas shall be designed to incorporate an 8” standpipe with grated cap. The standpipe shall be connected to a proposed leaching pipe located beneath the bioretention area within the parent soil material. The configuration shall be consistent with Standard Detail DR-3
4. Safe overflow of these devices shall be provided in the event of severe storm events or clogging of the soils surrounding the device. Discharge of the overflow shall be incorporated into the drainage design.

C. Detention/Infiltration Basins:

1. Basins shall be designed to provide a minimum of 1’ of freeboard above the proposed 100 year flood elevation.
2. Basins shall be designed to provide an emergency spillway with an invert elevation at the 100 year flood elevation. The design shall be consistent with Standard Detail DR-15 and be a rip rap trapezoidal channel.

3. Infiltration basins shall only utilize bottom of pond areas when calculating the time to drain and basin infiltration rates.
4. Infiltration basins will be designed to utilize a sand bottom consistent with Standard Details DR-12 & DR-12A.
5. The top of berm in all basins shall be a minimum of 5' wide.
6. Basins proposed to be maintained by the Town, shall be designed to incorporate a 10' wide access road on the embankment to all critical basin components. This includes but is not limited to: forebay embankment, emergency spillway, outlet control structure, emergency drawdown. etc.
7. Basins shall be designed to have a maximum ponding depth of 3'.
8. Basins shall be designed with an outlet control structure consistent with Standard Details DR-16 and DR 16A.
9. Basin outlet control structures shall be furnished with an emergency drawdown device.

D. *Forebay/Sediment Trap:*

1. Forebay berms shall be a minimum of 4' wide and contain a low-flow-through stone outlet consistent with Standard Detail DR-14.
2. Forebay shall be sized for the contributing water quality volume.
3. Forebay bottoms shall be designed to be a stable surface to promote sediment removal.
4. Forebay volume shall not be included within detention basin design volume.
5. Forebay area shall not be utilized for stormwater infiltration within the design.

E. *Leaching Basins/Drywells/Underground Infiltration Systems:*

1. Leaching basins, drywells, and underground infiltration systems shall only be used in areas with highly permeable soils (i.e. Hydrologic Soils Group A & B). Testholes shall be required within the proposed footprint of all infiltrative BMPs to verify the HSG. All testholes shall be witnessed by CPW.
2. Unless designed to infiltrate rooftop runoff, leaching basins drywells, and underground infiltration systems shall be designed as offline systems.
3. Safe overflow of these devices shall be provided in the event of severe storm events or clogging of the soils surrounding the device.
4. Discharge of the overflow shall be incorporated into the drainage design.
5. Systems shall be sited a minimum of 10 feet away from buildings and property lines and meet applicable Title V setbacks.

F. Swales

1. The maximum depth of a swale shall be 24 inches. Side slopes shall be no steeper than 2:1 (horizontal: vertical) with a minimum grade of 1%.
2. The minimum bottom width for a swale, whether earthen, gravel, or paved is 2 feet.
3. The maximum velocity for earthen/grass swales is 3 cfs.
4. The use of swales draining across a sidewalk into the gutter or discharging to the Town right-of-way is generally unacceptable.

2.2.5 Culverts

- A. All new culverts shall be designed to convey the 100 year frequency, Type III, 24 hour storm events, using the Soil Conservation Service (SCS) unit hydrograph method or other approved method.
- B. All new culverts designed to convey a perennial stream as depicted on the current USGS maps shall be designed to meet Massachusetts River and Stream Crossing Standards developed by the River and Stream Continuity Partnership, dated March 1, 2006 and as amended.
- C. All new culverts shall be a manufactured concrete box oversized to be embedded and provide an 8" thick minimum natural stream bottom.
- D. The proposed line and grade of the culvert shall match the existing stream/wetland slope.
- E. The concrete box shall meet HS-25 loading criteria.
- F. All culverts shall be designed to provide 24" cover from finish grade.
- G. Utility sleeves for water, sewer, etc., may be required beneath the culvert to allow for future maintenance of utility.

