* This system will be added to the engineered list in section 4.1.

4.27 Subsurface Flow Constructed Wetland

Revision: November 5, 2015

4.27.1 Description

Subsurface flow constructed wetlands are secondary wastewater treatment systems that receive and treat wastewater that has undergone primary treatment in a septic tank. Wastewater flows through a lined constructed wetland cell filled with porous media in which climate and anaerobic, water-tolerant vegetation is planted. The vegetation provides up-take of the wastewater in addition to a surface for microorganisms to grow that aid in wastewater treatment. Wastewater exits the horizontal constructed wetland cell and proceeds to a watertight overflow basin which then either discharges to another constructed wetland cell in series with the first or to a subsurface sewage disposal drainfield. Figure 4-46 provides a diagram of a subsurface flow constructed wetland.

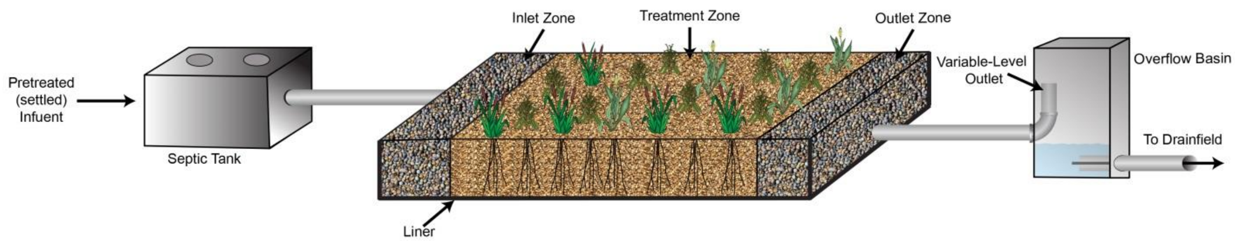

Figure 4-46. Cross-sectional view of a subsurface flow constructed wetland.

4.27.2 Approval Conditions

1. The system must be designed by a PE licensed in Idaho.
2. Wastewater must remain below the ground surface in the constructed wetland.
3. Nondomestic wastewater must be pretreated to residential strength before discharge to the constructed wetland.
4. Effluent shall not discharge to the drainfield without passing through the constructed wetland first.
5. The bottom of the constructed wetland must not come within 12 inches of seasonal high ground water.
6. The constructed wetland shall meet the same separation distance requirements as a septic tank.
7. The design engineer shall provide an O&M manual for the system to the health district before permit issuance.
8. All pressure distribution components shall be designed according to the pressure distribution system guidance (section 4.19).

4.27.3 Design Requirements

Minimum design requirements for the subsurface flow constructed wetland are provided below.

4.27.3.1 Septic Tank

1. The septic tank shall be sized according to the requirements of IDAPA 58.01.03.007.07.
2. The septic tank shall have an approved effluent filter (section 5.9) installed at the outlet.
3. The outlet manhole shall be brought to grade utilizing a riser and secured lid to provide maintenance access to the effluent filter.

4.27.3.2 Effluent Transport to the Subsurface Flow Constructed Wetland

1. Gravity flow is the preferred method to transport wastewater from the septic tank to the subsurface flow constructed wetland.
2. If gravity flow is not possible a dosing chamber may be installed meeting the requirements of section 4.19.3.4 and the effluent shall break to gravity following the requirements of section 4.19.3.6 prior to entering the subsurface flow constructed wetland.
3. If the installation of a pump to gravity distribution component is necessary the drop box shall be accessible from grade for maintenance purposes.
4. Pressurized doses should have a small volume so the subsurface flow constructed wetland does not receive large surge flows.

4.27.3.3 Subsurface Flow Constructed Wetland

1. The subsurface flow constructed wetland container shall be constructed of reinforced concrete or other materials where equivalent function, workmanship, watertightness, and at least a 20-year service life can be documented, or
2. The subsurface flow constructed wetland container shall be constructed of a flexible membrane liner meeting the following requirements:
   a. Have properties equivalent to or greater than 30-mil PVC and be compatible with wastewater.
   b. Have field repair instructions and materials provided to the purchaser of the liner.
   c. Have factory fabricated boots for waterproof field bonding of piping to the liner.
   d. Liner must be placed against smooth, regular surfaces free of sharp edges, nails, wire, splinters, or other objects that may puncture the liner. A 4-inch layer of clean sand should provide liner protection.
3. The subsurface flow constructed wetland shall have a berm that is at least 1 foot above the surface of the planting media with sides that are as steep as possible, consistent with the soils, construction methods and materials.
4. Filter construction media shall meet the following specifications:
   a. Section 3.2.8.1.3 for planting media (pea gravel)
   b. Section 3.2.8.1.1 for inlet and outlet zone media (drainrock)

c. Treatment zone media shall have an average diameter between 3/4 inch to 1 inch and be free of fines.

