Chapter 7.4 - Gravel Wetlands

The subsurface gravel wetland is designed as a system with two horizontal flow-through treatment cells and a forebay in series and where stormwater passes through a saturated gravel substrate that acts as a natural microbial habitat capable of denitrification (i.e., conversion of nitrate to nitrogen gas). From a process perspective, the forebay is maintained as a dry basin and provides pre-treatment under aerobic conditions, the basins of the wetland cells provide sedimentation and some quality treatment from the wetland plants. Anaerobic treatment is effectively provided by the saturated drainage layer of the cells. A multiple-staged outlet controls the channel protection volume as well as the volume from larger storms. The soil in the cells should remain continuously saturated 4 inches below the ground surface to promote water quality treatment conditions and to support wetland vegetation.

Basin Siting: The following criteria apply to all gravel wetlands:

- *Wetland alterations:* Any alteration to existing natural wetlands is subject to regulation by the Maine DEP and the U.S. Army Corps of Engineers and appropriate permits will be required.
- *Natural Soils*: The created gravel wetland must remain wet at all time; and either the structure is located within undisturbed tight soils such as soils Type D or C, below the groundwater table, or the basin structure is lined with an impermeable membrane.
- *Relationship to Groundwater:* The elevation of the created wetland outlet may be at the elevation of the seasonal high groundwater table.
- *Drainage Area:* The size of the underdrained soil filter and storage capacity over the filter is based on the size and land use within the area draining to the structure. Upgradient areas not intended to be treated should be directed around the filter basin.

Basin Sizing: When used to meet the phosphorus allocation in lake watersheds, the sizing of the gravel wetland structure needs to be adjusted in accordance with Volume II of this BMP manual.

- *Water Quality Volume:* The created wetland must contain the full water quality volume from one inch of runoff over the impervious area within the subarea and 0.4 inch over the vegetated or landscaped area. The target detention time for the treatment volume should be between 24 to 48 hours.
- *Wetland Treatment cells:* The two wetland cells must be capable of holding 45% of the water quality volume each and may provide flood storage if necessary.
- *Forebay:* The forebay and any swale or discharge pipe to the system should be capable of holding 10% of the water quality volume.
- *Surface area:* The total surface area of the bottom of the cells needs to add up to 5% of the impervious area plus 2% of the vegetated area draining to the structure.
- *Treatment Depth:* The ponding depth of the treatment volume within the system should not exceed 18 inches over the vegetation.
- *Storage for quantity control*: A gravel wetland may also provide flooding control; but at maximum flood level elevation, ponding should be no deeper than three feet as large changes in water level are not conducive to the growth of wetland plants.

Basin Plan: The following criteria apply to all gravel wetlands. A plan view of a gravel wetland is shown on Figure 7.4.1 and a cross section is shown on Figure 7.4.2.

- *Side slopes:* All side slopes to the forebay and the treatment cells should be 3:1 or flatter for maintenance access.
- *Geotextile Fabric:* A geotextile fabric should be placed between the gravel layer and adjacent soil. The fabric will prevent the surrounding soil from migrating into the trench and clogging the outlet. Use an appropriate mesh size that is compatible with the surrounding soil. Overlap seams should be a minimum of 12 inches.
- *Impermeable Membrane:* A low permeability liner or soil may be necessary to contain the system and prevent infiltration or loss of moisture, preserve horizontal flow within the treatment layer and sustain the wetland plants. If geotechnical testing confirms the need for a liner, an impermeable liner such as

