# Benton County Public Works

# STORMWATER DESIGN MANUAL

Photo Credit: Guzzardo Partnership

# BENTON COUNTY STORMWATER MANUAL

**Sourced from Cities of Albany, Philomath, Corvallis and Independence Stormwater Design Standards*


***1.0 STORMWATER RUNOFF CONTROL (DETENTION) 1***

**1.1 GENERAL DESIGN CONSIDERATIONS 1**

**1.2 DESIGN CALCULATIONS AND CAPACITY 3**

Table 1 24-hour Precipitation Depth-Frequency Relationships for Benton County Zones Defined from ODOT's Rainfall Intensity-Depth-Recurrence Interval (IDRI) Maps. 4

Figure 1 ODOT IDRI zones in Benton County 4

Table 2 Depth-Area Reduction Factors (DARFs) 5

Table 3 Design Storm Frequency 5

Table 4 Runoff Coefficients 6

**1.3 OPEN CHANNELS 7**

**1.4 STORM DRAIN ALIGNMENT AND LOCATION 7**

Table 5 Minimum Storm Drain Easement Widths 8

**1.5 STORM DRAIN MINIMUM PIPE SIZE 9**

**1.6 STORM DRAIN MINIMUM COVER 9**

**1.7 STORM DRAIN MINIMUM SLOPE & ROUGHNESS COEFFICIENT 9**

Table 6 Minimum Storm Drain Pipe Slopes 10

**1.8 TRACER WIRE 11**

**1.9 MANHOLES AND CATCH BASINS 11**

**1.10 DETENTION FACILITIES 14**

**1.11 PRIVATE STORM DRAINAGE COLLECTION SYSTEMS 19**

**1.12 INFILTRATION SYSTEMS, DRYWELLS AND FRENCH DRAINS 19**

***2.0 STORMWATER QUALITY CONTROL (TREATMENT) 21***

**2.1 STORMWATER QUALITY FACILITIES 21**

Table 7 Blended Water Quality Mix Gradation 25

**2.2 INFILTRATON SYSTEMS, DRYWELLS AND FRENCH DRAINS 26**

***APPENDIX A DEFINITIONS AND TERMS 29***

***APPENDIX B LOW IMPACT DEVELOPMENT 32***

B.1 Purpose 32

B.2 Introduction 33

B.3 LID Measures: Retention Facilities - Stormwater Management Method 35

B.4 Cisterns 36

B.5 Rain Barrels 37

B.6 Green Roofs & Blue Roofs 38

B.7 Permeable Pavement 39
B.8 Rain Gardens 41
B.9 Bio-swales 42
B.10 Downspout Modifications 43
B.11 Exempt Underground Injection Control Wells 43
B.12 Soil Amendments 44
***APPENDIX C STORMWATER MANAGEMENT FACILITIES LONG-TERM MAINTENANCE AGREEMENT 46***
RECITALS 46
TERMS OF AGREEMENT 46
SECTION 1: CONSTRUCTION, OPERATION & MAINTENANCE OF FACILITIES 46
SECTION 2: MAINTENANCE OF FACILITIES 46
SECTION 3: SEDIMENT MANAGEMENT 47
SECTION 4: ANNUAL INSPECTION REPORT AND RECORD KEEPING 47
SECTION 5: ACCESS TO PROPERTY 47
SECTION 6: REPAIR AND MAINTENANCE OF FACILITIES 48
SECTION 7: FAILURE TO CORRECT DEFICIENCIES 48
SECTION 8: AGREEMENT RUNS WITH LAND 48
SECTION 9: INDEMNIFICATION 48
SECTION 10: NO ADDITIONAL LIABILITY 49
SECTION 11: PERFORMANCE FINANCIAL ASSURANCE 49
SECTION 12: SEVERABILITY 49
SECTION 13: RECORDATION 50
***APPENDIX D OPERATIONS & MAINTENANCE PLAN (OMP) MINIMUM REQUIRED COMPONENTS 51***
OMP – Required Information 51
Facility Types & Treatments 51
OMP Formatting 52
***APPENDIX E BENTON COUNTY RAINFALL INTENSITY- DURATION-FREQUENCY (IDF) CURVES FOR USE UNDER THE RATIONAL METHOD FOR ODOT ZONES 3, 4, 5, 7 & 8 53***

# 1.0 STORMWATER RUNOFF CONTROL (DETENTION)

## 1.1 GENERAL DESIGN CONSIDERATIONS

### A. General Requirements

1. The design of storm drainage systems shall include provisions to adequately control runoff from all public and private streets and the roof, footing, and area drains of residential, multifamily, commercial and industrial developments, and to provide for the future extension of the storm drainage system to serve the entire drainage basin.

2. All storm water runoff shall be conveyed to an approved point of disposal. In the case of private development, the developer shall pay all costs associated with designing and constructing the facilities necessary to meet this requirement.

3. The design storm peak discharge from the subject property may not be increased from conditions existing prior to the proposed development except where it can be satisfactorily demonstrated by the applicant that there is no adverse impact to downstream properties, and that the remaining available downstream capacity for the site being developed is not exceeded.

4. Public storm drains within easements will be permitted only upon showing that drainage cannot be provided from within a right-of-way. Minimum easement widths shall be as outlined herein.

5. Gravity Flow: Where possible, all public & private storm drains shall be designed to flow by gravity to an existing or new storm drain system without lift stations.

6. Self-Cleaning: Except for pollution control or water quality structures, all storm drain system components shall be designed to be self-cleaning to the extent possible.

### B. Approved Point of Discharge

1. Surface or subsurface drainage caused or affected by alteration of the natural grade of the existing ground or removal of natural ground cover or placement of impervious surfaces shall not be allowed to flow over adjacent public or private property in a volume or location materially different from that which existed before development occurred unless written approval is first granted by all agencies with jurisdiction and by affected property owners, and all such drainage shall be collected and conveyed in an approved manner to an approved point of disposal.

2. The approved point of disposal for all stormwater may be a storm drain, ditch, existing well-defined open channel, or creek as approved by the County Engineer. Acceptance of proposed point of disposal will depend upon the prevailing site conditions, condition and capacity of existing downstream facilities, and feasibility of alternate design.

3. When private property must be crossed in order to reach an approved point of disposal (or if downstream improvements are required across private property in

order to provide required capacity or depth), it shall be the developer's responsibility to acquire a recorded drainage easement from the private property owner meeting the approval of the County Engineer. Drainage ditch facilities must be engineered to contain the stormwater without causing erosion or other adverse effects to the private property.

## C. Providing for Future Development & Collection of Upstream Drainage

1. As a condition of development, all developments will be required to provide public storm drainage conveyance systems (or private storm drainage systems where approved by the County) to serve adjacent upstream parcels in order to provide for the orderly development of the drainage area, as well as connection (to the new system) of existing storm lines, laterals, or conveyances crossed or intercepted by the new storm lines (including manholes or catch basins which can be served by the new storm lines), at locations as required by the County Engineer.

2. The requirement above shall include the extension of storm drain conveyances in easements across the property as required to collect drainage from adjoining upstream/uphill properties, and across street/road frontages of the property to adjoining properties when the storm drain system is located in a public right- of-way. This shall include extension to the far side of streets/roads fronting or adjacent to the development as required to avoid work within or under these streets/roads in the future.

3. The requirements above shall include storm conveyances which are oversized to provide capacity for future upstream development, or as required to meet the minimum sizes shown in the applicable storm master plan.

4. Where private swales through private properties are required, reciprocal access easements and agreements with the County must be executed to ensure long-term maintenance and repair responsibility of the subject owners. A Stormwater Management Facility Long-Term Maintenance Agreement (LTMA) shall be executed between the responsible parties and the County. The LTMA shall be supported by an Operations and Maintenance Plan (O&MP) approved by the County Engineer. The agreement shall be recorded and shall travel with the land.

## D. Design Factors

1. The following factors as a minimum shall be addressed in the design of storm drain systems and determination of design flows.

    a. Drainage basin the subject property or properties are in

    b. Topography of the subject and surrounding property or properties

    c. Adjacent or tributary wetlands, seasonal streams, riparian areas, waterways, and sensitive lands

    d. Depth of excavation

e. Soil condition, type, and composition

f. Land use and zoning of the subject and surrounding property or properties

g. Projected density and impervious area created by the subject and surrounding property or properties at build-out

h. Flows from commercial, industrial or institutional users

i. Condition and size of existing storm drains, ditches, and conveyances

j. Location of approved disposal point(s)

k. Long-term maintenance responsibility, including accessibility for cleaning, inspection, personnel, and equipment.

## 1.2 DESIGN CALCULATIONS AND CAPACITY

### A. Design Calculations

1. Design calculations shall be submitted for all drainage facilities and shall be stamped by a professional engineer licensed in the State of Oregon. Peak flows shall be calculated using either the Rational Method or the Santa Barbara Urban Hydrograph (SBUH) method, subject to requirements herein and direction from the County Engineer and/or other agencies with jurisdiction.

    a. A summary of these drainage calculations, including basin maps, shall be included on the site plan drawings.

2. Rational Method: One method used for calculating peak flows from small drainages less than 200 acres is the Rational Method.

    a. Peak design discharges shall be computed using the rational method formula, Q=CiA, where Q = flow in cfs, C = runoff coefficient, i = rainfall intensity, and A = area in acres.

    b. The County Engineer reserves the right to verify all calculations using the Rational Method, and to require larger pipe sizes if the Rational Method calculations result in higher flows than the SBUH methodology.

3. SBUH: Another method of involves the use of the Santa Barbara Urban Hydrograph (SBUH) method to develop runoff hydrographs using 24-hour storm data for the local area, based on current NOAA Atlas 24-hour isopluvials for Oregon.

    a. For Philomath, the 24-hour precipitation values from the NOAA Atlas 2, Volume X, for use with the SBUH method are as follows (ODOT design rainfall intensities may differ):

        i. 5-YR 24-Hr = 3.7"

        ii. 10-YR 24-Hr = 4.3"

        iii. 25-YR 24-Hr = 5.0"

iv. 50-YR 24-Hr = 5.7"

b. For Corvallis and within the Corvallis urban growth boundary use the methods described in the City of Corvallis Stormwater Design Criteria.

c. For Albany and within the Albany urban growth boundary use the methods described in the City of Albany Engineering Standards, Division E, Stormwater Management Engineering Standards.

d. For the balance of the unincorporated areas of Benton County use the 24-hour precipitation values calculated using ODOT IDF and local precipitation data, for use with the SBUH method as follows:

e. The County Engineer reserves the right to verify all calculations using the Rational Method, and to require larger pipe sizes if the Rational Method calculations result in higher flows than the SBUH methodology.

**Table 1 24-hour Precipitation Depth-Frequency Relationships for Benton County Zones Defined from ODOT's Rainfall Intensity-Depth-Recurrence Interval (IDRI) Maps.**

| Zone | Area ($mi^2$) | Average Annual Depth (inches) | Precipitation Depth (inches) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2-yr | 5-yr | 10-yr | 25-yr | 50-yr | 100-yr | 500-yr | 1000-yr |
| 3 | 10.3 | 75 | 3.7 | 4.4 | 4.9 | 5.7 | 6.3 | 6.9 | 8.3 | 8.9 |
| 4 | 153.2 | 80 | 4.0 | 4.7 | 5.3 | 6.1 | 6.8 | 7.4 | 8.9 | 9.5 |
| 5 | 127.5 | 74 | 3.8 | 4.6 | 5.1 | 6.0 | 6.6 | 7.2 | 8.7 | 9.4 |
| 7 | 10.8 | 43 | 2.4 | 2.9 | 3.3 | 3.9 | 4.3 | 4.8 | 5.9 | 6.4 |
| 8 | 376 | 53 | 2.9 | 3.5 | 4.0 | 4.7 | 5.2 | 5.7 | 7.0 | 7.5 |

**Figure 1 ODOT IDRI zones in Benton County**

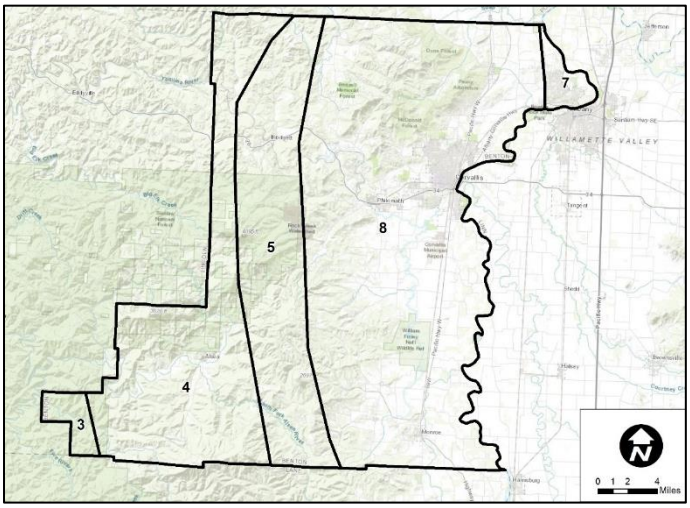

**Table 2 Depth-Area Reduction Factors (DARFs)**

| 1.2 Area (mi$^2$) 1.2 | 1.2 Depth-area reduction factor |
|---|---|
| 1.2 1 | 1.2 1.000 |
| 1.2 10 | 1.2 1.000 |
| 1.2 50 | 1.2 0.964 |
| 1.2 100 | 1.2 0.935 |
| 1.2 500 | 1.2 0.844 |
| 1.2 1,000 | 1.2 0.774 |

## B. Design Storm

1. **Rational Method Rainfall Intensity-Duration Curve** - The rainfall intensity-duration-frequency (IDF) curve for use under the Rational Method in Benton County shall be the ODOT Zone 3, 4, 5, 7 & 8 IDF curves (see **Appendix E**.)