2.2.6 Private Connections to Town Drainage System

- A. It is the policy of the Town of Concord to prohibit direct physical connections to the Town's storm drainage infrastructure. However, it is recognized that there may arise a public interest or a hardship situation where such a connection may be warranted. The Town has developed *the Town of Concord - Concord Public Works - Storm Water Regulations* to set forth the conditions under which a connection may be allowed. They are not intended to promote connections to the Town storm drainage system. Rather, they are intended to provide relief to those property owners who are threatened with property damage by excess on-site storm water or high groundwater levels. It is incumbent upon the applicant to demonstrate that the need to connect is dire, and that no reasonable alternate means of disposal exists.

2.3 Construction

2.3.1 Methods

- A. All construction methods shall conform to the requirements contained in the latest version of the Massachusetts Department of Transportation – Highway Division (MassDOT), formerly Massachusetts Highway Department, *Standard Specifications for Highways and Bridges and Construction and Traffic Standard Details* as amended. These two

documents are referred to collectively as the MassDOT Standards within these Standards.

- B. Construction methods shall also conform to the *Massachusetts Stormwater Management Standards* and the *Massachusetts Stormwater Handbook* (Massachusetts Department of Environmental Protection, January 2008 et seq.).
- C. All work shall be completed to the lines and grades shown on the approved plans.
- D. Concord Public Works field inspectors may approve field changes that differ from approved plans or Town standards when determined to provide a public interest. No field changes are allowed without prior written approval from CPW.
- E. Each step within the construction process shall be inspected and approved by the Concord Public Works before the next step in the process shall begin.

2.3.1.1 Separation of Storm Drains and Water or Sewer Mains

- A. Horizontal Separation: Drainage mains shall be located at least 5 feet horizontally from water and sewer mains as described in the Concord Public Works Water/Sewer Division Standards. The distance shall be measured from inside edge of pipe.
- B. Vertical Separation: Drainage mains shall be laid to provide a separation of at least 18 inches from either water or sewer lines. The minimum vertical separation is measured from outside of water or sewer main to outside of the storm drain main. In instances when vertical separation cannot be achieved with existing water/sewer mains utility support shall be provided consistent with standard detail DR-9.
- C. Unusual Conditions: Storm drain crossings that cannot meet standard separations due to existing and unusual conditions must be approved on a case by case basis by Concord Public Works.

2.3.1.2 Pipe Laying

A. Minimum Cover over Drainage Pipes

1. The minimum flow line depth for drainage pipes shall be 4 feet. The minimum cover over RCP drainage pipes shall be 3 feet below the pavement slab or as specified by the type of pipe per manufacturer's specifications, whichever is greater. Where the clearance is less than 1 foot below the pavement, provide a design method to maintain the integrity of the pipe and right of way. For drainage pipe outside of the pavement, the minimum cover shall be 18 inches or as specified by the type of pipe, whichever is greater.
2. No backfilling of the pipe in the trench shall take place unless approved by a CPW inspector.

B. Minimum Drain Pipe Grades

1. Main lines and cross runs – grades 1% minimum
2. Building storm drainage stubs – 1% minimum
3. Subdrains – 0.5% minimum
4. All other – 0.5% minimum.