5. The surface of the subsurface flow constructed wetland shall be level.

6. The bottom of the subsurface flow constructed wetland shall maintain a uniform slope from the inlet to the outlet of 1/2% to 1% to maintain flow conditions and allow for complete drainage.

7. Minimum filter construction specifications shall also meet the dimensions, ratios, and locations depicted in Figure 4-47.

8. The inlet and outlet zones should be designed to prevent accidental contact with effluent from the surface including:

    a. Chain-link fence or another acceptable protective barrier shall be placed below the planting media and at the top of the inlet/outlet media and cover the entire surface of the inlet and outlet areas to prevent access, unless fencing is placed around the entire system to prevent access.

    b. Geotextile fabric shall be placed over the access barrier.

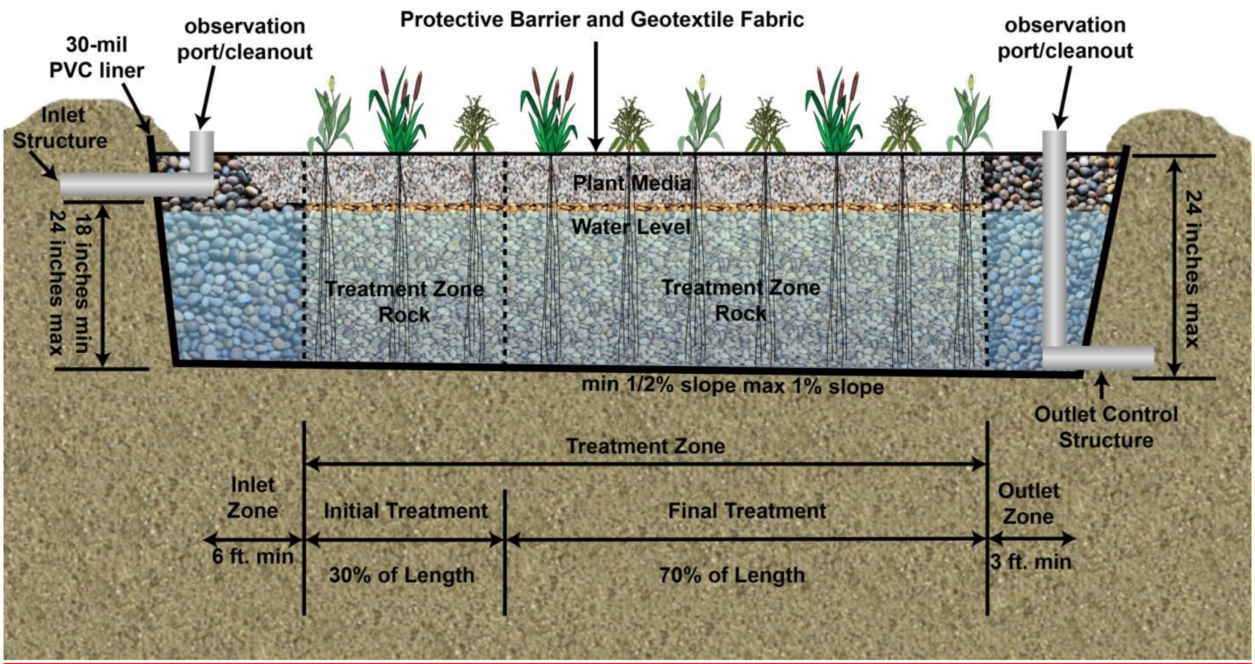

Figure 4-47. Cross sectional view of a constructed wetland cell.

4.27.3.4 Subsurface Flow Constructed Wetland Sizing

Sizing of a subsurface flow constructed wetland must take into account the loading of BOD and TSS from the wastewater. In addition the treatment zone of the subsurface flow constructed wetland should be capable of maintaining a hydraulic retention time of at least 2 days. Use Table 4-31 with the information provided in this subsection to size the wetland correctly.

1. Determine the minimum treatment zone surface area for both pollutants (BOD and TSS) and utilize the largest area.

(a) BOD surface area: $A_{SB} = (Q)(B)/(53.5 \text{ lb/acre/day})$

(b) TSS surface area: $A_{ST} = (Q)(T)/(44.5 \text{ lb/acre/day})$

Equation 4-17. BOD and TSS surface area in square feet.

Where:

A_{SB} and A_{ST} = total surface area of the treatment zone in square feet (ft^2) for BOD (A_{SB}) and TSS (A_{ST}).

Q = total daily design flow in gallons per day (gal/day).

B = 0.0018 lb/gal (constant value for the maximum BOD discharged to the system per gallon).

T = 0.00071 lb/gal (constant value for the maximum TSS discharged to the system per gallon).