2. **Rational Method Design Frequency** - The intensity-duration design frequency for use under the Rational Method is based on the time of concentration for the area and the size of the drainage facility. The adopted criteria are listed in the following table.

3. **SBUH Design Storm for Pipe Sizing** - Where a Santa Barbara Urban Hydrograph (SBUH) based computer program is proposed for use in sizing storm drain pipes, a 50 year 24 hour SBUH storm event must be used in lieu of the 10 year or 25 year rational storm frequency to provide equivalent capacity for peak discharge.

**Table 3 Design Storm Frequency**

| **Rational Method - DESIGN STORM FREQUENCY[1]** | |
|---|---|
| **AREA** | **FREQUENCY** |
| Residential areas | 10-year storm |
| Commercial and high value districts[2] | 10-year storm |
| Trunk lines *(18"pipe and larger)* | 25-year storm |
| Minor creeks, open channels and drainage ways *(not shown as a flood plain on the Flood Insurance Rate Map (FIRM))* | 50-year storm |
| Major creeks/channels *(shown as a flood plain on the FIRM)* | 100-year storm |
| 1 See 1.2.C.2 (below) regarding design storm when SBUH methodology is used for pipe sizing. | |

## C. Runoff Coefficients

1. The Rational Method coefficients of runoff "C" are listed below (i.e.. for use with rational method calculations). Use of coefficients other than those listed must be based on field investigations which demonstrate conclusively that the proposed coefficients are justified.

2. All CN parameters (runoff curve number) used for SBUH calculations shall be as conservative or more conservative than the equivalent Rational Method runoff coefficients listed in these standards.

**Table 4 Runoff Coefficients**

| Rational Method - RUNOFF COEFFICIENTS | | | |
|---|---|---|---|
| SOIL COVER | FLAT TERRAIN S<2% | ROLLING TERRAIN 2% ≤ S ≤ IO % | STEEP TERRAIN S>IO% |
| Cultivated Land | 0.30 | 0.35 | 0.40 |
| Parks & Cemeteries | 0.15 | 0.20 | 0.30 |
| Woodlands & Forests | 0.10 | 0.15 | 0.20 |
| Meadows & Pasture Land | 0.25 | 0.30 | 0.35 |
| I)Low density residential | 0.40 | 0.45 | 0.50 |
| 2) Medium density residential | 0.50 | 0.55 | 0.60 |
| 3) High density *(multi-family)* residential | 0.70 | 0.75 | 0.80 |
| 4) Gravel parking lots | 0.50 | 0.55 | 0.60 |
| 5) Mobile home parks | 0.60 | 0.65 | 0.70 |
| Commercial | 0.50-0.90 | | |
| Light Industrial | 0.70 | | |
| Heavy Industrial | 0.80 | | |
| Highly impermeable *(roofs and paved areas)* | 0.90 | | |

## D. Time of Concentration

1. For land in a pre-development condition, the minimum time of concentration from the most remote point in the basin to the first defined channel (i.e. gutter, ditch or pipe) shall be 10 minutes.

2. For developed residential and commercial/industrial property, the maximum post-development time of concentration from the most remote point in the development to the closest inlet shall be 10 minutes, unless calculations by an acceptable method show the time to be longer for very large developments.

## 1.3 OPEN CHANNELS

A. Within a city UGB, creation of new open channels will not generally be allowed. Where allowed by the County, ditches or open channels shall be offset from lot lines, to allow monitoring, maintenance, and repair access. Ditches or open channels shall be designed and oriented so survey monuments are not set within the open channel.

B. For reasons of maintenance and safety, bank slopes generally shall be 3H:1V or flatter unless otherwise required by the County Engineer. Unless otherwise required by the County Engineer, open channels shall generally be provided with a minimum of 1 foot freeboard above the design high water level, where required to ensure that the channel does not overflow onto private property between periods when the ditch is mowed or cleaned.

C. The maximum allowable design velocity shall be 7 fps.

D. The minimum allowable design velocity shall be 2½ fps. The installation of a concrete lined low-flow channel may be required to achieve minimum velocity necessary to ensure that the channel is self-cleaning to the extent feasible.

E. All piped discharges to open channels (existing or new) shall be mitered to match the channel side slope and armored with Class 50 or Class 100 Rip Rap as defined by ODOT/APWA Oregon Standard Specifications for Construction.

## 1.4 STORM DRAIN ALIGNMENT AND LOCATION

### A. General

1. Generally, storm drains shall be laid on a straight alignment between catch basins and between manholes. Lines 15-inch in diameter and smaller may be laid on horizontal curves conforming to the street curvature provided the radius of the horizontal curve is not less than 200 feet.

2. Variance for horizontal curves on larger size pipes shall be reviewed by the County Engineer on a case by case basis.

3. Where storm drains are being designed for installation parallel to other utility pipe or conduit lines, the vertical location shall be in such a manner that will permit future side connections of main or lateral storm drains and avoid conflicts with parallel utilities without abrupt changes in vertical grade of main or lateral storm drains.

### B. Storm Drain Location in Relation to Water and Sewer Lines and Other Utilities

1. Public storm drainage lines shall be separated from all other parallel public utilities by a minimum of 5 feet between utility centerlines, but in all cases a minimum of 3 foot clear separation shall be provided.

2. Installation of franchise or private utilities in a common trench with storm drain lines shall be prohibited.

### C. Storm Drain Location in Easements, Easement Widths, Maintenance Access Requirements

1. Minimum Easement Widths: Unless otherwise specified or authorized by the County, minimum easements widths for storm drains shall be as follows:

**Table 5 Minimum Storm Drain Easement Widths**

| MINIMUM STORM DRAIN EASEMENT WIDTHS | | |
|---|---|---|
| Storm Drain Diameter | DEPTH TO INVERT ≤ 6 feet | DEPTH TO INVERT > 6 feet |
| 10 - 15 inches | 12 feet | 12 feet plus 2 feet for each foot (or fraction thereof) deeper than 6 feet to invert. |
| 18 - 24 inches | 16 feet | 16 feet plus 2 feet for each foot (or fraction thereof) deeper than 6 feet to invert. |
| > 24 inches | 20 feet | 20 feet plus 2 feet for each foot (or fraction thereof) deeper than 6 feet to invert. |
| Note: Easements shall be a constant width between manholes or other in-line structures. Easement width shall be based on the deepest portion of the line between such structures. | | |

2. Open channels located outside of public rights-of-way shall be provided with an easement widths as follows:

    a. Channel width less than 14 feet at top of banks: Channel width plus 12 feet on one side and 2 feet on the other.

    b. Channel width greater than 14 feet at top of banks: Channel width plus 12 feet on both sides.

3. Offset. When storm drains in easements are approved by the County, the storm drain line shall be offset a minimum of 6 feet from any property line or easement boundary, or 1/3 the required easement width (rounded up to the nearest foot), whichever is greater.

4. Easement locations for public storm drain lines serving institutional developments, apartment complexes or commercial/industrial developments shall be in parking lots, private drives or similar open areas which will permit an unobstructed vehicle access for maintenance by County forces

5. Maintenance Access Requirements. Where required by the County Engineer, public storm drain lines located outside of developed road right-of- ways will require all-weather maintenance access (i.e.. all-weather access lanes along mainlines and/or for access to manholes including flow control manholes, inlets, valves or other structures, etc.).

6. Easements granted to the County shall not be used for any purpose which would interfere with the unrestricted use for stormwater management and drainage purposes. Under no circumstances shall a building, structure, tree, garden or septic drain field be placed over a storm drain pipe or easement, nor shall any parallel fences or parallel utilities be constructed within the easement (*access*

*gates acceptable to the County shall be installed in fences which the County Engineer approves to be constructed across County easements*). Prohibited structures shall include decks, as well as footings or overhanging portions of structures located outside the easement.

7. Common placement in the easements of other public utilities may be allowed under certain conditions subject to approval by the County Engineer. Easements wider than the minimum may be required. Franchise utilities shall not be placed in County utility easements unless approved in writing by the County Engineer, subject to separation requirements in excess of minimums as dictated by Public Works.

8. Common easements will be reviewed on a case-by-case basis. Separation of utilities must meet Oregon State Department of Environmental Quality (DEQ) requirements.

9. All easements must be furnished to the County for review and approval prior to recording. All recording costs shall be borne by the Developer.

## 1.5 STORM DRAIN MINIMUM PIPE SIZE

A. Public mainline, lateral or connector pipe storm drains shall not be less than 12-inches inside diameter, and shall begin at a structure and terminate at an approved point of disposal.

B. Driveway culverts (or any other pipe specifically approved with an open inlet end) shall be a minimum of 12-inches diameter. Larger diameters shall be provided where required for flow capacity or where required to match the size of adjacent existing street crossings or storm drainpipes.

C. When two parallel pipes are installed in lieu of a box culvert, the minimum separation between the pipes shall be one foot or 1/3 the diameter, whichever is greater. This requirement may be waived if the void between the pipes below the spring line is filled by grouting or other approved method.

## 1.6 STORM DRAIN MINIMUM COVER

A. All storm drains shall be laid at a depth sufficient to protect against damage by traffic and to drain building footings where practical. Sufficient depth shall mean the minimum cover from the top of the pipe to finish grade at the storm drain alignment.

B. Under normal conditions minimum cover shall be 24-inches above the top of the pipe in paved areas and 30-inches at all other locations.

C. In areas of relatively flat terrain, the design engineer must demonstrate that sufficient depth is provided at the boundary of the development to properly drain the reminder of the upstream basin area tributary to the site.

## 1.7 STORM DRAIN MINIMUM SLOPE & ROUGHNESS COEFFICIENT

A. All storm drains shall be laid on a grade which will produce a mean velocity (when flowing full) of at least 2½ feet per second, based upon Manning's pipe friction formula using a roughness coefficient as noted below.

1. Roughness Coefficient:

    a. A minimum "n" value of 0.013 shall be used in Manning's formula for the design of all smooth wall pipe and 0.024 for corrugated wall pipe, or per the pipe manufacturer's recommendations, whichever is greater. The use of higher "n" values for existing pipe may be required by the County Engineer as deemed necessary.

    b. In theory, new PVC and HDPE pipes have manufacturer's "n" value of 0.009 to 0.012. However, sand, dirt and rock and other deposits tend to build up in pipes over time. Hence, an "n" value of less than 0.013 will not be considered for approval.

B. The minimum acceptable slopes for various pipe sizes and types are listed below:

**Table 6 Minimum Storm Drain Pipe Slopes**

| **MINIMUM STORM DRAIN PIPE SLOPES (for 2.5 fps velocity)** | |
|---|---|
| **Inside Pipe Diameter (inches)** | **Smooth Wall (n = 0.013) % Slope (ft/100 ft)** |
| **10** | **0.39** |
| **12** | **0.30** |
| **15** | **0.23** |
| **18** | **0.18** |
| **21** | **0.14** |
| **24** | **0.12** |
| **27 & larger** | **0.10** |

C. In general, gradients greater than those shown above are desirable and are particularly recommended on connector pipes and the upper ends of laterals.

