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Section 500 General

The City of Beaverton has adopted the current version of the Clean Water Services Design and Construction Standards, Resolution and Order. All surface water management (SWM) facilities must be in substantial conformance with the CWS Standards unless specifically modified herein. In the event of a conflict, the City Engineer may consult with the CWS Conveyance Systems Director prior to issuing a decision or interpretation. The City Engineer’s decision or interpretation is final. **Stormwater Infrastructure:** Any structure, feature, or drainage ditch that is designed, constructed, and maintained to collect and filter, convey, retain, or detain stormwater runoff during and after a storm event for the purpose of water quality improvement or quantity management. It includes, but is not limited to, features such as constructed wetlands, water quality swales, landscaped retention areas, and detention ponds that are maintained as stormwater quality or quantity control facilities.

Unless specifically documented in the land use conditions of approval, all development outside of the Cooper Mountain Planning area:

- Shall provide treatment of surface water runoff in compliance with Clean Water Services Design and Construction Standards section 4.05.5, and
- Shall provide stormwater quantity detention on-site. Detention facilitys shall be designed to capture runoff so the post-development runoff rates from the site do not exceed the pre-development runoff rates from the site, based on 24-hour storm events ranging from the 2-year return storm to the 25-year return storm. Specifically, the 2, 10, and 25-year post-development runoff rates will not exceed their respective 2, 10, and 25-year pre-development runoff rates.

Development in the Cooper Mountain Planning area shall provide surface water runoff management (quality and quantity) in compliance with section 550 of this document.
Section 510  General Revisions to CWS Design and Construction Standards

The following are City of Beaverton modifications to the Clean Water Services, Design and Construction Standards, April 2017, (R&O 17-5)

CWS 2.03.3.b. Submittal Requirements

The application for an Erosion Control Only permit shall include the following:

1.  **If paper plans are submitted, provide** four sets of folded plans on 22” x 34” sheets, to the District or City for review. This plan set shall include the title sheet, grading and Erosion Prevention and Sediment Control Plan, and related sheets. The plan shall be clearly marked for Erosion Control Only and shall be separate from the development plan submittal. With District or City concurrence, some or all documents in a submittal may be submitted in an electronic format approved by the reviewing jurisdiction. **Plans shall be drawn to scale.**

CWS 2.03.4.d. Erosion Control Permit Not Required

**Add:**

5.  *Maintenance or enhancement activity for a SWM facility*

CWS 2.04.2 Initial Plan Submittal Requirements

  c.  **If paper plans are submitted, provide** three sets of folded plans on 22” x 34” sheets, or as otherwise approved by the District, and two copies of associated documents such as drainage reports. Individual plan sets that exceed 20 pages may be rolled and stapled. With District or City concurrence, some or all documents in a submittal can be submitted in an electronic format approved by the reviewing jurisdiction. **Plan details shall be drawn to scale.**

CWS 2.04.2.g. If a water quantity or quality facility is required, a plan sheet(s) showing all the following information:

  3.  For water quantity facilities, detail of the outlet structure including orifice sizes and elevations. Standard details of structures to be included. **Special or custom details shall be drawn to scale.**

**Add:**

9.  *A basin map showing the tributary area that drains to the water quality/quantity facility.*

CWS 4.02.3 Fencing

  a.  **Vertical drops of 30” or greater trigger** fall protection. Unless otherwise approved by City Engineer, facilities and/or tracts containing facilities **shall have no fencing other than what is required for fall protection and/or to prevent adjacent property owner encroachment into the city owned/controlled stormwater facility.**
b. If fall protection fencing is required it shall be black vinyl clad chain link with matching anodized fence post and stringers, minimum four feet high and maximum of six feet high conforming to CWS Standard Drawing No. 740. The fence shall include a 12-foot wide lockable gate for maintenance access conforming to CWS Standard Drawing No. 740.

c. If a facility is located adjacent to a Vegetated Corridor, and/or if the City Engineer determines that fencing is required, wildlife friendly fencing shall be utilized.

d. Encroachment prevention fencing shall be a wood fence or City Engineer approved equivalent and shall be located on the private property side of the property line.

Add:

e. Private property owners shall be required to maintain fencing adjacent to SWM Facilities. Adjacent private property owners shall not be allowed to remove, modify, or allow a fence to deteriorate.

CWS 4.02.4 Access:

b. Standard Road Design for SWM facilities

1. Replace CWS 4.02.2.b.1 with the following:

   The road section shall be three (3) inches of asphalt concrete pavement (ACP) and 10 inches of aggregate base (AB) over a subgrade geotextile. ACP shall be Level 2 according to ODOT/APWA spec section 00744 with PG-64-22 binder. AB shall be ¾-inch minus according to ODOT/APWA spec section 00641 and the subgrade geotextile shall be according to ODOT/APWA spec section 00350. Subgrade should be scarified and compacted to 95-percent AASHTO T-99; or, the design Engineer may submit an alternate design certified as capable of supporting a 40-ton maintenance vehicle in all weather conditions. Alternate design must be approved by City Engineer.

2. Strengthened sidewalk and parkway strip sections shall be used where maintenance vehicles will cross.

4. Minimum width shall be 12 feet with one (1) foot rock shoulder on either side on straight runs, the aggregate base will extend one (1) foot beyond the edge of the path, for curves (including the turn onto the maintenance road), a truck turning design shall be used to provide access for the vehicle shown in figure 510.1.
9. A vehicle turnaround shall be provided when the access road exceeds 150’ in length for straight roads and 40’ in length for roads with curves.

Add:

10. Maintenance access shall be on street with lowest classification or lowest ADT.
Add:

11. SWM facilities that have structures that require periodic maintenance (such as, but not limited to, flow control structures/manholes, pretreatment structures/manholes, ditch inlets with sumps) shall have a geometric layout so that the structure(s) are located no further than 9-feet from the front tires, and 19-feet from the side of where the maintenance vehicle can drive and park. Other infrastructure such as signs, street lights, meter vaults, street trees, etc. must be located so as to not impede maintenance vehicle access. See images below.

![Image 1](Figure 510.3 – Maintenance Vehicle Access)

![Image 2](Figure 510.4 – Maintenance Vehicle Access)
CWS 4.03.2.b On-site facilities shall be constructed when any of the following conditions exist:

1. There is an identified downstream deficiency, and the District or City determines that detention rather than conveyance system enlargement is the more effective solution. *Erodible soils in the area of the development is considered a downstream deficiency. See definition of Erodible Soils in Preface.*

CWS 4.03.3 Hydraulic Design Criteria
d. Provide an emergency spillway sized to pass the 100-year storm event or an approved hydraulic equivalent. Emergency spillway shall be located in existing soils when feasible and armored with riprap or other approved erosion protection extending to the toe of the embankment. *The EOR may provide an alternative emergency spillway; however, the design engineer must demonstrate 100 year storm conveyance, provide erosion protection, a solution to prevent damage to adjacent properties, and receive written approval from the city engineer for the alternative design.*

CWS 4.04.1 Facility Design Criteria
b. Interior side slopes up to the Maximum Water Surface: 3H:1V or flatter. *If retaining walls are used, at least 25% of the pond perimeter shall be vegetated to a side slope of 4H:1V or flatter.*

