Camas Stormwater Design Standards Manual

Resolution #1193

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Chapter 1: General Requirements

1.01 Purpose

The purpose of the Camas Stormwater Design Standards Manual (CSDSM) is to identify stormwater management requirements for new development and redevelopment projects in accordance with Camas Municipal Code (CMC) Chapter 14.02.

Camas's National Pollutant Discharge Elimination System (NPDES) Phase II permit identifies stormwater management requirements for the City. One of the requirements is that the City must adopt the Stormwater Management Manual for Western Washington (Stormwater Manual; Department of Ecology 2005) or an equivalent. The City has elected to adopt the Stormwater Manual.

Local jurisdictions may modify or add to the Stormwater Manual requirements, as long as the requirements are equivalent to or stricter than the Stormwater Manual requirements. This manual supplements and clarifies sections of the Stormwater Manual to provide guidance for and tailor to local conditions. It does not repeat the contents of the Stormwater Manual, so both manuals must be consulted. If a topic or standard is not addressed in these design standards, refer to the Stormwater Manual for guidance.

Where portions of the Camas SDSM and the Stormwater Manual conflict, the requirements in the Camas SDSM apply. Where a provision of the CAMAS SDSM is not equivalently addressed in the Stormwater Manual the Camas SDSM provisions shall be deemed as a supplemental requirement.

Where provisions of the Camas SDSM conflict with other City Code, state, or federal requirements, the more stringent provisions apply, as determined by the Director.

1.02 Applicability

All new development and redevelopment activities shall refer to Figure 1.1 on the following page to determine the stormwater requirements that will apply to the project.

Figure 1.1: Flow Chart for Determining Stormwater Requirements

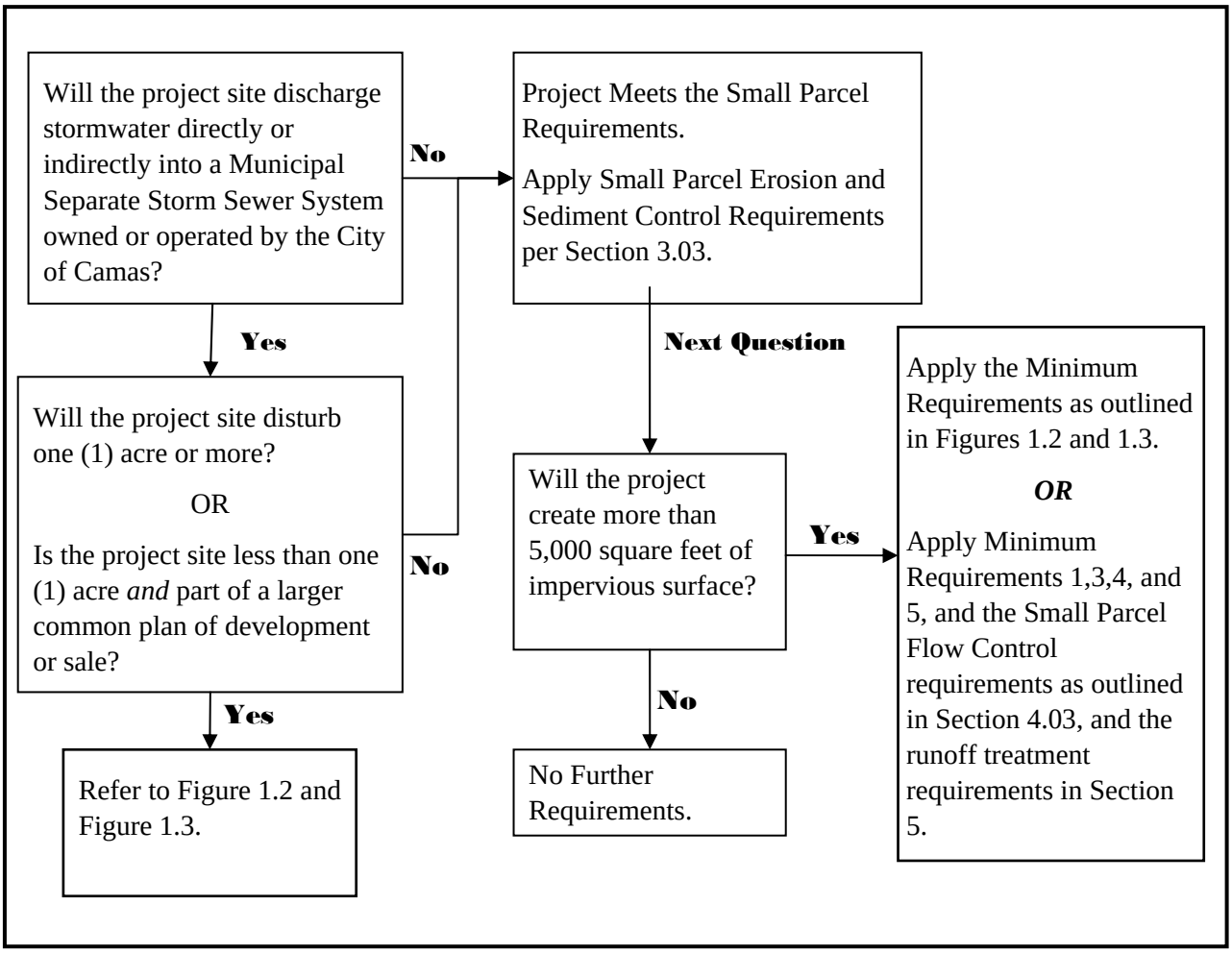


Figure 1.2: New Development Minimum Requirements Flow Chart

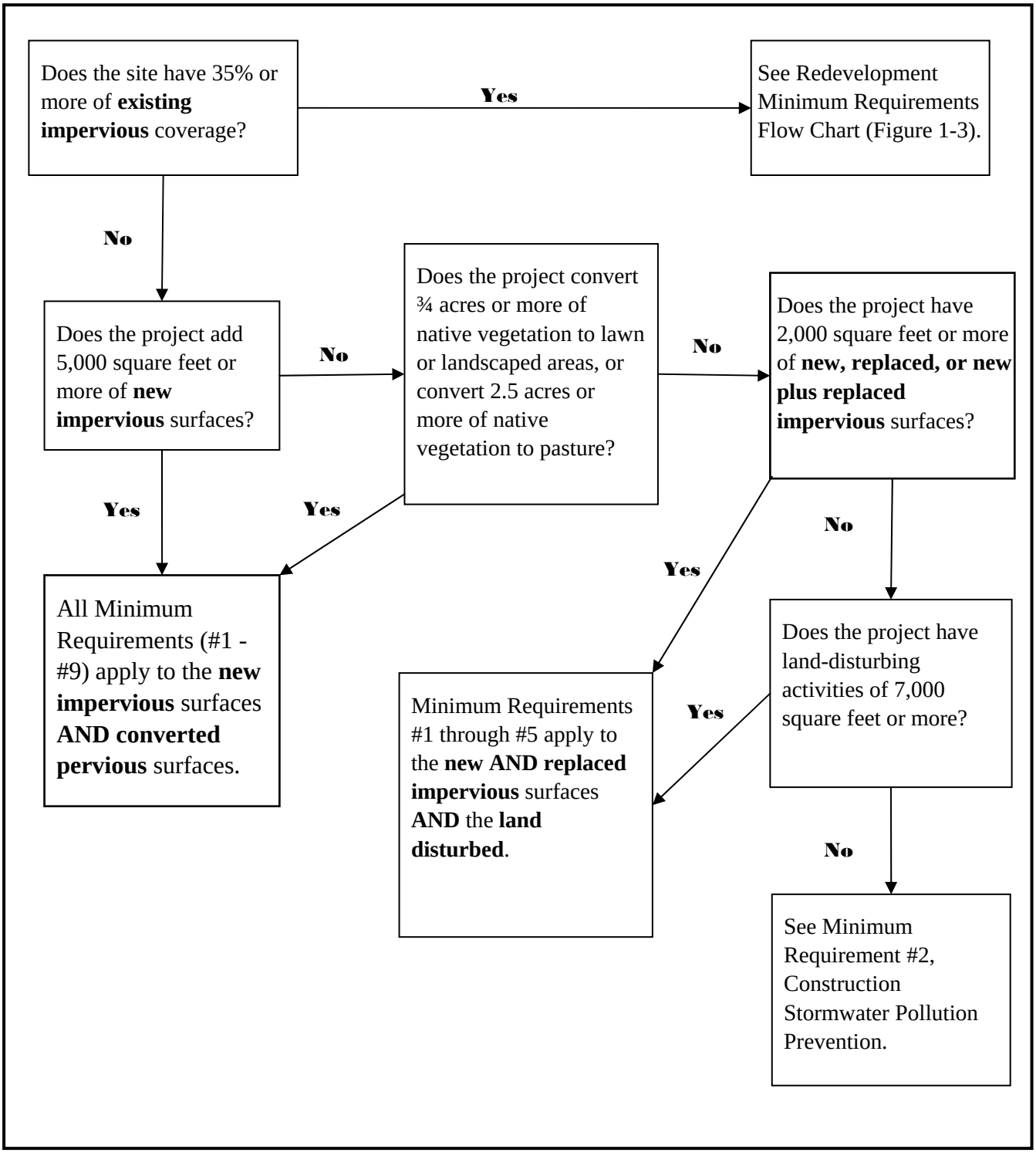
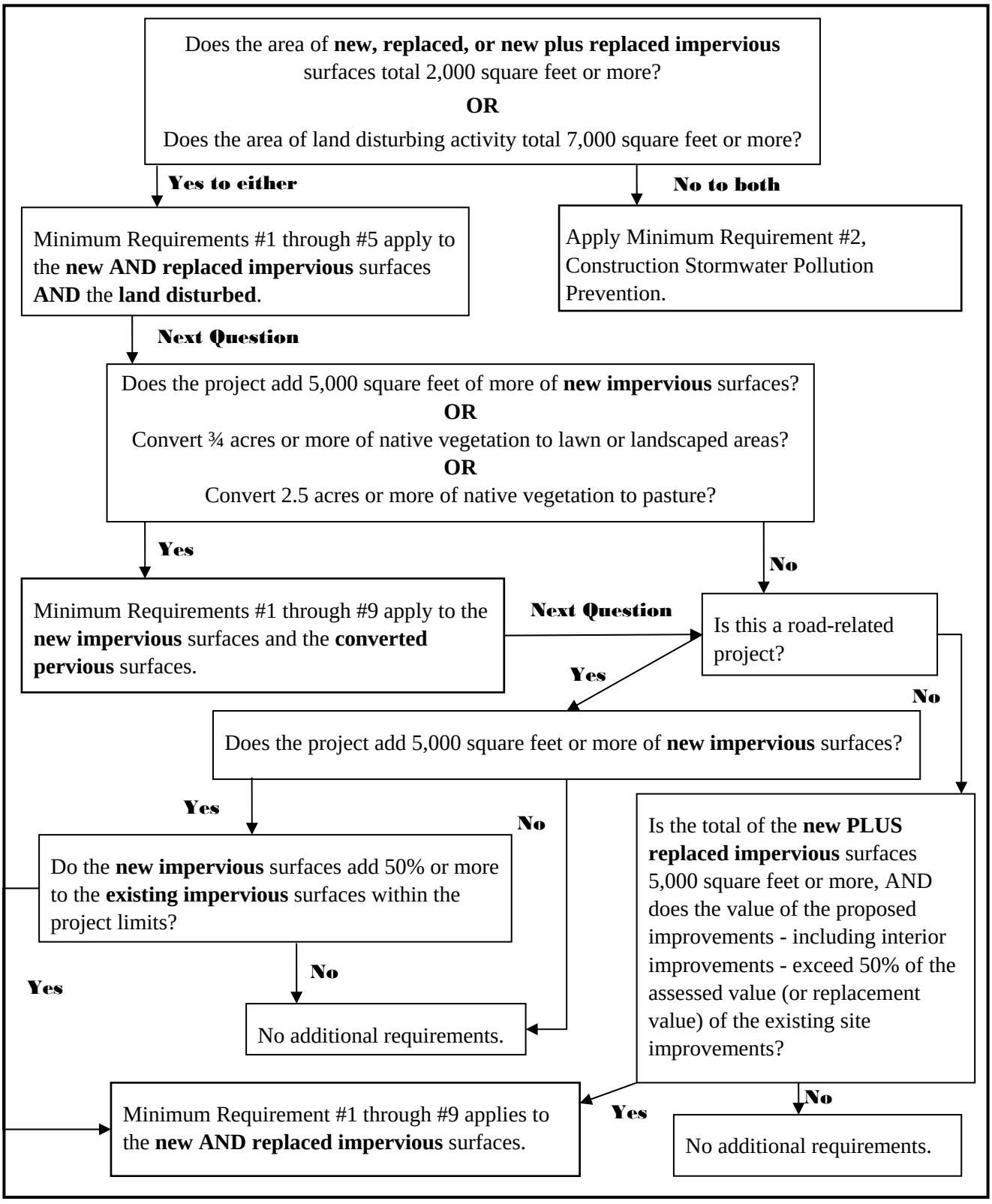


Figure 1.3: Redevelopment Minimum Requirements Flow Chart



Minimum Requirements that may apply to a new development or redevelopment activity include:

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention Plan
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems & Outfalls
5. On-site Stormwater Management
6. Runoff Treatment
7. Flow Control
8. Wetlands Protection
9. Operation and Maintenance

In addition to the applicable Minimum Requirements, all new underground injection control wells shall meet the requirements of the Washington State Department of Ecology Underground Injection Control (UIC) Program. Information regarding Ecology's requirements can be found on their website: http://www.ecy.wa.gov/programs/wq/grndwtr/uic/.

Projects that disturb less than one acre and are not part of a larger common plan of development or sale that will disturb one acre or more, but create more than 5, 000 square feet of impervious surface shall meet Minimum Requirements 1, 3, 4, and 5 and the Small Project requirements for erosion and sediment control, runoff treatment and quantity control as specified in Chapters 3, 4 and 5 of this manual, or shall meet the applicable minimum requirements as described in Figures 1.2 and 1.3, this manual and the Stormwater Manual.

1.03 Exemptions

Total Exemptions

The following types of projects are exempt from Camas Municipal Code 14.02 and this manual. Other state and federal requirements may apply.

1. Forest practices regulated under Title 222 Washington Administrative Code, except for Class IV General Forest practices that are conversions from timber land to other uses.
2. Commercial agricultural practices involving working the land for production. However, the conversion from timberland to agriculture and the construction of new impervious surfaces are not exempt.
3. Oil and gas field activities or operations, including construction of drilling sites, waste management pits, and access roads, as well as construction of transportation and treatment infrastructure such as pipelines, natural gas treatment plants, natural gas pipeline compressor

stations, and crude oil pumping stations. Operators are encouraged to implement and maintain best management practices to minimize erosion and control sediment during and after construction activities to help ensure protection of surface water quality during storm events.

4. The following road maintenance practices:
   a. Pothole and square cut patching.
   b. Overlaying existing asphalt or concrete pavement without expanding the area of coverage.
   c. Shoulder grading.
   d. Regrading/reshaping drainage systems.
   e. Crack sealing.
   f. Resurfacing with in-kind material without expanding the road prism.
   g. Vegetation management.

Partial Exemptions

The following types of projects are exempt from Camas Municipal Code 14.02 and this manual except as described:

1. Residential short plats of lots less than one acre that create less than 5,000 square feet of new impervious surface shall submit a stormwater plan limited to conveyance and disposal, and an Erosion and Sediment Control Plan as outlined in Chapter 3 of this manual.
2. The construction of single-family homes, duplexes, and their accessory structures are exempt from Minimum Requirements 6 through 9, provided the following conditions are met:
   a. The project site is included in a stormwater plan previously approved by the City.
   b. The stormwater plan provides for runoff treatment, and detention or retention of runoff from residential lots.
3. Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics shall be exempt from all of the Minimum Requirements except Minimum Requirement #2, Construction Stormwater Pollution Prevention.
4. Drainage Projects are exempt from Minimum Requirement #6, and the Director may also waive all or parts of Minimum Requirement 1, if the project meets the other appropriate parts of this chapter.
5. New development and redevelopment that meet the criteria in Appendix I-E (Flow

Control-Exempt Surface Waters) of the Stormwater Manual and all of the following criteria are exempt from Minimum Requirement 7 (Flow Control):

a. Project meets the exemption requirements (described in Volume I, Section 2.5.7 of the Stormwater Manual) for discharges to one of the following water bodies:
    - Columbia River
    - Lacamas Lake
    - Round Lake

b. Runoff is treated in accordance with Minimum Requirement 6 (Runoff Treatment).

c. The discharge structure is designed to avoid erosion during all storms up to the 100-year storm.

d. If an existing discharge structure is used the discharge structure and conveyance system leading to the discharge must have adequate capacity to meet the requirements of Chapter 7 (Conveyance Systems) of this manual.