D. The minimum grade may be reduced from the above table to produce an absolute minimum velocity of 2.0 fps upon approval of the County Engineer. Cases requiring a flatter grade than permitted above shall also be reviewed on a case by case basis for approval by the County Engineer.

E. Engineers are cautioned not to specify sewers of sizes which are obviously larger than necessary for satisfactory carrying capacity but which are specified in order to meet grade requirements (e.g. a 15-inch pipe for an 12-inch pipe to acquire a decrease in slope).

F. Storm drains shall be laid with uniform slope between structures.

G. Grades (slopes) shall be determined to the pipe invert at the edge of the catch basin or manhole and lengths to the center of the catch basin or manhole.

1. The difference between the inlet pipe slope (Si) and outlet pipe slope (So) at any catch basin or manhole shall not exceed 25 percent.

H. Storm drains on slopes of 20 percent or more shall be anchored with concrete anchor walls or other restraining methods approved or specified by the County.

I. Where velocities greater than fifteen (15) feet per second are attained, the pipe material shall be ductile iron and special provision shall be made to protect manholes against erosion and displacement by shock. This may be accomplished by installing one additional manhole to decrease the slope or to split a 90° horizontal direction change into two 45° incremental changes.

## 1.8 TRACER WIRE

A. All storm piping (both public and private) shall have an electrically conductive tracer wire, 12 gauge minimum size single strand insulated copper with green sheathing, installed in the trench for the purpose of locating the pipe in the future. The tracer wire shall run the full length of the installed pipe, with each end accessible from the surface through a manhole, cleanout or catch basin.

## 1.9 MANHOLES AND CATCH BASINS

### A. General

1. All junctions between storm drains shall be made at manholes, catch basins or detention basins.

2. Manholes or junction boxes shall be required at the following locations or as determined by the County Engineer:

   a. All changes in horizontal or vertical alignment. Minor horizontal curvature in pipe less than 15 degrees may be allowed, (without manholes or cleanouts), depending on pipe size, street alignment, degree of curvature and reason. Maximum joint deflection shall be per manufacturer's recommendation.

   b. All connections unless otherwise noted herein.

   c. All changes in pipe size.

   d. At a spacing no greater than five hundred (500) feet.

3. For new storm mainline and/or new catch basin construction, catch basin laterals of 10 feet or less in length and 10 inches in diameter or less may connect to the main line with a shop fabricated 90 degree "T", provided the connection is located not more than one hundred (100) feet from a manhole or cleanout on the main line and the main line is a minimum of 15-inches or larger in diameter.

4. In lieu of connecting to manholes, catch basins or junction boxes, storm drain laterals draining private property may be connected directly to a larger main line, (private or public), provided the private storm lateral diameter is 8-inches or less and is no more than half the diameter of the main line. Unless otherwise

approved by the County Engineer, the connection to the mainlines shall be with an Inserta-Tee connection so as to provide a strong, leak-proof joint. The lateral shall not project inside the main line.

a. Where an Inserta-Tee connection to mainline pipe is used, the maximum lateral size shall be 2 nominal sizes smaller than the mainline pipe (e.g. 4" lateral on an 8" main; 6" lateral on a 10" main, etc.)

## B. Catch Basins

1. General

   a. Curb inlet catch basins shall be used at all locations. Exceptions will be considered on a case by case basis and approved by the County Engineer.

   b. Catch basins may be used for the junction of pipes 15-inches in diameter or less where the depth from rim to invert is less than 4 feet.

   c. Catch basins shall be designed to completely intercept the 5 year design storm gutter flow.

2. Location

   a. The maximum length of curb and gutter which may be drained by a catch basin is 500 feet.

   b. The maximum impervious area which may be drained by a catch basin is 20,000 square feet.

   c. Catch basins shall be installed where the improvement ends on all streets terminating on a descending grade, and piped to an approved point of disposal.

   d. Catch basins on corners shall not be located in front of handicap access ramps. Catch basins shall be set to minimize gutter flows across new pedestrian access ramps to the extent practicable, as determined by the County Engineer. A catch basin shall be set on the uphill side of pedestrian ramps, unless otherwise approved on a case-by-case basis.

   e. Catch basins shall be installed at all low spots, whether on private or public property, and shall be connected to a storm drainage facility.

   f. Maintenance of Private Catch Basins. All catch basins on private property (parking lots, etc.) which drain to a public storm system shall be provided with a recorded agreement allowing for inspection entry by Public Works, unless catch basins are located within a County easement, or otherwise covered by a detention system maintenance agreement. Maintenance of private catch basins and private stormwater systems shall be an ongoing responsibility of the property owner, whether or not a maintenance agreement is recorded.

3. Drop Across Catch Basin Structure

   a. The vertical drop across flow-through storm drain catch basins shall not be less than 0.1 feet.

## C. Manholes

1. Manhole Size

    a. Manhole size shall conform to the requirements shown in the standard details.

2. Manhole Location

    a. Manholes shall be installed at all pipe junctions where the depth from rim to invert exceeds 4 feet or where the pipe is 18-inches in diameter or greater. Exceptions will be reviewed on a case by case basis.

3. Drop Across Manhole Structure

    a. Generally, the minimum vertical drop across a 4-foot diameter manhole is required as shown below (drops across large diameter manholes shall be increased to provide the same channel slope across the manhole as the main).

        i. Straight through runs: 0.1' minimum drop

        ii. Bends greater than 45°: 0.2' minimum drop

    b. Maximum vertical drop across a 4-foot diameter manhole shall not exceed 18-inches with a beaver slide channel (drops of more than 18- inches require an inside drop assembly).

    c. Where pipes of different sizes enter the same manhole, the design shall generally provide that the crowns of the pipes are set at the same elevation.

    d. In cases where two pipes discharge into a manhole from opposite directions and one pipe has a slope more than 4% steeper than the pipe opposite, the invert of the pipe with the lower slope shall be set a minimum of 0.35 feet or½ the pipe diameter, whichever is greater, above invert of the steeper pipe.

    e. Manhole Flow Channels

        i. Flow channels in manholes shall be of such shape (semi-circular bottoms) and slope to provide smooth transition between inlet and outlet sewer size/ invert to minimize turbulence and to ensure that the manhole channels are self- cleaning.

        ii. Flow channel height shall typically be to the crowns of the storm pipes, but in no case shall channel depth be less than 2/3 the pipe diameter. Benches beside flow channels shall be sloped from the manhole wall toward the channel to prevent accumulation of solids.

        iii. Beaver slide channels shall be shaped to allow the insertion of a 6-inch diameter by 3-foot long TV camera into the downstream sewer.

4. Rim Elevation

    a. The rims of all manholes located within paved or other hard surfaced areas (or where paved pads are required around manholes per standard details) shall be set to finished grade. Manholes outside of these areas shall be set above finish grade as shown on the standard details.

    b. Concrete riser rings shall be used to bring casting to grade. The height from the top of the cone or flattop section to the rim shall not exceed 18 inches.

### D. Mainline Storm Cleanouts

1. Mainline storm cleanouts will not be approved as substitutes for manholes or terminal catch basins. Cleanouts shall only be allowed at the upper end of main storm lines less than 150 feet long which will be extended on the same grade and alignment during the next construction phase of a multiphase development, and which do not have any storm drain service laterals.

2. All mainline cleanouts will be considered on a case-by-case basis and approved by the County Engineer. In all cases, plan and profile showing the alignment and depth of the anticipated future extension from the proposed cleanout to the next manhole shall be submitted prior to approval of cleanouts

## 1.10 DETENTION FACILITIES

### A. Where Required

1. Peak storm water runoff shall be controlled by detention facilities for all developments that create one quarter acre (0.25 ac) or more of new impervious surface in the post-construction condition.

2. Developers shall be responsible for demonstrating to the satisfaction of the County Engineer that the downstream system has capacity for the proposed flows.

3. Developers proposing to not provide detention or control shall be responsible for demonstrating to the satisfaction of the County Engineer that such control is not necessary.

### B. Allowable Runoff Rate (Outflow)

1. Peak runoff rate shall be limited to that which would occur in a 5-year frequency storm with pre-development conditions, or the remaining available downstream capacity for the site being developed, whichever is more stringent.

2. Remaining available downstream capacity is defined as the downstream capacity unused during the design storm event. The remaining available downstream capacity for the site being developed is that portion of the remaining available downstream capacity equivalent to the ratio of the site being developed to the total undeveloped land in the basin.

## C. Detention Facility Siting & Maintenance

1. Unless otherwise approved by the County Engineer, all surface and piped detention facilities shall be located on private property (i.e. surface detention is not allowed within the County right-of-way).

2. Detention Easement & Maintenance Responsibility. All detention facilities shall be maintained by the property owner or Home Owner's Association (or similar entity/instrument acceptable to the County), including but not limited to cleaning and maintenance of outlet/flow control structures, irrigation (via a permanent automatic underground irrigation system) & mowing as applicable, etc.

    a. Maintenance shall be assured through a recorded maintenance agreement acceptable to the County (see Appendix C and D).

    b. All detention basins shall be within a storm/detention and access easement to the County.

3. Flow Control Structure Maintenance Access Requirements. Unless otherwise approved in writing by the County Engineer, provisions for all weather maintenance vehicle access to detention flow control structure shall be installed by the developer.

4. Irrigation & Landscaping.

    a. Grass and a permanent automatic underground irrigation system shall be provided and installed by the developer for open detention basins outside of parking lots (number of zones as required based on basin size and full irrigation coverage of interior & exterior slopes & bottom).

    b. Irrigation controllers shall be mounted in a secure location, and shall be battery or solar powered unless a permanent power supply is installed and provided by the developer.

    c. Any deficiencies in the irrigation system coverage or irrigation controllers during the warranty period shall be corrected by the developer or their contractor.

## D. Detention Facility Design

1. General

    a. All detention facilities and drainage calculations shall be designed and stamped by a Professional Engineer registered in the State of Oregon. Detention facilities shall be designed to protect public and private property.

    b. Off-Stream Storage. Unless otherwise approved by the County Engineer, all open detention basins (including detention chambers with open bottoms) shall be designed as off-stream storage basins, sloped to drain completely between design storms.

    c. The water level in the receiving stream during the design storm event must be lower than the bottom of the detention basin, unless otherwise approved

by the County Engineer on a case-by-case basis. Any portion of the detention basin below the design water level in the receiving stream or storm system, or below the highest seasonal groundwater level (for open basins or detention systems with open bottoms), may not be utilized for storage volume in detention calculations.

d. Detention Basin Drainage Between Storms. Except for detention systems designed as water quality facilities with underdrain systems, all detention systems shall be sloped towards the outlet to allow the facility and the upstream pipe system to drain completely between storms (bubbler systems are not typically allowed, to prevent sediment and/or debris buildup inside upstream pipes and structures).

2. Detention Basin Storage Capacity

   a. Detention facilities shall have storage capacities to detain the greater of the following:

      i. The difference between a 5-year frequency storm with pre- development conditions and a 25-year frequency storm under developed conditions.

      ii. The difference between the remaining available downstream capacity for the site being developed (as defined above) under design storm conditions and a 25 year frequency storm under developed conditions

3. Orifice

   a. The orifice size and the hydraulic head shall be adjusted to produce the allowable outflow based on the following formula:

$$D = 6.166 \times \left[\frac{Q}{H^{0.5}}\right]^{0.5}$$

Where:

D=Orifice diameter in inches

Q=Discharge in cubic feet per second

H=Hydraulic head above the orifice in feet

   b. To prevent plugging, the minimum orifice diameter shall be 1½ inches. The orifice shall be located in a pollution control manhole in a location accessible to maintenance vehicles, outside of the detention basin.

   c. The outlets of all detention basins shall be provided with suitable debris barriers designed to protect the outlet from blockage or plugging.

   d. Flow control orifice assemblies shall substantially conform with the general configuration shown on the Benton County standard details, or as approved

by the County Engineer (even if installed in a structure other than a manhole as shown on the details).

i. Details for alternate structures to house the flow control assembly shall be drawn to scale, and to demonstrate that the assembly fits in the proposed structure while allowing for equivalent maintenance & cleaning access.

ii. If an alternate flow control outlet assembly is proposed which does not allow for continuous outflow from the detention system equivalent to the predevelopment flowrate, the detention storage volume shall be increased to compensate for antecedent rainfall which reduces the available detention storage prior to the start of the design storm event.