Add:
h. *Flow Control Structures with orifices(s) less than 2.5-inch diameter shall have maintenance accessible durable stainless steel screening (316 SS) that will prevent objects greater than 10-millimeters (0.4 inches) in diameter from reaching the orifice.*

i. *All weather walking surface such as 3 ft. wide ¾”-0” crushed gravel, 2 in. deep, for the purpose of accessing the SWM Facility water outlet structures.*

j. *Outflow control structure and orifice plate and guide, CWS dwg. no. 720 and 730, shall not be used as a flow control device in public SWM Facilities.*

k. *City of Beaverton Detail 360 shall be used as the outflow flow control structure. Vegetated SWM quantity facility shall have a minimum of two ditch inlets (CWS D&C Standard Drawing No. 390) connected to the flow control structure.*

l. *A Stormwater Detention Facility Data sheet that summarizes the stage, discharge, and storage data of the proposed stormwater detention facility shall be included in the storm drainage report and in the detail sheets of the construction plans.*

m. *Include a scaled section view of SWF and corresponding Stage / Storage table on construction plans. See figure 510.5 for sample diagram for stage / storage.* Click on figure 510.5 to download a fillable pdf of the detail.
CWS 4.04.2  Walls in public SWM Facilities

a. Retaining walls may serve as pond walls if the design is prepared and stamped by a registered professional engineer for the expected hydrological conditions and a fence is provided along the top of the wall for fall protection purposes. At least 25% of the pond perimeter shall be vegetated to a side slope of 4H:1V or flatter.

b. The footing of the retaining wall shall be located above the maximum water quality elevation of the SWM facility, unless specifically approved by the City Engineer.

Add:

c. Retaining walls located in area of earthen fill, or where deemed necessary by the City Engineer, shall be watertight, poured-in-place reinforced 4000 PSI (minimum) Portland cement concrete, cobblestone face texture or similar rough surface to discourage graffiti. At the top of the wall there shall be a minimum 18-inch wide, 4-inch thick concrete walkway for maintenance access.

d. Retaining walls located in areas of earth cut shall be design to so that stored water will not leave the facility area via the wall’s granular backfill and/or Wall drain system.

e. Retaining walls and/or perimeter fencing (or guardrails) may cause sun/shade conditions that adversely impact the success of vegetation growth in the SWM facility. The SWM facility wall and fencing orientation and landscaping shall be designed to promote successful vegetated growth in the facility. See section 810 – Guardrails from the Oregon Standard Specifications for Construction.
CWS 4.05.6.3. Water Quality Flow (WQF)

The WQF is the average design flow anticipated from the water quality storm as shown in the formulas below:

\[
\text{Water Quality Flow (cfs)} = \frac{\text{Water Quality Volume (cu. ft.)}}{10,800 \text{ seconds}}
\]

or

\[
\text{Water Quality Flow (cfs)} = \frac{0.36 \text{ (in.) x Area (sq. ft.)}}{12 \text{ (in/ft.) (3 hr.) (60 min/hr.) (60 sec/min.)}}
\]

CWS 4.05.8.c Proprietary treatment systems shall be allowed in situations meeting one of the following criteria:

5. Treatment of runoff as part of a planned regional facility. Projects shown in a City Council approved Capital Improvement Plan are considered a planned regional facility.

Add:

6. Treatment of runoff from within the Beaverton Urban Renewal District.
https://www.beavertonoregon.gov/DocumentCenter/View/8293

7. Treatment of runoff from areas within Beaverton jurisdiction that have a Downtown Regional Center (RC) or Station Community (SC) or Town Center (TC) land use designation where the City Engineer has approved the use such approval is documented in the land use conditions of approval. https://www.beavertonoregon.gov/DocumentCenter/Home/View/876

CWS 4.06.1.b Water Quality Manholes: Design Criteria:

4. Sump Depth: No less than 5 feet from invert out to bottom of sump

5. Volume of sump: 20 cubic feet/1.0 cfs (minimum) of flow into the water quality manhole, up to the 25-year flow. Flow calculations shall include the effect of an upstream flow splitter.

CWS 4.06.2.a Vegetated Swale: Hydraulic Design Criteria

3. Maximum Water Design Depth: 0.33 feet

CWS 4.06.2.b Vegetated Swale: Design Criteria

2. The use of intermediate flow spreaders may be required. Flow spreaders shall be rock as depicted in figure 510.6 below (Standard Drawing 510). Use of concrete flow spreaders require approval of the City Engineer. It is the designer’s responsibility to properly size the flow spreader to accommodate the 100-year storm event.
Figure 510.6 – Typical Rock Flow Spreader

Flow spreader rock
Swale bottom
Flow
River rock
Native soil
Flow spreader - section

Bank reinforcement to prevent side slope erosion at rock flow spreader is not shown for clarity. For this location, reinforcement will be via vegetative fascine.
CWS 4.06.8.b  LIDA Swale: Design Criteria

12. Street-side swales shall be designed to permanently impede the possibility of water flow from the swale to the adjacent roadway subgrade without the use of flexible liners as well as be designed to withstand a dynamic 40 ton wheel load on the adjacent roadway located between 6 to 24 inches from the roadside curb face.

13. Vegetation quantities per 100 square feet:
   A) Treatment Area: 115 herbaceous plants, 1 foot on center spacing, \( \frac{1}{2} \)-gallon container size; or 100 herbaceous plants, 1 foot on center, and 4 shrubs, 1-gallon container size, 2 feet on center or location specific city approved landscape plan.

14. Treatment area shall have high density jute or coconut matting over the entire surface or other base stabilization method as approved by the City.

CWS 4.06.9.b  Street side Planter: Design Criteria

8. Inflow structure - Curb cut out with splash pad (CWS LIDA Handbook dwg. no. 401) or with inlet structure (CWS LIDA Handbook dwg. no. 407) shall not be used without specific approval by City Engineer. Modified CG-30 inlet structure with sump (CWS LIDA Handbook dwg. no. 403) is the required structure type for inflow to LIDA Facilities.

13. Street side planters shall be designed to permanently impede the possibility of water flow from the swale to the adjacent roadway subgrade without the use of flexible liners as well as be designed to withstand a dynamic 40 ton wheel load on the adjacent roadway located between 6 to 24 inches from the roadside curb face.

One option is to use a thickened curb and gutter. See example thickened curb and gutter detail Figure 510.7.

**Figure 510.7 – Thickened Curb and Gutter Example**
14. Vegetation quantities per 100 square feet: 115 herbaceous plants, 1 foot on center spacing, ½-gallon container size; or 100 herbaceous plants, 1 foot on center, and 4 shrubs, 1-gallon container size, 2 feet on center or location specific city approved landscape plan.

15. Refer to the LIDA Handbook for additional guidance. 4” exposed sidewalk curb shall only be used if fall protection is needed.

(This note applies to CWS dwgs. No. 795.1 and 795.2 in the LIDA Handbook.)
Section 520  General Design Criteria

A. Public SWM facilities shall be designed to allow the logical service of all parcels or tracts of land within the basin. SWM lines shall be extended, at owner’s or applicants expense, to adjacent parcels to facilitate future development. SWM facilities shall be designed to accommodate all future (full build-out) flows from upstream development.

B. Public SWM facilities shall be designed to facilitate accomplishment of the following maintenance mandates using the maintenance vehicles owned by the City of Beaverton. Reference the current version of the CWS Resolution and Order manual. See City of Beaverton Engineering Design Manual.

C. Permanent compression style (Cherne) plugs are not allowed. Compression plugs may be used for testing purposes only. Permanent plugs for the ends of mainlines and laterals shall be rigid pipe plugs or caps. Cleanouts shall end with a threaded cap fitting. All fittings shall be water tight and conform to the specifications of the host pipe material. The pipe trench shall be properly compacted to ensure that the plug or cap is sufficiently restrained. This requirement applies to sewer lines proposed to be extended with later phases of development as well.