Example:

A_{SB} = (250 GPD)(0.0018 lb/gal)/(53.5 lb/acre/day) = 0.0084 acres

(0.0084 acres)(43560 ft^2/acre) = 366 ft^2

A_{ST} = (250 GPD)(0.00071 lb/gal)/(44.5 lb/acre/day) = 0.004 acres

(0.004 acres)(43560 ft^2/acre) = 175 ft^2

Use A_{SB} = 366 ft^2

2. Apply a 25% safety factor to the required size of the treatment zone.

   Example:

   (366 ft^2)(1.25) = 458 ft^2

3. Determine the size of the initial treatment zone and final treatment zone within the total treatment zone using the following requirements:

   a. Initial treatment zone = 30% of the overall treatment zone area

      Example:

      A_{IT} = 0.3(458 ft^2) = 138 ft^2

   b. Final treatment zone = 70% of the overall treatment zone area

      Example:

      A_{FT} = 0.7(458 ft^2) = 321 ft^2

4. The hydraulic conductivity (K) of clean treatment zone media meeting the sizing requirements in section 4.XX.3.3(4) is 30,500 ft/day. Due to filtration and settling of materials the hydraulic conductivity of the treatment zone is:

   a. Initial treatment zone is 1% of the clean K, or 305 ft/day.

   b. Final treatment zone is 10% of clean K, or 3,050 ft/day.

5. Determine the minimum width based on the hydraulic loading rates that will maintain all flow below the surface of the submerged flow constructed wetland using Darcy's Law. The largest width should be used for the overall system design.

$Q = KWD_W(d_h/L)$

Equation 4-18 Darcy's Law

Where:

L = length of treatment zone = area/width; therefore:

$W^2 = (QA_{si})/(KD_w d_h)$

Where:

A_{si} = Surface area of the treatment zone (ft^2)

D_w = Depth of water (ft)

W = Width of cell (ft)

Q = Flow into cell (ft^3/day) (1 ft^3 = 7.48052 gal)

K = Hydraulic conductivity (ft/day)

d_h = Maximum permissible headloss (ft) (assume = 50% of difference between depth of media and depth of water)

Example:

Initial Treatment Zone = $W^2 = [(33.42)(458\ ft^2)]/[(305\ ft/day)(1.33\ ft)(0.167\ ft)] = (15306.36\ ft^2)/(67.74\ ft) = 226\ ft \rightarrow (\sqrt{226}) = 15\ ft$

Final Treatment Zone = $W^2 = [(33.42)(458\ ft^2)]/[(3050\ ft/day)(1.33\ ft)(0.167\ ft)] = (15306.36\ ft^2)/(677.4\ ft) = 22.6\ ft \rightarrow (\sqrt{22.6}) = 4.8\ ft$

Use 15 ft. for both treatment zone widths.

6. Determine the maximum length of each treatment zone by dividing the required treatment area by the width.

$L_{IT} = (0.3A_T)/W$

Equation 4-19. Initial Treatment Zone Length

Where:

L_{IT} = Total length of the initial treatment zone

A_T = Total required treatment area

W = Width (determined in step 5)

0.3 = Constant described in step 3

Example:

$L_{IT} = [(0.3)(458\ ft^2)/(15\ ft) = 9.2\ ft. \rightarrow$ use 10 ft.

$L_{FT} = (0.7A_T)/W$

Equation 4-20. Final Treatment Zone Length

Where:

L_{FT} = Total length of the final treatment zone

A_T = Total required treatment area

W = Width (determined in step 5)

0.7 = Constant described in step 3

Example:

$L_{IT} = [(0.7)(458\ ft^2)/(15\ ft) = 21.4$ ft. → use 22 ft.

7. Verify that the total treatment zone has a hydraulic retention time of at least 2 days assuming a porosity of the treatment media of 30% and that the length to width ratio of the submerged flow constructed wetland (inlet zone, total treatment zone, and outlet zone) is 3:1 or less. If the hydraulic retention time and/or the length to width ratio of the system do not meet the requirements above adjust the system dimensions to meet the requirements while maintaining the minimum treatment area and minimum width required.

$HRT = (L_{TZ}W_{TZ}(1.33)(0.3))/Q$

Equation 4-21. Hydraulic Retention Time

Where:

HRT = Hydraulic retention time

L_{TZ} = Length of the total treatment zone

W_{TZ} = Width of the treatment zone

1.33 = Depth of the water level within the submerged flow constructed wetland at normal operating level

0.3 = Porosity of the treatment zone media

7.48052 = Gallons per cubic foot

Q = Total daily design flow

Example:

$HRT = [(41\ ft)(15\ ft)(1.33\ ft)(0.3)(7.48052\ gal/ft^3)]/(250\ GPD) = (1835.6\ gal)/(250\ GPD) = 7.34$ days

$L:W = (L_{TZ}+L_{IZ}+L_{OZ})/W_{TZ}$

Equation 4-22. Length to Width Ratio of the Subsurface Flow Constructed Wetland

Where:

L:W = Length to width ratio

L_{TZ} = Length of the treatment zone

L_{IZ} = Length of the inlet zone

L_{OZ} = Length of the outlet zone

W_{TZ} = Width of the treatment zone

Example:

L:W = (32 ft+6 ft+3 ft)/15 ft = 41 ft/15 ft = 2.73/1

Table 4-31. Subsurface flow constructed wetland sizing checklist.