4. Overflow System

a. The detention facility shall have a primary overflow system with the capacity to pass a 50-year frequency storm. Detention basin overflows shall discharge into a public storm drain facility or the natural drainage course for the drainage basin where the development is located (without flowing across adjacent property where a recorded easement or an established natural drainage channel does not exist), and shall be designed to minimize the impact to downstream systems (the design engineer shall identify the flow path that overflow water will follow to demonstrate that this requirement is satisfied).

b. The primary overflow elevation shall be a minimum of 1 foot below the top of the structure designed to contain the water.

c. The design engineer shall also demonstrate how emergency overflow (for flows which exceed the primary overflow capacity) will get from the detention basin to an approved downstream storm system without causing damage to the detention system or adjacent properties.

d. The design of detention facilities shall ensure that primary or secondary overflow or system failure will not cause flooding in any habitable building area.

5. Open Basins

a. Depth - At maximum storage, the maximum allowable water depth shall not exceed 5 feet. See section c. below for fencing requirements.

b. Freeboard - The maximum water surface elevation at overflow shall be a minimum of 1.0 feet below the top of the structure (curb, bank, berm, etc.) designed to contain the water.

c. Side Slopes & Top Width

i. The interior side slopes for detention basins shall be no steeper than 4H:1V. Exterior side slopes shall be no steeper than 3H:1V for maintenance. Steeper slopes or retaining walls may be used where approved in writing by the County Engineer and if access to the detention

facility is restricted by chain link or other approved fencing a minimum of six (6) feet high. Chain link fences, posts & hardware along public right-of-ways shall be vinyl coated.

ii. Unless greater width is required based on site specific geotechnical or maintenance access considerations, dikes surrounding open basin detention systems shall generally have a minimum top width of 4 feet.

d. Bottom Slope - The bottom of all constructed and graded detention basins shall be sloped a minimum of 1% towards the outlets for drainage. Flatter slopes will require the use of a concrete valley gutter or similar method as approved by the County Engineer.

e. Maintenance and/or Mowing Access - Provisions for maintenance and/or mowing access shall be provided for interior and exterior slopes, and for the bottom of open basins (provide an access ramp if mowing is required and side slopes exceed 4H: IV, or provide concrete or similar access steps if mowing is not required).

6. Parking Lot Detention Basins

a. Depth - The maximum water depth for parking lot detention basins shall be 1 foot.

b. Freeboard - The maximum water surface elevation at overflow shall be a minimum of 0.25 feet below the top of any and all structures designed to contain the water. A landscape berm is typically not allowed for containing water on parking lot detention basins.

c. The maximum water level (overflow) in parking lot detention basins shall be a minimum of 1 foot below the lowest habitable floor elevation of buildings within the proximity of the basin.

d. No parking lot detention basins shall be located within the primary ingress/egress portions of the site. Parking lot detention basins shall be designed to provide a minimum 11 foot wide unflooded emergency access route at maximum water level conditions (i.e. overflow conditions), and shall not encroach into designated fire lanes.

7. Piped or Arched Bottomless Underground Detention System

a. Unless otherwise approved, piped detention systems shall be designed as a watertight subsurface pipeline, and shall be sloped a minimum of 0.1% towards the outlet to drain.

b. Maintenance Access Points - A pollution control manhole with an orifice shall be provided at the downstream end of the piped detention system, and a standard manhole shall be provided at the upstream end.

c. Pipe type shall be based upon the depth of cover and loading conditions as specified herein.

d. Where open-bottom arched subsurface stormwater detention chambers are proposed, they shall be designed as off-stream storage basins, and licensed as infiltration systems by DEQ as applicable. Where sediment or debris can enter the chambers, a double layer continuous geotextile fabric shall be provided on top of the angular stone foundation rock, extended laterally beyond the base legs of the arched detention chambers per manufacturer's recommendations, to allow the chambers to be cleaned of silt or debris with a hydro-cleaner/jet-vac as applicable, from a manhole located at the end of the chamber row(s).

e. Easement widths shall conform to the minimum requirements outlined in Section 1.4 above.

## 1.11 PRIVATE STORM DRAINAGE COLLECTION SYSTEMS

A. Private storm drainage collection systems shall be designed in conformance with main line standards specified herein when plumbing code grade requirements of Oregon Plumbing Specialty Code (OSPC) cannot be met. The private storm drainage collection systems shall conform to the detention requirements contained herein as applicable.

B. These provisions and standards do not, nor are they intended to supersede the Oregon Plumbing Specialty Code (OPSC), but are intended to allow the design engineer flexibility in the design of private storm drainage systems where the OPC minimum slope requirements cannot be satisfied.

## 1.12 INFILTRATION SYSTEMS, DRYWELLS AND FRENCH DRAINS

A. Infiltration systems, drywells and French drains are not allowed as a sole method for draining public rights-of-way but may be used for developments on private property for buildings, paved driveways, parking and loading spaces, subject to the all of the following conditions:

1. There are no public storm drain facilities, available within a reasonable distance of the development as determined by the County Engineer. The need to acquire easements across private property to access a public storm drain facility that is within a reasonable distance shall not be grounds for allowing an infiltration system unless all other criteria are met.

2. If a design based on stormwater infiltration is proposed, soil infiltration tests shall be performed by a registered Professional Engineer licensed in the State of Oregon to document the permeability and infiltration capacity. The Engineer shall develop a recommended infiltration testing methodology using test methods and sound engineering principles appropriate to the specific site being tested (test methods proposed must demonstrate infiltration capacity of the site soils, as opposed to percolation capacity). A detailed summary of the proposed methodology and test procedures shall be submitted to the County Engineer a minimum of 7 business days in advance of the proposed testing, for review and comment by the County Engineer. Infiltration tests shall be conducted at the location and depth of the proposed infiltration facility. The Engineer shall perform a field evaluation of the soils to demonstrate that the highest seasonal water

table is not within 5 feet of the ground surface, or within 2 feet of the bottom of the proposed infiltration facility. A final infiltration report stamped by the Engineer shall be provided with the design drawings submitted for review by the County.

3. The system shall be engineered to ensure that adequate reserve capacity is available. Adequate reserve capacity shall include all runoff assuming the maximum amount of impervious area allowed by County Code, and shall include a recorded LTMA against the property reserving an area adequate for a replacement infiltration system equal in size to the primary system.
4. Provisions shall be made for grease and fines removal.
5. The site shall be graded so that it does not drain onto a public right-of-way without a storm drain system or onto neighboring property in the event that the drywell or French drain fails. The site and adjacent down gradient areas shall have no history of groundwater surfacing or being within 12-inches of the ground surface during the wet winter months, and shall not have field tile systems which may convey the infiltration water onto neighboring property.
6. The design shall include pretreatment conforming with Oregon DEQ standards for groundwater injection wells, shall be acceptable to the County Engineer, and shall be approved by and registered with DEQ prior to final plan approval by the County.

B. DEQ Registration Required. Where drywells, French drains or other infiltration systems are authorized & allowed, they shall be registered with the Oregon DEQ to the extent required by DEQ under OAR 340-044-005 through 340-044-055 prior to final approval by the County and construction (in addition to the standards above). Only DEQ "rule authorized" infiltration systems are acceptable, unless otherwise approved by DEQ and the County Engineer. Under these DEQ regulations, stormwater dry wells are "rule authorized" if they meet certain standards as determined by DEQ (conformance with current DEQ/EPA standards must be confirmed prior to submittal for review by the County). These standards restrict the use of dry wells under the rule authorized provisions to the following.

1. No other method of storm water disposal, including construction or use of surface discharging storm sewers or surface infiltration systems, is appropriate. An appropriate method shall protect groundwater quality and may consider management of surface water quality and watershed health issues.
2. No domestic drinking water wells are present within 500 feet of the injection system.
3. The injection system does not exceed a depth of 100 feet and the bottom of the infiltration structure is a minimum of 10 feet above the highest seasonal groundwater level.
4. It should be noted that DEQ standards consider water draining from building roof areas (that has not been mixed with any other stormwater) differently, in that it can be discharged in a dry well without the same level of treatment required for other types of runoff, although it must still comply with the County and DEQ

criteria above and receive DEQ approval prior to final County approval or construction.

## 2.0 STORMWATER QUALITY CONTROL (TREATMENT)

### 2.1 STORMWATER QUALITY FACILITIES

#### A. Where Required

1. Development and other activities which create or replace 10,890 square feet or more of impervious surfaces, or increase the amount or concentration of runoff are required to provide permanent water quality facilities to reduce contaminants entering the storm water system and the Benton County stormwater conveyances.

2. An on-site water quality facility shall be constructed unless, in the judgment of the County Engineer, any of the following conditions exist:

    a. There is a more efficient and effective regional site within the sub-basin that was designed to incorporate the development or is in the near vicinity with the capacity to treat the site.

    b. A sufficient buffer exists between the constructed impervious surfaces and open conveyances (ditches, streams, creeks, rivers).

3. If an on-site water quality facility cannot be constructed to treat the runoff from the development's impervious surface, or if portions of the on-site runoff cannot be treated, then the County Engineer may allow an offsite water quality facility to be designed to treat runoff from an equivalent area of adjacent untreated impervious surfaces.

4. Exempt from this requirement are water lines, sanitary sewer lines, private utilities, or other land development activities that will not directly add impervious surface area or increase the amount of storm water runoff or pollution leaving the site once construction has been completed and the site is either restored to or not altered from its approximate original condition. Projects will be considered on a case-by-case basis by the County Engineer, based on existing facilities, nature of construction activities, maintenance considerations, State and Federal permitting requirements and other factors.

#### B. Stormwater Quality Design

1. The stormwater quality facilities shall be designed to remove suspended solids, debris, oil and grease carried by the storm drain system, and retain them for safe and easy removal. The stormwater quality facility chosen shall possess design features to prevent resuspension of previously collected contaminants and materials.

2. The stormwater quality facilities shall treat the runoff from all newly constructed impervious surfaces. For purposes of stormwater quality requirements, impervious surfaces shall include pavement, gravel roads, buildings, public and private roadways, and all other surfaces with similar runoff characteristics.

3. Design Rainfall. The stormwater quality facilities shall be designed for the runoff from one half of the 2-year; 24-hour storm event (i.e. first flush). Flows resulting from rainfall greater than one half of the 2-year; 24-hour storm event may either bypass the water quality facility or pass through the water quality facility with a reduced level of treatment.

4. Residential Subdivisions, Impervious Area. The water quality facilities for any residential subdivision shall be adequately sized to accommodate the public streets & infrastructure within the subdivision, as well as for the future construction of housing on the individual lots based on an assumed 10,890 square feet of impervious surface per dwelling unit.

5. An Operations & Maintenance Plan or Manual (O&MP or O&MM) shall be prepared detailing how the water quality facility is to be maintained, and shall be submitted for review with the final design.

6. Long-Term Maintenance Agreement. (LTMA) For private stormwater quality facilities, an executed LTMA approved by the County Engineer prior to final approval or acceptance of the water quality facility, and recorded against all affected properties.

7. Infiltration Testing Requirements. If a design based on stormwater infiltration is proposed, soil infiltration tests shall be performed as summarized in Section 2.2 below, including type of testing, notice of testing, location and depth of testing, etc. A final infiltration report stamped by the Engineer shall be provided with the design drawings submitted for review by the County.

## C. Water Quality BMPs

1. Approval of the appropriate BMP for each development will be considered on a case-by-case basis by the County Engineer, and shall be based on maintenance considerations, nature of activities within the development, and other factors.

2. The following are guidelines for BMPs generally acceptable to the County. This listing is not all inclusive, and other design options which are functionally equivalent may be proposed for consideration by the County Engineer.

3. Mechanical Treatment

    a. The device shall be capable of removing at least 80% of suspended fine and coarse sediment load and 80% of the floatable oil and grease.

    b. The selected device shall incorporate a high-flow bypass or contain an internal built-in diversion structure to divert intense runoff events and prevent scouring of the previously collected contaminants.

    c. The device shall be capable of storing a minimum of 24-inches of sediment or 15% of the operating volume, whichever is greater. The storage chamber shall incorporate a means of inspecting sediment levels, as well as oil and grease accumulation levels, without entering the structure.

d. The device shall be a system that complies with the State of Washington Department of Ecology GULD rating as approved by the County Engineer.

e. The devices shall be sized and installed per manufacturer's recommendations and as approved by the County Engineer.