D. Manhole components shall conform to the following requirements:

1. Standard manholes require a minimum of one 2-inch concrete grade ring. Flat top manholes require a minimum of 4 inches of concrete grade rings.

2. No metal grade rings shall be used on new manholes. With specific, case by case, approval of the City Engineer, a maximum of one metal grade ring may be allowed on existing manholes for pavement overlays. An additional concrete grade ring is preferred over a metal grade ring for manhole frame and grate adjustments.

3. Up to 10 inches of concrete grade rings may be used for adjusting the elevation of manhole castings. Elevation adjustments greater than 10 inches require an additional section of manhole be installed. If adjustment is greater than 10 inches, add 12-inch riser section.

4. All manholes shall use standard 7-inch castings. In some specific situations, a suburban 3-inch casting with specific, case by case, approval of the City Engineer.

5. To prevent manhole lids from rocking and clanging, the contractor shall ensure the following requirements are met prior to inspection and acceptance by the City:
   a. The lid sits flat within the frame and attain a true bearing all around.
   b. Bearing surfaces have been machine planed or ground by the manufacturer prior to delivery to the jobsite.
   c. All lids shall be test fit to frame prior to installation.

6. The first step shall be no closer than 18” minimum from the top of the manhole cone per COB dwg. no. 330. The same shall be true for Flat Top Manholes.
7. Manholes lids shall not encroach into the wheel-path, as defined in Figure 520.1.

8. Manholes in roadways having a speed limit of 50 MPH or higher require a bolt-down lid.

9. Defective manhole channels shall be corrected by removing and replacing the defective channel in its entirety.

10. Manholes with snouts shall have a bottom that slopes toward the center of the structure and away from the snout.

11. All new inside drop manholes must be at least 60 inches in diameter, or be an equivalently sized rectangular structure approved by the City.

12. Inside drop manholes shall use drop bowls. The maximum slope of the pipe entering the drop bowl is 2 percent.

13. Manholes with inside structures (weir wall or inside drop) shall not have steps in them unless requested by City Engineer.

14. Center partition style flow control manholes shall accomplish the water tight seal of the concrete baffle wall and manhole wall/floor via integrally cast construction by the manhole manufacture or equivalent.
   Reason: A water tight seal capable of withstanding differential and dynamic hydraulic elevations for the long term is difficult to achieve via field applied grouting.

15. Structures 60” in diameter or greater must remain their size for the entire depth of the structure below the cone section or flat top. Incoming and outgoing conduits must be visible and accessible from the surface. Manholes greater than 60” diameter require dual access lids.

16. There shall be a minimum of 8-inches of inside manhole structure between pipe coring’s. Roll-out details may need to be provided on the plans to verify.

E. Prior to acceptance, all new public SWM lines shall be thoroughly cleaned, tested, and then inspected by the contractor in accordance with CWS standards. Contact the City’s inspector 30 days after backfilling of the trenches and around structures to schedule video inspection for acceptance. City maintenance crews shall conduct the conduit video inspection and prepare a punch list. All punch list items shall be completed by the contractor and approved by the City prior to paving. If ductile iron or concrete pipe is used, the 30 day wait for testing can be waived (ODOT/APWA 00445.73)

F. Upon completion of construction of the SWM facilities, all accumulated sediment shall be removed.

G. Prior to acceptance of new infrastructure and the completion of the maintenance warranty period, the following will be performed by the owner, developer, builder or responsible party:

   1. All storm water facilities associated with the project and permitted by the city, shall have all accumulated sediment deposits removed.
H. Prior to approval of the final building associated with new development projects, the following shall be performed by the owner, developer, builder or responsible party:

1. All City streets used to access, or constructed under the permitted development, shall be cleaned and accumulated debris shall be removed.

2. SWM facilities associated with the development shall have all accumulated sediment deposits removed.

I. See City of Beaverton Standard Drawing 125 for utility locations within the public right-of-way.

J. Type CG-2 inlets or any other grated inlet structure, shall not be used on public, curbed streets with existing or proposed, on motor vehicle pavement, bike lanes or identified neighborhood bikeway routes without case-by-case specific approval from City Engineer. See city’s active transportation plan for locations of existing and proposed bike lanes and neighborhood bikeway routes.

K. Off right-of-way public SWM drainage conduits (back yard drain lines).

1. Furthest upstream manhole must provide standard manhole and access located in the road right of way. One angle point is allowed if the deflection is less than 30 degrees. The angle point must include a standard manhole or area drain structure with no sump.

2. The storm line must be centered within a 15’ wide utility easement.

3. If pipe cover is less than 30”, a seamless pipe material (HDPE SDR17) or Class 52 ductile iron with restrained joints shall be used for fence post protection.

4. The maximum distance between access structures is 500 feet manhole to manhole.

5. If there is no upstream access point in the road right-of-way, the maximum pipe length shall be 350 feet for lines at 1% or less; 250 feet for lines between 1.1% and 2%; 150 feet for lines between 2.1% and 3%; and the upstream point will be a standard manhole or Area Drain with no sump (CWS Std. DWG 380).

L. All SWM drainage conduits (also including sanitary sewer) that serve more than one lot, or crosses onto another lot, shall be considered a public system and shall be constructed to public standards with appropriate easements to the city. Reference sections 307 and 311 of the Oregon Uniform Plumbing Code.

M. Detention conduits are conditionally allowed in the roadway right-of-way with written approval from the City Engineer. The following criteria must be demonstrated through design alternatives, calculations, details, and specifications.

- Materials design life of minimum 100 years.
- Capable of overweight vehicle loading. Apply standard trench backfill/compaction methods for the entire trench / pipe section.
- Provide maintenance access points every 200 feet maximum.
- If practical, detention conduits shall be designed so as the detention volume backs-up into the underground conduits.
- In event that a flow-through detention piping is the only practical option, a pre-treatment water quality manhole (CWS detail 250/260 or equivalent) shall be provided prior to the detention pipe to reduce the amount of material accumulation.
Section 530  Surface Water Management (SWM)

A.  SWM Facility Order of Precedence

1. The following table lists the various types of SWM facilities by order of precedence. Prior to receiving City approval, the Engineer must demonstrate that the preceding facility types aren’t feasible.

<table>
<thead>
<tr>
<th>Order</th>
<th>Facility Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Enhancement and/or Expansion of an Existing Public SWM Facility</td>
<td>See Subsection 530.B</td>
</tr>
<tr>
<td>2nd</td>
<td>New Public Vegetated SWM Facility, CWS D&amp;C section 4.06.2, .3, &amp; .4</td>
<td>Requires to be located in a tract for new development. For redevelopment, may be located in a recorded access easement if located outside of right-of-way.</td>
</tr>
<tr>
<td>3rd</td>
<td>Private Vegetated SWM Facility</td>
<td>Located on private property and serves only one legal lot. Privately owned and maintained by property owner.</td>
</tr>
<tr>
<td>4</td>
<td>Private Proprietary Treatment Facility</td>
<td>Located on private property and serves only one legal lot. Privately owned and maintained by property owner.</td>
</tr>
<tr>
<td>4th</td>
<td>Street-side LIDA Swale/Planter in the Public ROW</td>
<td>See additional requirements for LIDA SWM facilities constructed within the R-O-W below and adjustments to CWS D&amp;C sections 4.06.6.8.b and 4.06.6.9.b above</td>
</tr>
<tr>
<td>5th</td>
<td>Public Proprietary Treatment Facility</td>
<td>Requires a recorded access easement if located outside of right-of-way. Requires a pre-design meeting. Approval must be documented in the land use conditions of approval</td>
</tr>
<tr>
<td>6th</td>
<td>Fee-in-lieu</td>
<td>See the current City of Beaverton SDC Fee Schedule</td>
</tr>
</tbody>
</table>

B. Use of Existing SWM Facilities

1. Use of an existing SWM facility to meet treatment and/or detention requirements is encouraged, but is subject to the following conditions:

   a. A mandatory pre-design meeting with City staff shall be held to determine the requirements related to the specific existing facility.

   b. The existing facility must substantially meet current standards and be functioning correctly. Existing facility deficiencies or deferred maintenance may need to be corrected by the developer proposing to use an existing facility.

   c. Expansion of existing facilities for treatment of new development may require additional enhancement to the remainder of the facility, in addition to the expansion.

   d. Enhancement of public facilities shall qualify for a partial or full SDC and fee-in-lieu reduction of charges.
e. Existing public facilities shall not be removed until a new facility has been constructed and accepted by the City. The new facility shall have a minimum treatment capacity equal to the facility being removed.