1.04 Relationship to Other City of Camas Codes

1. CMC 16.53; Wetlands

   This section describes wetland buffer widths for stormwater facilities, requirements for locating stormwater facilities in buffers, and requirements for locating stormwater facilities in wetlands.

2. CMC 16.55; Critical Aquifer Recharge Areas (CARAs)

   This section describes allowable and restricted uses in CARAs, including limitations for the use of injection wells and dry wells. Contact City of Camas personnel to determine if the project site is within a CARA.

3. CMC 16.59; Geologically Hazardous Areas

   This section of code describes standards for geologically hazardous areas, including Erosion Hazard Areas, Landslide Hazard Areas, Seismic Hazard Areas, and other areas determined by the City to be susceptible to other geological events, including mass wasting, debris flows, rock falls, and differential settlement, as defined in CMC 16.59.020.

   See this section for requirements when locating detention facilities within 200 feet of the top of a Landslide Hazard Area.

4. CMC 16.61; Fish and Wildlife Habitat Conservation Areas

This section discusses requirements for placement of stormwater conveyance facilities in Habitat Conservation Areas.

5. CMC 17.19.040(C)3; Design and Improvement Standards; Storm Drainage

   This section provides general stormwater requirements, and it describes requirements for placement of storm drainage facilities on properties.

1.05 Basin Plans

As allowed by the City's permit, basin planning may be used by the City as an available option to tailor Minimum Requirement 6 Runoff Treatment, Minimum Requirement 7 Flow Control, and/or Minimum Requirement 8 Wetland protection. Basin planning may be used to support alternatives to treatment, flow control, and/or wetland protection contained in Section 4 of Appendix 1 of the City's NPDES permit. It may also be used to demonstrate an equivalent level of treatment, flow control, and/or wetland protection through the construction and use of regional stormwater facilities.

In order for a basin plan to serve as a means of modifying the minimum requirements, the following conditions must be met:

1. The plan must be formally adopted by all jurisdictions with responsibilities under the plan.
2. All ordinances or regulations called for by the plan must be in effect.
3. The basin plan must be reviewed and approved by the Washington State Department of Ecology.

1.06 Regional and Subregional Facilities

The City encourages multiple users of stormwater facilities. If regional or subregional facilities are used to meet some or all of the requirements for stormwater quality treatment and quantity control, the following conditions shall be met:

1. Stormwater runoff shall be transported from a project site to a regional/subregional facility through a pipe or manmade open channel conveyance system, or through a natural drainageway if approved by the Director.
2. If the regional/subregional facility does not yet exist, interim quantity control and treatment methods shall be used to meet the requirements of this chapter. All interim methods shall be reviewed and shall require written approval by the Director.
3. The facility must have sufficient capacity to meet applicable water quality treatment and/or quantity control requirements.

Chapter 2: Submittal Requirements

2.01 Introduction

A Stormwater Site Plan is a comprehensive plan and report containing all the technical information and analyses necessary for the City to evaluate proposed new development or redevelopment activities for compliance with stormwater requirements. The contents of the Stormwater Site Plan will vary with the type and size of the project and the individual site characteristics.

This section describes the submittal package that is required for projects within the City of Camas. Additional guidance on preparing a Stormwater Site Plan is contained in Volume I, Chapter 3 of the Stormwater Manual.

2.02 Erosion Prevention and Sediment Control Plan

An Erosion Prevention & Sediment Control Plan (EPSCP) is required for Small Parcels, as defined in Figure 1.1.

The plan shall be submitted to and approved by the City prior to demolition, street cuts, clearing, grading, filling or issuance of City permits. Items that are to be included in an EPSCP:

1. Existing and proposed contours for the site and adjacent properties.
2. Location of all existing drainage facilities and water resource features.
3. Identification of all sensitive lands including wetlands and steep slopes.
4. Areas of cuts and fills.
5. Site plan showing significant trees, as defined in Camas Municipal Code Section 18.62.030.
6. Existing and proposed structures.
7. Proposed erosion prevention and sediment control BMPs.

See Chapter 3 of this manual for more information on erosion control requirements.

2.03 Construction Stormwater Pollution Prevention Plan (SWPPP)

In accordance with Minimum Requirement 2, a Construction Stormwater Pollution Prevention Plan (SWPPP) is required for all project sites where the new, replaced, or new plus replaced impervious surfaces total 2,000 square feet or more or where 7,000 square feet or more of land is disturbed. The Construction SWPPP shall be submitted before undertaking any land-disturbing activity. The Construction SWPPP shall be stamped by an engineer licensed in the state of Washington and submitted with the final stormwater plan. Chapter 3 of this manual provides guidance for developing the Construction SWPPP.

The Construction SWPPP shall consist of two parts: a narrative and the drawings. The following two sections describe the contents of the narrative and the drawings.

Note that an NPDES Construction Site Stormwater Discharge permit is may still be required by the Washington Department of Ecology. Consult Ecology regulations to determine whether this permit is required.

Section A – Narrative

The narrative shall address the following:

1. Twelve (12) Elements – Describe how the Construction SWPPP addresses each of the 12 required elements (See Chapter 3 of this manual). Include the type and location of BMPs used to satisfy the required element. If an element is not applicable to a project, provide a written justification for why it is not necessary.
2. Project description - Describe the nature and purpose of the construction project. Include the total size of the area, any increase in existing impervious area; the total area expected to be disturbed by clearing, grading, excavation or other construction activities, including off-site borrow and fill areas; and the volumes of grading cut and fill that are proposed.
3. Existing site conditions - Describe the existing topography, vegetation, and drainage. Include a description of any structures or development on the parcel including the area of existing impervious surfaces.
4. Adjacent areas - Describe adjacent areas, including streams, lakes, wetlands, residential areas, and roads that might be affected by the construction project. Provide a description of the downstream drainage leading from the site to the receiving body of water.
5. Critical areas - Describe areas on or adjacent to the site that are classified as critical areas. Critical areas that receive runoff from the site shall be described up to ¼ mile away. The distance may be increased by the Director. Describe special requirements for working near or within these areas.
6. Soil - Describe the soil on the site, giving such information as soil names, mapping unit, erodibility, settle-ability, permeability, depth, texture, and soil structure.
7. Potential erosion problem areas - Describe areas on the site that have potential erosion problems.
8. Construction phasing - Describe the intended sequence and timing of construction activities and any proposed construction phasing.
9. Construction schedule - Describe the construction schedule. If the schedule extends into the wet season, describe what activities will continue during the wet season and how the transport of sediment from the construction site to receiving waters will be prevented.
10. Financial/ownership responsibilities - Describe ownership and obligations for the project.

Include bond forms and other evidence of financial responsibility for environmental liabilities associated with construction.

11. Engineering calculations – Attach any calculations made for the design of such items as sediment ponds, diversions, and waterways, as well as calculations for runoff and stormwater detention design (if applicable). Engineering calculations must bear the signature and stamp of an engineer licensed in the state of Washington.

12. A responsible, certified erosion control specialist shall be identified. Telephone and/or pager numbers should be included.

Section B – Drawings

1. Vicinity map - Provide a map with enough detail to identify the location of the construction site, adjacent roads, and receiving waters.

2. Site map - Provide a site map(s) showing the following features:

   a. A legal description of the property boundaries or an illustration of property lines (including distances) in the drawings.

   b. The direction of north in relation to the site.

   c. Existing structures and roads, if present.

   d. The boundaries of and label the different soil types.

   e. Areas of potential erosion problems.

   f. Any on-site and adjacent surface waters, critical areas, their buffers, FEMA base flood boundaries, and Shoreline Management boundaries.

   g. Existing contours and drainage basins and the direction of flow for the different drainage areas.

   h. Final and interim grade contours as appropriate, drainage basins, and the direction of stormwater flow during and upon completion of construction.

   i. Areas of soil disturbance, including all areas affected by clearing, grading and excavation.

   j. Locations where stormwater discharges to surface waters during and upon completion of construction.

   k. Existing unique or valuable vegetation and the vegetation that is to be preserved.

   l. Cut and fill slopes indicating top and bottom of slope catch lines.

   m. Stockpile, waste storage, and vehicle storage/maintenance areas.

   n. Total cut and fill quantities and the method of disposal for excess material.

3. Conveyance systems - Show on the site map the following temporary and permanent conveyance features:
   a. Locations for swales, interceptor trenches, or ditches.
   b. Drainage pipes, ditches, or cut-off trenches associated with erosion and sediment control and stormwater management.
   c. Temporary and permanent pipe inverts and minimum slopes and cover.
   d. Grades, dimensions, and direction of flow in all ditches and swales, culverts, and pipes.
   e. Details for bypassing off-site runoff around disturbed areas.
   f. Locations and outlets of any dewatering systems.
4. Location of detention BMPs - Show on the site map the locations of stormwater detention BMPs.
5. Erosion and Sediment Control (ESC) BMPs - Show on the site map all major structural and nonstructural ESC BMPs including:
   a. The location of sediment pond(s), pipes and structures.
   b. Dimension pond berm widths and inside and outside pond slopes.
   c. The trap/pond storage required and the depth, length, and width dimensions.
   d. Typical section views through pond and outlet structure.
   e. Typical details of gravel cone and standpipe, and/or other filtering devices.
   f. Stabilization technique details for inlets and outlets.
   g. Control/restrictor device location and details.
   h. Stabilization practices for berms, slopes, and disturbed areas.
   i. Rock specifications and detail for rock check dam, if used.
   j. Spacing for rock check dams as required.
   k. Front and side sections of typical rock check dams.
   l. The location, detail, and specification for silt fence.
   m. The construction entrance location and a detail.
6. Detailed drawings - Any structural practices used that are not referenced in this manual or other local manuals should be explained and illustrated with detailed drawings.
7. Other pollutant BMPs - Indicate on the site map the location of BMPs to be used for the control of pollutants other than sediment.
8. Monitoring locations - Indicate on the site map the water quality sampling locations, if

required by the Department of Ecology. Sampling stations shall be located in accordance with applicable permit requirements.

9. Notes addressing construction phasing and scheduling shall be included on the drawings.

2.04 Preliminary Stormwater Site Plan

In accordance with Minimum Requirement #1, a preliminary stormwater site plan is required for all new development and redevelopment projects that are not exempt from all Minimum Requirements (as described in Section 1.01). The purpose of the preliminary stormwater site plan is to allow the City to determine whether a proposal can meet the requirements of Camas Municipal Code Chapter 14.02.

The preliminary stormwater site plan shall be submitted with the land use application and shall consist of:

1. A preliminary development plan.

2. A preliminary Technical Information Report, bound, and prepared in the standardized format described in the sections below.

The preliminary stormwater site plan shall identify how stormwater runoff that originates on the site, or flows through the site, is currently controlled and how this will change with the proposed development or redevelopment project. If the site is within a region covered by a basin plan, the information needed in the preliminary stormwater site plan may be reduced.

The project engineer shall include a statement that all the required information is included in the preliminary stormwater site plan and that the proposed stormwater facilities are feasible. All plans, studies, and reports that are part of the preliminary and final stormwater site plans shall be stamped, signed and dated by the professional civil engineer(s), registered in the state of Washington, responsible for preparation of the report.

Modification of Content Requirements

The Director may waive in writing some or all of the content requirements in the preliminary stormwater plan if:

- The development project is included in an approved final stormwater plan that meets the requirements of this chapter; or
- A basin plan exists that makes some of the information irrelevant.
- The City determines, upon receipt of a letter of request from the applicant, that less information is required to accomplish the purposes of this chapter.

The waiver of some or the entire preliminary stormwater plan does not relieve the applicant of the requirement to prepare a final stormwater plan.

Preliminary Development Plan

The preliminary development plan shall consist of 22-inch x 34-inch or 24-inch x 36-inch drawings. The preliminary development plan shall show the character of the existing site and proposed features, including but not limited to:

1. Existing and proposed property boundaries, easements, and rights-of-way.
2. Existing and proposed contours with a 2-foot maximum contour interval, unless the Director determines a lesser interval is sufficient to show drainage patterns and basin boundaries.
3. Offsite areas contributing runoff to the site.
4. Natural and manmade drainage features adjacent to the site, including existing and proposed (if known) stormwater facilities.
5. Existing onsite water wells, known agricultural drain tiles, areas of potential slope instability, structures, utilities, and septic tanks and drain fields.
6. Location of the 100-year floodplain and floodways and shoreline management area limits on the site.
7. Existing water resource features on and adjacent to the site, including streams, wetlands, springs, sinks, and stormwater facilities.
8. Existing and proposed drainage flow routes for each threshold discharge area (TDA) to and from the site, including bypass flows.
9. Proposed location of structural source control BMPs implemented in accordance with Minimum Requirement 3 (Source Control of Pollution), where applicable.
10. Point of discharge locations from the proposed project site that preserve the natural drainage patterns and existing outfall locations, in accordance with Minimum Requirement 4 (Preservation of Natural Drainage Systems and Outfalls).
11. Areas of the project site where onsite stormwater management BMPs will be effectively implemented, in accordance with Minimum Requirement 5 (Onsite Stormwater Management), including low impact development BMPs. The plan must show the areas of retained native vegetation, required flow lengths, and vegetated flow paths for proper implementation of these BMPs.
12. All existing drainage facilities, including structural water quality or flow control BMPs and conveyance systems.
13. Existing and proposed pollution-generating pervious surfaces (PGPS), including lawn,

landscaped areas, and pasture areas.

14. Existing areas of the site predominantly covered by native vegetation (i.e., native trees, shrubs, and herbaceous plants as defined by the Washington State Department of Ecology (Ecology)) and areas of native vegetation to be preserved under proposed conditions.

15. Approximate location and size of proposed runoff treatment and flow control facilities implemented in accordance with Minimum Requirements 6 and 7.

16. The delineated wetland boundary (for sites that discharge stormwater to a wetland, either directly or indirectly through a conveyance system, and must meet Minimum Requirement 8, Wetlands Protection).

17. A conceptual grading plan that verifies the constructability of a stormwater facility (for sites with slopes greater than five percent).

18. The Director may require additional site or vicinity information if needed to determine the feasibility of the stormwater proposal.

Preliminary Technical Information Report (TIR)

The preliminary TIR shall be bound and contain all technical information and analyses necessary to determine that the proposed stormwater facilities are feasible. The required contents of the preliminary TIR are identified below.

Table of Contents

1. List of section headings and their respective page numbers.
2. List of tables with page numbers.
3. List of figures with page numbers.
4. List of attachments, numbered.
5. List of references.

Map Submittals

All maps shall contain a scale and north arrow.

1. **Vicinity Map:** All vicinity maps shall clearly show the project site.
2. **Soils Map**: The soils map shall show soils within the contributing area that drains to the site itself. Soils maps may be obtained from the following sources:
    a. Updated version of the Soil Survey of Clark County, Washington, originally published in 1972, and updated by the Natural Resources Conservation Service (NRCS).
    b. Geographic information system (GIS) maps of soils from Clark County GIS.

c. Washington soil survey data as available on the NRCS website (http://websoilsurvey.nrcs.usda.gov).

d. If the maps do not appear to accurately represent the soils for the site, the applicant is responsible for verifying the actual soils for the site.

3. **Other Maps**: The following additional maps shall be required in the situations noted:

a. Floodplains. If a floodplain mapped by the Federal Emergency Management Agency (FEMA) exists on or adjacent to the site, a map showing the floodplain is required.

b. Shoreline Management Area. If the site contains or is adjacent to a stream or lake regulated under the Washington Shorelines Management Act, a map showing the boundary of the shoreline management area in relation to the site is required.

Section A – Project Overview

1. Describe the site location.

2. Describe the topography, natural drainage patterns, vegetative ground cover, and presence of critical areas (CMC Title 16). Critical areas that receive runoff from the site shall be described to a minimum of ¼ mile away from the site boundary.

3. Identify and discuss existing onsite stormwater systems and their functions.

4. Identify and discuss site parameters that influence stormwater system design.

5. Describe drainage to and from adjacent properties.

6. Describe adjacent areas, including streams, lakes, wetland areas, residential areas, and roads that might be affected by the construction project.

7. Generally describe proposed site construction, size of improvements, and proposed methods of mitigating stormwater runoff quantity and quality impacts.

Section B – Minimum Requirements

Describe the land-disturbing activity and document the applicable minimum requirements for the project site. Include the following information in table format:

1. The amount of existing impervious surface.

2. The amount of new impervious surface.

3. The amount of replaced impervious surface.

4. The amount of native vegetation converted to lawn or landscaping.

5. The amount of native vegetation converted to pasture.

6. The total amount of land-disturbing activity.

Provide a statement that confirms the minimum requirements that will apply to the development activity. For land-disturbing activities where Minimum Requirements 1 through 9 must be met:

1. Provide the amount of effective impervious area in each TDA, and document through an approved continuous runoff simulation model (e.g., the Western Washington Hydrologic Model (WWHM) or MGS Flood) the increase in the 100-year flood frequency from pre-developed to developed conditions for each TDA.
2. List the TDAs that must meet the runoff control requirements listed in Minimum Requirement 6.
3. List the TDAs that must meet the flow control requirements listed in Minimum Requirement 7.
4. List the TDAs that must meet the wetlands protection requirements listed in Minimum Requirement 8.