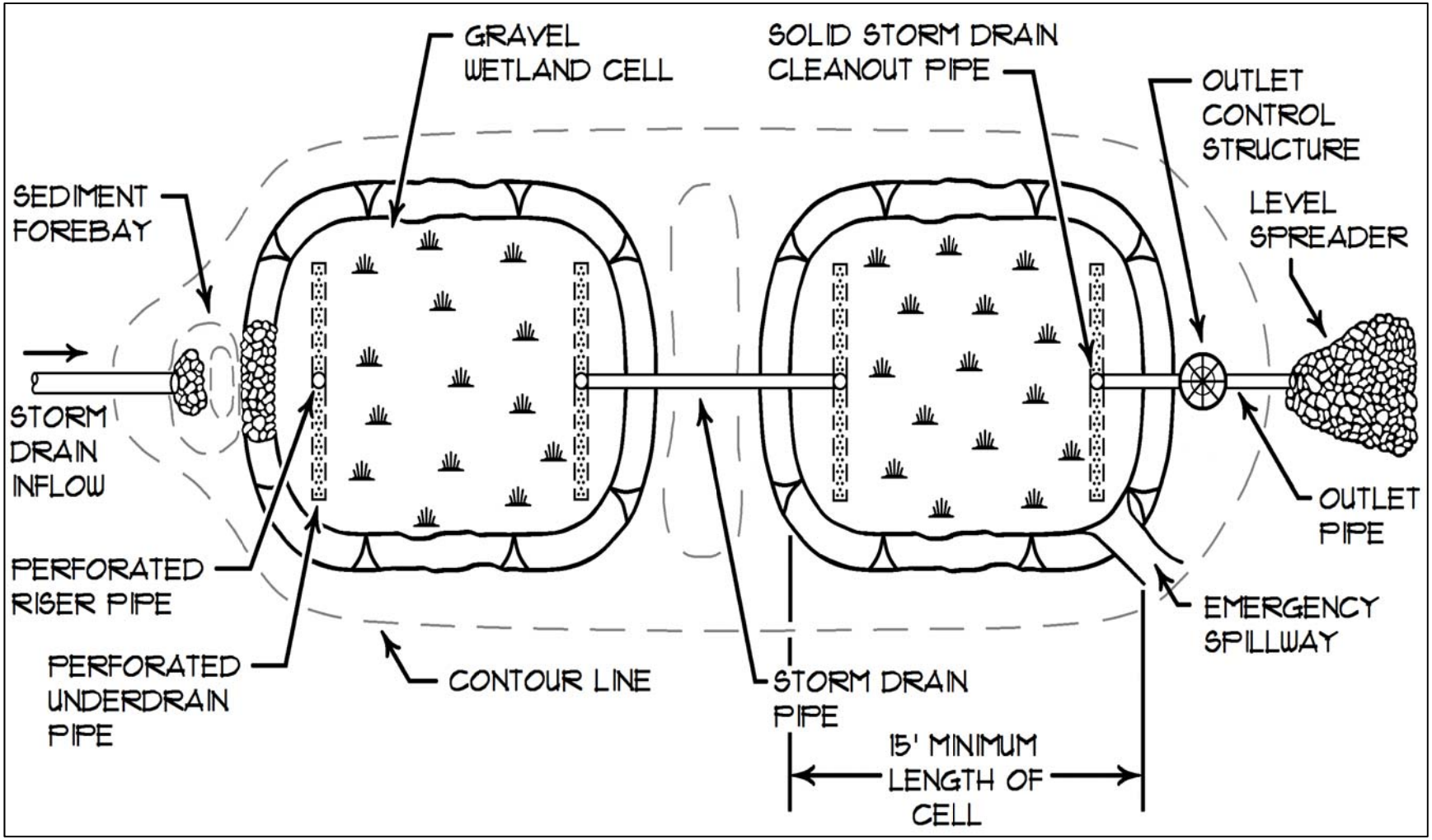

Figure 7.4.1– Gravel Wetland Plan View

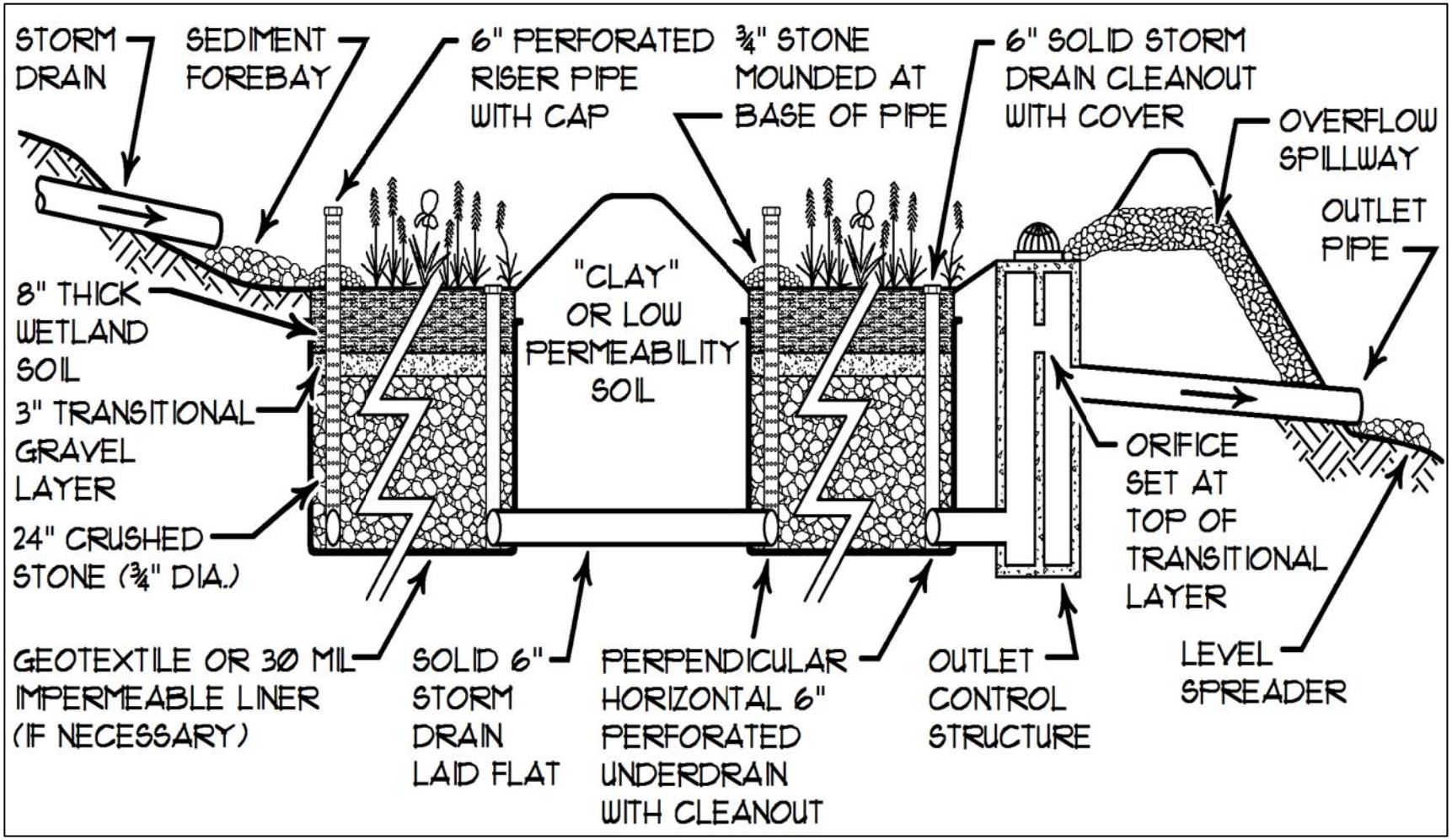

Figure 7.4.2 – Gravel Wetland Cross-Section

- a 30 ml HDPE liner or equal will be necessary. If the undisturbed native soils where the gravel wetland will be located have a low hydraulic conductivity (such as a soil type D) or the water table is near the top of the basin, a liner will not be necessary.
- *Wetland Soil*: The wetland soil should have a thickness of 8 inches minimum and should have a low hydraulic conductivity (0.1-0.01 ft/day). This soil can be manufactured, using compost, sand and fine soils, into a blend with more than 15% organic matter. It should contain more than 15% silt (passing the #200 sieve); but with a clay size portion that is less than 2%.
- *Intermediate Layer*: An intermediate layer (6 inches thick) of aggregate filter (pea gravel) is needed to prevent the wetland soil from migrating into the crushed-stone (gravel) saturated drainage layer. Do not use a geotextile fabric as it will restrict root growth.
- *Saturated Drainage Layer:* Below the wetland soil and intermediate layer is a crushed stone (or very coarse gravel) drainage layer with a 24-inch minimum thickness. Angular ¾" crushed stone, is recommended as large angular particles are needed to maintain the permeability of the system. The pipe underdrains should have at least 2 feet of gravel cover and six inches below the pipe.
- *Underdrains:* Horizontal underdrains and risers distribute the inflow through the gravel layer within each of the cells; and at the downstream, an outflow underdrain recollects the water to distribute it to the next cell or for discharge.
- *Treatment length:* The flow path between the inflow and the outflow subdrains within each cell's saturated drainage layer should be 15 feet at a minimum.

Outlets: The channel protection volume must be discharged solely through the underdrained gravel outlet having a weir or a single elbowed pipe outlet placed at the elevation of the wetland basin to force a near-surface groundwater condition (with as an invert 4 inches below the wetland ground surface). The outlet needs to be sized to provide the slow discharge (24-48 hours) of the water quality volume.