530.1 Surface Water Management (SWM) Facilities

A. General Requirements

1. SWM facilities, including side slopes, retaining walls, perimeter fencing (when required) and all associated structures, shall not be installed within a PUE, sanitary sewer, water, or other incompatible private easement.

2. LIDA swales and infiltration planters shall be constructed with a perforated pipe made of solid wall PVC pipe with holes on the bottom of the pipe. Corrugated PVC pipe shall not be used. A perforated drain pipe underdrain system shall be connected to a downstream public or private storm system unless the following occurs:
   a. A geotechnical or drainage report concludes that infiltration at the proposed location is a minimum of 1 inch per hour during all times of year.
   b. The drain rock of the facility can be installed above the elevation of the water table.

3. No utility lines shall be located under any type of facility with the exception that service lines may be installed under facilities within the ROW.

4. For single-family residential projects involving multiple parcels, individual lot LIDA systems cannot be used to meet the SWM treatment and/or detention requirements for the project. This requirement does not prohibit individual lot LIDA systems, it only prevents these systems from being part of the system intended to meet a project’s SWM requirements. For improvements to an existing individual lot, the City’s preferred approach to meeting storm water treatment/detention requirements is payment of fee in lieu of providing treatment. LIDA systems in these situations will only be approved if other alternatives are not feasible and the LIDA can realistically be assumed to function long-term without City intervention.

5. SWM facilities shall be designed to prevent backwatering into the facility during storm events.
   a. The invert elevation and the permanent pool elevation of the facility’s treatment and detention area and all associated conveyance structures, excluding the outfall, must be constructed at least 1 foot in elevation above the discharge stream’s 10-year storm event water surface elevation. The outfall invert must be constructed no lower than the discharge stream’s 10-year storm event water surface elevation. This requirement applies to all types of facilities, including underground detention systems. Facilities designed at or below the 100-year flood elevation shall include additional analysis of backwater effects during the 10, 25, and 100-year storms, as applicable, and include a maintenance plan with more frequent routine maintenance by the owner.
   b. Landscape filter strips must be constructed at least 1 foot above the 10-year flood elevation.
   c. Facilities shall be constructed such that the invert elevation of the treatment area or permanent pool elevation is higher in elevation than the 10-year storm water surface elevation of the receiving body of water.
6. Any SWM facility designed into a slope steeper than 3:1 and exceeding 3 feet in height shall be designed with a 5-foot minimum setback as shown in Figure 530.2.

7. CWS Drawing No. 720/730 shall not be used for any City of Beaverton maintain SWM facility. Use of this detail is discouraged for privately maintain SWM facility.

8. Provisions must be made for gravity drainage of roofs and foundation drains for all new buildings and structures. For multi-family residential, commercial, or industrial developments, these drains shall be piped to the storm drain system. In single-family residential developments, these drains shall be piped to the street gutter or directly to the public storm drain system. The connection to the street gutter must be through a three (3) inch plastic pipe set in the curb during construction or bored through an existing curb. In single family residential developments where topography prevents connecting foundation and roof drains as required above, or if the street is superelevated and the lot is on the high side of the street, drains for each lot shall be directly piped to the public storm drain system.

B. Additional Requirements for LIDA SWM facilities constructed within the ROW

1. When private development creates new, or alters existing, impervious surface within the ROW and no other treatment options are available, construction of new public SWM facilities within the ROW will be allowed.
2. Should there be no other option to having a utility line crossing the facility, such utility service lines must be installed below the facility’s drain rock and have the utility trench line sealed with bentonite clay, or equivalent, at the edges of the facility to impede ground water flow traveling outside the facility footprint.

3. Franchise utilities are prohibited from installing conduit, pedestals, vaults, or junction boxes within the defined facility boundary.

4. Water meters, fire hydrants, street signs, street lights, and other City utility infrastructure shall only be installed in the upland slope opposite the curb (if present) and not within the defined treatment area of the facility. Installation of such equipment shall not damage subgrade components of the facility.

5. Street-side Infiltration Planters:
   a. Require adjacent maintenance vehicle access, without closing a motor vehicle travel lane, on streets with a posted speed of 35 mph or higher.
   b. Require a 3-foot or wider step-out zone for access to parked car doors when adjacent to on-street parking.
   c. Require that the adjacent private property owner, or Home Owner association, or equivalent entity, accept the obligation of bi-weekly trash/debris pick-up and proper disposal from the SWM facility. Purpose: The City of Beaverton has funding for only 4-visits a year. This obligation will be recorded in a form acceptable to the City Engineer.

C. Pretreatment

1. Water quality manholes (WQMH’s) shall be installed in locations that require minimal traffic control to access. In addition, WQMH’s shall be located no further than 4.5 feet from the front and 19 feet side of where the maintenance vehicle can drive and park. Other infrastructure such as signs, street lights, meter vaults, street trees, etc. must be located to not impede maintenance access. Snout sizing for the WQMH is per manufacture’s recommendations. The snout size/model number shall match with the recommended structure width/diameter.

D. High-Flow Bypass

1. All Vegetated swale SWM facilities shall include a system to bypass flows larger than the water quality flow if the facility’s total contributing impervious surface area is 5 acres or larger.

2. All proprietary storm filter treatment SWM facilities shall have a bypass structure when facility’s total contributing impervious surface water runoff area is 1.5 acres or greater. The proprietary (storm filter) treatment system shall have any internal overflow sealed; high flow bypass shall occur via the upstream bypass system where the weir (or equivalent) is set to 0.5 to 1.5 feet above the top of the storm filter cartridge.

3. Facilities that directly receive sheet flow do not require a bypass system.

4. High flows shall be diverted upstream of pretreatment manholes.

5. The bypass shall be constructed with a stilling basin at the outfall.
Figure 530.3 – A

SWM Facility Diagram for Vegetative Type Facility with No Detention Element
CWS D&C 4.06 2, 3, 4

NOTES:
1. All vegetated type facilities shall have a bypass structure when the facility's total contributing impervious surface area is 5 acres or greater.
2. All outlet pipes 8-inches or larger that discharge to an open system (creek, vegetated corridor ditch, sensitive area, etc.) shall be constructed with a structurally reinforced concrete headwall and located such that no increase in downstream erosion, scouring or environmental damage will occur.
3. Provide slope stabilization and/or water velocity reduction measures, as necessary, between the outfall and the receiving water body to prevent erosion and slope destabilization.