	Treatment Zone Surface Area	
1	Determine daily design flow (Q)	Q = ________ GPD
2	Determine the treatment zone surface area based on BOD and TSS A_{SB} = *[(Q)(0.0018 lb/gal)]/(53.5 lb/acre/day); and* A_{ST} = *[(Q)(0.00071 lb/gal)]/(44.5 lb/acre/day)* *Convert acreage to square feet and add safety factor using* *[(Acres)(43560 ft^2/acre)(1.25)] = ft^2*	A_{SB} = ________ ft^2 A_{ST} = ________ ft^2 *Use largest value (A)*
	Initial Treatment Zone and Final Treatment Zone	
3	Determine the size of the initial treatment zone A_{IT} = 0.3 (A)	Initial Treatment Zone = ________ ft^2 (B)
4	Determine the size of the final treatment zone A_{FT} = 0.7(A)	Final Treatment Zone = ________ ft^2 (C)
5	Determine the minimum width of the treatment zones $W^2 = (QA_{si})/(KD_w d_h)$ Round up to nearest foot	Initial Treatment Zone Width = ________ ft Final Treatment Zone Width = ________ ft *Use largest value (D)*
6	Determine the maximum length of the initial treatment zone L_{IT} = (B)/(D) Round up to nearest foot	Maximum Length of the Initial Treatment Zone Length = ________ ft (E)
7	Determine the maximum length of the final treatment zone L_{FT} = (C)/(D) Round up to nearest foot	Maximum Length of the Final Treatment Zone Length = ________ ft (F)
	Retention Time	
8	Verify the total treatment zone has a hydraulic retention time of at least 2 days HRT = $(L_{TZ}W_{TZ}(1.33)(0.3))/Q$	Hydraulic Retention Time = ________ days
	Length to Width Ratio	
9	Verify that the length to width ratio of the wetland is 3:1 or less L:W = $((E+F)+L_{IZ}+L_{OZ})/D$	Length to Width Ratio = ________

Notes: gallons per day (GPD); pounds per gallon (lb/gal); pounds per acre per day (lb/acre/day); square feet per acre (ft^2/acre); square feet (ft^2); feet (ft)

4.27.3.5 Subsurface Flow Constructed Wetland Cells

1. Subsurface flow constructed wetlands may be divided into multiple cells in series to maintain length to width ratios (Figure 4.48).
2. Subsurface flow wetlands shall be divided into multiple parallel trains that contain one or more cells as described in Table 4-31.
3. For wetlands with daily design flows of 2,500 gallons per day or more piping shall be included in the design that allows each cell to be taken off line and bypassed for maintenance and repair needs.
4. Daily flows must be divided equally among each train.
5. Each subsurface flow constructed wetland cell shall contain its own watertight overflow basin described in section 4.27.3.6.