5. Any slope greater than 8% requires CPW approval.

C. *Reinforced Concrete Pipe (RCP):*

1. Pipe shall be carefully laid to the lines and grades as shown on the approved plans. The Contractor, when possible, shall use laser beam aligning equipment.
2. See Section 2.3.2.1 for bedding material. The bottom of the trench shall be excavated to a flat grade 6 inches below the pipe invert for trenches in suitable earth and 12 inches below pipe invert for trenches in rock. When rock or ledge is encountered it shall be removed to such widths as will give a clearance of at least 12 inches on each side of the pipe or other structure and a sand cushion used. The width of trenches shall be sufficient to allow thorough compacting of the refill adjacent to the lower quarters of the pipe.
3. Trenches at pipe joints shall be excavated as necessary to give ample room for properly making and inspecting the pipe joints. RCP pipe joints shall be cement mortared (as specified in MassDOT Section M4.02) carefully placed in the joints around its entire perimeter and mixed relatively dry, in the ratio of one part cement to two parts sand.
4. Pipe bedding material shall be carefully and lightly tamped under pipe to provide uniform support. Fill to a minimum depth of 12 inches above the top of the pipe. Material for backfilling the rest of the trench, except for sub base (top 15 inches) shall be suitable material, approved by CPW. The compaction process shall be material placed in 12-inch lifts and thoroughly compacted by mechanical rammers, vibrators, or other methods to be approved by Concord Public Works (e.g., hydraulic plate compactors) to 90 percent Modified Proctor density in off-road or nonstructural areas and 95% in roadway or structural areas. **Bucket compaction will not be accepted.**
5. When laying pipe in groundwater, pipe material and method of installation shall be approved by Concord Public Works. Water must not be permitted to rise in the trench until all pipes have been securely bedded, jointed and observed by the town and until backfilling has progressed to an elevation at least one foot above the top of the pipe. Temporary plugs shall be installed in open ends of pipe to prevent silt from washing into pipe during construction; and open ends of the pipe shall be closed with suitable plugs upon suspension of the work for any reason.

D. *High Density Polyethylene (HDPE) Pipe:* **HDPE shall not be permitted to be used within Town right-of-way. For uses outside of the ROW,** the requirements for laying of RCP pipe also apply to HDPE pipe. The following additional requirements apply to HDPE pipe:

1. Installation of HDPE pipe shall be in accordance with either AASHTO Section 30 or ASTM D2321 and as recommended by the manufacturer.
2. Because HDPE pipe will float in standing water, a dry trench shall be provided prior to laying the pipe. A qualified engineer shall be consulted to determine dewatering methods.
3. Haunching large-diameter pipes (greater than 30 inches) shall be performed using maximum 8-inch lifts and compacted to 95 percent standard proctor density.

4. Water tight joints shall be used. Pipe shall be watertight according to the ASTM D3212. Joint design shall be bell-and-spigot with an elastomeric rubber gasket meeting ASTM F477 or equal approved by the Engineering Division.

E. Ductile Iron (DI) Pipe

1. Where minimum cover requirements are not able to be met, ductile iron pipe may be substituted for RCP pipe if approved by CPW.
2. Requirements of Section 2.3.1.2 C – Items 1,2,4,5 shall apply for installing ductile iron pipe.

F. Pipe Testing:

1. At the discretion of Concord Public Works, a mandrel test shall be conducted following completion of pipe laying. Placement of curb, gutter, sidewalk, or asphalt concrete pavement shall not occur until the CPW Inspector has approved the mandrel test. The CPW Inspector shall be present through the duration of the mandrel testing. Alternatively, a television survey may be performed on the line after installation, with the results being provided to CPW in electronic format as directed by CPW.
2. The allowable deflection (reduction in vertical inside diameter) for all non-rigid pipe shall be 7.5 percent maximum. The deflection shall be tested by pulling a mandrel which is 92.5 percent of the inside pipe diameter through all installed pipe. The mandrel shall be the "go/no-go" type and shall be pulled without mechanical assistance. At each location in which the mandrel cannot pass, the cause shall be ascertained. Obstacles in the pipe shall be removed. If it is determined that the deflection exceeds 7.5 percent, that a gasket has been improperly installed or that the pipe has been damaged due to trenching for another utility, the respective section of pipe shall be re-bedded or removed, replaced and re-bedded using water tight repair couplings. A passing mandrel retest is required. At the contractor's discretion, any sections of non-rigid pipe not passing the mandrel test may be televised to ascertain the problem.