LEGEND
- Untreated flow
- Water quality flow

Discharge to downstream receiving system, creek, wetland, or sensitive area
(See notes 2 & 3)
Figure 530.3 - B

SWM Facility Diagram for Vegetative Type Facility with a Detention Element

CWS D&C 4.06.3 & 4

Water quality (pretreatment) manhole may be combined with the high-flow bypass manhole. CWS Dwg. 250 / 260

High-flow bypass manhole:
Weir control preferred. Offset pipe elevations allowed on a case by case basis

Dual Opening Lid with 12” Min Staff Maintenance & Equipment Access

Vegetative SWM Facility Both Treatment and Detention

Flow Control Structure with Separate Emergency Spillway

Discharge to downstream creek or wetland (See notes 4-6)

NOTES:
1. All outlet pipes 8-inches or larger that discharge to an open system (creek, vegetated corridor ditch, sensitive area, etc.) shall be constructed with a structurally reinforced concrete headwall and located such that no increase in downstream erosion, scouring or environmental damage will occur.
2. Provide slope stabilization and/or water velocity reduction measures, as necessary, between the outfall and the receiving water body to prevent erosion and slope destabilization.

LEGEND
- Untreated flow
- Water quality flow

FIGURE 520.3-B
Figure 530.3 - C

SWM Facility Diagram for Privately Maintained Proprietary Storm Filter Type Facility

LEGEND
- **Un-treated flow**
- **Water quality flow**

NOTE:
Publicly maintained proprietary storm filter treatment SWM facilities require a pre-design meeting with Public Works staff to determine the design requirements.

NOTES:
1. All proprietary storm filter treatment SWM facilities shall have a bypass structure when the facility’s total contributing impervious surface area is 1.5 acres or greater. The proprietary storm filter treatment system shall have an internal overflow scoured high flow bypass shall occur via the upstream bypass system where the weir (or equivalent) is set to 0.5 to 1.5 feet above the top of the storm filter cartridge.
2. Bypass manholes shall be installed in front of pretreatment manholes when discharging to detention type of facilities.
3. All outlet pipes 8-inches or larger that discharge to an open system (creek, vegetated corridor ditch, sensitive area, etc.) shall be constructed with a structurally reinforced concrete headwall and located such that no increase in downstream erosion, scouring or environmental damage will occur.
4. Provide slope stabilization and/or water velocity reduction measures, as necessary, between the outfall and the receiving water body to prevent erosion and slope destabilization.
E. Outfalls

1. Headwalls for pipes larger than 18” shall be constructed per Std. Drg. No. 420-2.

2. Headwalls for pipes 8” to 18” shall be constructed per Std. Drg. No. 420-3.

3. SWM Outfalls into Vegetated Corridors and stream corridors shall be located such that no increased downstream erosion, scouring or environmental damage will occur.

4. Outfalls into SWM facilities shall be aligned and orientated according to the following:
   a. Linear facilities: Outfall should direct flows parallel to the centerline of the treatment channel.
   b. Pond facilities: Outfall should direct flows to the center of the pond.
   c. Outfalls shall not be located in close proximity to a facility’s outlet which may reduce retention time and treatment efficiency. The storm drainage report must demonstrate that flow from each outfall location will receive the required treatment and detention time within the facility prior to discharge.
   d. A second facility outlet structure shall be installed for emergency high flow conveyance.

5. Provide slope stabilization and/or water velocity reduction measures, as necessary, between the outfall and the receiving water body to prevent erosion and slope destabilization within the Vegetated Corridor and/or sensitive area.

F. Riprap

1. For facilities with no high-flow bypass manhole, riprap armoring is required on the outside corners within the treatment channel anywhere the channel changes direction more than 30 degrees as shown in Figure 530.4.

2. Minimum size rip-rap shall be class 100 to discourage vandalism.
G. Vegetation

1. All trees planted within any CWS D&C section 4.06.2, .3, & .4 vegetative SWM facility shall not be located within the treatment areas. See the CWS approved plant list.

2. Public SWM facilities shall not be planted with fruit bearing vegetation or vegetation types that contain thorns. Vegetation deemed by the City Engineer that becomes excessively large for the particular location when mature will not be allowed within the limits of the facility.

3. Planting plans shall show all plants in the facility. Plant size, quantity, and species shall be in conformance with CWS D&C requirements for the applicable storm water facilities.

4. All facility vegetation must meet sizing requirements at final inspection. 100 percent of all required plant stock must be correctly planted and alive to receive a final approval and move the facility into the warranty period.

5. A minimum of 80 percent survival of each plant community is required prior to the release the 2-year maintenance security (such as a warranty bond). Installation of a temporary irrigation system is recommended to assist in the required plant survival rate.

   a. If 80 percent survival has not been achieved by the end of the warranty period, replant and add the necessary vegetation to meet the survival requirement. Replanting extends the maintenance warranty period up to an additional 2 years.
H. Filter Vaults
City maintain proprietary (storm filter) requires a pre-design meeting with City Public Works staff to determine the design requirements that includes, but are not limited to:

a. Pretreatment via the Beaverton primary treatment vault that has 5 mm screens and a snout.

b. Locating the structure only in areas of seldom traffic loading.

c. Sealing the internal bypass to restrict trapped floatables to leave the storm filter vault.

d. Arranging the design configuration so that in the event of storm filter clogging, bypass would occur via the upstream high-flow bypass manhole.

e. Construct with an aft bay and ¼ turn cartridge assemblies.

f. Structure access shall be multiple, removable, standard 13 ½” by 32” grates (reference CWS Dwg. 320).

g. Vaults located in the sidewalk is prohibited. However, if the City Engineer provides written approval, the lids or grates shall have welded non-skid steel walking surface with the frame height adjusted to account for the increased grate depth and shall have two ¾” pickholes.

530.2 Private SWM Facility Maintenance
All SWM facilities shall be maintained in accordance with CWS standards and Table 530.2.

**Table 530.2 – Required SWM Facility Maintenance Actions**

<table>
<thead>
<tr>
<th>Category</th>
<th>Required Maintenance Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretreatment</td>
<td>All upstream sumped structures shall be cleaned annually.</td>
</tr>
<tr>
<td>Vegetation</td>
<td>All weeds, invasive and volunteer vegetation shall be removed annually. All required vegetation quantities shall be maintained and replanted when necessary to maintain the original vegetation quantities identified within the approved plans.</td>
</tr>
<tr>
<td>Structures</td>
<td>All structures placed within the facility shall be inspected and maintained by the property owner annually. Structures shall remain functional, not blocked or impaired by vegetation, debris, or animal activity. Structures should be cleaned annually to remove all deposits and accumulated material.</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>The original design elevation of the treatment area shall be monitored and maintained by the property owner through the removal of all excess sedimentation deposits. All inlet and outlet pipes, structures, and riprap shall not be buried or partially buried by sedimentation deposits.</td>
</tr>
<tr>
<td>Perimeter Boundaries</td>
<td>All fences, retaining walls, and adjacent existing topography shall be monitored and maintained to their original design and condition. All walls shall be maintained such that the integrity of the wall does not negatively impact the facility.</td>
</tr>
</tbody>
</table>
530.3 Erosion Prevention and Sediment Control Requirements

A. Inlet protection shall include both CWS inlet protection standard drawing 905 and 920 combined together.

B. CWS Dwg No. 925 (Type 6 Inlet protection) or the equivalent bio-filter bag version shown in CWS Drawing No. 915 (Type 4 inlet protection) shall NOT be used on streets with existing, on motor vehicle, pavement bike lanes or identified neighborhood bikeway routes.