4. Water Quality Swale (Bio-swale)

a. The swale width and profile shall be designed to convey the water quality design storm event at a maximum design depth of 0.5 feet and maximum design velocity of 0.9 foot per second, maximum slope of 1.5 percent, designed using a Manning "n" value of 0.25, having a minimum of 3H:1V side slopes in the treatment area and a minimum length of 100 feet. A minimum of one foot of freeboard above the design water surface (i.e. high flow storm) shall be provided for facilities not protected by high flow storm diversion devices.

b. The swale shall have a minimum hydraulic residence time of 9 minutes.

c. Woody or shrubby vegetation shall not be planted in the active treatment area of the swale.

d. The swale shall incorporate an energy dissipation feature and a flow spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. For a swale wider than 8 feet a flow spreader shall be installed every 50 feet.

e. To minimize flow channelization, the swale bottom shall be smooth with uniform longitudinal slope, and with a minimum bottom width of 2 feet. Check dams shall be provided as necessary or as directed to reduce flow channelization.

f. Grasses shall be established as soon as possible after the completion of the swale. The initial rate of application shall be 5 pounds of water quality seed mix per 1000 square feet or as approved by the County Engineer. The water quality seed mix shall be a low maintenance variety.

g. Unless otherwise approved by the County Engineer, the swale shall be designed for the storm event described above. Larger storm events may be directed around the water quality swale by a flow diversion structure.

h. Maintenance Access Provisions for maintenance and mowing access shall be provided for interior and exterior slopes, and for the bottom of bioswales (i.e. same access provisions as required for open detention basins). The County Engineer will determine the acceptability of the proposed maintenance access provisions.

5. Stormwater Planter or Rain Garden

a. Facilities may be designed as strictly filtration systems, or as strictly infiltration systems with an overflow, or as partial infiltration systems with an overflow.

b. Facilities may be designed as a facility to combine both stormwater detention and water quantity treatment in a common facility. In the event of conflicts between water quality standards and detention standards, the more stringent shall apply (as determined the by County Engineer).

c. The horizontal bottom dimension of the facility shall be a minimum of 3 feet. Facilities shall be designed to evenly distribute and filter flows. Surface longitudinal slopes must be 1.0% or less.

d. Facilities may be designed with side slopes or structural retaining walls. Where retaining walls taller than 24" are proposed adjacent to areas accessible to pedestrians, rails or fall protection shall be provided along the top of the walls. If side slopes are used, a maximum slope of 3H:1V must be used for systems which do not include stormwater detention.

e. The cross section of the facility is to be composed of the following (listed from bottom to top):

    i. Drain Rock: 12 inches min. to 48 inches max., 1½" - ¾" clean, open-graded crushed rock.

    ii. Choker Course: 3 inches, ¾" - ¼" clean, open-graded crushed rock.

    iii. Water Quality Soil Mix: 18 inches.

f. Facilities may be designed without drain rock and choker course rock. If used, however, the above cross section thickness requirements apply.

g. Water Quality Soil Mix (Stormwater Planter or Rain Garden).

    i. The water quality soil mix shall be equal parts organic compost, sand, and loam (i.e. topsoil). The compost shall be weed free, decomposed, non-woody plant material; animal waste is not allowed. Compost must be supplied by a member of the Seal of Testing Approval (STA) program. See a list of local providers at www.compostingcouncil.org.

    ii. Water quality mix material must be tested (per ASTM D2434, constant head test) to meet an infiltration rate of 4 inches per hour. Prior to construction, test results must be submitted to the Design Engineer (project Engineer of Record) and the County Engineer for approval.

    iii. The blended water quality mix must be analyzed for particle gradation in conformance with ASTM C117 / C136. The analysis shall include the sieve sizes listed below and meet the following gradation criteria. The material shall also have a Coefficient of Uniformity (D60 / D10) of six or greater. Results are to be submitted to the Design Engineer (project Engineer of Record) and the County Engineer prior to construction.

**Table 7 Blended Water Quality Mix Gradation**

| Sieve Size | Percent Passing |
|---|---|
| I-inch | 100 |
| #4 | 75-100 |
| #10 | 40-100 |
| #40 | 15-50 |
| #100 | 5-25 |
| #100 | 5-15 |

h. Infiltration Testing, Capacity, Design Loading, etc.

i. A report by a Geotechnical Engineer or geologist investigation is required to determine the seasonally high groundwater level. Sites with groundwater levels within 3 feet of the lowest elevation of the stormwater facility cannot use infiltration as a water quality BMP.

ii. If a design based on stormwater infiltration into native soils is proposed, soils infiltration tests shall be performed by a registered Professional Engineer licensed in the State of Oregon to document the permeability and infiltration capacity, based on ASTM standard testing methods.

iii. Under Drain Requirements. Where the measured infiltration of the underlying native soils is less than 2 inches per hour, a perforated collection pipe must run the length of the facility within the drain rock layer to prevent long-term ponding. The perforated pipe is to collect flows passing through the growing medium and convey it by gravity to an approved point of discharge.

iv. Storage volume within the water quality mix and choker course is to be calculated with a 20% void ratio and storage volume within the drain rock is to be calculated with a 40% void ratio.

v. Filtration through the water quality mix is to be assumed at 2 inches per hour times the wetted surface area of the facility.

vi. The facility must be designed with a maximum treatment water depth of 12 inches (measured from top of water quality soil mix) and filter the entire water quality storm through the water quality soil mix. For facilities not protected by a high flow storm diversion device, a minimum freeboard of 12 inches is required above the design water surface (i.e. high flow storm), except that freeboard may be reduced to 6 inches where perimeter curbs are provided.

vii. The facility must be designed to drain stormwater below the bottom of the water quality soil mix within 30 hours after the end of the water quality storm event.

viii. For facilities with side slopes, the water quality soil mix should extend 3 inches minimum above the peak water surface reached during the water quality storm event.

ix. The facility shall incorporate an energy dissipation feature at the inlet. The inlet(s) and outlet must be located to provide the maximum linear separation feasible.

i. Planting Requirements (Stormwater Planter or Rain Garden).

i. The entire facility should be planted with herbaceous rushes, sedges, perennials, ferns and shrubs that are well-suited to wet- to-moist soil conditions. If the facility has side slopes, soil conditions will vary from wet to relatively dry and several planting zones should be considered. Areas above the designed high water line are to be planted with self-sustaining, low maintenance grasses, ground covers, perennials, and shrubs suitable for the local climate.

ii. All vegetation should be planted densely and evenly in quantities per 100 square feet of:

- 115 herbaceous plants, 1' on center spacing, 4" pot container size; or
- 100 herbaceous plants, 1' on center (4" pot container size), and 4 shrubs 2' on center (1-gal container size).

iii. Prior to planting, facility treatment areas shall install coconut or jute matting over the entire surface or equivalent approved by the County Engineer.

iv. Bark mulch is not allowed on the interior slopes or top of the facility.

v. Provide supplemental water for a minimum of two years from June 1st to October 15th with 1" of water per week.

j. Construction & Permanent Setbacks (Stormwater Planter or Rain Garden).

i. Before site work begins, clearly mark infiltration facility areas to avoid soil disturbance during construction. No vehicular traffic should be allowed within 10 feet of infiltration facility areas, except as necessary to construct the facility.

ii. Facilities infiltrating directly to the underlying soils shall be located at least ten feet from building foundations and shall not be located immediately upslope of building structures.

iii. All stormwater treatment facilities shall be set back a minimum of five feet from side lot property lines and easements where the adjoining property is downslope. Where the adjoining property is at the same grade or upslope from the facility, no set back is required.

## 2.2 INFILTRATON SYSTEMS, DRYWELLS AND FRENCH DRAINS

A. Infiltration systems, drywells and French drains are not allowed as a sole method for draining public rights-of-way but may be used for developments on private property for buildings, paved driveways, parking and loading spaces, subject to the all of the following conditions:

1. There are no public storm drain facilities, available within a reasonable distance of the development as determined by the County Engineer. The need to acquire easements across private property to access a public storm drain facility that is within a reasonable distance shall not be grounds for allowing an infiltration system unless all other criteria are met.

2. If a design based on stormwater infiltration is proposed, soil infiltration tests shall be performed by a registered Professional Engineer licensed in the State of Oregon to document the permeability and infiltration capacity. The Engineer shall develop a recommended infiltration testing methodology using test methods and sound engineering principles appropriate to the specific site being tested (test methods proposed must demonstrate infiltration capacity of the site soils, as opposed to percolation capacity). A detailed summary of the proposed methodology and test procedures shall be submitted to the County Engineer a minimum of 7 business days in advance of the proposed testing, for review and comment by the County Engineer. Infiltration tests shall be conducted at the location and depth of the proposed infiltration facility. The Engineer shall perform a field evaluation of the soils to demonstrate that the highest seasonal water table is not within 5 feet of the ground surface, or within 2 feet of the bottom of the proposed infiltration facility. A final infiltration report stamped by the Engineer shall be provided with the design drawings submitted for review by the County.

3. The system shall be engineered to ensure that adequate reserve capacity is available. Adequate reserve capacity shall include all runoff assuming the maximum amount of impervious area allowed by County Code, and shall include a recorded LTMA against the property reserving an area adequate for a replacement infiltration system equal in size to the primary system.

4. Provisions shall be made for grease and fines removal.

5. The site shall be graded so that it does not drain onto a public right-of-way without a storm drain system or onto neighboring property in the event that the drywell or French drain fails. The site and adjacent down gradient areas shall have no history of groundwater surfacing or being within 12-inches of the ground surface during the wet winter months, and shall not have field tile systems which may convey the infiltration water onto neighboring property.

6. The design shall include pretreatment conforming with Oregon DEQ standards for groundwater injection wells, shall be acceptable to the County Engineer, and shall be approved by and registered with DEQ prior to final plan approval by the County.

7. <u>DEQ Registration Required.</u> Where drywells, French drains or other infiltration systems are authorized & allowed, they shall be registered with the Oregon DEQ to the extent required by DEQ under OAR 340-044-005 through 340-044-055

prior to final approval by the County and construction (in addition to the standards above). Only DEQ "rule authorized" infiltration systems are acceptable, unless otherwise approved by DEQ and the County Engineer. Under these DEQ regulations, stormwater dry wells are "rule authorized" if they meet certain standards as determined by DEQ (conformance with current DEQ/EPA standards must be confirmed prior to submittal for review by the County). These standards restrict the use of dry wells under the rule authorized provisions to the following.

8. No other method of storm water disposal, including construction or use of surface discharging storm sewers or surface infiltration systems, is appropriate. An appropriate method shall protect groundwater quality and may consider management of surface water quality and watershed health issues.
9. No domestic drinking water wells are present within 500 feet of the injection system.
10. The injection system does not exceed a depth of 100 feet and the bottom of the infiltration structure is a minimum of 10 feet above the highest seasonal groundwater level.

B. It should be noted that DEQ standards consider water draining from building roof areas (that has not been mixed with any other stormwater) differently, in that it can be discharged in a dry well without the same level of treatment required for other types of runoff, although it must still comply with the County and DEQ criteria above and receive DEQ approval prior to final County approval or construction.

# APPENDIX A
# DEFINITIONS AND TERMS

The following definitions may apply particularly to stormwater systems. Unless otherwise defined in this manual, the following definitions and abbreviations shall apply whenever used. Other definitions as outlined in the Oregon Plumbing Specialty Code (OPSC) shall also apply.

**Abbreviations:** Acceptable abbreviations for showing types of new and existing pipe materials and facilities on the plans are as follows:

**CI** - Cast Iron

**CHDPE** - Corrugated High Density Polyethylene

**CMP** - Corrugated Metal Pipe (Aluminum)

**CP** - Non-reinforced Concrete Pipe

**CSP** - Corrugated Steel Pipe

**DI** - Ductile Iron

**HDPE** - High Density Polyethylene

**PVC** - Polyvinyl Chloride

**RCP** - Reinforced Concrete Pipe

**Building Drain:** The building drain is that part of the lowest piping of the drainage system which receives the discharge from stormwater drainage pipes inside or within 5 feet of the outside walls of the building and conveys it to the building sewer, which begins five (5) feet outside the building wall or building foundation.

**Building Storm Drain:** That part of the piping of a stormwater drainage system which begins at the connection to the building drain and conveys stormwater to an approved point of disposal.

**Catch Basin:** An approved receptacle designed to receive surface drainage and direct it to a stormwater collection system.

**Creek:** Any and all surface water generally consisting of a channel having a bed, banks, and/or sides in which surface waters flow to drain higher land to owner land, both perennial and intermittent, excluding flows which do not persist for more than 24-hours after the cessation of ½-inch of rainfall in a 24- hour period from October through March.