Section C – Soils Evaluation

1. Describe the site's suitability for stormwater infiltration for flow control, runoff treatment, and LID measures.
2. Identify water table elevations, flow directions (where available), and data on seasonal water table fluctuations with minimum and maximum water table elevations where these may affect stormwater facilities.
3. Identify and describe soil parameters and design methods for use in hydrologic and hydraulic design of proposed facilities.
4. Report findings of testing and analysis used to determine the infiltration rate.
5. Where unstable or complex soil conditions exist that may significantly affect the design of stormwater facilities, the Director may require a preliminary soils report that addresses stormwater design considerations arising from soil conditions. The preliminary soils report shall be prepared by a registered professional engineer proficient in geotechnical investigation and engineering or a registered soil scientist. The preliminary soils report shall include a soils map developed using the criteria set in the NRCS National Soil Survey Handbook (NRCS 2007) and the SCS Soil Survey Manual (SCS 1993), at a minimum scale of 1:5,000 (12.7 inch/mile).

Section D – Source Control

If the development activity includes any of the activities listed in Section 2.2 of Volume IV of the Stormwater Manual, identify the source control BMPs to be used with the land-disturbing activity.

Section E – Onsite Stormwater Management BMPs

1. On the preliminary development plan or other maps, show the site areas where onsite stormwater management BMPs will be effectively implemented. (See Volume III, Chapter 3 and Volume V, Chapter 5 of the Stormwater Manual.) The plan must show the areas of retained native vegetation and required flow lengths and vegetated flow paths, as required for proper implementation of each onsite stormwater BMP. Arrows must show the stormwater flow path to each BMP.
2. Identify and describe geotechnical studies or other information used to complete the analysis and design of each onsite stormwater BMP.
3. Identify the criteria (and their sources) used to complete analyses for each onsite stormwater BMP.
4. Describe how design criteria will be met for each proposed onsite stormwater management BMP.
5. Describe any onsite application of LID measures planned for the project. Provide a plan that shows the proposed location and approximate size of each LID facility.
6. Identify and describe any assumptions used to complete the analysis.
7. Describe site suitability, including hydrologic soil groups, slopes, area of native vegetation, and adequate location of each BMP.

Section F – Runoff Treatment Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement 6 indicate that runoff treatment facilities are required:

1. Document the level of treatment required (basic, enhanced, phosphorus, oil/water separation), based on procedures in Volume V, Chapter 2 of the Stormwater Manual and Chapter 5 of this manual.
2. Provide background and description to support the selection of the treatment BMPs being proposed. Include an analysis of initial implementation costs and long-term maintenance costs.
3. Identify geotechnical or soils studies or other information used to complete the analysis and design.
4. Identify the BMPs used in the design, and their sources.
5. Summarize the results of the runoff treatment design, and describe how the proposed design meets the requirements of CMC Chapter 14.02 and the Stormwater Manual.
6. Provide a table that lists the amount of pollution-generating pervious surfaces (PGPS) and pollution-generating impervious surfaces (PGIS).

Section G – Flow Control Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement 7 indicate that flow control facilities are required:

1. Identify the site's suitability for stormwater infiltration for flow control, including tested infiltration rates, logs of soil borings, and other information.
2. Identify and describe geotechnical or other studies used to complete the analysis and design.
3. If infiltration cannot be provided for flow control, provide the following additional information:
    a. Identify the areas where flow control credits can be obtained for dispersion, LID, or other measures, per the requirements in the Stormwater Manual.
    b. Provide the approximate sizing and location of flow control facilities for each TDA, per Volume III of the Stormwater Manual.
    c. Identify the criteria (and their sources) used to complete the analyses, including pre-developed and post-developed land use characteristics.
4. For sites considered to be historical prairie, submit a project site report prepared by a wetland scientist or horticulturist experienced in identifying soils, plant, and other evidence associated with historic prairies to demonstrate the existence of historic prairie on the project site. Areas within Camas that were historically prairie include Fern and Lacamas prairies. Contact City staff for a map showing potential prairie locations.
5. Complete a hydrologic analysis for existing and developed site conditions, in accordance with the requirements of Chapter 4 of this manual and Chapter 2, Volume III of the Stormwater Manual, using an approved continuous runoff simulation model. Compute existing and developed flow durations for all subbasins. Provide an output table from the continuous flow model.
6. Include and reference all hydrologic computations, equations, graphs, and any other aids necessary to clearly show the methodology and results.
7. Include all maps, exhibits, graphics, and references used to determine existing and developed site hydrology.

Section H – Wetlands Protection

For projects with stormwater discharges to a wetland, either directly or indirectly through a conveyance system, the preliminary TIR shall describe wetland protection measures to be implemented in accordance with Minimum Requirement 8. The narrative shall describe the

measures that will maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

2.05 Final Stormwater Plan

Purpose

In accordance with Minimum Requirement 1, the final stormwater plan provides final engineering design and construction drawings for the stormwater aspects of a proposed new development or redevelopment project. The final stormwater plan shall be submitted and approved by the Director before construction of the development can begin.

Modification of Content Requirements

The Director may waive in writing some or all of the content requirements in the final stormwater plan if:

- The development project is included in an approved final stormwater plan that meets the requirements of this chapter; or
- A basin plan exists that makes some of the information irrelevant.

Final Stormwater Plan Submittal

The final stormwater plan submittal shall include the following:

1. Any easements, covenants, or agreements necessary to permit construction.
2. Final engineering plans that provide sufficient detail to allow construction of the stormwater facilities. These plans shall be stamped, signed, and dated by the engineer(s), registered in the state of Washington, responsible for hydrologic, hydraulic, geotechnical, structural and general civil engineering design and by the project engineer responsible for the preparation of the final stormwater plan. The final engineering plan shall show all utilities to ensure that conflicts between proposed utility lines do not exist.
3. The approved preliminary stormwater site plan, with an explanation of any differences between the design concepts included in the preliminary and final stormwater plans.
4. A final development plan (which may be a part of the final engineering plans or a separate plan). See the requirements identified below.
5. A bound copy of the final technical information report (TIR). See the requirements identified below.
6. The EPSCP or SWPPP prepared in accordance with Section 2.02 or 2.03.

Final Development Plan

The final development plan shall be consistent with the preliminary development plan and may be combined with the final engineering plans. In addition to the information required in the preliminary development plan, the final plan requires the following information:

1. Threshold discharge area (TDA) delineations, and total impervious and pervious area delineations and acreages by TDA.
2. The acreage of pollution-generating pervious surfaces (PGPS) and pollution-generating impervious surfaces (PGIS) used in the hydraulic/hydrologic calculations both onsite and offsite that contribute surface runoff.
3. Directions and lengths of overland, pipe, and channel flow.
4. Outfall points from each TDA and overflow routes for the 100-year storm.
5. Onsite conveyance systems, including pipes, catch basins, channels, ditches, swales, and culverts.
6. Primary flow path arrows for drainage under developed conditions, with the calculated flow rates. Cross-reference the flow rates to the hydrological model output file used to calculate the flow rates.
7. The Director may require additional site or vicinity information if needed to determine the feasibility of the stormwater proposal.

Final Technical Information Report (TIR)

The final TIR shall be a bound, comprehensive report, supplemental to the final engineering plans, that contains all technical information and analyses necessary to complete final engineering plans based on sound engineering practices and appropriate geotechnical, hydrologic, hydraulic, and water quality design.

The final TIR shall be stamped, signed, and dated by the professional engineer(s), registered in the state of Washington, responsible for the hydrologic, hydraulic, geotechnical, structural and general civil engineering design.

The required contents of the final TIR, which is part of the final stormwater plan, are identified below.

Table of Contents

See the preliminary TIR requirements in Section 2.04.

Map Submittals

See the preliminary TIR requirements in Section 2.04.

Section A – Project Overview

Provide the information from the preliminary TIR, with the following additional elements:

1. Reference the conceptual design proposed in the preliminary stormwater plan.
2. Identify revisions to the conceptual design contained within the final engineering plans.

Section B – Minimum Requirements

Provide the information from Section B of the preliminary TIR, revised as necessary for the final design. Confirm the applicable minimum requirements identified in the preliminary TIR. For land-disturbing activities where Minimum Requirements 1 through 9 must be met, provide the required information listed in Section B of the preliminary TIR, revised to reflect the final design.

Section C – Soils Evaluation

See the preliminary TIR requirements in Section 2.04.

Section D – Source Control

See the preliminary TIR requirements in Section 2.04.

Section E – Onsite Stormwater Management BMPs

Provide the information from the preliminary TIR, with the following additional elements:

1. Reference the conceptual design proposed in the preliminary stormwater plan.
2. Identify revisions to the conceptual design contained within the final engineering plans.
3. For bioretention systems, provide the following:
    a. The proposed soil matrix for the facility.
    b. The planting plan, listing proposed plant types and locations.
    c. Detail drawings, including the following:
        - If an underdrain is used, show drain rock, pipe, and filter fabric specifications.
        - All stormwater piping associated with the facility, including catch basin, pipe materials, sizes, slopes, and invert elevations.
        - Rain garden width, length, side slopes, and maximum design water depth.
        - Irrigation system, if installed.
        - Designs for any retaining walls proposed. Structural walls shall meet city building permit requirements.
4. For porous pavements:

a. Supporting design calculations showing adequate infiltration rates to accommodate flows from all impervious surfaces directed onto any porous pavement.

b. Geotextile specification.

c. Base material gradation.

d. Asphalt mix design and void calculations.

e. Acceptance test procedures.

f. Detail drawings, including the following:

- Geotextile
- Base material
- Asphalt layer

5. Reversed slope sidewalks:

a. Details on the planting plan for any areas receiving water from reversed slope sidewalks.

Section F – Runoff Treatment Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement 6 indicate that runoff treatment facilities are required, provide the information from the preliminary TIR, with the following additional elements:

1. Reference the conceptual runoff treatment design proposed in the preliminary stormwater plan.

2. Identify revisions to the conceptual runoff treatment design contained in the preliminary stormwater plan.

3. Complete a detailed analysis and design of all proposed runoff treatment system elements, in accordance with Chapter 5 of this manual and Volume V of the Stormwater Manual. Reference runoff treatment system elements to labeled points shown on the site location map or final development plan.

4. Include and reference all computations, equations, charts, nomographs, detail drawings, and other tabular or graphic aids used to design water quality system elements in the technical appendix.

5. Summarize the results of the runoff treatment design and describe how the proposed design meets the requirements of CMC Chapter 14.02 and the Stormwater Manual.

Section G - Flow Control Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement 7 indicate that flow control facilities are required:

1. Identify revisions to the conceptual design proposed in the preliminary stormwater plan.
2. Identify initial conditions, including stream base flows, beginning water surface elevations, hydraulic or energy grade lines, initial groundwater elevations, beginning storage volumes, and other data or assumptions used to complete the analyses of initial conditions. Reference the sources of information.
3. Describe any assumptions used to complete the analysis, including flow credits through the use of onsite stormwater BMPs or LID measures.
4. Complete a detailed hydrologic analysis for existing and developed site conditions, in accordance with the requirements of Chapter 2, Volume III of the Stormwater Manual, using an approved continuous runoff simulation model. Compute pre-developed and developed flow durations for all subbasins. Provide an output table from the continuous flow model, including the following:
    a. Flow rates for the 2-, 10-, and 100-year return periods for pre-developed and developed conditions.
    b. A table listing the pass/fail rates for each flow level where duration statistics were calculated.
    c. A graph showing the flow rate on the y axis and percent time exceeding on the x axis for pre-developed conditions and post-developed mitigated conditions, from 50 percent of the 2-year flow rate through the 50-year flow rate.
5. Provide a hydraulic analysis of pipes and/or channels that lead to and/or from the outlet structure. The analysis should confirm the capacity of pipes and channels to convey the peak flow rates for the 2-, 10-, 50-, and 100-year return period flow rate with the water surface elevation of the pond at the elevation for those return period flow rates.
6. Submit electronic copies of the WWHM (.wdm, .prj, .usi) project files to allow reviewers to run the model and confirm the model results.
7. Refer to labeled points shown on the site location map and development plan.
8. Include and reference all hydrologic and hydraulic computations, equations, rating curves, stage/storage/discharge tables, graphs, and any other aids necessary to clearly show the methodology and results.
9. Include all maps, exhibits, graphics, and references used to determine existing and developed site hydrology.

Flow Control System Plan

1. Provide an illustrative sketch of the flow control facility and its appurtenances.
2. Show basic measurements necessary to confirm storage volumes.

3. Show all orifice, weir, and flow restrictor dimensions and elevations.

4. The sketch shall correspond with final engineering plans. Alternatively, a final site grading plan that incorporates the above information may be included as an attachment to the final stormwater plan.

5. Provide electronic copies of the drawings used for analysis, measurement, and design inputs for the hydrologic analysis submitted with the final drawing in one of the following approved file formats: Portable Document Format (.pdf), or AutoCAD (.dwg, .dxf).

Section H – Wetlands Protection

For projects with stormwater discharges to a wetland, either directly or indirectly through a conveyance system, the TIR shall describe wetland protection measures to be implemented in accordance with Minimum Requirement 8. The narrative shall describe the measures that will maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

Section I – Other Permits

Construction of roads and stormwater facilities may require additional permits from other agencies. These permits may contain requirements that affect the design of the stormwater system. This section lists the titles of other possible required permits, the agencies that require the permits, and the permit requirements, if known, that affect the final stormwater plan. Approved permits that are critical to the feasibility of the stormwater facility design shall be included in this section.

1. Underground injection control (UIC) well registration: DOE. Proposed public UIC wells shall receive Washington State Department of Ecology UIC Program rule authorization prior to civil plan approval. Provide a copy of the authorization during the plan review process. A copy of the registration application will be accepted if rule authorization notification has not been received from Ecology within 60 days of application for well registration.

Section J – Conveyance Systems Analysis and Design

1. Reference the conceptual drainage design proposed in the preliminary stormwater plan.

2. Identify revisions to the conceptual drainage design contained in the preliminary stormwater plan.

3. Identify the criteria used to complete the analyses and their sources.

4. Identify and discuss initial conditions, including stream base flows, beginning water surface elevations, hydraulic or energy grade lines, beginning storage elevations, and other data or assumptions used to complete the analyses of initial conditions. Reference the sources of information.

5. Describe any assumptions used to complete the analyses.

6. Complete a detailed hydraulic analysis of all proposed collection and conveyance system elements and existing collection and conveyance elements, including outfall structures and outlet protection, that influence the design or are affected by the proposal, in accordance with Chapter 7 (Conveyance Systems) of this manual. Compute and tabulate the following:

   a. Identify design flows and velocities and conveyance element capacities for all conveyance elements within the development.

   b. Identify the 10 year recurrence interval stage for detention facility outfalls (See Chapter 7). Provide stage-frequency documentation from the continuous runoff model.

   c. Compute existing 100-year floodplain elevations and lateral limits for all channels, and verify no net loss of conveyance or storage capacity from development.

   d. Reference conveyance system elements to labeled points shown on the site location map or development plan.

   e. Verify the capacity of each conveyance system element to convey design flow and discharge at non-erosive velocities. Verify the capacity of the onsite conveyance system to convey design flows that result from ultimate build-out of upstream areas.

   f. Include and reference all hydraulic computations, equations, pipe flow tables, flow profile computations, charts, nomographs, detail drawings, and other tabular or graphic aids used to design and confirm the performance of conveyance systems.

   g. Summarize the results of system analyses, and describe how the proposed design meets the requirements of this chapter.

Section K – Off-site Analysis

If applicable, provide the results of an offsite analysis prepared in accordance with Chapter 9 (Offsite Analysis and Mitigation) of this manual. (See exemptions in Chapter 9.)

Section L – Approval Conditions Summary

List each preliminary approval condition related to stormwater control, wetlands, floodplains, and other water-related issues, and explain how the final design addresses or conforms to each condition.

Section M – Special Reports and Studies

Where site-specific characteristics, such as steep slopes, wetlands, and sites located in wellhead protection areas, present difficult drainage and water quality design problems, the Director may require additional information or the preparation of special reports and studies that further address the specific site characteristics, the potential for impacts associated with the development, and the measures that would be implemented to mitigate impacts. Special reports

shall be prepared by professionals with expertise in the particular area of analysis, who shall date, sign, stamp, and otherwise certify the report. Subjects of special reports may include, but are not be limited to:

1. Geotechnical
2. Wetlands
3. Floodplains and Floodways
4. Groundwater
5. Structural Design
6. Fluvial Geomorphology (erosion and deposition)

All special reports and studies shall be included in the technical appendix.