- *Risers:* In both wetland cells, vertical perforated or slotted risers deliver the outflow to the horizontal and perpendicular sub-drains imbedded in the gravel drainage layer. The perforated/slotted riser should extend 18-24 inches above the surface of the wetland soil. A riser should be provided for every 10 feet of linear inflow sub-drain.
- *Underdrain Pipe:* The underdrain piping should be 6 inch diameter with slotted, rigid Schedule 40 PVC or SDR35 pipe.
- *Overflow Spillway:* An armored spillway should be provided between the cells for larger storms to flow through without causing erosion. The spillway should be 18 inches above the wetland surface.
- *Emergency Spillways:* Emergency spillways should be designed to independently convey the routed runoff from larger storms (2, 10 and 25-year, 24-hour storms) while maintaining at least one foot of freeboard; and to safely convey the 100-year storm without overtopping the embankment. Overflow must discharge to a stable channel or vegetated area. The emergency spillways should be located on undisturbed, non-fill soil wherever possible. If the spillway must be located on fill soils, then it must be horizontally offset at least 20 feet from the principal outlet and appropriately stabilized.
- *Cleaning Ports:* A clean-out port should be provided for each of the horizontal underdrain pipe structure in both basins.

Vegetation: Appropriate wetland species should be carefully selected to stabilize the sides and bottom of the basins. The creation of a marsh environment at the pond inlet will help to trap sediment. Fertilizer should not be used unless necessary to establish new vegetation. Allowing for the natural invasion of native species may encourage healthier growth than planting species not already found on site.

- *Wetland Plants:* Wetland plants function in two important ways: the stems and leaves provide a large surface area for the attachment of microbial populations; and the plants transport oxygen to the root zone. The by-products produced by the aerobic microbes are then easily utilized by the anaerobic microbes in the saturated layer. Leaves and stalks provide a canopy of shade, which limit sunlight penetration and alga growth (the algae can deter the oxygen transfer and creates a toxic environment for the plants). The most appropriate wetland plants are the following:
    - *Reeds (Juncus effusus)* are the "worker plants" in a gravel wetland. Their roots go down quickly and deeply. They spread across the media and they are pest resistant and winter hardy.

- *Cattails (Typha latifolia)* are the plants most often associated with wetlands. They work well and have a positive impact on treatment. The larger, native varieties, however, can be dominant and take over a small filter if not removed in later years.
- *Bulrush (Scirpus)* can produce dense stands of vegetation. It can survive unfavorable conditions like prolonged flooding, or drought as buried seeds.
- *Phragmites (reed)* is very invasive and is not recommended.

Construction: The subarea draining to a created wetland must be completely stable before runoff is directed to the basin to prevent sedimentation of the drainage layer; or all runoff should be re-directed until construction is finalized. The vegetation within the structure is equally important and must be well established before it can accept any runoff. Construction should be started no later than September 1 or earlier than June 1; and if vegetation cannot be established by the end of the growing season, construction should be delayed to the following year. Seeding or stabilization must occur by September 15 in preparation for the winter season.

- *Oversight:* A gravel wetland should only be constructed under the supervision from the design engineer.

Maintenance: Operation and maintenance requirements similar to those for underdrained filter basins should be expected. The plant biomass should be harvested annually, and accumulated sediment removed at intervals of 5-10 years. These activities may disrupt the wetlands system and may require some vegetation re-establishment. The riser pipes may clog and will require annual clean-out (it should be done in the winter time when one can walk on the wetland).

- *First Year Post-Construction:* Inspection frequency should occur after every major storm in the first year following construction.
  - Inspect that the system drains within 24-48 hours.
  - The plants may need watering if necessary during the first growing season. Revegetate if the vegetation is poorly establishing.
  - Identify areas of erosion and make timely repairs.
  - Check all inlets, outlets and subdrains for proper functioning. Risers may need to be cleaned.
- *Post-Construction:* Inspection frequency should occur at least every 6 months and after every major storm. Activities are expected to include:
  - Check the basin for a dense root mat establishment of wetland vegetation.
  - Check and clean the risers if there is evidence of standing water, discolored water or accumulated sediments in the cells.
  - Check and clean the forebay for sediments, trash and debris. When sediments have accumulated to a depth of 12 inches, standing water is persistent or wetland vegetation become established, the forebay will need to be excavated and reformed.
  - Verify that the cells drain within 24-48 hours. Sediment will need to be removed when an accumulation of 4 inches is evident over the wetland surface.
  - Check and clean all outlets and overflow spillway if blocked or there is evidence of structural damage or erosion.
  - Remove decaying vegetation, litter and debris.
  - Check for foreign species. Particular care must be used to avoid the unintended introduction of invasive species such as purple loosestrife (Lythrum salicaria) and common reed (Phragmites australis). It is recommended that a qualified wetland biologist be consulted when these are found in the area of the gravel wetland.