**Detention:** The holding of runoff for a short period of time while releasing it to the downstream drainage system at a controlled rate.

**Drainage Facilities/System:** Pipes, ditches, detention basins, creeks, culverts, etc. used singularly or in combination with each other for the purpose of conveying or storing stormwater runoff.

**Impervious Areas/Surfaces:** Those hard surface areas located upon real property which either prevent percolation of water into the land surface or reduce the percolation rate which existed

under natural conditions prior to development. Also surfaces which cause water to run off the land surface in greater quantities or at increased flow rates than under natural conditions which existed prior to development. Common impervious surfaces include but are not limited to rooftops, driveways, parking lots or storage areas, sidewalks, patios, etc.

**Long-Term Maintenance Agreement:** (LTMA) A standard agreement utilized by the County to formalize property owner responsibilities for maintenance and repair of private stormwater facilities. The agreement shall be recorded and travel with the land to future property owners.

**Natural Location:** The location of those channels, swales, and other non-man- made drainage conveyance systems as defined by the first documented topographic contours existing for the subject property either from maps or photographs.

**On-site Detention:** The storage of excess runoff on the development site and gradual release of the stored runoff into a public storm drain system after the peak of the runoff has passed.

**Operations & Maintenance Plan (O&MP)**: A plan developed by an engineer licensed in the State of Oregon to document the long term operation and maintenance requirements for a stormwater detention and treatment system or facility. The O&MP supports the LTMA and must be approved by the County Engineer prior to recording the LTMA.

**Peak Discharge:** The maximum water runoff rate determined for the design storm.

**Pre-Development Conditions.** Defined as a site with natural vegetation on native soil, unless otherwise approved in writing by the County Engineer, based on the storm system having adequate remaining available downstream capacity for the site being developed (as defined in these standards), based on calculations and storm system modeling provided by the developer's engineer to the satisfaction of the County.

**Private Storm Drain:** A storm drain located on private property serving parking lot catch basins or more than one structure on the same premises, and not operated or maintained by the County.

**Public Storm Drain:** Any storm drain in a public right-of-way or easement operated or maintained by the County.

**Receiving Body of Water:** Creeks, streams, lakes, and other bodies of water into which runoff is naturally or artificially directed

**Release Rate:** The controlled rate of release of drainage and runoff water from property, storage ponds, detention basins, or other facility during and following a storm event.

**Retention Facility:** Facilities which hold water for a considerable length of time and then consume it by evaporation, plant transpiration, or infiltration into the soil.

**Sedimentation:** Deposition of erosional debris and soil sediment displace by erosion and transported by water from a higher elevation to an area of lower gradient where sediments are deposited as a result of slack water.

**Terrace:** A relatively level step constructed in the face of a slope for drainage, erosion control and maintenance purposes.

**Trunk Drainage System:** That portion of the drainage system which receives waters from upstream land areas in excess of 20 acres, or with pipe diameters of 18-inches or larger. The drainage system may consist of watercourses or man-made facilities such as pipes, ditches, and culverts.

**Wetlands:** As defined by the Division of State Lands and/or the US Army Corps of Engineers.

# APPENDIX B
# LOW IMPACT DEVELOPMENT

## B.1 Purpose

A. The purpose of this document is to guide developers, community members, landscape and road designers seeking to implement Low Impact Development in land development projects in Benton County. This manual is divided into specific LID design measures identifying advantages, disadvantages and maintenance measures associated with the LID design. Each property location and site design is unique. The designer or individual referencing this manual should be aware that not all designs outlined in this document are synonymous with every site.

| Condition | Action |
|---|---|
| Steep Slopes | Do not design infiltration facilities in the area that may lead to changes in soil water levees in critical slopes. Avoid installing infiltration facilities on slopes >20%. On slopes <20% infiltration beds should be graded horizontal (terraced) to optimize infiltration capacity and minimize down slope interflow. |
| Shallow Water Table | Do not design infiltration facilities in areas with seasonal shallow water tables. Headspace between bed of infiltration facility and water table must be sufficient, based on soil type, to accommodate mounding due to infiltration, and treatment in the soil matrix to prevent groundwater contamination |
| Unstable Soils | Periodic saturation of unstable soils, combined with increased soil loading due to building and traffic loads, may result in soil bearing capacity failures. |
| High Sediment Loads | Do not use LID practices that are vulnerable to surface clogging, such as pervious paving in areas where waterborne and/or airborne sediment loads are significant |

B. The goal for successful implementation of LID measures is to identify and protect the most valuable natural hydrological feature of the site, the project will minimize the need for additional management practices. Additionally manage runoff close to the source to reduce the sediment transport and implement infiltration, using the natural topography to link multiple small facilities by a slow shallow swale allows for infiltration whenever it's appropriate. Lastly try to design an LID measure around a multi-functional use, for example bioswales are excellent designs from a stormwater control and landscape standpoint reducing the need for irrigation and adding to the aesthetic value of the property.

C. This document is a guide for putting together low impact development providing developers and designers with advantages, disadvantages, and maintenance

components requirements for BMPs and how to ensure optimum performance during installation and how to maintain their performance over time.

## B.2 Introduction

A. Starting March 23, 2023, Benton County is implementing new permit requirements for development and re-development in order to remain in compliance with the Oregon Department of Environmental Quality's National Pollutant Discharge Elimination System (NPDES). Benton County is permitted through DEQ for stormwater and water quality related measures as a 'small community'. The changes in stormwater regulation include two new control measures for construction site runoff, and post-construction stormwater management.

B. In addition to the new control measures, the threshold for ground disturbance which triggers an OR DEQ and Benton County erosion and sediment control permit will drop from 1 full acre to ¼ acre across the County. In addition, the area of impervious surface that will necessitate the implementation of stormwater treatment measures and a long-term stormwater management and maintenance plan will be ¼ acre.

C. In order to assist residents and developers in the creation of projects that exceed this threshold, Benton County is offering the opportunity for projects to incorporate **Low Impact Development (LID) and Green Stormwater Infrastructure (GSI)** features to mitigate for the impacts of impervious surface. Including the options in this guide may help reduce or eliminate your need for stormwater treatment and management after your project's completion.

D. All LID and GSI options must be included in the original site plan, be designed by an engineer and be approved by Benton County Public Works in order to serve as a stormwater credit. In addition, these features must be appropriately maintained in working order, and may include a maintenance agreement with the County upon permit approval.

E. Frequently Asked Questions

1. **What is a stormwater management system?**

   A stormwater management system is a system that controls stormwater runoff and discharge from storm events and can include collecting, conveying, storing, absorbing, treating, using or reusing water to reduce flooding and water pollution. Stormwater management systems can be as complicated as a municipal stormwater system or as simple as a raingarden or bio-swale (ditch) that helps direct and slow the flow of water.

2. **What is Low Impact Development? Why do we use it?**

   Low Impact Development is a broad category of stormwater and development strategies that strive to mimic pre-development functions of stormwater control. This includes infiltration, filtration, storage and other means in which stormwater would move through a natural area. The purpose is to prevent excess runoff, erosion, and transport of contaminants that can increase with the installation of artificial structures.

3. **What is Green Stormwater Infrastructure?**

   Green Stormwater Infrastructure GSI) is a method of stormwater management that reduces stormwater volume, flow and allows stormwater to infiltrate, be treated by vegetation and soil naturally, or be stored for reuse. These features can include pervious paving, bio-retention basins and ponds, vegetated swales and cisterns.

4. **Why are LID and GSI important and how do they help improve water quality?**

   Low Impact Development mimics natural processes like infiltration and evapotranspiration to naturally 'scrub' stormwater which protects the environment from contaminant runoff. It is one of many aspects of water management that ensures our waters remain drinkable, fishable, and swimmable for present and future generations.

5. **Are rain barrels and rainwater collection legal?**

   There is a common misconception that it is illegal to collect rainwater in Oregon and other states. **The truth is that it is legal to gather rainwater everywhere in the state.** In fact, many communities, such as Eugene, actively encourage residents to collect rainwater to supplement wells and watersheds.

6. **What other municipalities have LID and GSI programs?**

   There are too many LID and GSI programs in Oregon to note them all. Good examples can be found at the following organizations and agencies: City of Portland Environmental Services, City of Salem, City of Eugene, Clean Rivers Coalition, Clean Water Services, Oregon State University Extension Service, United States Environmental Protection Agency, Willamette Partnership and many others.

7. **Do Underground Injection Control systems need a separate permit?**

   No, as long as an underground injection control (UIC) system is collecting rainwater from a single family dwelling it would not require a permit from Oregon Water Resource Department or Oregon Environmental Quality. If an UIC is proposed it must be installed and verified by a geologist. Placement of UIC in shallow groundwater areas is not advised.

8. **What are the different types of stormwater treatment that are performed by LID and GSI development?**

   Stormwater retention, supplemental irrigation, infiltration, detention, removal of pollutants, and storage for reuse.

## B.3 LID Measures: Retention Facilities - Stormwater Management Method

### A. What is a stormwater retention facility?

A stormwater retention facility is a pond, pool or basin used for storage of stormwater runoff which is constructed to receive and hold stormwater for release at a controlled weight.

### B. What is the difference between stormwater retention vs. detention?

Stormwater retention is typically a permanent pool of water that is retained on site. A stormwater retention generally have liners present to retain the water and prevent infiltration. A stormwater retention system would be suited for high yielding short rain events followed by long dry events. The water would be used for irrigation purposes. If a retention basin meets capacity and additional rain event occur the functionality of the retention basin is inadequate Overflow of the retention basin would then exit the site at a rate of accumulation.

Stormwater detention is a feature that keeps water onsite so that it can naturally infiltrate after large precipitation events. Detention basins are ideal for areas that have high infiltration and not situated with shallow groundwater. Detention basins are designed to collect the water that naturally cumulates or is directed into it. Once the water is present within the detention basin it will naturally infiltrate. If the rate of saturation exceeds the rate of infiltration overland flow will occur. This flow is then be directed out of a riser or overflow to a controlled bio-swale. When the rate of infiltration exceeds the rate of saturation the water flow is directed downwards into the subsurface to recharge the local groundwater. The spillway should be constructed with concrete to prevent any scouring and channelizing therefore maintaining the integrity of the detention basin. Detention basins can be dug into the ground or formed up above ground, note that when formed above ground further engineering is required to ensure the sides are adequate and the chances of blowout failures are eliminated.

To retain something means to keep it; detention – just like what might happen to a challenging student – only keeps water around for a shorter period of time and keeps it from running offsite in large volumes. These features also help treat stormwater by allowing it to infiltrate and settle naturally, thus reducing the amount of pollutants that would be carried with the runoff.

### C. What are the advantages and disadvantages of stormwater retention facilities?

#### 1. Advantages

a. Are simple and generally space-efficient

b. Improve water quality using natural means

c. Do not require additional equipment or structures

d. Create habitat for amphibians and other species

e. Can be incorporated into landscape in a visibly-pleasing manner

**2. Disadvantages**

a. Can attract mosquitos, but can be omitted by adding a circulation pump.

b. In some cases they may be required to be quite large to manage runoff

c. Can present a standing water hazard

d. Are not allowed in areas of creeks or streams without obtaining a permit from Oregon Water Resource Department.

## B.4 Cisterns

### A. What is a cistern?

A **cistern** is typically a large-volume container used for holding rainwater for re-use. These can be located above or below ground and can be made of a variety of materials and configurations. Cisterns are relatively easy for set up and collection however do require proper sizing, construction and maintenance. Placement of a cistern is considered a structure and would require setbacks should it exceed 120 SF.

### B. What are the advantages and disadvantages of cisterns?

**1. Advantages**

a. Cisterns are a good supply of water during dry periods or droughts.

b. Gravity-fed cisterns don't require electricity or additional power.

c. Cisterns can store larger volumes of water than rain barrels for later use.

d. They can be used as gravity-fed systems or in-ground collection facilities depending on your needs and design specifications.

**2. Disadvantages**

a. Cistern systems can be unwieldy and difficult to install.

b. Water should be inspected regularly to make sure it is safe for your desired irrigation use.

c. Not everyone likes the appearance of a cistern.

d. An in-ground cistern requires excavation and professional installation.

e. Water collected from a cistern cannot be used for drinking water as pathogens and bacteria can be present in stagnate water.