C. A concrete washout location and detail shall be included in all projects involving concrete work, including single-family residential.
   1. Proposed concrete washout locations will not be placed within the existing or proposed right-of-way for linear projects and are required to be located behind the curb.

D. A dewatering plan is required for all construction projects performing mass grading cut and fill activities during the defined wet weather period. All construction projects performing mass grading cut activities below the calculated water table elevation shall also include a dewatering plan during the time of plan review for approval.
   1. Include a dewatering plan with the grading and erosion control plans at the time of plan review for approval.
      a. Projects with unanticipated dewatering must submit revised grading and erosion control plans with a dewatering plan and receive approval prior to any work requiring the dewatering activity.
   2. Dewatering plans shall show the locations of any proposed temporary storage of onsite sediment laden water and method of treatment prior to discharge.
      a. Temporary sediment basins shall include a 90 degree upright elbow perforated pipe wrapped in filter fabric.
      b. Temporary sediment basins shall include a rock berm and use of silt curtains in-lieu of sediment fence adjacent to perforated pipe to aid in velocity reduction and settlement of fines.
      c. Additional dewatering filtration treatment systems may be required to prevent sediment laden water discharges.
   3. Dewatering systems must be installed and ready for operational use prior to beginning mass grading and trenching activities during site development.

E. Once a SWM facility has been planted, it may not be used as a temporary sediment or stilling basin.
   1. Future facilities that are used as sediment basins shall have all excess material removed and returned to the final grade shown on the approved plans prior to the addition of topsoil and vegetation.

F. If a site is known to have existing underground drainage systems (field tiles), they shall be shown on the Grading and Erosion Control Plan and submitted to the City for approval. If they are unexpectedly encountered during construction, the systems shall be added to the Grading and Erosion Control Plan and resubmitted to the City for approval. Impacts to the drainage patterns of adjacent properties shall be addressed according to Subsection 420.4. The systems shall either be:
1. Removed; or
2. Left in place and connected to the storm system.
   a. If left in place, the design documents, including the drainage report, shall be amended to account for the additional flow that the downstream SWM facility will receive while continuing to demonstrate compliance with all applicable design standards. Record drawings shall depict all field tile connections to the public storm system.

G. Department of State Lands (DSL) and US Army Corps of Engineers (USACE) environmental permit requirements shall be integrated into the local grading and erosion control plans at the time of review. This includes the following:
   1. Required stream dewatering and by-pass systems
   2. Wetland removal, expansion and offsite mitigation

H. Disturbance within a Vegetated Corridor, including plant removal, enhancement, and/or any other ground disturbing activity over 500 square feet, shall be shown in the erosion control plans with sediment control BMP’s as required.

530.4 Grading Requirements

A. Within a proposed development creating multiple tax lots, grading shall direct storm water towards a public conveyance system or an existing natural drainage. Grading shall not direct storm water onto, or across, a series of adjacent tax lots thereby inundating the lot at the lowest point.

B. See the ODOT Hydraulics Manual for more information regarding Oregon drainage law.

C. Grading plan for each lot shall have a minimum building pad elevation that is at least one foot higher than the maximum possible high-water elevation (emergency overflow) of the SWM facility. Additionally, a minimum finish floor elevation that is at least three feet higher than the maximum possible high-water elevation shall be established for each new building lot and documented on the plans. Minor grade changes less than four vertical feet variance that comply with the intent of this section shall be allowed without additional land-use applications, as determined by the City Engineer and the City Planning Director.

530.4.1 Oregon Drainage Law

A. Oregon drainage law, which originates from common law or case law, has developed without legislative action, and it is embodied in the decisions of the courts. Therefore, there are no Oregon Revised Statues to cite pertaining to Oregon drainage law.

B. Oregon has adopted the civil law doctrine of drainage. Under this doctrine, adjoining landowners are entitled to have the normal course of natural drainage maintained. The lower owner must accept water that naturally comes to his land from above, but he is entitled to not have the normal drainage changed or substantially increased. The lower landowner may not obstruct the runoff from the upper land if the upper landowner is properly discharging the water.

C. For a landowner to drain water onto lands of another in the State of Oregon, one of two conditions must be satisfied initially: (1) the lands must contain a natural drainage course; or, (2) the landowner must have acquired the right of drainage supported by valuable consideration (i.e. a purchased drainage easement).
In addition, because Oregon has adopted the civil law doctrine of drainage, the following three basic elements must be followed.

1. A landowner may not divert water onto adjoining land that would not otherwise have flowed there. "Divert water" includes but is not necessarily limited to:
   a. water diverted from one drainage area to another, and,
   b. water collected and discharged which normally would infiltrate into the ground, pond, and/or evaporate.

2. The upper landowner may not change the place where the water flows onto the lower owner's land. (Most of the diversions not in compliance with this element result from grading and paving work and/or improvements to water collection systems.)

3. The upper landowner may not accumulate a large quantity of water, then release it, greatly accelerating the flow onto the lower owner's land. This does not mean that the upper landowner cannot accelerate the water at all; experience has found the drainage to be improper only when the acceleration and concentration were substantially increased.

D. Subsurface waters which percolate to the surface can be intercepted and diverted for the protection of the highway without regard for the loss of these waters to the adjacent landowners. In those cases where wells and springs are involved, the right-of-way agent should contact the affected owner(s) to prevent any misunderstanding over damage that could be claimed.

E. Drainage designs should satisfy Oregon drainage law to avoid claims or litigation resulting from improper drainage design. When it is apparent that the drainage design will not satisfy the law, then drainage easements should be obtained from the affected property owners. The legal staff should be consulted in those situations that appear to be unique and could result in litigation.

F. Where certain drainage patterns have been established over long periods of time (i.e. in excess of at least 10 years), that are not the original natural drainage, there may be legal rights acquired which allow the continuance of the altered drainage pattern. Again, legal staff should be consulted in such situations.
Section 540 Existing Underground Drainage

As part of any development, underground drainage and/or sub drainage conduits (field tile, perf pipes, etc.) shall be located and mapped.

Underground drainage and/or sub drainage conduits having a tributary drainage area greater than 10 acres shall be rebuilt to current City standards in the same alignment as mapped and shall have a surface and subsurface storm drainage easement or roadway right-or-way centered along the alignment that has the following widths:

<table>
<thead>
<tr>
<th>Tributary Drainage Area</th>
<th>With of easement centered on mapped conduit alignment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥10 to &lt; 50 acres</td>
<td>30 feet</td>
</tr>
<tr>
<td>≥50 to &lt; 100 acres</td>
<td>50 feet</td>
</tr>
<tr>
<td>≥100 acres</td>
<td>100 feet</td>
</tr>
</tbody>
</table>

As an option, a restored, open, vegetated surface drainage way may be constructed in the easement area. Development site surface water runoff shall be treated and quantity mitigated prior to discharge to a restored, open, vegetated surface drainage way.

For the reconstructed underground conduit case, any off-development-site, upstream, surface water runoff tributary area shall be conveyed separately through the development site. As an option, in the event the off-development-site, upstream, surface water runoff tributary area is less than 10-acres, the site’s quantity mitigation and treatment SWM facility may enlarged using the assumption of 40% impervious and no quantity mitigation for the off-development-site tributary areas.

In either case, a 100-year design storm conveyance capacity shall be provided any off-development-site, upstream, surface water runoff tributary area assuming it is 40% impervious and has no quantity mitigation.

All underground drainage and/or sub drainage conduits having a tributary drainage area of less than 10 acres shall be removed, nearby/associated unsuitable material removed, and compacted fill per professional geotechnical/soils engineer’s recommendations install in its placed.