2.3.1.3 Structures

A. General:

1. Contractor shall excavate to a depth of 12 inches below the bottom of and all around the proposed manhole or catch basin base, compact and fine grade and install washed screened gravel as a sub-base material. Pipes shall extend no more than 3 inches inside the interior wall and all openings around pipe entrances and lift holes shall be thoroughly grouted with non-shrink grout prior to back filling. Compaction process shall be the same manner as compaction around pipe.
2. The tops of frames and grate shall be set 1/8 inch below finish grade pavement in the street. Final grade locations for installations outside of the paved roadway shall be as approved by Concord Public Works.
3. All joints between the frame, grade rings, dome, barrels and base shall be set in place with non-shrink mortar. Inside the manhole, all joints where the sealing material is not flush with the inside wall shall be grouted with nonshrink mortar and finished by hand / wet-brushed.
4. Grade adjustments shall be made using clay bricks.

5. No backfilling of the structure in the excavation shall take place unless approved by a CPW inspector.
6. As circular concrete block walls are laid, the horizontal joints and key ways shall be flush full with mortar. As rectangular blocks are laid, all horizontal and vertical joints shall be flushed full with mortar. Vertical joints shall be staggered.

B. Manholes:

1. Manholes spacing shall exceed 250 feet, unless otherwise approved by CPW.
2. Manholes shall be required at all changes of drainage pipe material, changes in horizontal pipe alignment and changes in vertical elevation (i.e. elevation drop), unless otherwise approved by CPW

C. Catch Basins:

1. Maximum spacing for catch basins installed on new roadways shall be 250 feet. In some cases CPW may require grate inlet capacities provided for review to verify proper basin spacing.
2. Catch basins shall not be connected in series unless permitted by CPW.
3. CPW requires the installation of all catch basins within public ways to be in line with the edge of pavement. In instances where an existing utility conflicts with the proper installation of a catch basin, CPW requires the use of a gutter inlet and deep sump manhole configuration as shown in standard detail DR-2.
4. Double catch basin grates shall be installed perpendicular to the curb line.

D. Leaching Basins/Drywells:

1. Leaching basins shall be set in an excavation lined with a geotextile. The basin shall be placed on a pad of free draining double washed crushed stone, with the excavation around the basin back-filled with similar material.
2. Excavated material shall be placed away from the excavated sides to prevent wall instability during excavation and backfilling.
3. Large tree roots shall be trimmed flush with the sides to prevent puncturing or tearing of filter fabric during installation.
4. The side walls shall be roughened where sheared and sealed by heavy equipment.
5. No construction sedimentation control measure shall be sited within the footprint of leaching basins.

2.3.1.4 Best Management Practices

A. Bioretention Areas/Rain Gardens

1. All vegetation, top and subsoils shall be removed within the footprint of bioretention areas.
2. Care shall be taken not to compact underlying parent "C" Horizon soils during construction.

3. No construction sedimentation control measure shall be sited within the footprint of a bioretention area/rain garden.
4. No construction equipment shall be parked over or driven over the footprint of proposed bioretention areas/rain gardens.

B. Detention/Infiltration Basins

1. All vegetation, top and subsoils shall be removed within the footprint of the detention/infiltration basins.
2. Contractor shall excavate to a depth of 12 inches below the bottom of the basin's outlet control structure compact, fine grade and install washed screened gravel as a sub-base material prior to placing the structure.
3. Basins constructed in a fill condition will require the basin berm/dyke to be constructed with a low permeability glacial till core. The low perm berm/dyke core will be constructed in 6" lifts. The low perm fill will be compacted to 95% of its maximum proctor density and placed within $\pm 2\%$ of the optimum moisture content.
4. The basin's emergency spillway shall be lined with rip rap placed on a 6" gravel base consistent with Standard Detail DR-15

C. Forebay/Sediment Trap

1. Construction sedimentation control measures may be sited within the footprint forebays and sediment traps. All sediment collected during site preparations must be removed prior to beginning construction.

D. Underground Infiltration Systems

1. Systems shall be set in an excavation lined with a geotextile. The system shall be placed on a pad of free draining double washed crushed stone, with the excavation around the basin back-filled with similar material.
2. Excavated material shall be placed away from the excavated sides to prevent wall instability during excavation and backfilling.
3. Large tree roots shall be trimmed flush with the sides to prevent puncturing or tearing of filter fabric during installation.
4. The side walls shall be roughened where sheared and sealed by heavy equipment.
5. Drainage aggregate (double washed) shall be placed in lifts of no more than 12 inches and compacted using plate compactors. Voids between the fabric and excavation sides due to boulders or other obstacles shall be filled with natural soils to ensure fabric conformity to excavation sides.
6. No construction sedimentation control measure shall be sited within the footprint of the underground infiltration systems.
7. No construction equipment shall be parked over or driven over the footprint of the underground infiltration systems.