## B.5 Rain Barrels

### A. What is a rain barrel?

A **rain barrel** is a container that is connected to a roof downspout in order to collect and store water for later use, or for detention in order to release it at a slow rate of discharge to an approved location. Rain barrels are typically 55 gallons and can be made from a variety of materials depending on your needs. They can also be configured in a variety of ways, including connecting multiple barrels or adding an overflow to a rain barrel to a bio-swale. Placement of rain barrels should be on a solid foundation or earth or cement. Given the weight of a full rain barrel it is advised to not place a rain barrel on a patio or deck.

Rainwater harvesting systems such as rain barrels are a great way to capture and store roof runoff for use on-site and contribute to reduction in stormwater flow volumes. The water can be stored for irrigation or used inside for non-potable water use. The system must be sized using the water balance analysis, this analysis calculates the optimum tank size using annual precipitation cycles.

### B. What are the advantages and disadvantages of stormwater retention facilities?

#### 1. Advantages

a. Rain barrels are a simple LID measure that can be implemented in almost every situation.

b. They are easy to build and install and do not take special tools or expertise.

c. There are many ways rain barrels can be set up to both your downspouts and to one another, creating many possibilities.

d. A single barrel with a diverted rain spout can fill up within a day.

#### 2. Disadvantages

a. Some people do not like the appearance of above-ground rain barrels.

b. Once full, a 55-gallon barrel can weigh more than 450 pounds so they should be set up and secured in a well-planned manner.

c. Custom systems can be more expensive.

d. Rain barrels need to be maintained on a regular basis and will often need repair every couple of years.

e. Only collection of roof water is legal in the state of Oregon

**C. Maintenance**

1. Test your water for bacteria and contaminants regularly; warmer months can be especially problematic.
2. Applying a filter or piece of screen to the input of your rain barrel will prevent mosquitos, leaves, and other unwanted debris from ending up in your barrel. Once these materials enter the barrel they may be difficult to clean out.
3. Power wash and clean your barrel at least once a year after the rainy season. Over time it will build up moss or algae, pollen and other contaminants that will settle and/or coat the inside of your barrel.
4. Ensure that your spigot or other fixtures are sealed and free of leaks; reseal with waterproof silicone if needed.

## B.6 Green Roofs & Blue Roofs

### A. What is a 'green roof'?

A 'green roof' is a roof that is partially or fully covered by vegetation. This vegetation enhances the building's energy efficiency and reduces the amount and/or rates of stormwater runoff that must be conveyed from the roof. They can help capture, absorb and return water to the atmosphere through a process called evapotranspiration. Further structural considerations should be required prior to implementation of a green roof.

### B. What is a 'blue roof'?

A '***blue roof***' is a roof that is designed to hold and collect rainwater so that it can be drained slowly or redirected for re-use. These roofs prevent high velocity runoff and reduce the burden on other stormwater systems. Rather than using plants, 'blue roofs' use engineering methods to control water movement.

### C. What are the advantages and disadvantages of modified roofs?

#### 1. Advantages

a. These modifications help absorb heat from the rooftop and can help cool structures.

b. Blue roofs are designed to hold water and thus reduce likelihood of roof leaks over time.

c. While the initial cost of a modified roof can be more expensive than a typical roof, they can decrease your energy costs overtime.

d. Green roofs can absorb up to 30% of noise pollution in urban areas.

**2. Disadvantages**

a. Green roof systems are dependent on the structural limitations of your roof and home/building. They also typically cannot be installed on roof slopes greater than 25 degrees.

b. Green roofs can cost $10-$24 per square foot.

c. The plant species appropriate for use on a green roof are relatively limited.

## B.7 Permeable Pavement

### A. What is permeable pavement?

**Permeable (sometimes referred to as pervious)** pavement is an alternative to traditional asphalt or pavement that allows for water to penetrate the surface. Once water passes through the surface, it collects in a base layer of gravel and naturally soaks into the ground. Types of permeable pavement include pervious concrete, porous asphalt, permeable paver systems, turf block systems, and others.

Pervious pavement is ideal for sites with limited space for other surface stormwater BMPs. Depending on the native soils and physical constraints, the system may be designed with no underdrain for full infiltration or detention and filtration only. Permeable paving allows for filtration, storage, or infiltration of run off and can reduce or eliminate surface stormwater flows compared to traditional impervious paving surfaces like concrete and asphalt. The slope of permeable pavement surface should be at least one percent and no greater than five percent. Local soil that have a low infiltration should be designed to have incorporation of perforated pipe underdrain.

Most pollutants in urban runoff are well retained by infiltration practices and soils and therefore, have a low to moderate potential for groundwater contamination. Chloride and sodium from de-icing salts applied to roads and parking areas during winter are

not well attenuated in soil and can easily travel to shallow groundwater contaminating the local groundwater.

**Permeable interlocking concrete pavers (block pavers)**: Concrete pavers are designed with gaps between them that allow stormwater to infiltrate into the aggregate reservoir. The gaps are approximately 10% of the surface area and are filled with small stone.


Permeable paver parking lot in Mississauga, ON (Source: CVC)

**Plastic or concrete grid systems** are concrete or durable plastic grids filled with gravel or a pervious planting mix for grass or low ground cover. The grids provide support for vehicles or foot traffic while preventing compaction and rutting of the fill material. Grid systems are appropriate for applications such as walkways, overflow parking, firelanes, maintenance and utility acccess lanes, or driveways.


Residential driveway (Source: R. Bannerman); Plastic grid filled with gravel (Source: Gravelpave®)

**Pervious Concrete and Porous Asphalt** have pavement mixes with reduced or no fines which creates stable void spaces. The void spaces allow stormwater to drain through to the underlying stone reservoir. They require different pouring and setting procedures than their impervious versions.


Pervious concrete(Source: Hunt and Collins, 2008); Porous asphalt parking lot (Source: University of New Hampshire Stormwater Center)

**B. What are the advantages and disadvantages of stormwater retention facilities?**

**1. Advantages**

a. Permeable paving options allow for rainwater management on your property without using extra space. These materials can be walked on, parked on and used for landscaping.

b. Most permeable pavement options are visually attractive.

c. Because permeable pavement has built-in spaces, it is much less prone to cracking or buckling than traditional pavement. It can last up to 20 years.

**2. Disadvantages**

a. Often cannot be used on steep slopes (>5% grade) as they lose functionality.

b. Some soils with slow infiltration rates are not compatible with permeable pavement options.

c. Permeable pavement is more expensive than traditional paving options, and requires regular maintenance to remain functional.

d. To work properly, permeable paving options must be kept clean and free of objects.

## B.8 Rain Gardens

**A. What is a rain garden (or bio-retention cell)?**

A **rain garden** (sometimes called 'bio-retention features or bio-retention cells' is a shallow landscaped depression planted with vegetation including grasses, flowers, herbs, or shrubs that is designed to catch and filter stormwater runoff. The water naturally infiltrates into the ground assisted by the plants. Rain gardens often include amended soils or compost to improve infiltration and make the rain garden amenable to vegetation.

**B. What are the advantages and disadvantages of a rain garden?**

**1. Advantages**

a. Rain gardens are visually-pleasing natural features.

b. Rain gardens can attract wildlife, birds and pollinators; because rain gardens typically drain within 48 hours, they do not attract mosquitos.

c. Rain gardens are simple to install and require minimal maintenance as long as plants are properly selected and established.

d. Rain gardens are a cost-effective water quality measure

**2. Disadvantages**

a. Rain gardens involve live plants and may need more upkeep while the plants establish.

b. Rain gardens are not intended as high-volume features and may be inadequate for treating all stormwater runoff.

c. Native plants should always be used for a rain garden to prevent spread of noxious weeds.

d. Rain gardens are not a good fit for steep slopes as they will often overflow and drain downhill or erode.

## B.9 Bio-swales

### A. What is a bio-swale?

A **bio-swale** is a shallow channel lined with grass or other vegetation which is designed to collect stormwater runoff and slow the velocity of sheet flows. The most typical example of a simple bio-swale is a vegetated ditch line. The vegetation in the swale allows for the water to slow and release sediment from its flow. (sedimentation).

### B. What are the advantages and disadvantages of a bioswale?

**1. Advantages**

a. Bio-swales are very common and simple methods for slowing and collecting water flow.

b. Bio-swales typically require very little maintenance and no artificially-constructed features.

c. The plants in a bio-swale naturally infiltrate and filter water which prevents runoff and pollution from traveling offsite.

d. Bio-swales are natural features that are generally visually-pleasing and low profile.

**2. Disadvantages**

a. Bio-swales can accumulate sediment and debris over time which must be controlled to maintain function.

b. If the bio-swale becomes de-vegetated or the vegetation dies it can lose function.

c. Bio-swales may take up a long distance on a property in order to have the appropriate capacity and may not be suitable for high urban density.

## B.10 Downspout Modifications

### A. What are downspout modifications?

A **downspout modification** is an alteration to the basic function of a rain gutter and downspout system that change the flow of water in a way which creates less potential for high volume runoff from an impervious feature such as a roof. These can include manifolds, spreaders, extenders or redirecting or slowing drainage of stormwater. Downspout disconnection or modification should be constructed to discharge the water at least five feet away from the foundation of the house. All outflows should be equipped with a splash block or other dispersing mechanisms.

### B. What are the advantages and disadvantages of downspout modifications?

#### 1. Advantages

a. There are a wide variety of options to modify downspouts, and water can be redirected away from foundations, or into rain gardens, vegetable gardens, or reserve water supplies.

b. These options are generally fairly inexpensive and most materials can be easily purchased by individual homeowners.

c. Downspout modifications can be made visually-appealing or minimal as compared to other LID and GSI options.

#### 2. Disadvantages

a. These features can degrade over time and must be maintained in working order.

b. Outflow and/or overflows must be designed to not infiltrate under the existing house foundation.

## B.11 Exempt Underground Injection Control Wells

### A. What is an underground injection control (UIC) well?

An **Underground Injection Control (UIC)** is a manmade well or subsurface water distribution system which discharges water into the ground rather than running off

the surface. It can include various options like drywells, pipes or French drains, drain fields or other devices. Single family residential roof drains can be connected to an injection device that would infiltrate the clean water from the roof into the subsurface. Design professionals should construct these devices with an overflow and a check valve preventing surface contamination. Federal and state rules prohibit the construction, operation, maintenance, conversion, plugging or abandonment of any time of injection system that would allow for the direct or indirect movement of contaminated fluids into groundwater. Per federal rules the burden of proof is on the owner/operator of the system to prove that an injection activity does not have the potential to cause violation of primary drinking water standards.

If a design profession is interested in installing an exempt underground injection control well that connects a single dwelling roof, it is highly advise to communicate with an engineer to establish the following: rate of infiltration, depth of UIC, and overflow device. Benton County does not inspect underground injection control wells.

**B. What are the advantages and disadvantages of an underground injection control?**

**1. Advantages**

a. Takes up very little area on a project site and idea for smaller lots or limited space.

b. Can be engineered for various capacities depending on needs.

**2. Disadvantages**

a. Permanent feature that must be installed and designed correctly to ensure proper function and capacity.

b. Underwater injection controls designed for stormwater should be used for stormwater drainage (for example, off a roof) only and should not be contaminated with chemicals, household gray water, detergents, or other additives.

## B.12 Soil Amendments

**A. What are soil amendments?**

A **soil amendment** is changing the physical makeup of soil to enhance its ability to maintain vegetation, drainage, or other desired features.

**B. What are the advantages and disadvantages of soil amendments?**

**1. Advantages**

a. Amending soils is a simple way to change the drainage capacities of your worksite and can reduce flooding, runoff, and make your site `more amenable to vegetation.

b. Soil amendments do not require the addition of structures or other features which take up space.

2. **Disadvantages**

    a. Soil amendments are often not a ‘fix all’ for runoff or erosion issues.

    b. Amending soils requires a specific goal and testing to ensure that the desired soil characteristics are met.

# APPENDIX C
# STORMWATER MANAGEMENT FACILITIES LONG-TERM MAINTENANCE AGREEMENT

This Stormwater Management Facilities Long-Term Maintenance Agreement ("Agreement") is between Benton County, Oregon ("County") and **[---insert full legal name of Property Owner(s)---],** Property Owner(s) ("Owner").