Any surface water runoff component will be conveyed either in a surface and subsurface storm drainage easement or in roadway right-or-way.
Section 550  Surface Water Runoff Management for Slopes V Requirements

In certain geographical areas of Beaverton, a development project will receive the equivalent of the following land-use Condition of Approval:

Provide final construction plans and final drainage report demonstrating compliance with City Storm Detention Requirements, Beaverton Engineering Design Manual, and with CWS Resolution and Order 2017-05 (Clean Water Services’ Design and Construction Standards) in regard to surface water runoff [water quality] treatment. In addition, the final drainage report shall also demonstrate that the entire development proposal shall meet U.S. Army Corps of Engineers (USACE) Standard Local Operating Procedures for Endangered Species V (SLOPES V) requirement for stormwater management.

Per SLOPES V, Surface Water Management (SWM) facilities must limit discharge to match pre-developed discharge rates (i.e., the discharge rate of the site based on its natural groundcover and grade before any development occurred) using a continuous simulation for flows between 50% of the 2-year event and the 10-year flow event (annual series). Reference: Section 36.c.iii  http://www.oracwa.org/documents/2014_03-14_SLOPESVTransportation_NWR-2013-10411.pdf

In addition to SLOPES V requirements, SWM facilities shall be designed to capture runoff such that the post-development discharge rates from the site do not exceed the pre-development discharge rates from the site based on a single 25-year, 24-hour storm event. Specifically, the 25-year post-development discharge rates will not exceed their respective 25-year pre-development runoff rates.

The SWM facility configuration shall meet the following guidelines in the Clean Water Services Design and Construction Standards (CWS D&C), Resolution and Order 17-05: 1) Water Quantity Facility Design Standards (Section 4.04) and 2) design criteria for an Extended Dry Basin (Section 4.06.3.b). Compliance with runoff treatment requirements (CWS D&C Section 4.05.6) is presumed to be achieved if the above two (2) criteria are met. Reference: http://cleanwaterservices.org/permits-development/design-construction-standards/

If an alternate SWM facility configuration is desired, please schedule a meeting with Public Works Engineering staff to discuss. City staff will determine if the alternate SWM facility is acceptable.

Modeling Methodology

Multiple approved/adopted modeling methodology/software may be used, as needed, to show substantial compliance with the Condition of Approval, including the following:

Methodology 1 – Tualatin River Urban Stormwater Tool (TRUST) Tool

This SWM facility sizing tool is hosted by Clean Creek Solutions. Reference: http://www.clearcreeksolutions.com/ProductDetails.asp?ProductCode=TRUST

Methodology 2 – Single Event Approximation using Santa Barbara Urban Hydrograph (SBUH) or Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55) methodology

The following criteria apply for the 2- and 10-year events with this methodology:
2-year post-developed discharge rate to be released at 0.42 (42%) of 2-year pre-developed discharge rate [pre-developed site = woods in fair condition for time of concentration (Tc) and curve number (CN) with appropriate
hydrologic soil condition per the NRCS Soil Survey]. To obtain the 42% discharge rate for the pre-developed condition, execute the SBUH calculation using the 2-year rainfall depth (2.5 inch), woods in fair condition CN and pre-developed Tc, then multiply the resulting peak discharge rate result by 0.42.

10-year post-developed discharge rate to be released at 10-year pre-developed discharge rate (pre-developed site = woods in fair condition for Tc and CN with appropriate hydrologic soil condition).

**Modeling Mechanics for 25-Year Flood Control Event Compliance**

Hydraulic modeling provided for the 25-year design storm event shall be in substantial conformance with CWS D&C Section 4.03.3. Note: For Methodology 2, 42% of the 2-year discharge rate and the 10-year discharge rate criteria is presumed to achieve compliance with SLOPES V.

Pre-developed site conditions shall be shown in 2012 aerial photo for Tc. CN determination will be for appropriate hydrologic soil condition per the NRCS Soil Survey. City staff will provide aerial photo image at no charge upon request.

**Flow Control Orifice Sizing**

Compliance with SLOPES V standards may result in a flow control orifice(s) that is smaller than 2.5 inches. Should this be the case, an orifice(s) that is less than 2.5-inch diameter shall have maintenance accessible and durable screening that will prevent objects 10 mm in diameter and larger from reaching the orifice. The detail below is for an orifice less than 2-inches in diameter. Click on figure 550.1 to download a pdf of the detail.

---

**Figure 550.1 – Flow Control Structure Detail**

---
Technical Guidance Discussion

Description of Tc for SLOPES V Methodology 3 – Single Event Approximation as well as 25-year Flood Control Compliance:


Travel time (Tt) is the time it takes water to travel from one location to another in a watershed. Tt is a component of Tc, which is the time it takes for runoff to travel from the hydraulically most distant point of the watershed to the outlet. Tc is computed by summing the travel times for consecutive components of the drainage conveyance system from the hydraulically most distant point to the watershed outlet. Tc influences the shape and peak of the runoff hydrograph, with shorter Tc resulting in higher peak flow rates. Urbanization usually decreases the Tc, thereby increasing the peak discharge. Tc can be increased by adding storage volume to inadequate drainage systems (including storm drain inlets and road culverts), increasing the discharge flow path, or by reduction of land slope through grading.

Water successively moves through a watershed as 1) sheet flow, 2) shallow concentrated flow, 3) open channel flow or some combination of these. The type of flow that occurs at a given point in the watershed is best determined by field inspection.

1. Sheet flow is runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel. It usually occurs in the headwater of streams. With sheet flow, the friction value (n_s; a modified Manning's effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges and rocks; and erosion and transportation of sediment) is used. These n_s values are for very shallow flow depths of about 0.1 foot and are only used for travel lengths up to 300 feet. It is recommended that a maximum of 150 feet be used for sheet flow calculations.

2. Shallow Concentrated Flow: After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. The average velocity for this flow can be calculated using the k_s values, which average velocity is a function of watercourse slope and type of channel.

3. Open Channel Flow: Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams appear (in blue) on United States Geological Survey (USGS) quadrangles.
Table 550.1 – Table 2.4 from Stormwater Management Manual for Western Washington

<table>
<thead>
<tr>
<th>“n” and “k” Values Used in Time Calculations for Hydrographs</th>
</tr>
</thead>
<tbody>
<tr>
<td>“n,” Sheet Flow Equation Manning’s Values (for the initial 300 ft. of travel)</td>
</tr>
<tr>
<td>Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)</td>
</tr>
<tr>
<td>Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)</td>
</tr>
<tr>
<td>Fallow fields or loose soil surface (no residue)</td>
</tr>
<tr>
<td>Cultivated soil with residue cover ( \leq 20% )</td>
</tr>
<tr>
<td>Cultivated soil with residue cover ( &gt; 20% )</td>
</tr>
<tr>
<td>Short prairie grass and lawns</td>
</tr>
<tr>
<td>Dense grasses</td>
</tr>
<tr>
<td>Bermuda grass</td>
</tr>
<tr>
<td>Range (natural)</td>
</tr>
<tr>
<td>Woods or forest with light underbrush</td>
</tr>
<tr>
<td>Woods or forest with dense underbrush</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>“k” Values Used in Travel Time/Time of Concentration Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, ( R = 0.1 ))</td>
</tr>
<tr>
<td>1. Forest with heavy ground litter and meadows (( n = 0.10 ))</td>
</tr>
<tr>
<td>2. Brushy ground with some trees (( n = 0.060 ))</td>
</tr>
<tr>
<td>3. Fallow or minimum tillage cultivation (( n = 0.040 ))</td>
</tr>
<tr>
<td>4. High grass (( n = 0.035 ))</td>
</tr>
<tr>
<td>5. Short grass, pasture and lawns (( n = 0.030 ))</td>
</tr>
<tr>
<td>6. Nearly bare ground (( n = 0.025 ))</td>
</tr>
<tr>
<td>7. Paved and gravel areas (( n = 0.012 ))</td>
</tr>
</tbody>
</table>