2.3.1.5 Rip Rap/Pipe Ends

- A. Pipe ends shall be accurately aligned on compacted gravel fill unless otherwise approved by CPW. Rip Rap stone shall be placed to line and grade as shown on the plans on a prepared bed of gravel material. Layout shall create a sediment trap as depicted on Standard Details DR-10 and DR-10A.
- B. Each stone shall be placed by hand, normal to the slope and firmly embedded. Larger stones shall be placed directly at the drainage end to prevent erosion and displacement. Stone size shall be determined by the design storm flow discharging from the pipe. When appropriate, smaller chink stones shall be provided to lock in rip rap stone.

Headwalls

- A. Field stone headwalls shall be constructed at open ends of any drainage pipes where the same serve as outlets or inlets to the drainage system. All pipe ends/outfalls shall have a field stone headwall installed and shall conform to Standard Detail DR-11.

2.3.2 Materials

- A. All construction materials shall conform to the requirements contained in the latest version of the Massachusetts Department of Transportation (MassDOT), formerly Massachusetts Highway Department, Standard Specifications for Highways and Bridges as amended, unless otherwise specified herein or approved by Concord Public Works.
- B. All materials shall conform to the highest quality and applicable standards. If there is a conflict within these Standards, or between other standards referenced herein and these Standards, then the most stringent criteria shall be used.

2.3.2.1 Bedding Material

- A. Pipe, manholes, catch basins, and leaching basins shall be laid in any of the following materials, as specified hereafter or as approved by the inspector.
 - 1. Pea stone (3/8 inch in size)
 - 2. Angular crushed stone or rock, dense or open graded with little or no fines (1/4 inch to 1 1/2 inches in size).
 - 3. AASHTO classifications A1 and A3: Clean, coarse grained materials, such as gravel, coarse sands and gravel/sand mixtures (1 1/2 inches maximum in size).
 - 4. AASHTO classifications A-2-4 and A-2-5: Coarse grained materials with fines including silty or clayey gravels or sands. Gravel or sand must comprise more than 50 percent of Class III materials (1 1/2 inches maximum size).
 - 5. Approved material shall be sifted to remove rocks larger than 3 inches.

2.3.2.2 Pipe

- A. *Reinforced Concrete Pipe (RCP)*: Pipe shall conform to the AASHTO M170 for Standard Strength Reinforced Concrete Culvert Pipe for class III Pipe, Wall B. All pipe 24 inches in diameter or smaller shall be of the bell and spigot type. Pipes larger than 24 inches in diameter shall be tongue and groove or bell and spigot. A preformed flexible plastic sealing compound of Butyl Mastic Rope Sealer " 1" size, "EZ Stick" as

manufactured by Concrete Products supply or an approved equal shall be used for sealing water-tight joints.