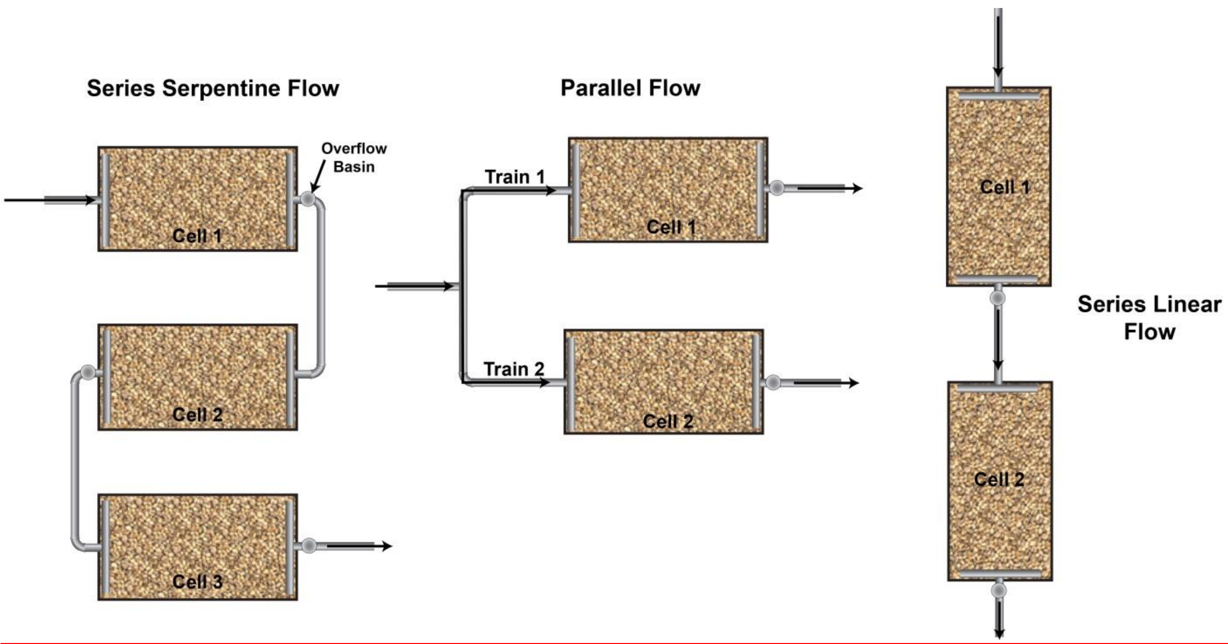

Figure 4-48. Configuration of wetland cells in series and parallel.

Table 4-31. Required subsurface flow constructed wetland trains and cells based on daily design flow.

Daily Design Flow (GPD)	Minimum Number of Trains	Minimum Number of Cells per Train	Minimum Number of Cells
< 2,500	1	1	1
2,500-4,999	2	2	4
≥5,000	4	2	8

Note: GPD – gallons per day

4.27.3.6 Inlet and Outlet Structures in the Subsurface Flow Constructed Wetland

1. The inlet control structure should uniformly distribute the inflow across the entire width of the constructed wetland (Figure 4.49).

2. The inlet and outlet piping and control structures shall have a minimum diameter of 4 inches.
3. The inlet and outlet control structures shall have cleanouts that are accessible from grade.
4. The inlet control structure shall be located at the top of the drainrock in the inlet zone, be located as close to the inlet wall of the wetland as possible, and be level across its entire length.
5. Orifices on the inlet and outlet control structures should be evenly spaced with a maximum distance between orifices equal to 10% of the wetland width.
6. The outlet control structure should uniformly collect wastewater effluent across the entire width of the wetland.
7. The outlet control structure shall be located at the bottom of the drainrock in the outlet zone, be located as close to the outlet wall of the wetland as possible, and be level across its entire length.
8. The outlet control structure shall discharge to a watertight overflow basin located outside of the constructed wetland.
9. The watertight overflow basin (Figure 4.50) shall:
    a. Have a minimum diameter of 20 inches and be accessible from grade.
    b. Contain a water level control device that allow the operator to flood the constructed wetland to a point that is level with the surface of the planting media, completely drain the constructed wetland, and maintain the water level within the constructed wetland anywhere in between these two points and maintain a 2 day hydraulic retention time. *Note: Normal operating level is located 4 inches below the surface of the treatment media.*
    c. Gravity flow to the drainfield. If gravity flow is not achievable and/or pressurization of the drainfield or transport piping is necessary then the watertight basin must be an approved dosing chamber or septic tank that meets the requirements of section 4.19.3.4.