Section N – Maintenance and Operations Manual

The project engineer shall prepare maintenance and operations manual for each stormwater control or treatment facility to be privately maintained, and for those that constitute an experimental system to be maintained by the City. The manual shall be written in an orderly and concise format that clearly describes the design and operation of the facility. The manual shall also provide an outline of required maintenance tasks; with the recommended frequencies each task should be performed. The manual shall contain or reference procedures from the Stormwater Manual.

If the site has media filtration systems, the manual shall clearly describe a long-term plan for maintaining these facilities, including who will provide the maintenance and how it will be funded.

Technical Appendix

The TIR shall contain a technical appendix that includes all computations completed in the preparation of the TIR, together with copies of referenced data, charts, graphs, nomographs, hydrographs, stage-storage discharge tables, maps, exhibits, and all other information required to clearly describe the stormwater flow control and runoff treatment design for the proposed development activity. The format of the technical appendix shall follow as closely as possible the section format of the TIR and shall be adequately cross-referenced to ensure that the design may be easily followed, checked, and verified. The technical appendix shall also contain all special reports and studies, other than those included as attachments to the TIR.

2.06 Stormwater Plan Changes

If the designer must make changes or revisions to the final stormwater plan after final approval, the proposed revisions shall be submitted to Camas prior to construction. The submittals shall include the following:

1. Substitute pages for the originally approved final stormwater plan, identifying the proposed changes.
2. Revised drawings, showing any structural changes.
3. Any other supporting information that explains and supports the reason for the change.
4. A compliance letter from the planning department that no plat amendment is required.

All revisions shall be stamped, signed, and dated by the professional engineer(s), registered in the state of Washington, responsible for hydrologic, hydraulic, geotechnical, structural and general civil engineering design.

Chapter 3: Erosion and Sediment Control

3.01 Applicability

All projects must provide erosion and sediment control per CMC 14.06. Projects that meet the Small Parcel requirements per Figure 1.1 shall follow the standards in Section 3.03. Projects that do not meet the Small Parcel Standards are required to follow the standards in the Stormwater Manual, outlined in Minimum Requirement 2, except as revised by this chapter.

If a SWPPP is required, a copy shall be provided for review to the City of Camas.

3.02 Construction SWPPP Requirements

The Construction SWPPP shall include a narrative and drawings. The narrative shall include documentation to explain and justify the pollution prevention decisions made for the project.

All BMPs shall be clearly referenced in the narrative and marked on the drawings.

Construction SWPPP Elements

Each of the 12 elements below shall be included in the Construction SWPPP, unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the Construction SWPPP. Note that these elements shall be followed in place of the elements listed in Section 2.5.2 of the Stormwater Manual.

1. Preserve Vegetation/Mark Clearing Limits
    a. Prior to beginning land-disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area.
    b. The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum degree practicable.
2. Establish Construction Access
    a. Construction vehicle access and exit shall be limited to one route, if possible.
    b. Access points shall be stabilized with quarry spalls, crushed rock, or other equivalent BMP to minimize the tracking of sediment onto public roads.
    c. Wheel wash or tire baths shall be located onsite if the stabilized construction entrance is not effective in preventing sediment from being tracked onto public roads.
    d. If sediment is tracked offsite, roads shall be cleaned thoroughly at the end of each day or more frequently during wet weather. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area.

e. Street washing is allowed only after sediment is removed in accordance with 2.d. above. Street wash wastewater shall be controlled by pumping back onsite or otherwise be prevented from discharging into systems tributary to waters of the state.

f. Construction entrances that have become ineffective shall be reconstructed or replaced.

3. Control Flow Rates

a. Properties and waterways downstream from development sites shall be protected from erosion resulting from increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site.

b. Where necessary to comply with 3.a. above, stormwater retention or detention facilities shall be constructed as one of the first steps in grading. Detention facilities shall be functional prior to construction of site improvements (e.g., impervious surfaces).

c. If permanent infiltration ponds are used for flow control during construction, these facilities should be protected from siltation during the construction phase in accordance with the project SWPPP, including but not limited to temporary sedimentation ponds.

4. Install Sediment Controls

a. Stormwater runoff from disturbed areas shall pass through a sediment pond or other appropriate sediment removal BMP prior to leaving a construction site or prior to discharge to an infiltration facility. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but shall meet the flow control performance standard of 3.a, above.

b. Sediment control BMPs (sediment ponds, traps, filters, etc.) shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land-disturbing activities take place.

c. BMPs intended to trap sediment onsite shall be located in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages.

5. Stabilize Soils

a. Exposed and unworked soils shall be stabilized by application of effective BMPs that prevent erosion.

b. No soils shall remain exposed and unworked for more than the time periods set forth below to prevent erosion:

i. During the dry season (July 6th – September 30): 7 days.

ii. During the wet season (October 1 – July 6th): 2 days.

c. Soils shall be stabilized at the end of the shift and before a holiday or weekend if needed, based on the weather forecast.

d. Soil stockpiles shall be stabilized from erosion, protected with sediment trapping measures, and, where possible, located away from storm drain inlets, waterways, and drainage channels.

6. Protect Slopes

a. Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion.

b. Offsite stormwater (run-on) or groundwater shall be diverted away from slopes and undisturbed areas with interceptor dikes, pipes and/or swales. Offsite stormwater shall be managed separately from stormwater generated on the site.

c. At the top of slopes, drainage shall be collected in pipe slope drains or protected channels to prevent erosion. Temporary pipe slope drains shall handle the expected peak 10-minute flow velocity from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate predicted by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis shall use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis shall use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If the Western Washington Hydrology Model is used to predict flows, bare soil areas shall be modeled as “landscaped area.”

d. Excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.

e. Check dams shall be placed at regular intervals within constructed channels that are cut down a slope.

7. Protect Drain Inlets

a. Storm drain inlets made operable during construction shall be protected so stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.

b. Inlet protection devices shall be cleaned or removed and replaced when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

8. Stabilize Channels and Outlets

a. All temporary onsite conveyance channels shall be designed, constructed, and stabilized to prevent erosion from the following expected peak flows. Channels shall handle the expected peak 10-minute flow velocity from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate predicted by an approved continuous runoff model, increased by a factor of 1.6,

may be used. The hydrologic analysis shall use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis shall use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If the Western Washington Hydrology Model is used to predict flows, bare soil areas shall be modeled as "landscaped area."

b. Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches shall be provided at the outlets of all conveyance systems.

9. Control Pollutants

a. All pollutants, including waste materials and demolition debris, that occur onsite shall be handled and disposed of in a manner that does not cause contamination of stormwater.

b. Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health or the environment. Onsite fueling tanks shall include secondary containment.

c. Maintenance, fueling, and repair of heavy equipment and vehicles shall be conducted using spill prevention and control measures. Contaminated surfaces shall be cleaned immediately following any spill incident.

d. Wheel wash or tire bath wastewater shall be discharged to a separate onsite treatment system or to the sanitary sewer with local sewer district approval.

e. Application of fertilizers and pesticides shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' label requirements for application rates and procedures shall be followed.

f. BMPs shall be used to prevent or treat contamination of stormwater runoff by pH-modifying sources. These sources include, but are not limited to: bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, dewatering concrete vaults, concrete pumping and mixer washout waters. Construction site operators are required to adjust the pH of stormwater if necessary to prevent violations of water quality standards.

g. Construction site operators shall obtain written approval from the City and the Department of Ecology prior to using chemical treatment other than CO2 or dry ice to adjust pH.

10. Control Dewatering

    a. Foundation, vault, and trench dewatering water, which have similar characteristics to stormwater runoff at the site, shall be discharged into a controlled conveyance system prior to discharge to a sediment trap or sediment pond.

    b. Clean, non-turbid dewatering water, such as well-point ground water, can be discharged to systems tributary to or directly into surface waters of the state, as specified in 8, above, provided the dewatering flow does not cause erosion or flooding of receiving waters. Clean dewatering water shall not be routed through stormwater sediment ponds.

    c. Other dewatering disposal options may include: (i) infiltration; (ii) transport offsite in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters; (iii) onsite chemical treatment or other suitable treatment technologies approved by the county; (iv) sanitary sewer discharge with local sewer district approval, if there is no other option; or (v) use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

    d. Highly turbid or contaminated dewatering water shall be handled separately from stormwater.

11. Maintain BMPs

    a. All temporary and permanent erosion and sediment control BMPs shall be inspected, maintained, and repaired as needed to ensure continued performance of their intended function in accordance with BMP specifications.

    b. All temporary erosion and sediment control BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed.

12. Manage the Project

    a. Development projects shall be phased to the maximum degree practicable and shall take into account seasonal work limitations.

    b. Construction site operators shall maintain, and repair as needed, all sediment and erosion control BMPs to ensure continued performance of their intended function.

    c. Construction site operators shall periodically inspect their sites. Site inspections shall be conducted by a Certified Erosion and Sediment Control Lead who shall be identified in the Construction SWPPP and shall be present onsite or on call at all times.

    d. Construction site operators shall maintain, update, and implement their Construction SWPPP. Construction site operators shall modify their Construction SWPPP whenever there is a change in design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state.

3.03 Small Parcel Erosion and Sediment Control Requirements

The following erosion/sediment control measures are required for small parcels:

1. Only construction vehicles are allowed off-street and must be utilized only on gravel construction access areas.
2. Workers' personal vehicles shall be parked on adjacent streets or other approved areas.
3. All unworked and exposed soils must be stabilized by seeding, covering, or mulching from the curb line to at least ten feet from the building envelope.
4. Pre-grade all sidewalk areas receiving runoff from the subject lot and stabilize for use as sediment traps.
5. Gravel drives used as site entrances shall be constructed of minimum two-inch diameter gravel and no finer materials are allowed.
6. Construction materials such as lumber shall be delivered and stored on designated locations which are stabilized and protected from erosion.
7. Each owner, builder, or permit holder shall install and maintain inlet protection on street storm drain inlets downslope from their site.
8. Erosion control measures shall be reviewed and inspected at the end of each day. In nonwork periods, inspections shall take place after each rainfall or at least once a week, whichever is more frequent. Needed corrections shall be made immediately.

3.04 Sediment Trap and Temporary Sediment Pond Sizing

For sediment traps and temporary sediment ponds, it is acceptable to use an approved continuous runoff model to calculate the design flows, Q2 and Q10, as follows:

Sediment Trap

Q2 = design inflow (cfs) based on the 2-year flow rate (1-hour time step in an approved continuous runoff model) for the developed (unmitigated) site, multiplied by a factor of 1.3. The 10-year peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. Q10 is the 10-year flow rate (1-hour time step in an approved continuous runoff model) for the developed (unmitigated) site, multiplied by a factor of 1.6.

Temporary Sediment Pond Sizing

Q2 and Q10 are the same as those used for **Sediment Trap,** above.

If using a continuous runoff model to design the principal spillway, Q10 is the 10-year flow rate (1-hour time step) for the developed (unmitigated) site, multiplied by a factor of 1.6.

If using a continuous runoff model to design the emergency spillway, the 100-year flow is the 100-year flow rate (1-hour time step) for the developed (unmitigated) site, multiplied by a factor of 1.6.

Note that single event models can also be used for sizing these facilities. See the Stormwater Manual for further information.

Chapter 4: Flow Control and Infiltration Systems

4.01 Applicability

Projects must provide flow control to reduce the impacts of stormwater runoff from impervious surfaces and land cover conversions per the applicability thresholds in Chapter 1. That portion of any development project in which the thresholds are not exceeded in a Threshold Discharge Area shall apply On-site Stormwater Management BMPs in accordance with Minimum Requirement 5.

4.02 Flow Control

1. Refer to Volume I, Chapter 2.5.7 of the Stormwater Manual to fulfill Minimum Requirement 7.
2. Flow control facilities, with the exception of UIC wells, shall use Volume III of the Stormwater Manual for design requirements.
3. Runoff discharges from all new development and redevelopment sites shall follow Minimum Requirement Number 4.
4. Infiltration is the preferred BMP if site conditions are appropriate and groundwater quality will not be impaired. All applicable discharges to groundwater shall comply with the requirements of the Washington State Department of Ecology Underground Injection Control Program and the City's CARA ordinance.
5. To insure the standards in this chapter are met, the volume available for storing runoff in a stormwater facility shall be reduced by seasonal high groundwater and/or ordinary high water unless a liner and buoyancy calculations are provided for the facility.
6. Residential and commercial structures meeting the requirements in Chapter 3.1, Volume III of the Western Washington Manual shall direct roof runoff to roof downspout control systems.
7. All facilities shall provide emergency overflow routes for storm events that exceed the design capacity of the facility.
8. The Western Washington Hydrology Model (WWHM) and MGS Flood are currently the only continuous simulation hydrologic models approved for use by the City of Camas.
9. See Section 4.06 (Infiltration Systems) of this manual for infiltration requirements in Camas.
10. Closed depression analysis shall be performed as required in Chapter 2.4 of Volume III of the Western Washington Manual. See Section 4.06 of this manual for more information.

4.03 Flow Control – Small Parcel Requirements

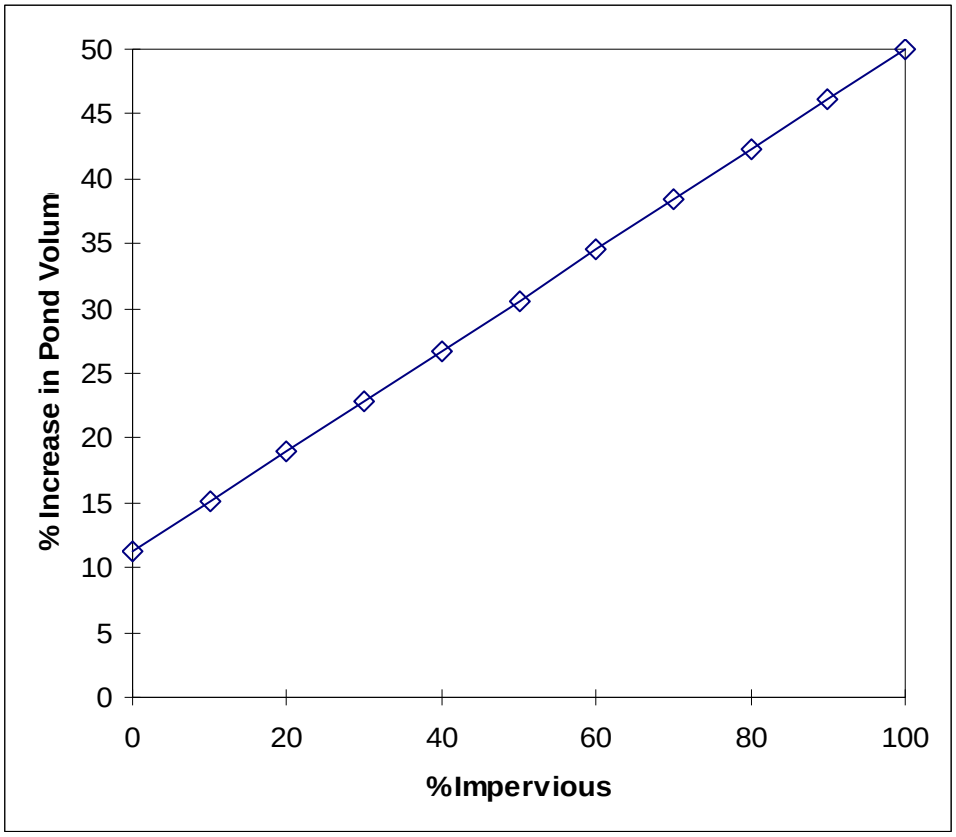
New development, redevelopment, and construction site activities that meet the Small Parcel Requirements as outlined in Figure 1.1 shall design flow control facilities using the following methods:

1. Projects shall utilize the Santa Barbara Unit Hydrograph (SBUH) method for hydrologic analysis and the level pool routing method for facility sizing.
2. Projects must limit the peak rate of runoff from individual development sites as follows:
   a. The peak release rate for the 2-year design storm after development shall not exceed one-half the pre-developed 2-year design storm peak runoff rate.
   b. The peak release rate for the 10- and 100-year design storms after development shall not exceed the respective pre-developed design storm peak runoff rates.
3. The pre-developed land cover shall be the existing land cover present at the time of development.
4. A correction factor shall be applied to the detention facility depending on project site impervious cover. The correction factor can be determined from Figure 4.1or from the following equation:

   Multiplication Factor = (composite runoff curve number/46) - 0.6

   This correction factor is to be applied to the volume of the pond without changing its depth or the design of its outlet structure, which shall result in an increase in surface area.
5. A Soil Conservation Society (SCS) Type 1A rainfall distribution resolved to a maximum of 10-minute time intervals shall be used. This distribution can be found in Appendix A.
6. Time of Concentration shall be calculated as described in Section 4-4.6.2 of the Washington Department of Transportation's Highway Runoff Manual. "n" and "k" values used in the equations may be found in Appendix A.
7. Isopluvial maps used for analysis shall be "Isopluvial Maps for Design Storms in Clark County," as published in National Oceanic and Atmospheric Administration (NOAA) Atlas 2, "Precipitation - Frequency Atlas for the Western United States," Volume IX, Washington. These isopluvial maps are included in Appendix A.
8. Curve numbers used for analysis shall be as specified in Appendix A.
9. Soil groups used for analysis shall be as defined in the most current version of "Hydrologic Soil Groups for Soils in Clark County," published by the SCS. Alternatively, hydrological soil groups from the United States Department of Agriculture (USDA) "Web Soil Survey" can be used, or soil groups can be developed by a Registered Soil Scientist. These hydrologic soils groups can be found in Appendix A.