- B. *High Density Polyethylene (HDPE) Pipe* –**HDPE shall not be used within the Town ROW.** For uses outside of the ROW, the pipe shall conform to MassDOT Section M5.03.10. Pipe shall be smooth interior wall and corrugated exterior wall, and be water-tight. Pipe shall be minimum 12-inch diameter. Ends shall be bell-and-spigot unless approved by CPW for the specific application. Pipe shall comply with the requirements for test methods, dimensions and markings found in AASHTO Designations M252 and M294. Pipe shall support an HS-20 live load with a maximum deflection of 5% of the minimum pipe diameter. Pipe and fittings shall be made from virgin polyethylene compounds which conform to the applicable current edition of the AASHTO Material Specifications for cell classification as defined and described in ASTM D3350. Nominal sizes of 12- to 60-inch shall be either AASHTO Type 'S' or Type 'D.'
- C. *Ductile Iron Pipe:* Ductile iron pipe shall conform to the requirements of AWWA C150, C151, C111 and shall be double cement lined and asphalt seal coated in accordance with AWWA C104. The wall thickness shall be Class 52.
- D. *Perforated Drain Pipe Trenches (Subdrain) :*
 - 1. Drain Pipe Trenches shall meet MassDOT Standard Specifications Section 260 and MassDOT Construction and Traffic Standard Details Drawing 209.1.0. Perforated pipe shall be either of the following.
 - a. Polyvinyl chloride (PVC) pipe up to and including 15 inches in diameter, conforming to ASTM D3034, SDR 35.
 - b. Perforated, polyethylene (PE) (flexible) pipe and fittings per AASHTO M252. Joints shall be coupling type.
 - 2. Filter fabric shall meet MassDOT Standard Specifications Section M9.50.0; complying with AASHTO M 288 for use with subdrains.
 - 3. Subdrain bedding and fill material shall be crushed stone, 3/8 inch to 1 inch.

2.3.2.3 Drainage Structures

A. Manholes

- 1. *General:*
 - a. Manholes over 8 feet in depth shall have minimum of 5 feet inside diameter. When drop manholes are used the drop shall not be more than 3 ½ feet without the installation of a granite stone bottom. Risers shall be brick, not concrete blocks. Risers shall be clay or shale brick, and shall conform to the requirements of AASHTO M 91, Grade MM or as specified in MassDOT M4.05.
- 2. *Precast Manholes:*
 - a. Precast Manholes shall be constructed of reinforced precast concrete monolithic base section, barrel section and dome section meeting the latest applicable requirements of ASTM C478 I and AASHTO M 199, or latest revision thereto. Special manholes shall also meet the requirements of MassDOT Standard Specifications, section M4.02.14, Precast Units. After curing a minimum of 14 days, the outside surface of the tapered or cone section of precast cement concrete drainage structures shall be dried and cleaned.
 - b. Manhole steps are required if manhole is over 4 feet in height, and shall line up from section to section. They shall be aluminum alloy 6061 T6, 12 inch on center cast in place at point of manufacturer plus 2 inches shall be coated with aluminum oxide. Tongue and groove sections between barrel sections shall be

mortared or use butyl rubber sealants. Live load design shall be HS-25 loading. A 26-inch opening will be cast in the top section to accept a cast iron frame and cover. Inside diameter shall be a minimum of 4 feet.

- c. All precast drainage manholes shall conform to Standard Detail DR-5.

3. *Constructed-in-Place Manholes:*

- a. CPW prefers the use of precast catch basin structures but recognizes the need to use constructed in place structures (block) under certain circumstances. Use of block structures requires CPW approval.
- b. All manholes constructed in place shall conform to the Block Drainage Structure Standard Detail DR-6 and shall support HS-25 live loading.
- c. Cement concrete blocks used in the construction of drainage structures shall meet the requirements of MassDOT standard specification M4.05.1.

4. *Manhole Covers:*

- a. Cast iron frames and covers shall conform to MassDOT Standard Specification M8.03.0 and Standard Detail DR-5A. Manhole frame shall have a clear opening of 24 inches and be a minimum of 8 inches in height. The frame and cover shall have a combined weight of 475 pounds.
- b. Manhole covers shall have a diamond pattern; pick holes and the word "DRAIN" cast in 3-inch letters.
- c. Frames and covers shall be as manufactured by East Jordan Iron Works model number (frame) OMA211000038 and (cover) OMA211000041, or approved equivalent.

B. Catch Basins

1. *General:*

- a. All basins shall have a sump of at least 48 inches (4 feet) below the invert of the outlet pipe, or otherwise approved by CPW, and an inside diameter of 4 feet minimum.
- b. In locations where existing utilities preclude the installation of a full deep sump catch basin, a gutter inlet/sump drain manhole configuration shall be substituted as shown on Standard Detail DR-2.

2. *Precast Catch Basins:*

- a. All precast catch basins shall conform to Standard Detail DR-1.
- b. Live load design shall meet HS-25 loading. Catch basins which are limited by height shall be installed with a flat top slab, cast in place, designed for HS-25 loading.