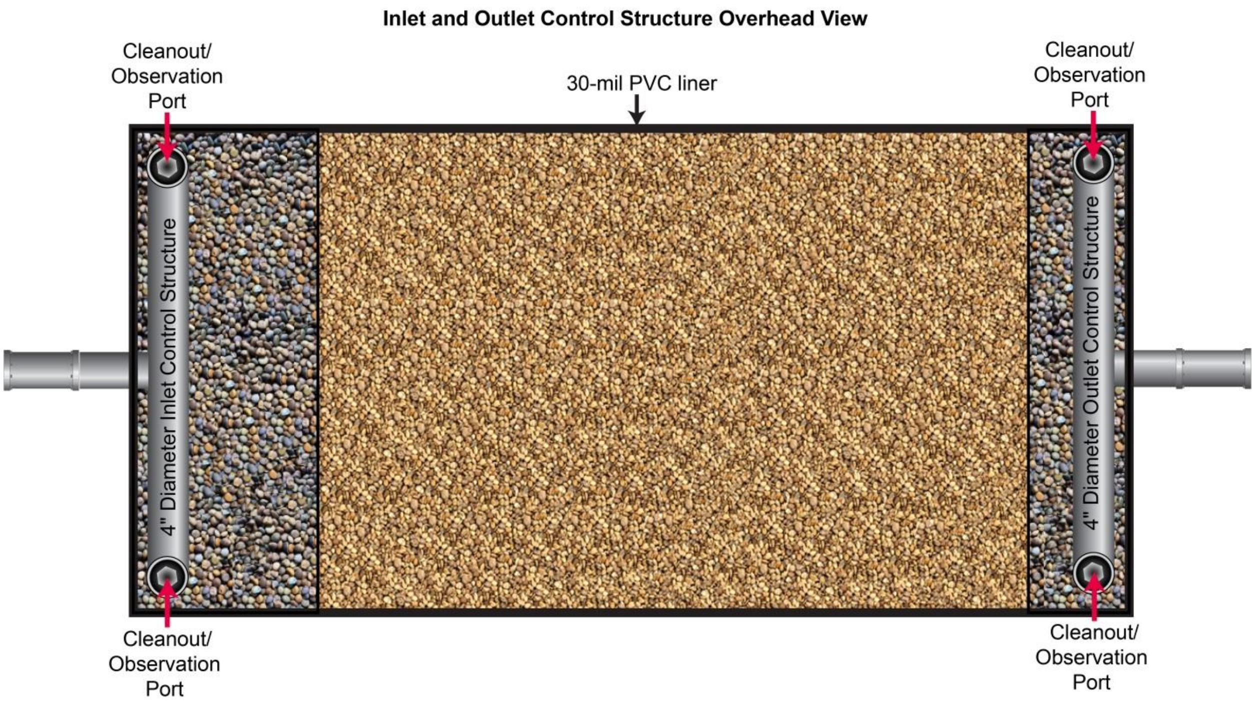

Figure 4.49. Overhead view of a wetland showing the inlet and outlet control structures in relation to the wetland width.

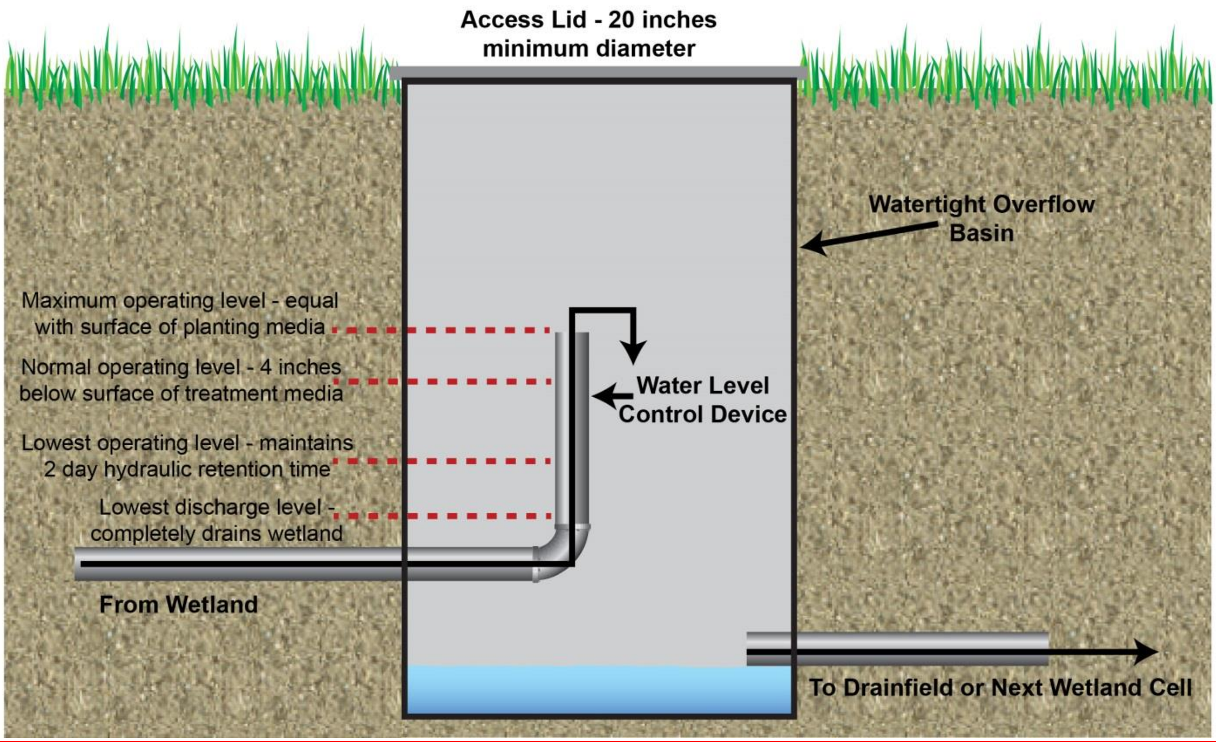

Figure 4.50. Cross-sectional view of an overflow basin.