Figure 4.1: Pond Volume Correction Factor



4.04 Retrofit of Existing Flow Control Facilities

This procedure is to be used for a new project site where flow control requirements are to be met using a pond that was originally designed using a peak flow control standard and single-event methodology. The original flow control release rates for the existing pond are to be added to the flow control targets for the new project. If the existing detention facility is not sized sufficiently for the new flow targets, the pond size will need to be revised.

Step 1:

Estimate the predevelopment target peak flows for the existing drainage area tributary to the facility. Use the same predevelopment land covers that were originally approved for designing the pond. Do not include the area from the new project. Use the SBUH method to determine the target peak flows of the following:

- ½ of the predevelopment peak flow of a 2-year, 24-hour storm.
- The predevelopment peak flow of a 10-year, 24-hour storm.
- The predevelopment peak flow of a 100-year, 24-hour storm.

Step 2:

Estimate the predevelopment runoff flows for the new project site. The pre-developed land cover requirements of this manual shall be used for determining the pre-development flows. The pre-development runoff flows of interest are:

- ½ of the peak flow of a 2-year, 24-hour storm.
- The peak flow of a 2-year, 24-hour storm.
- The peak flow from a 10-year, 24-hour storm.

Restricted Variable Assumptions

1. The flow path length assumed for sheet flow runoff in the pre-developed condition calculations shall not be less than 300 feet.

2. The Manning's effective roughness coefficient for pre-developed forested conditions shall be 0.8. For pasture conditions, the coefficient shall be 0.15.

Curve numbers for pre-developed forest and pasture conditions shall be selected from the "fair" category.

Step 3:

Determine the regulatory target flows by summing the flows of Steps 1 and 2, as follows:

Step 1		Step 2		Regulatory Target Flows
½ the 2-year	+	½ the 2-year	=	the target control level for the 2-year post-development peak flow
10-year	+	2-year	=	the target control level for the 10-year post-development peak flow
100-year	+	10-year	=	the target control level for the 100-year post-development peak flow

Step 4:

Determine the post-development flows of the entire drainage area for the 2-year, 24-hour storm; the 10-year, 24-hour storm; and the 100-year, 24-hour storm. For existing land areas not proposed for improvement, use the same land covers and flow routing assumptions that were used in the original design. For the land that is proposed for improvement in the project, use the proposed land covers.

Step 5:

Using the existing detention basin and discharge structure, determine whether the post-development flows of Step 4 are controlled to the regulatory target flows in Step 3.

Step 6:

If the existing detention basin and discharge structure do not meet the regulatory target flows, modify the detention basin volume and/or the discharge structure until the targets are achieved.

Volume correction factor: If the pre-developed condition of the project site was modeled as pasture, the cubic foot increase in the detention volume of Step 4 must be increased by the percentage indicated in the y-axis in Figure 4.1. The percent impervious land cover of the x-axis pertains only to the project site.

4.05 Flow Control Facilities: Side slopes, Fencing, and Setbacks

Side slopes

1. Interior side slopes shall be 3:1 or flatter, or constructed with retaining walls.
2. Exterior side slopes steeper than 3:1 are allowed if it is demonstrated that the facility can be adequately maintained. Long-term erosion control shall be provided and an approved maintenance plan is required.
3. Use of retaining walls in stormwater facilities taller than four feet requires approval of the Director. The height of the wall shall be measured from the bottom of the footing to the top of the wall.
4. The City may grant a deviation from the side slope standards when the Director determines that the safety, health, and welfare of the public will not be compromised.

Fencing

Fences shall be required under the following conditions:

1. For all ponds with retaining walls 24-inches or higher (measured from the top of wall to the pond bottom),
2. Where a pond interior side slope is steeper than 3H:1V.
3. Where there is an adjacent or nearby (within two blocks) facility that provides care for the elderly or persons with disabilities including but not limited to Alzheimer's, dementia or vision impairment.
4. On school sites, parks and playgrounds where needed to comply with safety standards developed by the Department of Health (DOH) and the Superintendent for Public Instruction (SPI). These standards include what is called a 'non-climbable fence'. One example of a nonclimbable fence is a chain-link fence with a tighter mesh, so children cannot get a foot-hold for climbing.
5. Where a permanent pool is present, unless a 5-foot wide safety bench is provided above the permanent pool elevation, and side slopes are 4:1 or flatter.

Fences may be required in other instances as determined by the Director.

Other fencing requirements:

1. Fences shall be a minimum of 42 inches high, of such materials that would effectively prevent entry by small children, and complying with local permitting authority requirements (such as building codes).
2. Fences installed along public rights-of-way and adjoining public spaces shall be of "see-through" construction or materials, such that a person could not effectively hide behind the fence.
3. The use of other types of barriers (e.g. shrubs, split rail fences) or no barriers, are allowed for slopes flatter than 3H:1V, except near the areas described in Numbers 3 and 4 above.
4. Where less than 10 percent of the pond perimeter have side slopes steeper than 3:1, split rail fences (3-foot minimum height) or densely planted thorned hedges (e.g., barberry, holly, etc.) may be used.
5. Other materials meeting the requirements listed above may be used for fencing with prior approval by the director.

5. Gates are required for vehicle access and shall be a minimum of 16-feet wide.

Setbacks

Flow control facilities shall be setback as follows:

1. Per CMC 17.19.030(F) from streets and accessory structures.
2. At least 10-feet from neighboring property lines.
3. Per Washington Department of Health regulations for distances from septic system drainfields.
4. At least 50-feet from slopes 15 percent or steeper, unless a geotechnical analysis and report is prepared that includes an assessment of impoundment seepage on the stability of the natural slope. This report must be signed and stamped by an engineer with geotechnical expertise licensed in the state of Washington.
5. At least 100-feet from any well head.
6. A geotechnical analysis and report must be prepared for detention facilities located within 200 feet of the top of a Landslide Hazard Area. This report must include the assessment of impoundment seepage on the stability of the natural slope. This report must be signed and stamped by an engineer with geotechnical expertise licensed in the state of Washington.
7. Infiltration facilities shall also follow the setbacks in Section 4.15 of this manual.

Access

1. Access roads shall use the following design guidelines:
    a. Maximum grade of 15 percent.
    b. Outside turning radius of 40 feet minimum.
    c. Minimum of 15 feet wide on curves and 12 feet wide on straight sections.
    d. Constructed with asphalt, compacted gravel, or a similar all-weather surface receiving prior approval for use from the Director.
2. Access road must be paved between the abutting street and the gate.
3. Access to the bottom of the facility must be provided, unless otherwise approved by the Director, and sufficient evidence is provided that required access and maintenance can be accomplished from the perimeter.
4. Access per this section must be provided to the flow control structure and the emergency overflow structure.

4.06 Closed Depressions

Closed depressions require careful assessment of the existing hydrologic performance in order to evaluate the impacts of a proposed project. A calibrated continuous flow model must be used for close depression analysis.

Infiltration rates used in the analysis of closed depressions must be determined according to the procedures in Section 3.3 of the Stormwater Manual, and per this manual. A minimum of four infiltration tests must be performed to establish an average surface infiltration rate.

Closed depressions must first be modeled with the predevelopment site to determine the return frequency at which flooding first occurs and the water levels associated with return frequencies in excess of this frequency. Proposed detention facilities for the project site shall be sized such that discharge from the post-development site does not increase water surface levels for the frequencies at which flooding occurs, up to a 100-year event.

4.07 Infiltration Systems

Stormwater infiltration systems can be used for flow control and runoff treatment where appropriate. Infiltration facilities for flow control are used to convey stormwater runoff into the ground after appropriate treatment. Infiltration facilities for treatment purposes rely on the soil profile to provide treatment.

The following sections describe applicable regulations, soil testing requirements, and general design methodology for new infiltration facilities used for flow control in Camas. Refer to the

Stormwater Manual and the latest edition of Ecology's "Guidance for UIC Wells that Manage Stormwater" for additional information and requirements for infiltration facilities.

4.08 Other Applicable Infiltration Regulations

Washington State Department of Ecology Underground Injection Control Program

Some infiltration facilities are classified as Underground Injection Control (UIC) wells. UIC wells include drywells and perforated pipes and are regulated under Department of Ecology's UIC Program (WAC 173-218).

The two basic requirements of the UIC Program are registration of new UIC wells with the Washington State Department of Ecology and protection of groundwater from pollution associated with stormwater runoff.

1. Registration: UIC wells are required to be registered with Washington State Department of Ecology. Registration information can be found on Ecology's website: http://www.ecy.wa.gov/programs/wq/grndwtr/uic/registration/reginfo.html

2. Non-endangerment Standard: New UIC wells are required to meet a non-endangerment standard ensuring discharges from a UIC well will not contaminate groundwater. Department of Ecology's guidelines for meeting this standard are found in "Guidance for UIC Wells that Manage Stormwater". This guidance shall be followed for UIC installation. The guidance has requirements for minimum depth to groundwater, as well as siting and installation requirements. It also lists activities that are prohibited from using UIC wells. This document may be found at the following web site: http://www.ecy.wa.gov/pubs/0510067.pdf

   Proposed public UIC wells must receive Washington State Department of Ecology UIC Program rule authorization prior to civil plan approval. Provide a copy of the rule authorization during the plan review process. A copy of the registration application will be accepted if rule authorization notification has not been received from Ecology within 60 days of application for well registration.

   Private UIC wells are also required to meet WAC 173-218 and register with Ecology prior to construction. The City will require verification of Ecology's authorization of a proposed private infiltration facility or a demonstration by the applicant that the UIC facility will meet Ecology's water quality standards prior to civil plan approval.

   When UIC regulations conflict with City of Camas requirements, the regulations that are more protective as deemed by the Director shall apply.

Aquifer Recharge Areas - Camas Municipal Code 16.55

Camas Municipal Code 16.55.070(B), which is the City's Critical Aquifer Recharge Area (CARA) ordinance, prohibits dry wells in Critical Aquifer Recharge Areas. See CMC 16.55 for more information and contact City staff to determine if the project site is in a CARA.

4.09 Infiltration Investigation

Proper evaluation of soils is critical to the placement and design of infiltration facilities. A detailed soils report is required where infiltration systems, or LID practices that utilize infiltration, are proposed. This report shall characterize the soil profile, the infiltration rate of the soil and the depth to ground water. At a minimum, this report shall follow the content guidelines provided in Section 4.2 of the *SWWASCE Infiltration Standards.* The report shall be signed and stamped by a geotechnical engineer registered in the state of Washington.

Subsurface characterization shall be conducted to a depth of at least six-feet below the proposed facility base elevation, or lower if recommended by the geotechnical engineer.

Subsurface characterizations and infiltration testing shall be conducted at the proposed depth and location of the proposed system.

4.10 Groundwater Monitoring

A minimum of one groundwater monitoring well shall be installed in each proposed infiltration facility location, unless the highest groundwater level is demonstrated to be at least 15 feet, or 5 feet for sites smaller than one acre, below the proposed facility. These wells shall be installed and monitored during at least one wet season within three (3) years prior to the date of final approval.

The City may require additional testing, monitoring or groundwater mounding analysis in areas of known high groundwater or poor infiltration rates.

4.11 Groundwater Mounding

A groundwater mounding analysis shall be required if:

- The depth to either the seasonal groundwater table or a low permeability soil stratum is less than five (5) feet from the infiltration facility bottom; or
- If recommended by the geotechnical professional.

If the seasonal high groundwater level is less than 15 feet from the bottom of the proposed facility and a groundwater mounding analysis is not being performed, the geotechnical engineer

shall provide a discussion in the soils report explaining the rationale for not conducting the analysis.

4.12 Infiltration Testing Methods

The Single-Ring Falling Head Infiltration Test outlined in Section 4.1 of the *SWWASCE Infiltration Standards* is allowed for determining infiltration rates in Camas. Other acceptable test methods include:

1. The Pilot Infiltration Test (PIT) outlined in Volume III, Chapter 3 of the Stormwater Manual.
2. The USDA Soil Textural Classification and the ASTM Gradation Testing correlations provided in Chapter 3 of Volume III of the Stormwater Manual. In general these correlations provide conservative long-term infiltration rates; however, the presence of cemented, lithified, or indurated materials may make the use of these correlations unconservative. Therefore, these correlations should only be used if a registered professional engineer or engineering geologist proficient in geotechnical engineering has evaluated the site soils and deemed these correlations appropriate for the site.
3. The alternative Auger Borehole Falling-Head Infiltration Test method outlined in Section 4.1.6, Alternative Test Methods, of the *SWWASCE Infiltration Standards* may be used where explorations are conducted by advancing borings, as opposed to test pits.
4. Field test methods, such as the open test pit method discussed in 4.1.7 Specialized Testing for Unique Sites of *SWWASCE Infiltration Standards*, may be used only if the other test methods described above are not feasible or practical.

Regardless of the test methodology utilized, the Infiltration Investigation shall follow the guidelines outlined in Section 4.1, Field Test Methods, of the *SWWASCE Infiltration Standards* regarding frequency, location, and depth of testing; soil classification and testing; high groundwater characterization; and groundwater mounding analysis.

A final report shall be prepared in conformance with Section 4.2, Infiltration Investigation Report, of the *SWWASCE Infiltration Standards.*

Infiltration Testing Frequency

A minimum of one infiltration test shall be conducted at each proposed infiltration facility location.

4.13 Infiltration Design Rates

The design infiltration rate shall be determined by dividing the calculated coefficient of permeability or tested infiltration rate (depending on the testing method) by the appropriate correction factor. However, if the USDA Soil Textural Classification and the ASTM Gradation

Testing correlations are used, then no correction factors are utilized as those correlations provide factored long-term infiltration rates.

The following table (Table 4-1) shall be used to determine the total correction factors to obtain design infiltration rates for infiltration facilities. The maximum allowed design infiltration rate is 250 inches/hour.

Table 4-1: Coefficient of Permeability Correction Factors

Design Condition	Correction Factor (CF)
Base Correction Factor	
The base correction factor is meant to account for soil variability and long-term system degradation due to siltation, crusting, or other factors.	2
Soils Correction Factor	
Additive correction factor recommended by a geotechnical professional as a result of soil or groundwater conditions	As recommended by geotechnical professional
System Design Correction Factors	
If the infiltration facility serves a basin with an impervious area greater than two acres and less than five acres	Add ½
If the infiltration facility serves a basin with an impervious area greater than five acres	Add 1
Infiltration facilities in closed depressions	Add 2
If a sacrificial system is provided and left operational following permanent site stabilization	Subtract ½

Total CF = Base CF + Soils CF + System Design CF
When using WWHM, the Infiltration Reduction Factor is 1/CF.

4.14 Infiltration Design Guidelines

Infiltration Facilities designed for flow/quantity control shall be sized per the Stormwater Manual. An overflow route must be identified in the event that capacity is exceeded. Any runoff in excess of infiltration capacity shall also comply with the Flow Control requirement if applicable. If the overflow route is a piped connection facility to surface water, then the facility shall be modeled with WWHM or MGS Flood and meet the applicable Flow Control requirements.

Infiltration calculations for drywells and perforated pipe trench systems shall follow the recommendations outlined in Section 5.3, Infiltration Calculations for Selected Facilities, of the *SWWASCE Infiltration Standards.*

Public infiltration trenches shall have structures for access and maintenance on both ends of infiltration piping systems, with a minimum of either a drywell or manhole on one pipe end.

4.15 Infiltration Facility Setbacks

The base of infiltration facilities shall be a minimum of five feet above seasonal high water or an impermeable layer and meet Washington State Department of Ecology Underground Injection Control Rules water quality standards. A separation down to three (3) feet may be considered if the groundwater mounding analysis, the volumetric water holding capacity, and the design of an overflow and/or bypass structure is adequate to prevent overtopping and meet the site suitability criteria specified in the Stormwater Manual.

Infiltration facilities (except residential roof downspout systems) shall be set back a minimum of 20 feet down slope or 100 feet up slope from a building foundation.

Written justification from an appropriate qualified professional shall be submitted to and approved by the City to reduce these setbacks. Setback reductions shall also meet other applicable local, state and federal requirements.

Refer to the Stormwater Manual and the local building code for residential roof downspout systems.

4.16 Infiltration Construction Observation and Confirmation Testing

The completed facility must be tested and monitored to demonstrate that the facility performs as designed. If the tested coefficient of permeability determined at the time of construction is at least 90 percent of the uncorrected coefficient of permeability used to determine the design rate, construction shall be allowed to proceed. If the tested rate does not meet this requirement, the applicant shall submit an additional testing plan to the City that follows the requirements in Chapter 2 of this manual. This plan shall address steps to correct the problem, including additional testing and/or resizing of the facility to ensure that the system complies with the provisions of this chapter.