## RECITALS

A. To comply with the County's obligations under the Clean Water Act, the United States Environmental Protection Agency's NPDES Phase II program, federal and state law, and permit requirements required by law; the County must assure that all stormwater facilities are adequately operated and maintained by entities responsible for those facilities. The County needs information and access in order to comply with its responsibilities.
B. Owner is the owner of real property commonly known as **[---insert street address or map/tax lot number---]** and contained in Deed Record **[---insert deed record reference(s)---]** (the "Property"), and more particularly described/illustrated in **Exhibit 1** upon which stormwater facilities (the "Facilities") are located or to be constructed as shown on Exhibit 1.
C. The Facilities are a private system which is owned and maintained by the Owners of the Property noted above. Where there are multiple parties with interest in the Property on which the facilities are sited, the provisions of this agreement shall apply to all owners jointly and severally.
D. The Facilities enable development of property while mitigating the impacts of additional stormwater and pollutants associated with stormwater runoff prior to discharge from the Property to the public stormwater conveyance system.
E. The Facilities are designed by a registered professional engineer to accommodate the anticipated volume of runoff and to detain, treat, and manage stormwater runoff in accordance with the Benton County Stormwater Design Manual.
F. Failure to inspect and maintain the Facilities can result in an unacceptable impact to the public stormwater conveyance system and receiving waters.

## TERMS OF AGREEMENT

### SECTION 1: CONSTRUCTION, OPERATION & MAINTENANCE OF FACILITIES

Property Owner shall construct, operate and maintain the Facilities in strict accordance with the approved Engineering drawings, specifications, Operations & Maintenance Plan (OMP) and OMP checklist (**Exhibit 2**), and this Agreement. The Owner's responsibility for this maintenance agreement is joint and several.

### SECTION 2: MAINTENANCE OF FACILITIES

Owner shall not destroy or remove the Facilities from the Property nor modify the Facilities in a manner that lessens their effectiveness without express prior written permission of the County, and shall, at its sole expense, adequately maintain the Facilities in good working order acceptable to the County and in accordance with the maintenance section of the Benton County Stormwater Design Manual. This includes all pipes, channels or other conveyances built to convey stormwater to treatment measures(s), as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater. Adequate maintenance is defined as maintaining the described facilities in good working condition as outlined in the OMP so that these facilities continue to operate as originally designed and approved.

Facilities designed and constructed under outside agency guidelines, requirements and permit conditions shall be maintained as required by those agencies. Outside agencies include (but are not limited to) Oregon Department of Environmental Quality, Oregon Department of State Lands, United States Army Corps of Engineers, Oregon Department of Fish & Wildlife, United States Fish & Wildlife and Oregon Department of Forestry. Documentation of compliance with applicable guidelines, requirements and permit conditions shall be provided in the Annual Inspection Report (see Section 4).

## SECTION 3: SEDIMENT MANAGEMENT

Sediment accumulation resulting from the normal operation of the Facilities as approved in **[---insert LU / BUILDING PERMIT / ESC / PCSWMP number(s)---]** will be managed appropriately by the Owner as outlined in the OMP. The Owner will provide for the removal and disposal of accumulated sediments as needed for

the proper functioning of the Facilities. Disposal of accumulated sediments shall not occur on the Property, unless otherwise agreed to in writing by the County. Any disposal or removal of accumulated sediments or debris shall be in compliance with all federal, state and local law and regulations.

## SECTION 4: ANNUAL INSPECTION REPORT AND RECORD KEEPING

The Owner shall, on an annual basis **[Note to preparer – may amend to a shorter period based on site and facility characteristics]**, complete the Stormwater Facility OMP checklist attached to this agreement as Exhibit 2. Written documentation of all inspections and maintenance activities as itemized in the OMP checklist shall be kept on file by the Owner and submitted to the County on an annual basis no later than the 1st of June of each calendar year. The documentation shall at a minimum include:

- Date and time of inspections and maintenance activities.
- Name of person(s) conducting the inspections and maintenance activities.
- Written narrative of observations and actions taken during inspections and maintenance activities.
- Identify the disposal location of any sediment, oils and/or greases collected from the facilities.
- Written statement of assurance that facilities are in properly functioning order with signature of authenticity.
- Proof of compliance with permitting by agencies other than Benton County

## SECTION 5: ACCESS TO PROPERTY

The Owner grants permission to the County; and its authorized agents and employees to enter the Property at reasonable times and in a reasonable manner to inspect, assess or observe the Facilities to ensure that the Facilities are being properly maintained and are continuing to perform as documented in the OMP, the original design and specifications, and as approved in **[---insert LU / BUILDING PERMIT / ESC / SWM number(s)]**. This includes the right to enter upon the Property when it has a reasonable basis to believe that a violation of this Agreement or applicable regulations or permits has occurred or threatens to occur. The County also has a right to enter the Property when, in its sole discretion, it deems it necessary for abatement of a public nuisance or correction of a violation of this Agreement. When possible, the County shall provide 24-hour notice to the Property Owner before entering the Property. The notice will not be necessary if emergency conditions require immediate remedial action. This provision shall not be construed to allow the County to erect any structure of a permanent nature on the Property. The County is under no obligation to maintain or repair the Facilities.

## SECTION 6: REPAIR AND MAINTENANCE OF FACILITIES

All aspects in which the Facilities fail to satisfy the OMP, the original design and specifications, and as approved in **[---insert LU / BUILDING PERMIT / ESC / SWM number(s)]**, shall be noted as "Deficiencies". The County shall determine whether Deficiencies need to be corrected. Owner will be notified in writing through the US Mail of the Deficiencies and shall make corrections within ninety (90) days of the date of the notice. All Deficiencies shall be corrected at owner's expense within ninety (90) days after completion of the inspection. If more than ninety (90) days is reasonably needed to correct a Deficiency, owner shall submit a request for approval by the Benton County Engineer. The County reserves the right to establish a date for when all corrections must be completed.

## SECTION 7: FAILURE TO CORRECT DEFICIENCIES

If correction of all Benton County identified Deficiencies is not completed within ninety (90) days after notification by the County, the County shall have the right to have any Deficiencies corrected. The County (i) shall have access to the Facilities for the purpose of correcting such Deficiencies and (ii) shall bill Owner for all costs reasonably incurred by the County for work performed to correct the Deficiencies (County Correction Costs). Owner shall pay the County Correction Costs within thirty (30) days of the date of the invoice. Owner understands and agrees that upon non-payment, the County may record a lien against the Property to secure the County Correction Costs plus interest and penalties. The actions described in this section are in addition to and not in lieu of any and all legal remedies as provided by law, available to the County as a result of the Property Owner's failure to maintain the Facilities.

## SECTION 8: AGREEMENT RUNS WITH LAND

The County and Owner declare their intent and agree that this Agreement shall be deemed a covenant running with the land and shall be binding upon and inure to the benefit of the heirs, administrators, executors, successors in interest, transferees, and assigns of the Owner and County, regardless of any assignment, conveyance or transfer of the Property or any part thereof or interest therein. Any successor-in-interest to the Owner including without limitation any purchaser or transferee shall be subject to all of the duties and obligations imposed by this Agreement for the full term of this Agreement (which is considered to be in perpetuity for as long as the Facilities shall exist or be required on the Property). Each and every contract, deed, ground lease or other instrument affecting or conveying any interest in the Property shall conclusively be held to have been executed, delivered and accepted subject to the covenants, restrictions, duties and obligations set forth herein regardless of whether the covenants, restrictions, duties and obligations are set forth in the contract, deed, ground lease or other instrument.

## SECTION 9: INDEMNIFICATION

The Owner shall indemnify, hold harmless and defend the County and its authorized agents, officers, officials and employees from and against any and all claims, demands, suits, damages, liabilities, losses, accidents, casualties, occurrences, claims and payments, including attorney fees claimed or which might arise or be asserted against the County that are alleged or proven to result or arise from the construction, presence, existence or maintenance of the Facilities by the Owner. In the event a claim asserted against the County or its authorized agents, officers, officials or employees shall be allowed, the Owner shall pay for all costs and expenses. This section shall not apply to any claims, demands, suits, damages, liabilities,

losses, accidents, casualties, occurrences, claims and payments, including attorney fees claimed which arise due solely to the negligence or willful misconduct of the County.

## SECTION 10: NO ADDITIONAL LIABILITY

It is the intent of this agreement to ensure the proper maintenance of the Facilities by the Owner; provided, however, that this Agreement shall not be deemed to create or affect any additional liability not otherwise provided by law of any party for damage alleged to result from or caused by stormwater runoff.

## SECTION 11: PERFORMANCE FINANCIAL ASSURANCE

In cases when there is a history or pattern of non-compliance by an Owner, the County may request the Owner to provide a performance bond, security or other appropriate financial assurance providing for the maintenance of the Facilities pursuant to the County's ordinances, guidelines, criteria or written direction.

## SECTION 12: SEVERABILITY

The provisions of this Agreement shall be severable and if any phrase, clause, section, subsection, paragraph, subdivision, sentence or provision is adjudged invalid or unconstitutional by a court of competent jurisdiction, or the applicability to any Owner is held invalid, this shall not affect or invalidate the remainder of any phrase, clause, section, subsection, paragraph, subdivision, sentence or provision of this Agreement, nor shall any waiver of any breach of any provision of this agreement be a waiver of any succeeding breach of the provision or a waiver of the provision itself or any other provision.

## SECTION 13: RECORDATION

This Agreement shall be recorded by the County in the Benton County deed records, and a copy of the recorded Agreement will be retained in the records of Benton County Public Works. The Owner shall reimburse the County for the costs incurred by the County to record the Agreement.

BENTON COUNTY, OREGON

By _____

**Gary Stockhoff, Benton County Public Works Director**

STATE OF OREGON )
) ss
County of _____ )

The above and foregoing was acknowledged before me this _____ day of _____, 20____, by _____

**Gary Stockhoff, Benton County Public Works Director**

Witness my hand and official seal.

_____

**Notary Public**

My Commission Expires: _____

_____

**Property Owner**

STATE OF OREGON )
) ss
County of _____ )

The above and foregoing was acknowledged before me this _____ day of _____, 20____, by _____.

**Property Owner**

Witness my hand and official seal.

_____

**Notary Public**

My Commission Expires: _____

# APPENDIX D
# OPERATIONS & MAINTENANCE PLAN (OMP)
# MINIMUM REQUIRED COMPONENTS

## OMP – Required Information

Effective Date
Map and Tax Lot
Road Name & Number

Original Owner's Name(s)
    Address – Phone # – Email Address
Inspector's Name(s)
    Certification # and Expiration Date
    Address – Phone # – Email Address
Impervious Area Treated (acres & square feet)
Inventory of the Type(s) of Treatment (if hybrid systems are employed, itemize each component separately)
Maintenance Cycle – Annual Timeline
Annual Reporting Requirements:

- Date and time of inspections and maintenance activities.
- Name, address, phone #, email, and certification # of responsible person(s) conducting the inspections and maintenance activities.
- Written narrative of observations and actions taken during inspections and maintenance activities.
- Identify the disposal location of any sediment, oils and/or greases collected from the facilities.
- Written statement of assurance that facilities are in properly functioning order with signature of authenticity.

## Facility Types & Treatments

The O&MP must itemize the function, maintenance and repair of the site's water quality and detention facilities, including but not limited to:

Connections to and Maintenance of Existing Systems
Catch Basins and Inlets
Storm Piping and Outlets
Treatment and/or Detention Swales
Treatment and/or Detention Ponds
Check Dams
Pervious Pavement
Vegetated Filtration Structures, Buffer Strips, and Stormwater Planters
Bio-Retention Basins
Rain Barrels and Rain Gardens
Downspout Treatment Boxes
Green/Eco Roofs
Sand Filters
Drywells and/or Infiltration Structures
Vegetation for All Facility Types & Treatments

**OMP Formatting**

I. Introduction

II. Background

III. Associated Agreements (attach for reference)

IV. Funding Source for and Organization of Facility Operation and Maintenance

V. Site Description

VI. Designation and Training of Responsible Individuals

VII. Facilities To Be Maintained

   a. Connection to and Maintenance of Existing Facilities (prior to development)

VIII. General Maintenance Rules

IX. Maintenance Activities

X. Maintenance Schedule

   a. Routine Activities

   b. Following Significant Rain Events

   c. Prior to Start of Wet Weather Months

   d. Annually During Winter

   e. Annually at End of Winter or Early Spring

XI. Vegetation Management

   a. Removal of Invasive Species

   b. Plant Mortality Assessment

   c. Replanting

   d. Pruning & Mowing

# APPENDIX E

## BENTON COUNTY RAINFALL INTENSITY- DURATION-FREQUENCY (IDF) CURVES FOR USE UNDER THE RATIONAL METHOD FOR ODOT ZONES 3, 4, 5, 7 & 8

SEE PDF VERSION