4.27.3.7 Subsurface Flow Constructed Wetlands Vegetation

1. Planting densities shall be 1 ft. to 2 ft. on center in staggered rows throughout the treatment zone of the wetland (Figure 4.51).
2. Vegetation should not be established within the inlet and outlet zones of the wetland.
3. Vegetation shall not be established from seed.
4. Plant species should:
    a. Be capable of producing root depths that will extend to the bottom of the wetland (20 in.)
    b. Be tolerant of local climates and continuous submersion of their roots in anaerobic water
    c. Not be considered noxious or invasive plants
    d. Not be flowering or soft tissue plants that decompose rapidly
    e. Not be emergent woody plants or riparian trees and shrubs
    f. Not be submerged or floating aquatic plants
    g. Recommended species include, but are not limited to:
        i. Alkali bulrush (*Schoenoplectus maritimus*)
        ii. Baltic rush (*Juncus balticus*)
        iii. Broadleaf cattail (*Typha latifolia*)
        iv. Creeping spikerush (*Eleocharis palustris*)
        v. Hardstem bulrush (*Schoenoplectus acutus*)
        vi. Nebraska sedge (*Carex nebrascensis*)
5. Plants should be allowed to be established prior to discharging wastewater to the wetland for a period up to 6 weeks. This is done by raising the water level in the wetland to the top of the planting media. After rooting establishment the water level in the wetland should be lowered to the normal operating depth of 4 inches below the treatment media surface.
6. To promote plant growth and enhance root development it is beneficial to lower the water level within the wetland on an annual basis from the normal operating level to a level that is equivalent to a 2 day hydraulic retention time within the treatment zone. The water level should be lowered and raised back to a normal operational level over a several week period.

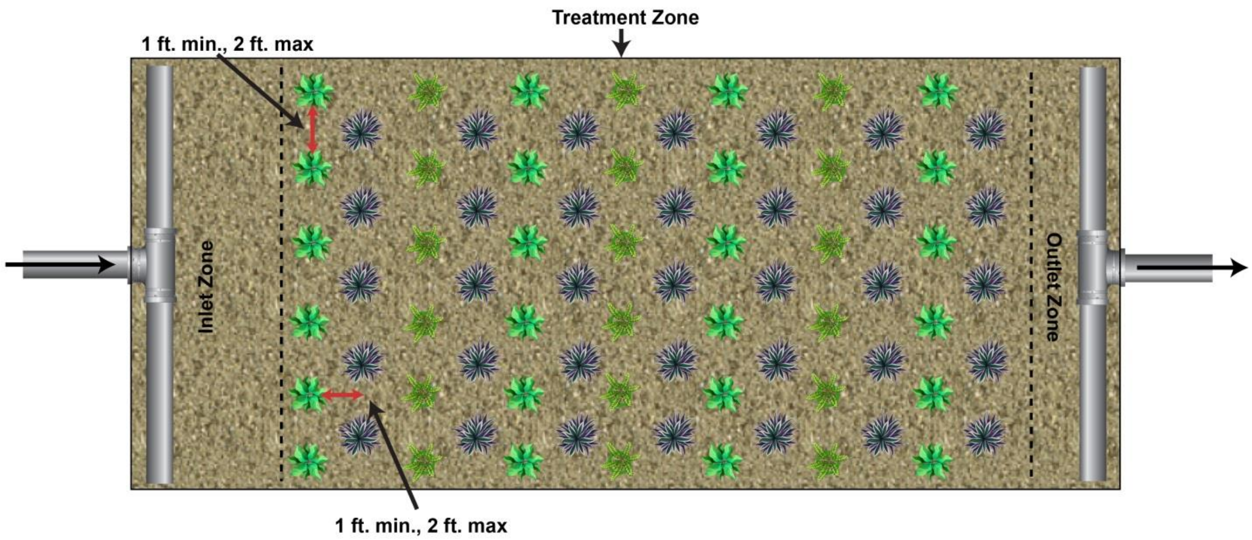

Figure 4.51. Vegetation and planting spacing throughout the wetland treatment zone.

4.27.3.8 Subsurface Flow Constructed Wetlands Temperature Protection

1. Temperature protection of the subsurface flow constructed wetlands and its components should be taken into consideration by the design engineer.
2. Several inches (≥ 6 inches) of insulating mulch or peat should be placed on a layer of geotextile fabric that covers the surface of the planting media.
3. Plants should not be cut back prior to the non-growing season.

4.27.4 Submerged Flow Constructed Wetlands Construction

1. All vegetation in the placement area of the wetlands should be cleared and grubbed to remove large roots and stumps. Large rocks should also be removed.
2. All soil used in constructing the wetland bottom and berm shall be compacted to at least 95% standard Proctor density.
3. When grading and constructing a wetland cell care must be exercised so as not to create low spots or preferred flows down a particular side of the wetland that will encourage short circuiting.
4. After grading and compaction construction equipment should not enter the constructed wetland cell.
5. If used, the flexible liner containment system shall be constructed on top of a protective layer of sand. The protective layer of sand shall consist of a 4 inch layer of clean sand placed, graded, and compacted to match the wetland slope requirements on the compacted native grade.
    a. The liner should be installed according to the manufacturer's recommendations and extend to a height of 12 inches above the treatment media and be located within the containment berm at all locations above the planting media.

b. It is recommended that a geotextile fabric with a weight of 4 ounces be placed over the liner prior to placing media in the constructed cell.