Chapter 5: Runoff Treatment

5.01 Applicability

Runoff from Pollution Generating Impervious Surfaces (PGIS) or Pollution Generating Pervious Surfaces (PGPS) shall be treated per the applicability thresholds in Chapter 1. That portion of any development project in which the PGIS or PGPS thresholds are not exceeded in a threshold discharge area shall apply On-site Stormwater Management BMPs in accordance with Minimum Requirement 5.

5.02 General Requirements

1. All sites with direct discharges to surface waters shall comply with the following state laws: The Water Pollution Control Act (Chapter 90.48 RCW) and Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC).

2. Treatment of runoff from sidewalks, separated bike paths, roofs, fenced fire lanes, and infrequently used maintenance access roads is not required if the stormwater drains away from pollution generating surfaces. Runoff from these surfaces that mix with runoff from pollution generating surfaces will require treatment.

3. Phosphorus treatment is required in the Lacamas watershed above the dam at the south end of Round Lake, for all development sites exceeding one (1) acre in size. All water leaving the site during the water quality design storm shall be treated.

4. Projects that meet the Small Parcel Requirements as defined in Figure 1.1 are exempt from the enhanced treatment requirements as defined in Volume V of the Western Washington Manual.

5. Proprietary media filtration systems shall be designed and installed per the manufacturer’s specifications and shall be easily accessible for maintenance and replacement.

5.03 Treatment Facility Sizing

Treatment BMPs shall be sized to capture, hold and treat the water quality design storm and shall be sized based on the following:

1. Water Quality Design Storm Volume

   The volume of runoff predicted from a 24-hour storm with a six-month return frequency shall be used to size wetpool facilities. This volume is determined using single-event hydrology and the NRCS curve number equations as described in Volume III, Chapter 2 of the Stormwater Manual and Chapter 4 of this manual. This storm shall be assumed to be 70 percent of the 2-year, 24-hour storm. Alternatively, the 91st percentile, 24-hour runoff volume indicated by a continuous runoff model may be used.

2. Water Quality Design Storm Flow Rate

   a. For projects that are required to comply with Minimum Requirement 6: the flow rate at or below which 91 percent of the runoff volume, as estimated by a continuous runoff model, will be treated.

   b. For Small Projects as defined in Figure 1.1, the flow rate predicted from a 24-hour storm with a six-month return frequency (a.k.a., 70 percent of the 2-year, 24-hour storm).

   c. Downstream of detention facilities the water quality design flow rate must be the full two-year release rate from the detention facility.

5.04 Treatment-Type Thresholds

Oil Control: Treatment to achieve Oil Control applies to "high-use" sites. High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:

1. An area of a commercial or industrial site subject to an expected Average Daily Traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area.
2. An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil.
3. An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).
4. A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Phosphorus Treatment: The requirement to provide phosphorous control is determined by the City, or the Washington State Department of Ecology (e.g., through a waste load allocation).

Phosphorus treatment is required in the Lacamas watershed above the dam at the south end of Round Lake, for all development sites exceeding one (1) acre in size. All water leaving the site during the water quality design storm shall be treated.

Enhanced Treatment: Enhanced treatment for reduction in dissolved metals is required for the following project sites that discharge to fish-bearing streams, lakes, or to waters or conveyance systems tributary to fish-bearing streams or lakes:

1. Industrial project sites.
2. Commercial project sites.
3. Multi-family project sites.
4. High AADT roads as follows:
    a. Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more.
    b. All other roads with an AADT of 7,500 or greater.

However, such sites listed above that discharge directly (or, indirectly through a municipal storm sewer system) to Basic Treatment Receiving Waters as specified in Volume I, Appendix I-C of the Stormwater Manual, and areas of the above-listed project sites that are identified as subject to Basic Treatment requirements, are also not subject to Enhanced Treatment requirements.

For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50 percent or more of the total runoff within a threshold discharge area.

Basic Treatment: Basic Treatment generally applies to:

1. Project sites that discharge to the ground, UNLESS:
    a. The soil suitability criteria for infiltration treatment are met; (see Volume III, Chapter 3 of the Stormwater Manual for soil suitability criteria), or
    b. The project uses infiltration strictly for flow control – not treatment – and the discharge is within ¼-mile of a phosphorus sensitive lake (use a Phosphorus Treatment facility), or within ¼ mile of a fish-bearing stream, or a lake (use an Enhanced Treatment facility).
2. Residential projects not otherwise needing phosphorus control as designated by the US Environmental Protection Agency, the Washington State Department of Ecology, or by the City of Camas; and
3. Project sites discharging directly to salt waters, river segments, and lakes listed in Volume I, Appendix I-C of the Stormwater Manual; and
4. Project sites that drain to streams that are not fish-bearing, or to waters not tributary to fish-bearing streams; and
5. Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites that do not involve pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals) other than parking of employees' private vehicles.

For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprises 50 percent or more of the total runoff within a threshold discharge area.

5.05 Additional Requirements for Public Facilities

The City encourages creativity to design swales and filter strips to reflect a natural setting and add visual appeal to the development. While the swale must remain functional, accessible and maintainable, consider options to make the facility more aesthetically pleasing such as the use of perimeter plant material and meander of the flow line.

Public facilities require adequate space to provide for safe maintenance operations. All aspects related to the safe operation and maintenance of facilities (i.e., access roads, vehicle parking and maneuvering space, traffic constraints, etc.) will be reviewed and approved with the design of the facility. Vaults used for public drainage will require hatch access doors; manhole access ports are not allowed on vaults.

5.06 Emerging Technologies

The City has conditionally approved alternative methods for stormwater quality treatment for use in both public and private areas as follows:

CONTECH Stormwater Solutions CDS Stormwater Treatment System has Washington State Department of Ecology's "General Use Level Designation For Pretreatment." This best management practice (BMP) may be used for treatment of stormwater run-off for storm systems in some areas that utilize drywells to dispose of stormwater. CDS pollution control manholes may be used in some areas to treat run-off from PGIS or PGPS that utilize drywells and require two stage drywells, or no treatment per the "*Guidance for UIC Wells that Manage Stormwater*" (Ecology 2006). They can be located within the public rights-of-way. CDS manholes are not approved for use in areas as defined by Ecology Underground Injection Control Rules.

CONTECH Stormwater Solutions Vortechs System has Ecology's "General Use Level Designation for Pretreatment." The City of Camas will consider use of this alternative on private development sites and for use as public treatment on a case-by-case basis. Use could include treatment of stormwater run-off for storm systems in some areas that utilize drywells to dispose of stormwater. Use for public drainage will require dedication of a separate tract for access and maintenance. Vortechs are not approved for use in areas as defined by Ecology Underground Injection Control Rules.

Other Stormwater Treatment Technologies approved through Ecology's TAPE and CTAPE programs may be allowed by the Director on a case-by-case basis.

Chapter 6: Low Impact Development

6.01 Applicability

At this time, the use of Low Impact Development (LID) is not mandated by the City of Camas, or by the Washington Department of Ecology. However, the City encourages the use of LID for new development and redevelopment projects in appropriate conditions. The City will review these on a case-by-case basis. Criteria to be considered include:

1. Availability of established design and maintenance procedures.
2. Other local agencies have used and approved the method proposed.

LID practices shall refer to the Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual) and Volume III, Appendix III-C of the Stormwater Manual for design recommendations. All uses of LID practices shall meet applicable regulations and requirements, and may require specific approval from other City departments (for example, Transportation or Building).

6.02 Bioretention Areas (Rain Gardens)

Bioretention areas in City of Camas rights-of-way require specific approval by the City.

To receive credit for flow control, bioretention facilities (rain gardens, stormwater infiltration planters, and curb extensions) must be designed and modeled in accordance with the bioretention areas section of Volume III, Appendix III-C of the Stormwater Manual and the LID Manual.

Bioretention facilities soil mixes shall be one of the following:

- A soil mix with a minimum depth of 18-inches meeting the following criteria:
  - The texture of the soil mix shall be loamy sand (USDA Soil Textural Classification) with a clay content of less than five percent by dry weight.
  - The pH for the soil mix shall be between 5.5 and 7.0.
  - The final soil mix shall infiltrate water without immediate ponding on the surface. If ponding occurs, the soil shall be retilled with additional sand and organic topsoil until infiltration occurs.
  - The completed facility shall infiltrate water at a rate of one (1) inch per hour or greater.
- A soil mix with a minimum depth of 24-inches meeting the following criteria:
  - The soil mix shall meet a minimum of five (5) milli-equivalents CEC/100 grams dry soil.
  - The soil mix shall contain a minimum 10 percent of organic content.

  - The soil must be composed of less than 25 percent gravel by weight with at least 75 percent of the soil passing the #4 sieve, and the portion passing the #4 sieve must meet one of the following gradations:
    - At least 50 percent must pass the #40 sieve and at least two percent must pass the #100 sieve, OR
    - At least 25 percent must pass the #40 sieve and at least five percent must pass the #200 sieve.
- A soil mix with a minimum depth of 24-inches meeting the following criteria:
  - The soil mix shall meet a minimum of five (5) milli-equivalents CEC/100 grams dry soil.
  - The soil mix shall contain a minimum 10 percent of organic content.
  - The soil must have a measured infiltration rate of nine inches per hour or less.

Compost used for bioretention soil mix must either be produced by a Washington State permitted composting facility under WAC 173-350-220 and/or meet the State of Washington regulatory standards for pathogen and contaminant standards.

Compost used in bioretention areas should be stable, mature and derived from organic waste materials including yard debris, wood wastes or other organic materials that meet the intent of the organic soil amendment specification. Biosolids and manure composts can be higher in bio-available phosphorus than compost derived from yard or plant waste, and therefore, are not allowed in bioretention areas.

If the catchment area exceeds 2,000 square feet or the bioretention area is on a roadway classified as an arterial and flow is concentrated, bioretention shall be preceded by a presettling BMP (e.g., presettling catch basin, or vault). The presettling is intended to remove larger solids, but not expected to meet water quality treatment goals or sizing guidelines for pretreatment facilities.

If concentrated flows are entering the cell, engineered flow energy dissipation (e.g., rock pad or flow dispersion weir) must be incorporated.

A minimum one inch grade change between the edge of a contributing impervious surface and the vegetated flow entrance is required.

Until the upstream catchment area is thoroughly stabilized, flow diversion and erosion control measures must be installed to protect the bioretention area from sedimentation.

Bioretention facilities are not permitted within five (5) feet of property lines (excluding the property line abutting the right-of-way) without agreement from the neighboring property owner.

6.03 Permeable Pavements

Permeable pavement in City of Camas rights-of-way requires prior approval from the City.

Permeable pavement systems may be applied to driveways, parking areas, sidewalks, and roads that are privately owned and maintained.

Modeling of runoff from areas of permeable pavement surfaces must conform to requirements in Volume III, Appendix III-C of the Stormwater Manual.

Permeable pavements installed on slopes have an increased potential for lateral flows through the storage reservoir aggregate. This reduces the storage and infiltration capacity of the pavement system. For longitudinal slopes greater than two percent, the subbase must be designed to create subsurface ponding to detain subsurface flow and increase infiltration. Ponding may be provided using design features such as terracing berms (check dams). The berms must not extend to the elevation of the surrounding ground. They must be designed to provide sufficient space to pass water from upgradient to lower gradient basins without causing flows to surface.

A minimum separation of 2.0 feet from the seasonal high water mark to the bottom of the base course is required.

Permeable pavement surfaces shall not be used to manage runoff from adjacent impervious surfaces without supporting design calculations showing adequate infiltration rates to accommodate flows. Otherwise, permeable pavements shall be solely for the purpose of infiltrating rainfall that falls directly upon them.

Pervious surfaces shall not drain to permeable pavement surfaces at any time. Debris, sediment, or any particulate material shall be prevented from migrating from pervious areas onto permeable pavement surfaces.

Permeable pavement surfaces shall not be used in areas subject to sanding for traction during snow and ice accumulation.

Permeable pavement surfaces shall not be used to mitigate runoff for the following land uses:

- An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal or greater than 100 vehicles per 1,000 square feet of gross building area.
- An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil.
- An area of a commercial or industrial site subject to parking, storage, or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).

- A road intersection with a 20-year projected ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements. The traffic count can be estimated using information from Trip Generation, published by the Institute of Traffic Engineers (ITE 2003), or from a traffic study performed by a professional engineer or transportation specialist with experience in traffic estimation.
- Areas of sites with industrial machinery and equipment.
- Railroad yards and areas where railroad equipment maintenance is performed.
- Log storage and sorting yards.
- Aircraft maintenance areas.
- Fueling stations.
- Vehicle maintenance and repair areas.

Chapter 7: Conveyance Systems

7.01 Introduction

This chapter presents design requirements for open channel and closed conduit stormwater conveyance systems.

7.02 Design and Construction Standards

The following design standards shall be followed:

- Culverts shall be designed in accordance with the Washington State Department of Transportation's *Hydraulics Manual*.
- Fish passage culverts shall meet the design criteria specified in WDFW's *Fish Passage Design at Road Culverts*.
- All pipe materials, joints, manholes, and other products associated with conveyance systems shall be designed and constructed in accordance with the most current city-adopted edition of Washington State Department of Transportation's *Standard Specifications for Road, Bridge, and Municipal Construction,* except as revised in this manual or the City's standard details.
- Conveyance systems shall be designed to meet the standards shown on City of Camas Stormwater details.
- All storm mains shall be located within the proposed or existing street rights-of-way unless otherwise approved.
- French drains may be required along proposed roadways depending on location and site conditions.

Minimum Pipe Diameter

- Public mainline storm sewers shall be a minimum of twelve (12) inches inside diameter. Downstream pipe diameters shall not be reduced except when approved by the City.
- Public storm sewer laterals shall be ten (10) inches inside diameter. Larger pipe diameter may be used with large capacity catch basins and when approved by the City.

Approved Pipe Materials

The following table lists approved pipe materials and their specifications for public storm sewers.

Table 7-1: Allowable Storm Sewer Pipes	
Approved Type of Pipe	**Specifications**
Corrugated Polyethylene (CPE)	AASHTO M252 or M294 Type S
Polyvinyl Chloride	ASTM D3034
Ductile Iron Pipe (DIP)	ANSI A21.51 or AWWA C151
Concrete Pipe (CP)	ASTM C14 Class II or III
Reinforced Concrete Pipe (RCP)	ASTM C76 Class IV or V
High Density Polyethylene (HDPE)	AWWA C906

Notes:

- CP and RCP are considered rigid pipe. See rigid pipe bedding details.
- PVC, CPE, HDPE and DIP are considered flexible pipe. See flexible pipe bedding details.
- Transitions in pipe sizes are only allowed at structures.

Pipe Slope

Minimum design and as-built slopes are listed in Table 7-2. As-built slopes shall produce a mean velocity (when flowing full or half full) of at least two (2) feet per second (fps), based upon a Manning's "n" of 0.013.

Laterals to inlets and catch basins shall have a minimum slope of 0.01 ft./ft.

Separation

Storm sewers shall be designed to provide six (6) inches minimum vertical and three (3) feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits. For crossings of sanitary sewers lines, Washington State Department of Ecology criteria apply.

Pipeline Alignments

Where a minimal fall is necessary between the inlet and outlet pipes in a structure, pipes shall be aligned vertically by one of the following, in order of preference:

- Match pipe crowns.
- Match 80 percent diameters of pipes.
- Match pipe inverts.

Pipe direction changes or size increases or decreases are allowed only at manholes and catch basins.

7.03 Manholes

Manholes are required at the following locations:

1. At every change in grade or alignment of sewer.
2. At every point of change in size of sewer or pipe material.
3. At each intersection or junction of sewer mains (See Section 8.03 for catch basin connections).
4. At intervals of 400 feet or less in developed areas, unless otherwise approved by the City.
5. At the end of a main pipe system, unless another structure is approved by the City.

Manhole spacing may be increased to 600 feet for sewers in excess of 36-inches diameter, subject to approval by the City. Whenever feasible, permanent vehicular access shall be provided to manholes located in easements.

Manholes outside of public right-of-way shall have locking frame and covers (i.e., Camlock). This requirement may be waived for manholes located in paved easements or fenced in areas.

Manholes outside of public right-of-way shall be designed to stand at least six (6) inches above finished grade.

The minimum required inside diameter for a manhole is 48-inches. Manholes built over large diameter pipes, those greater than 24-inches, require a special construction detail.

For construction of the mainline, provide a 0.2 foot minimum and 0.4 foot maximum drop in flow line elevation through manholes. Where grade considerations are considered critical, the design engineer may request a waiver. In such cases, the drop may be reduced to 0.1 foot for straight through manholes or to no drop if the pipe is laid through the manhole.