| Channel Flow (intermittent) (At the beginning of visible channels \( R = 0.2 \)) | \( k \) |
|-------------------------------------------------------------------------------|
| 1. Forested swale with heavy ground litter (\( n = 0.10 \)) | 5 |
| 2. Forested drainage course/ravine with defined channel bed (\( n = 0.050 \)) | 10 |
| 3. Rock-lined waterway (\( n = 0.035 \)) | 15 |
| 4. Grassed waterway (\( n = 0.030 \)) | 17 |
| 5. Earth-lined waterway (\( n = 0.025 \)) | 20 |
| 6. CMP pipe, uniform flow (\( n = 0.024 \)) | 21 |
| 7. Concrete pipe, uniform flow (\( n = 0.012 \)) | 42 |
| 8. Other waterways and pipe | 0.508/\( n \) |

| Channel Flow (Continuous stream, \( R = 0.4 \)) | \( k \) |
|-----------------------------------------------|
| 9. Meandering stream with some pools (\( n = 0.040 \)) | 20 |
| 10. Rock-lined stream (\( n = 0.035 \)) | 23 |
| 11. Grass-lined stream (\( n = 0.030 \)) | 27 |
| 12. Other streams, man-made channels and pipe | 0.807/\( n \) |
Example: The following is an example of Tt and Tc calculations.

Given: An existing drainage basin having a selected flow route composed of the following five segments. Note: Drainage basin is in Federal Way and has a P2 = 2.1 inches.

Segment 1:  L = 200 ft. Forest with dense brush (sheet flow)
so = 0.03 ft/ft, ns = 0.80

Segment 2:  L = 300 ft. Pasture (shallow concentrated flow)
so = 0.04 ft/ft, ks = 11

Segment 3:  L = 50 ft. Small pond (year around)
so = 0.00 ft/ft, kc = 0

Segment 4:  L = 300 ft. Grassed waterway (intermittent channel)
so = 0.05 ft/ft, kc = 17

Segment 5:  L = 500 ft. Grass-lined stream (continuous)
so = 0.02 ft/ft, kc = 27
Calculate travel times \((T_{ce})\) for each reach and then sum them to calculate the drainage basin time of concentration \((T_c)\).

**Segment 1:** Sheet flow \((L < 300 \text{ feet})\),

\[
T_1 = \frac{0.42(n_r L)^{0.8}}{(P_2)^{0.627} (s_p)^{0.4}}
\]

\[
T_1 = (0.42)(0.80)(200)^{0.8} = 68 \text{ minutes}
\]

**Segment 2:** Shallow concentrated flow,

\[
V = k \sqrt{s_o}
\]

\[
V_2 = (11) \sqrt{0.04} = 2.2 \text{ ft/s}
\]

\[
T_2 = \frac{L}{60V} = \frac{300}{60(2.2)} = 2 \text{ minutes}
\]

**Segment 3:** Flat water surface

\[T_3 = 0 \text{ minutes}\]

**Segment 4:** Intermittent channel flow

\[
V_4 = (17) \sqrt{0.05} = 3.8 \text{ ft/s}
\]

\[
T_4 = \frac{300}{60(3.8)} = 1 \text{ minute}
\]

**Segment 5:** Continuous stream

\[
V_5 = (27) \sqrt{0.02} = 3.8 \text{ ft/s}
\]

\[
T_5 = \frac{500}{60(3.8)} = 2 \text{ minutes}
\]

\[
T_c = T_1 + T_2 + T_3 + T_4 + T_5
\]

\[T_c = 68 + 2 + 0 + 1 + 2 = 73 \text{ minutes}\]

It is important to note how the initial sheet flow segment \(T_1\) is the largest component of the \(T_c\) computation. This will nearly always be the case for relatively small drainage basins and existing site conditions.
## Curve Number Selection Guidance

<table>
<thead>
<tr>
<th>Cover type and hydrologic condition</th>
<th>Curve Numbers for Pre-Development Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture, grassland, or range-continuous forage for grazing:</td>
<td>A</td>
</tr>
<tr>
<td>Fair condition (ground cover 50% to 75% and not heavily grazed)</td>
<td>49</td>
</tr>
<tr>
<td>Good condition (ground cover &gt;75% and lightly or only occasionally grazed)</td>
<td>39</td>
</tr>
<tr>
<td>Woods:</td>
<td></td>
</tr>
<tr>
<td>Fair (Woods are grazed but not burned, and some forest litter covers the soil)</td>
<td>36</td>
</tr>
<tr>
<td>Good (Woods are protected from grazing, and litter and brush adequately cover the soil)</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Curve Numbers for Post-Development Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)¹</td>
</tr>
<tr>
<td>Fair condition (grass cover on 50% - 75% of the area)</td>
</tr>
<tr>
<td>Good condition (grass cover on &gt;75% of the area)</td>
</tr>
<tr>
<td>Impervious areas:</td>
</tr>
<tr>
<td>Open water bodies: lakes, wetlands, ponds etc.</td>
</tr>
<tr>
<td>Paved parking lots, roofs², driveways, etc. (excluding right-of-way)</td>
</tr>
<tr>
<td>Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn)</td>
</tr>
<tr>
<td>Fair lawn condition (weighted average CNs)</td>
</tr>
<tr>
<td>Good lawn condition (weighted average CNs)</td>
</tr>
<tr>
<td>Paved</td>
</tr>
<tr>
<td>Gravel (including right-of-way)</td>
</tr>
<tr>
<td>Dirt (including right-of-way)</td>
</tr>
<tr>
<td>Pasture, grassland, or range-continuous forage for grazing:</td>
</tr>
<tr>
<td>Poor condition (ground cover &lt;50% or heavily grazed with no mulch)</td>
</tr>
<tr>
<td>Fair condition (ground cover 50% to 75% and not heavily grazed)</td>
</tr>
<tr>
<td>Good condition (ground cover &gt;75% and lightly or only occasionally grazed)</td>
</tr>
<tr>
<td>Woods:</td>
</tr>
<tr>
<td>Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)</td>
</tr>
<tr>
<td>Fair (Woods are grazed but not burned, and some forest litter covers the soil)</td>
</tr>
<tr>
<td>Good (Woods are protected from grazing, and litter and brush adequately cover the soil)</td>
</tr>
</tbody>
</table>
Section 560  Sanitary Sewer

A. Manholes constructed outside of roadways and developed areas shall be constructed with a finished rim elevation 1 foot above the surrounding elevation.

B. Lateral connections within 15 feet of the top of the system shall be made using an approved factory wye fitting. Other angled fittings shall be used as necessary to establish the required perpendicular angle at the mainline and at the right-of-way or property line. The pipe distance between fittings shall be minimized to establish the required straight line from the mainline to the ROW or easement boundary. Any wye connections shall be approved at the discretion of the City.

C. Pipes buried to a depth of 20 feet or greater, as measured from ground surface to the pipe invert elevation, shall use pipe material type C900 or C905.

D. At locations where a new manhole is constructed over an existing mainline for the purpose of connecting a new mainline or lateral, the manhole channel shall be constructed to smoothly transition the direction of incoming flows towards the pipe exiting the manhole.