6. All media should be washed on site prior to placement in the constructed cell.

4.27.5 Drainfield Trenches

1. Distances shown in Table 4-32 must be maintained between the trench bottom and limiting layer.
2. Capping fill may be used to obtain adequate separation distance from limiting layers but must be designed and constructed according to the guidance for capping fill trenches in section 4.3.
3. Pressure distribution may be used with the following design considerations:
   a. The pressure distribution system related to the drainfield is designed according to section 4.19.
   b. The dosing chamber for the drainfield trenches may be substituted for the overflow basin from the constructed wetland cell.
4. The drainfield shall be sized by dividing the maximum daily flow by the hydraulic application rate for the applicable soil design subgroup listed in Table 4-33.

Table 4-32. Submerged flow constructed wetland vertical separation distance to limiting layers (feet).

Limiting Layer	Flow < 2,500 GPD	Flow ≥ 2,500 GPD
	All Soil Types	All Soil Types
Impermeable layer	2	4
Fractured rock or very porous layer	1	2
Normal high ground water	1	2
Seasonal high ground water	1	2

Note: gallons per day (GPD)

Table 4-33. Secondary biological treatment system hydraulic application rates.

Soil Design Subgroup	Application Rate (gallons/square foot/day)
A-1	1.7
A-2a	1.2
A-2b	1.0
B-1	0.8
B-2	0.6
C-1	0.4
C-2	0.3

4.27.6 Inspection

1. A preconstruction meeting between the health district, responsible charge engineer, and installer should occur before commencing any construction activities.
2. The site must be inspected when the wetland cell has been excavated and formed, and prior to installation of the containment structure. Compaction test results for all fill materials, containment berms, and the wetland bottom shall be provided at this time.
3. The health district should inspect all system components before backfilling and inspect the filter container construction before filling with drainrock and treatment construction media.
4. The responsible charge engineer shall conduct as many inspections as needed to verify system component compliance with the engineered plans.
5. The responsible charge engineer shall provide the health district with a written statement that the system was constructed and functions in compliance with the approved plans and specifications. Additionally, the responsible charge engineer shall provide as-built plans to the health district if any construction deviations occur from the permitted construction plans (IDAPA 58.01.03.005.15).

4.27.7 Operation and Maintenance

1. The subsurface flow constructed wetland design engineer shall provide a copy of the system's operation, maintenance, and monitoring procedures to the health district as part of the permit application and prior to subsurface sewage disposal permit issuance (IDAPA 58.01.03.005.04.k).
2. Fertilizing the system is not required.
3. System irrigation is not required.
4. Systems with multiple cells must have directions on how each cell may be isolated so repair work can be performed without additional wastewater entering the cell.
5. Periodic surface maintenance may be required for any of the following reasons:
    a. In the spring, the thick layer of leaves and any other organic material that has been built up on the system surface should be removed and disposed of with other yard

refuse. Some wetland plants may require trimming, but should not be cut back or harvested.

b. In the summer, if the surface contains weeds, they should be removed and disposed of with other yard refuse. Some wetland plants may require trimming, but should not be cut back or harvested.

c. Autumn maintenance may include gently spreading leaves over the surface and/or replacing the thick layer of mulch or peat over the system. Wetland plants should not be cut back or harvested. Wetland plants and a thick layer of leaves will provide a thermal blanket that will help prevent the system from freezing during the winter.

d. All woody or fibrous plant starts (e.g., tree saplings, bushes, etc.) should be removed any time they are noticed as they may result in damage to the wetland cells or liners.

6. Inspection/maintenance schedule and instructions for the constructed wetland cell(s), septic tank, inlet and outlet control devices, overflow basin, and any mechanical parts associated with system design.

7. Methods to address odors if they become noticeable.

8. Methods to address burrowing animals if they become a problem in or around the wetland cell.

9. A plan to address freezing issues that may arise during colder months. Suggestions include placing a thick layer of mulch or peat over the wetland cell, placing a thick layer of leaves over the wetland cell, temporarily raising and then lowering the water level within the wetland cell after the top water level has frozen.

10. Operation and maintenance directions should be included describing the replacement of the wetland cell media and informing the system owner that a repair permit must be obtained from the health district for this activity.

11. Vegetation management instructions should be included for vegetation start-up, harvesting (if necessary), and replacement. Vegetation sourcing information should also be included.