7.04 Design Storm Frequency

The Santa Barbara Urban Hydrograph (SBUH) method or the Rational Method shall be used to determine peak flow rates for sizing conveyance systems. The peak runoff rate from the design storms to be used for design of stormwater conveyance systems shall be as follows:

- The 10-year storm: Contributing drainage areas less than 40 acres.
- The 25-year storm: Contributing drainage areas of 40 acres or more.
- The 100-year storm:
  - Culverts with contributing drainage areas greater than 200 acres.
  - Culverts in areas of special flood hazard, as described in FEMA Flood Insurance Rate Maps (FIRM) and reports for Clark County.

The design storm shall be applied to the entire contributing drainage area projected under full build-out conditions.

For sites that discharge to a Flow Control-Exempt Surface Water (see Appendix I-E of the Stormwater Manual and Chapter 1 of this manual) via a closed channel conveyance, the engineer shall demonstrate that sufficient downstream conveyance capacity exists to accommodate the increased flows from the project.

7.05 Hydraulic Methods

Two hydraulic methods can be used for the design of pipelines. The first method is a gravity flow or open channel design, which is most commonly performed using Manning's equation. This method assumes that flow is steady (does not change with time) and uniform (the depth and velocity remain constant throughout the pipe for a given flow). Manning's equation can be found in standard hydraulic textbooks and in the WSDOT *Hydraulics Manual* (WSDOT 2007).

The second method is a pressure flow design, where the water surface elevation rises above the crown of the pipe. A backwater analysis is performed to determine the level of the water surface (the hydraulic grade line) for a pipeline system with a given diameter, slope, and flow rate. This method also assumes steady flow, but the flow is not necessarily uniform (the slope of the hydraulic grade line differs from the slope of the pipe).

New pipes shall be designed to operate in an open-channel regime during the design storm and shall be sized using open channel design methods. Under certain hydrologic and hydraulic conditions, however, flow can rise above the pipe, creating a pressurized pipeline. For those situations, it is important to determine the hydraulic grade line to ensure that water does not overtop manholes and catch basins. A backwater analysis shall be calculated under any of the following conditions:

- Pipes with slopes less than 0.50 percent.
- Pipes with velocities over 6.5 feet per second (fps) (for subcritical flow only).
- Inlet and outlet pipes forming a sharp angle (45 degrees or greater) at junctions.
- Pipe inverts less than three (3) feet deep when entering and leaving junctions.

When using Manning's equation for the design, each pipe within the system shall be sized and sloped such that its barrel capacity at normal full flow is equal to or greater than the required conveyance capacity for the peak runoff of the design storm. A Manning's "N" of 0.013 shall be used for all pipes in Table 7-1. Table 7-2 provides the allowable minimum pipe slope and associated design capacity.

Table 7-2: Storm Sewer Pipe Capacity and Minimum Slopes			
Inside Pipe Diameter (inches)	Minimum Pipe Slope		Design Capacity (cfs)
	Design	As-Built	n=0.013
8	0.0039	0.0034	0.70
10	0.0030	0.0025	1.10
12	0.0025	0.0020	1.59
15	0.0020	0.0015	2.50
18	0.0017	0.0012	3.64
24	0.0011	0.0008	6.40
30	0.00088	0.00058	9.88
36	0.00065	0.00045	14.15
42	0.0005	0.00037	19.35
48	0.00045	0.00031	25.29

Allowable Velocities and Slopes

Table 7-3 lists maximum slopes, velocities, and anchor spacing. If velocities exceed 15 feet per second for the conveyance system design event, anchors shall be provided at bends and junctions.

Table 7-3: Maximum Pipe Slopes and Velocities			
Type of Pipe Material	Pipe Slope Above Which Pipe Anchors Required	Maximum Slope Allowed	Maximum Velocity Allowed
CPE	20% (1 anchor per 100 L.F. of pipe)	30%	30 fps
Concrete or smooth-lined CPE	10% (1 anchor per 50 L.F. of pipe)	20%	30 fps
Ductile Iron*	20% (1 anchor per pipe section)	None	None
HDPE**	40% (1 anchor per 100 L.F. of pipe)	None	None

** Flanged joints required.*

*** Butt-fused joints required.*

CPE = corrugated polyethylene; HDPE = high density polyethylene; L.F. = linear feet; fps = feet per second;

High-density polyethylene (HDPE) pipe systems longer than 100 feet shall be anchored at the upstream end if the slope exceeds 25 percent, and the downstream end shall be placed in a minimum four (4) foot long section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of the pipe material.

7.06 Open Channels

Open conveyances shall be designed by one of the following methods:

- Manning's equation (for uniform flow depth, flow velocity, and constant channel cross-section).
- Direct step backwater method (using the energy equation for varying stream channel cross-section).
- Standard step backwater method (using a computer program).

Manning's equation may be used where uniform flow conditions exist (i.e., the flow depth and velocity remain constant throughout the channel reach). However, if a flow restriction (such as a culvert or bridge) causes flows to rise above normal depth within a channel reach, a backwater analysis shall be performed, using either the direct step or standard step backwater methods.

Direct step methods may be calculated using a spreadsheet or computer program (see the 2005 King County *Surface Water Design Manual* for an example). The standard step method is a variation of the direct step method and is commonly performed using a computer program because of the iterative process involved. The most common program using the standard step method is the U.S. Army Corps of Engineers HEC-RAS program.

Allowable Velocities

Velocities must be low enough to prevent channel erosion, based on the native soil characteristics or the compacted fill material. For velocities above 5 fps, channels shall have an 8-inch- thick rock-lined bottom and side slope to the top of the roadway shoulder or shall be stabilized in a fashion acceptable to the county. Water quality shall not be degraded by passage through an open conveyance. Table 7-4 provides specific guidance on channel protection measures.

Table 7-4: Open Conveyance Protection			
Velocity at Design Flow (fps)	**Protection**	**Thickness**	**Min. Height Required Above Water Surface**
0-5	Grass lining**	N/A	0.5 feet
5-10	Light loose riprap*	1 foot	1.5 feet
10-20	Heavy loose riprap*	2 feet	1.5 feet
20+	Engineered dissipater required	Varies	2.0 feet
**Riprap shall be in accordance with WSDOT/APWA Standard Specifications (WSDOT 2008).*			
Note: Riprap sizing governed by side slopes on channel, assumed ~3.1.			
*** Bioengineered lining allowed for design flow up to 8 fps.*			

Channels with a slope of less than 6 percent and peak velocities of less than 5 fps shall be lined with vegetation. Other conveyance protection systems may be allowed if submitted through the appropriate variance process.

Side Slopes and Minimum Freeboard

Channel side slopes shall not exceed 2:1 for undisturbed ground (cuts) as well as for disturbed ground (embankments). All constructed channels shall be compacted to a minimum 95 percent compaction, as verified by a modified Proctor test (ASTM D1557 / AASHTO T180).

Channels shall be designed with a minimum freeboard of 0.5 feet when the design flow is 10 cfs or less and 1 foot when the design discharge is greater than 10 cfs.

7.07 Outfalls

All pipes and culverts that discharge to streams, rivers, ponds, lakes, or other open bodies of water are designated as outfalls. The design and installation of proper energy dissipaters is critical to prevent erosion at or downstream of the point of discharge. Energy dissipater systems include rock splash pads, flow dispersal trenches, and gabion mattresses.

All energy dissipation at outfalls shall be designed for peak flows from a 100-year, 24-hour storm event. Table 7-5 summarizes the rock requirements for rock splash pad outfalls.

Table 7-5: Rock Requirements for Rock Splash Pad Outfalls					
Discharge velocity (fps)	**Type[1]**	**Thickness**	**Width**	**Length**	**Height**
0-5	Quarry spalls	1 foot	Diameter + 6 feet	8 feet or 4 x diameter, whichever is greater	Crown + 1 foot
5-10	Light loose riprap	2 feet	Diameter + 6 feet or 2 x diameter, whichever is greater	12 feet or 4 x diameter, whichever is greater	Crown +1 foot
10-20	Heavy loose riprap	As required	As required	As required	Crown + 1 foot
20+	Engineered dissipater required				
1. Riprap and quarry spalls shall meet WSDOT specifications (2008) for the classes noted.					

Other energy dissipation systems may be allowed through the plan review process.

7.08 Outfalls to Detention Ponds

Invert elevations for conveyance outfalls into detention ponds shall be set at an elevation where the water surface elevation in the detention pond has a 10 percent or smaller chance of being equaled or exceeded in any given year. This is determined in WWHM by performing a stage-frequency analysis.

After performing the duration analysis and determining the final detention pond size, go to the "Analysis" section of WWHM, select the "STAGE Mitigated" dataset, and click on "run analysis". The stage frequency summary is tabulated in the upper right corner. Select the 10-year stage and set the invert elevation of the outfall pipe at or above this elevation.

7.09 Conveyance System Easements

Publicly Owned Systems

Easements shall be provided to the City for access and maintenance of all conveyance systems within the site that will be maintained by the City (including streams, if used). Easements shall be as shown on Detail G6 in the Camas Design Standards Manual.

Chapter 8: Drainage of Roadway Pavements

8.01 General Requirements

Drainage design for roadways shall be in accordance with "Hydraulic Engineering Circular No. 22, Urban Drainage Design Manual" (FHWA and NHI 2001).

The Santa Barbara Urban Hydrograph (SBUH) method or the Rational Method shall be used to determine peak flow rates for sizing collection systems (catch basins and inlets).

Roadway drainage shall not exceed the capacity of the inlet or produce a flow depth of greater than 0.12 feet at the edge of the travel lane for the ten-year storm. The travel lane shall remain open to emergency vehicles and the flow depth of any storm event, up to the 100-year storm event, will not exceed 0.5 feet. Flooding in parking lots shall not exceed 1.0 feet.

8.02 Catch Basin Locations

Catch basins and inlets are required at the following locations:

1. At any low point in the roadway or curb returns at intersections.
2. Where any roadway transitions from a crown section to a shed section to prevent gutter flow from flowing across the roadway.
3. Such that a maximum of 400 linear feet of paved street is collected by a single catch basin.
4. Inlets shall be used at intersections to prevent street cross-flow, which could cause pedestrian or vehicular hazards. It is desirable to intercept 100 percent of any potential street cross-flow under these conditions. Intersection inlets should be placed on tangent curb sections near corners. Catch basins and inlets shall be placed so that water will not accumulate on walking surfaces per ADA guidelines.
5. In sag vertical curves, where significant ponding may occur, flanking inlets shall be placed to limit spread on low gradient approaches to the level point. The flanking inlets are intended to provide relief if the inlet at the low point becomes clogged or if the design spread is exceeded.
6. Combination inlets or curb opening inlets shall be used in sag locations. Grate inlets are not allowed because of their tendency to become clogged.
7. Combination curb inlets are required on slopes greater than 10 percent or when necessary to prevent bypass flow from crossing an ADA ramp. Curb ramps and their approaches shall be designed so that water will not accumulate on walking surfaces per ADA guidelines.

8.03 Catch Basin Construction Standards

All pipe materials, joints, manholes, and other products associated with conveyance systems shall be designed and constructed in accordance with the latest City-adopted edition of the Washington State Department of Transportation's "Standard Specifications for Road, Bridge, and Municipal Construction" (WSDOT).

Conveyance systems shall be designed to meet the standards shown on City of Camas Stormwater details.

Public laterals shall be connected to a manhole or other accessible structure. Catch basin laterals shall not be connected to the storm main by tee or wye, unless specifically approved by the City. All connections to catch basins shall be water tight.

Chapter 9: Offsite Analysis and Mitigation

9.01 Introduction

This chapter provides requirements for offsite analysis and mitigation. These requirements are in addition to the minimum requirements.

The offsite analysis is a field investigation of downstream impacts on water quality and surface water conditions resulting from a development, redevelopment, or other land-disturbing activity. An offsite analysis must be performed for all development and redevelopment activities that meet the applicability thresholds identified under Minimum Requirement 7, except those that meet one of the exemptions identified in Section 9.2 of this chapter.

The information in this chapter is supplementary to Volume I, Section 3.3 of the SMMWW, Optional Guidance 2: Off Site Analysis and Mitigation.

9.02 Exemptions

A project is exempt from performing an offsite analysis if any of the following three conditions apply:

1. Based on information provided by the developer and included in the final technical information report (TIR), the City determines that there is sufficient evidence to conclude that the project will not have a significant adverse impact on the downstream and\or upstream drainage system.
2. The project:
    a. Adds less than 2,000 square feet of new impervious surface; and
    b. Adds less than 35,000 square feet of new pervious surface; and
    c. Does not construct or modify a drainage pipe/ditch that is 12-inches or more in size/depth or that receives runoff from a drainage pipe/ditch that is 12-inches or more in size/depth; and
    d. Does not contain or lie adjacent to a landslide, steep slope, or erosion hazard area.
3. The project does not increase the rate, volume, duration, or location of discharges to and from the project site for storms greater than ½ the 2-year event (e.g., where existing impervious surface is replaced with other impervious surface having similar runoff-generating characteristics or where pipe/ditch modifications do not change existing discharge characteristics).

9.03 Offsite Analysis

The offsite analysis shall extend downstream for the entire flow path, from the development site to the receiving water or up to one (1) mile, whichever is less. If the receiving water is within ¼ mile, the analysis shall extend within the receiving water to ¼ mile from the development site. The analysis shall extend upstream to a point where any backwater effects created by the project cease. The applicant shall use best efforts to obtain these data, while respecting private property.

Existing offsite impacts that are not affected by the project site do not require mitigation. However, in cases where the project site was the cause of the existing impact, it is the responsibility of the applicant to mitigate for those impacts. The offsite analysis should document any apparent existing deficiencies.

Qualitative Analysis

The following subsections describe components (or tasks) of the qualitative analysis.

Task 1: Map of the Study Area

A site map shall be submitted showing property lines, topography (at a minimum, a USGS 1:24000 quadrangle topographic map), site boundaries, study area boundaries, downstream flow path, and potential/existing problems.

Task 2: Review of All Available Information on the Study Area

This task shall include all available basin plans, groundwater management area plans, drainage studies, floodplain/floodway FEMA maps; wetlands inventory maps, critical areas maps, stream habitat reports, salmon distribution reports, and other applicable studies.

Task 3: Field Inspection of the Study Area

The design engineer shall physically inspect the existing onsite and offsite drainage systems of the study area for each discharge location for existing or potential problems and drainage features. An initial inspection and investigation shall include the following:

1. Investigate problems reported or observed during the review of available information.
2. Locate existing/potential constrictions or capacity deficiencies in the drainage system.
3. Identify existing/potential flooding problems.
4. Identify existing/potential overtopping, scouring, bank sloughing, or sedimentation.
5. Identify significant destruction of aquatic habitat (e.g., siltation, stream incision).
6. Collect qualitative data on features such as land use, impervious surface, topography,

7. Collect information on pipe sizes, channel characteristics, and drainage structures.
8. Verify tributary drainage areas identified in Task 1.
9. Contact City of Camas Public Works, neighboring property owners, and residents about drainage problems.
10. Note date and weather at time of inspection.

Task 4: Description of the Drainage System and Its Existing and Predicted Problems

For each drainage system component (e.g., pipes, culverts, bridges, outfalls, ponds, vaults), the analysis shall include the location, physical description, problems, and field observations.

All existing or potential problems (e.g., ponding water, erosion) identified in Tasks 2 and 3 shall be described. The descriptions shall be used to determine whether adequate mitigation can be identified or whether more detailed quantitative analysis is necessary. The following information shall be provided for each existing or potential problem:

1. Magnitude of or damage caused by the problem.
2. General frequency and duration.
3. Return frequency of storm or flow when the problem occurs (may require quantitative analysis).
4. Water elevation when the problem occurs.
5. Names and concerns of the parties involved.
6. Current mitigation of the problem.
7. Possible cause of the problem.
8. Whether the project is likely to aggravate the problem or create a new one.

Quantitative Analysis

Upon review of the qualitative analysis, the City of Camas may require a quantitative analysis, depending on the presence of existing or predicted flooding, erosion, or water quality problems and on the proposed design of the onsite drainage facilities. The analysis shall repeat Tasks 3 and 4 above, using quantitative field data, including profiles and cross-sections.

The quantitative analysis shall provide information on the severity and frequency of an existing problem or the likelihood of creating a new problem. It shall evaluate proposed mitigation intended to avoid aggravation of the existing problem and creation of a new problem.

9.04 Mitigation

The City may require mitigation measures, depending on the results of the above analyses. Mitigation measures shall take the form of acceptable BMPs for downstream erosion control. The publication entitled *Integrated Streambank Protection Guidelines* (WDFW et al. 2003) shall be used to guide design and installation of streambank erosion BMPs within and adjacent to streams. Where the offsite analysis reveals impacts other than the types listed in Task 4 above, the City may require mitigation of a type to be determined by the Director.

Chapter 10: Definitions

“Basin” means a topographic region in which all water drains to a common point.

"Basin plan" means a plan that assesses, evaluates, and proposes solutions to existing and potential future impacts to the beneficial uses of, and the physical, chemical, and biological properties of waters of the state within a basin.