3. *Constructed in Place Catch Basins:*

- a. CPW prefers the use of precast catch basin structures but recognizes the need to use constructed in place structures (block) under certain circumstances. Use of block structures requires CPW approval.
- b. When permitted by CPW, constructed in place structures shall conform to Block Drainage Structure Standard Detail DR-6 shall meet HS-25 live loading.
- c. Cement concrete blocks used in the construction of drainage structures shall meet the requirements of MassDOT standard specification M4.05.1.

4. *Catch Basin Grates:*

- a. Cast iron frames and grates shall conform to MassDOT Standard Specification M8.03.0 and Standard Detail DR-1A
- b. Frames shall have an 8" height. Shorter heights may be used if necessary to meet grades
- c. The frame and grate shall have a combined weight of 453 pounds.

- d. Inlet grates shall have be 24" x 24" with a pattern of 36 square holes.
 - e. Frames and grates shall be as manufactured by East Jordan Iron Works model number (frame) OMA552000029 and (cover) OMA552000075, or approved equivalent.
5. *Catch Basin Hoods*
- a. Catch basin hoods shall be used in off-roadway operations such as parking lots and service areas to minimize the entry of oil, gasoline, and debris into drainage pipes. Catch basin hoods shall also be used in urbanized roadways where drainage is contained by vertical curbs and sidewalks are adjacent to the roadway (increasing the likelihood of litter). Catch basin hoods shall protrude no more than 12 inches beyond the end of pipe into the structure. Acceptable hoods are Ground Water Rescue Inc. Eliminator, Best Management Practices Inc. Snout® or equal approved the CPW.
6. *Granite Curb Inlets (Throat Stones)*
- a. Granite curb inlets are required for all new catch basins installed.
 - b. Granite shall conform to MassDOT Standard Specifications Sections M9.04.0 and M9.04.5.
 - c. Where drainage inlets are installed adjacent to a vertical curb or edging, granite inlet stones conforming to the requirements of MassDOT Standard Specification Section M9.04.5.
 - d. Curb inlets set on a radius of 160 feet or less shall be cut to that radius. The gutter mouth at least 3 inches in depth and at least 2 feet in length shall be cut in the front face of the stone.
 - e. If there is no other curbing, or as applicable, transitional curbing shall be required on both sides of the inlet. The transitional curbing shall be 6 feet in length, with a height equal to the inlet and tapering to grade at the end.

2.3.2.4 Structural Best Management Practices

A. Bioretention Area

1. *Soil Mix:* The soil mix for bio-retention areas should be a mix of sand, compost, and soil meeting the percentages identified below and should conform to the specifications in the Massachusetts Stormwater Handbook (2008), Volume 2, Chapter 2, Page 26.
 - 40% Sand
 - 20-30% Topsoil
 - 30-40% Compost
2. *Perforated Pipe:*
 - a. PVC pipe and standpipe shall meet the requirements specified under section 2.2.2.3 of these Standards.
 - b. Standpipe shall have a grated cap in a beehive style.
3. *Plantings:* The number, type, and location of plantings shall be subject to approval by CPW. All planting shall be water tolerant.

B. Detention/Infiltration Basins

1. *Berm Material:* Low permeability fill utilized for the detention basin berm constructed within fill shall be a well graded glacial till material, free of rubbish, ice, snow, tree stumps, roots, organic material, or other deleterious materials. There shall be no stones greater than three inches in diameter.

Gradation of low permeability core fill shall conform to the following schedule:

<u>U.S. Standard</u> <u>Sieve</u>	<u>Minimum Passing by</u> <u>Weight</u>	<u>Maximum Passing</u> <u>by Weight</u>
3-inch	100%	-
#4	70%	95%
#40	40%	65%
#200	15%	35%

Soil characteristics shall conform to the following requirements:

<u>Soil Characteristic</u>	<u>Minimum</u> <u>Value</u>	<u>Maximum</u> <u>Value</u>
Plasticity Index (PI)	5	20
Uniformity Coefficient (C _u)	12	---
Coefficient of Curvature (C _c)	1	3

2. *Outlet Control Structures (OCS):*

- a. Basin outlet control structures shall be constructed of reinforced precast concrete monolithic base section, riser section and slab top meeting the latest applicable requirements of ASTM C478 I and AASHTO M 199, or latest revision thereto. Special manholes shall also meet the requirements of MassDOT Standard Specifications, section M4.02.14, Precast Units. After curing a minimum of 14 days, the outside surface of the tapered or cone section of precast cement concrete drainage structures shall be dried and cleaned.
- b. The OCS shall be fabricated with orifice and weir sizes and invert elevations as outlined within the drainage report and *Stormwater Management Plan*.
- c. Consistent with Standard Details DR-16 and DR 16A the OCS shall be designed to manufactured to incorporate the basin's emergency drawdown.
- d. The OCS shall have the top of concrete elevation set at the 100 year flood elevation.
- e. An aluminum grate shall be set into the top of OCS. The grate shall have a hinge and locking mechanism. The grate shall meet the requirements set forth in ASTM B 306, Alloy 6061-T6 or an equivalent performing alloy registered and recognized in the Aluminum Standards and Data book produced by the Aluminum Association.

3. *Emergency Drawdown System:*

- a. Emergency drawdown system shall utilize extruded aluminum stop logs/or sluice gate, lifting lugs, and frame.
- b. The Emergency drawdown system shall meet the requirements set forth in ASTM B 306, Alloy 6061-T6 or an equivalent performing alloy registered and recognized in the Aluminum Standards and Data book produced by the Aluminum Association.
- c. The emergency drawdown activation device shall be set below the grate so as not to be utilized unnecessarily.
- d. The manufacturer shall design the connection system between the emergency drawdown system and outlet control structure.
- e. Connection accessories shall be of stainless steel. The connection system shall include a resilient watertight gasket. Submit connection detail to the Town Engineer.
- f. The emergency drawdown system shall be sealed against the outlet control structure. The seals shall be made of neoprene rubber. Seals shall be mounted in a manner that allows for easy replacement in the event of damage.

- g. All welding shall be done in accordance with AWS D1.2 for aluminum and AWS D1.6 for stainless steel.
 - h. The emergency drawdown system shall have a locking system.
4. *Loam and Seed:*
- a. All basins shall be loamed with 6" of clean loam containing no stones over 3" in diameter and seeded with New England Erosion Control/ Restoration Mix for Detention Basins and Moist Sites from New England Wetland Plants, or approved equal.
5. *Infiltration Basin Bottom:*
- a. Infiltration basins shall have sand bottoms meeting Title V gradation requirements or double washed crushed stone with a diameter 2" and smaller.

B. Forebay/Sediment Trap:

- 1. Forebay embankments shall be loamed with 6" of clean loam containing no stones over 3" in diameter and seeded with New England Erosion Control/ Restoration Mix for Detention Basins and Moist Sites from New England Wetland Plants, or approved equal.
- 2. Bottom material shall promote ease of maintenance.
- 3. Flow-through stone outlet shall be constructed of gabion baskets, or double washed 1" to 1-1/2" crushed stone.

2.3.2.5 Culverts:

- A. Culvert, headwall, wingwall, and endwall materials and specifications shall meet MassDOT Standard Specifications Sections 230 and M4, and as shown on MassDOT Construction and Traffic Standard Details, Drawings 206.40 through 206.70, and 207.1.0 through 207.3.0.

2.3.2.5 Rip Rap/Pipe Ends:

- A. Stone shall conform to MassDOT Standard Specifications Section 258 and Standard Detail DR-10A. Stone size shall be determined by the design storm flow discharging from the pipe. Stone for drainage swales shall be no smaller than 3 inches, unless otherwise approved by CPW.

2.3.2.6 Headwalls:

- A. Headwall materials and specifications shall meet MassDOT Standard Specifications Sections 230 and M4, and as shown on Standard Detail DR-11.