"Best management practices" or "BMPs" means the schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices approved by the Washington State Department of Ecology that, when used singly or in combination, control, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.

“City” means the City of Camas.

"Collection and conveyance system" means the drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater to a receiving water or infiltration facility. The natural elements of the conveyance system include, but are not limited to, small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the collection and conveyance system include, but are not limited to, gutters, inlets, ditches, pipes, channels, and retention/detention facilities.

“Continuous Runoff Model” means the most current version of the Western Washington Hydrology Model (WWHM) or any other equivalent model approved by the Department of Ecology.

“Contributing drainage area” means the subject property together with the basin contributing water runoff to the subject property.

“Design storm” means the rainfall from a storm of 24-hour duration. For example, two-year storm means the two-year, 24-hour storm event.

“Development” means land disturbing activities, construction, installation or expansion of a building or other structure, creation or replacement of impervious surfaces, associated with residential, commercial, or industrial land use improvements.

"Director" means the director of the City of Camas public works department or designee.

“Downstream analysis” means an analysis of the stormwater impacts of proposed development activity including the effects on existing upstream and downstream drainage systems and property, and the ability of the natural drainage ways to pass additional flow created by the development.

“Drainage project” means the excavation or construction of pipes, culverts, channels, embankments or other flow altering structures in any stream, stormwater facility, or wetland.

"Flow control facility" means a drainage facility designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control facilities are designed to either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.

"Groundwater" means water in a saturated zone or stratum beneath the surface of land or below a surface water body.

“Hydrophytic Vegetation” means the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present.

“Impervious surface” means a hard surface area which either prevents or retards the entry of water into the soil. Examples include, but are not limited to, structures, walkways, patios, driveways, carports, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, haul roads and soil surface areas compacted by construction operations, and oiled or macadam surfaces.

“Infiltration Facility” means a drainage facility designed to use the hydrologic process of surface and stormwater runoff soaking into the ground, commonly referred to as a percolation, to dispose of surface and stormwater runoff.

"Land-disturbing activity" means any activity that results in a movement of earth or a change in the existing soil cover (both vegetative and nonvegetative) and/or existing soil topography. Land-disturbing activities include, but are not limited to, clearing, grading, filling and excavation. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices are not considered land-disturbing activity.

“Low Impact Development” or “LID” means a stormwater management and land development strategy applied at the parcel and subdivision scale that emphasizes conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic pre- development hydrologic functions.

“Low Impact Development Manual” or “LID Manual” means the Low Impact Development Technical Guidance Manual for Puget Sound dated January 2005 and updated errata sheets

issued or approved by the Director as may be necessary to correct clear and obvious mathematical and technical errors in manual criteria.

“National Pollutant Discharge Elimination System” or “NPDES” means the national program for issuing, modifying, revoking, and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the state from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.

“Native vegetation” means vegetation comprised of plant species, other than noxious weeds, that are indigenous to the Pacific Northwest and which reasonably could have been expected to naturally occur on the site. Examples include trees such as Douglas Fir, Western Hemlock, Western Red Cedar, Alder, Big-leaf Maple, and Vine Maple; shrubs such as Willow, Elderberry, Salmonberry, and Salal; and herbaceous plants such as Sword Fern, Foam Flower, and Fireweed.

“Natural location” means the location and elevation of those channels, swales, and other non-man-made conveyance systems as defined by the first documented topographic contours existing for the site, either from maps or photographs.

“New development” means land disturbing activities, including Class IV-general forest practices that are conversions from timber land to other uses; structural development, including construction or installation of a building or other structure; creation of impervious surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in Chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.

“Peak discharge” means the maximum stormwater runoff rate in cubic feet per second determined for the design storm.

“Pollution” or “pollutants” means such contamination, or other alteration of the physical, chemical or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.

“Pollution-Generating Impervious Surface” or “PGIS” means those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use, industrial activities or storage of erodible or leachable

materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Metal roofs are also considered to be pollution-generating unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating).

“Pollution-Generating Pervious Surface” or “PGPS” means any non-impervious surface subject to use of pesticides and fertilizers or loss of soil.

“Pre-developed condition” means the land cover that existed at a site prior to Development or Redevelopment. For projects required to comply with Minimum Requirement #7 for flow control as defined in BGMC 18.250.050(G) the pre-developed condition shall be assumed to be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

“Project site” means that portion of a property, properties, or right of way subject to land disturbing activities, new impervious surfaces or replaced impervious surfaces.

“Redevelopment” means, on a site that is already substantially developed (i.e., has 35% or more of existing impervious surface coverage), the creation or addition of impervious surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including construction, installation or expansion of a building or other structure; replacement of impervious surface that is not part of a routine maintenance activity; and land disturbing activities.

“Regional facility” means a facility designed to treat and control stormwater runoff from multiple project sites.

"Registered soil scientist" means a person who is qualified to evaluate and interpret soils and soil-related data for the purpose of understanding soil resources as they affect environmental quality and who is certified with the American Registry for Certified Professionals in Soil Science.

“Replaced impervious surface” means the removal and replacement of any exterior impervious surfaces or foundation for structures, or the removal down to bare soil or base course and replacement for other impervious surfaces.

“Roof downspout system” means infiltration or dispersion systems that meet the requirements stated in Chapter Three of Volume III of the Western Washington Manual.

“Runoff” means water that travels across the land surface and discharges to water bodies either directly or through a collection and conveyance system.

“Site” means the area defined by the legal boundaries of a parcel or parcels of land that is (are) subject to development. For road projects, the length of the project site and the right-of-way boundaries defining the site.

“Source control BMP” means a structure or operation that is intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. The Stormwater Manual separates source control BMPs into two types. Structural Source Control BMPs are physical, structural, or mechanical devices, or facilities that are intended to prevent pollutants from entering stormwater. Operational BMPs are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume IV of the 2005 Stormwater Management Manual for Western Washington for details.

“Stormwater” means runoff during and following precipitation and snowmelt events, including surface runoff and drainage.

"Stormwater facility" means a constructed component of a stormwater drainage system, designed and constructed to perform a particular function, or multiple functions. Stormwater facilities include, but are not limited to: pipes, swales, ditches, open channels, culverts, street gutters, detention ponds, retention ponds, constructed wetlands, storage basins, infiltration devices, catch basins, manholes, dry wells, oil/water separators, biofiltration swales, and sediment basins.

“Stormwater Manual” means the 2005 Stormwater Management Manual for Western Washington, which is the 5-volume technical manual (Publication Nos. 05-10-29 through 05-10-33) prepared by the Washington State Department of Ecology for use by local governments that contains BMPs to prevent, control, or treat pollution in stormwater.

“Stormwater site plan” means the comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics. It includes a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) that must be submitted to and approved by the Washington Department of Ecology, and a Permanent Stormwater Control Plan (PSC Plan). Guidance on preparing a Stormwater Site Plan is contained in the Stormwater Manual, Chapter 3 of Volume I. Modified submittals of stormwater site plans are permitted as specified in the General Requirements.

“Threshold Discharge Area” means an onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream as determined by the shortest flow path.

“Total Maximum Daily Load” or “TMDL” means a water cleanup plan. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant’s sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the water body can be used for the purposes the state has designated. The calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each water body, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

"Treatment BMP" means a BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs include, but are not limited to, wetponds, oil/water separators, biofiltration swales, and constructed wetlands.

“Underground Injection Control” or “UIC” well means a manmade subsurface fluid distribution system designed to discharge fluids into the ground, consisting of an assemblage of perforated pipes, drain tiles, or other similar mechanisms, or a dug hole that is deeper than the largest surface dimension. Subsurface infiltration systems include drywells, pipe or french drains, drain fields, and other similar devices.

“Wetlands” means those areas defined as wetlands under Chapter 16.53 CMC.

Any terms not defined in this chapter shall be as defined in the Stormwater Manual.

Appendix A: Hydrology Data

Table A-1: Sheet flow "n" Values and "k" Values Used in Time Calculations for Hydrographs

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 feet of travel)	n_s*
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s≤ 0.20 ft/ft)	0.06
Cultivated soils with residue cover (s> 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

*Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)

"k" Values Used in Travel Time/Time of Concentration Calculations

Shallow Concentrated Flow (After the initial 300 feet of sheet flow, R = 0.1)	k_s
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.25)	13
7. Paved and gravel areas (n = 0.012)	27

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

Channel Flow (Continuous stream, R = 0.4)	k_c
9. Meandering stream with some pools (n = 0.040)	20
10. Rock-lined stream (n = 0.035)	23
11. Grass-lined stream (n = 0.030)	27
12. Other Stream, man-made channels and pipe	0.807/n

Reference: DOE Stormwater Management Manual for the Puget Sound Basin, February 1992.

Table A-2: Type IA Rainfall Distribution

Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall	Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall
0.0	0	0.0	0.0	7.0	420	1.3	28.1
	10	0.4	0.4		430	1.3	29.4
	20	0.4	0.8		440	1.8	31.2
	30	0.4	1.2		450	1.8	33.0
	40	0.4	1.6		460	3.4	36.4
	50	0.4	2.0		470	5.4	41.8
1.0	60	0.4	2.4	8.0	480	2.7	44.5
	70	0.4	2.8		490	1.8	46.3
	80	0.4	3.2		500	1.3	47.7
	90	0.4	3.6		510	1.3	49.0
	100	0.4	4.0		520	1.3	50.4
	110	0.5	4.5		530	0.9	51.2
2.0	120	0.5	5.0	9.0	540	0.9	52.1
	130	0.5	5.5		550	0.9	53.0
	140	0.5	6.0		560	0.9	53.9
	150	0.5	6.5		570	0.9	54.8
	160	0.5	7.0		580	0.9	55.6
	170	0.6	7.6		590	0.9	56.5
3.0	180	0.6	8.2	10.0	600	0.9	57.4
	190	0.6	8.8		610	0.9	58.3
	200	0.6	9.4		620	0.9	59.2
	210	0.6	10.0		630	0.9	60.0
	220	0.6	10.6		640	0.9	60.9
	230	0.7	11.3		650	0.7	61.6
4.0	240	0.7	12.0	11.0	660	0.7	62.4
	250	0.7	12.7		670	0.7	63.1
	260	0.7	13.4		680	0.7	63.8
	270	0.7	14.1		690	0.7	64.5
	280	0.7	14.8		700	0.7	65.2
	290	0.8	15.6		710	0.7	66.0
5.0	300	0.8	16.4	12.0	720	0.7	66.7
	310	0.8	17.3		730	0.7	67.4
	320	0.8	18.1		740	0.7	68.1
	330	0.8	18.9		750	0.7	68.8
	340	0.8	19.7		760	0.7	69.6
	350	1.0	20.7		770	0.6	70.1
6.0	360	1.0	21.6	13.0	780	0.6	70.7
	370	1.0	22.6		790	0.6	71.3
	380	1.0	23.5		800	0.6	71.8
	390	1.0	24.5		810	0.6	72.4
	400	1.0	25.4		820	0.6	73.0
	410	1.3	26.8		830	0.6	73.6

Table A-2: Type IA Rainfall Distribution (continued)

Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall
14.0	840	0.6	74.1
	850	0.6	74.7
	860	0.6	75.3
	870	0.6	75.8
	880	0.6	76.4
	890	0.5	76.9
15.0	900	0.5	77.4
	910	0.5	77.9
	920	0.5	78.4
	930	0.5	78.9
	940	0.5	79.4
	950	0.5	79.9
16.0	960	0.5	80.4
	970	0.5	80.9
	980	0.5	81.4
	990	0.5	81.9
	1000	0.5	82.4
	1010	0.4	82.8
17.0	1020	0.4	83.2
	1030	0.4	83.6
	1040	0.4	84.0
	1050	0.4	84.4
	1060	0.4	84.8
	1070	0.4	85.2
18.0	1080	0.4	85.6
	1090	0.4	86.0
	1100	0.4	86.4
	1110	0.4	86.8
	1120	0.4	87.2
	1130	0.4	87.6
19.0	1140	0.4	88.0
	1150	0.4	88.4
	1160	0.4	88.8
	1170	0.4	89.2
	1180	0.4	89.6
	1190	0.4	90.0
20.0	1200	0.4	90.4
	1210	0.4	90.8
	1220	0.4	91.2
	1230	0.4	91.6
	1240	0.4	92.0
	1250	0.4	92.4
21.0	1260.0	0.4	92.8
	1270.0	0.4	93.2
	1280.0	0.4	93.6
	1290.0	0.4	94.0
	1300.0	0.4	94.4
	1310.0	0.4	94.8
22.0	1320.0	0.4	95.2
	1330.0	0.4	95.6
	1340.0	0.4	96.0
	1350.0	0.4	96.4
	1360.0	0.4	96.8
	1370.0	0.4	97.2
23.0	1380.0	0.4	97.6
	1390.0	0.4	98.0
	1400.0	0.4	98.4
	1410.0	0.4	98.8
	1420.0	0.4	99.2
	1430.0	0.4	99.6
24.0	1440.0	0.4	100.0

Figure A-1: Type IA Rainfall Distribution

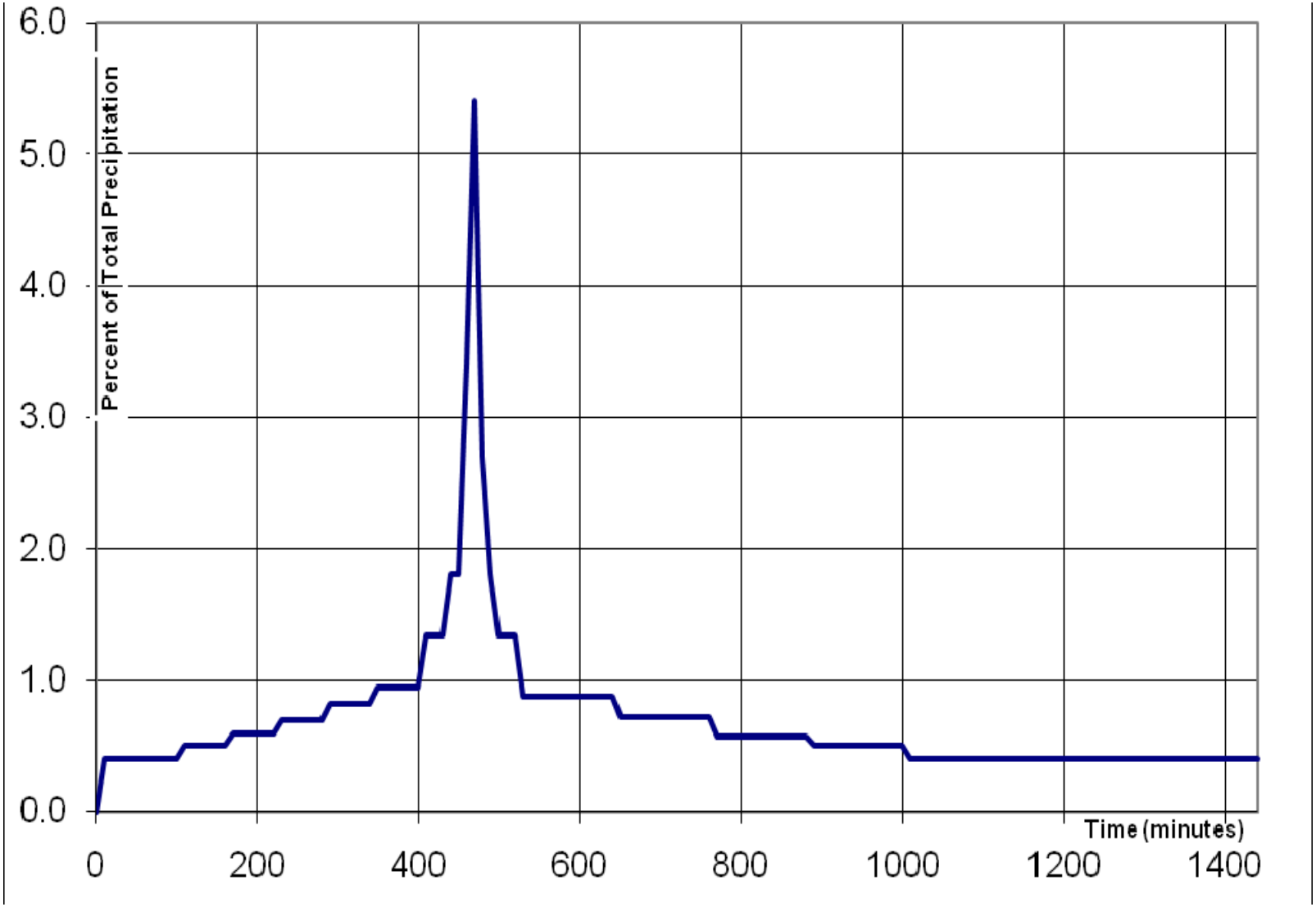


Figure A-2: 2-Year, 24-Hour Clark County Isopluvial Map

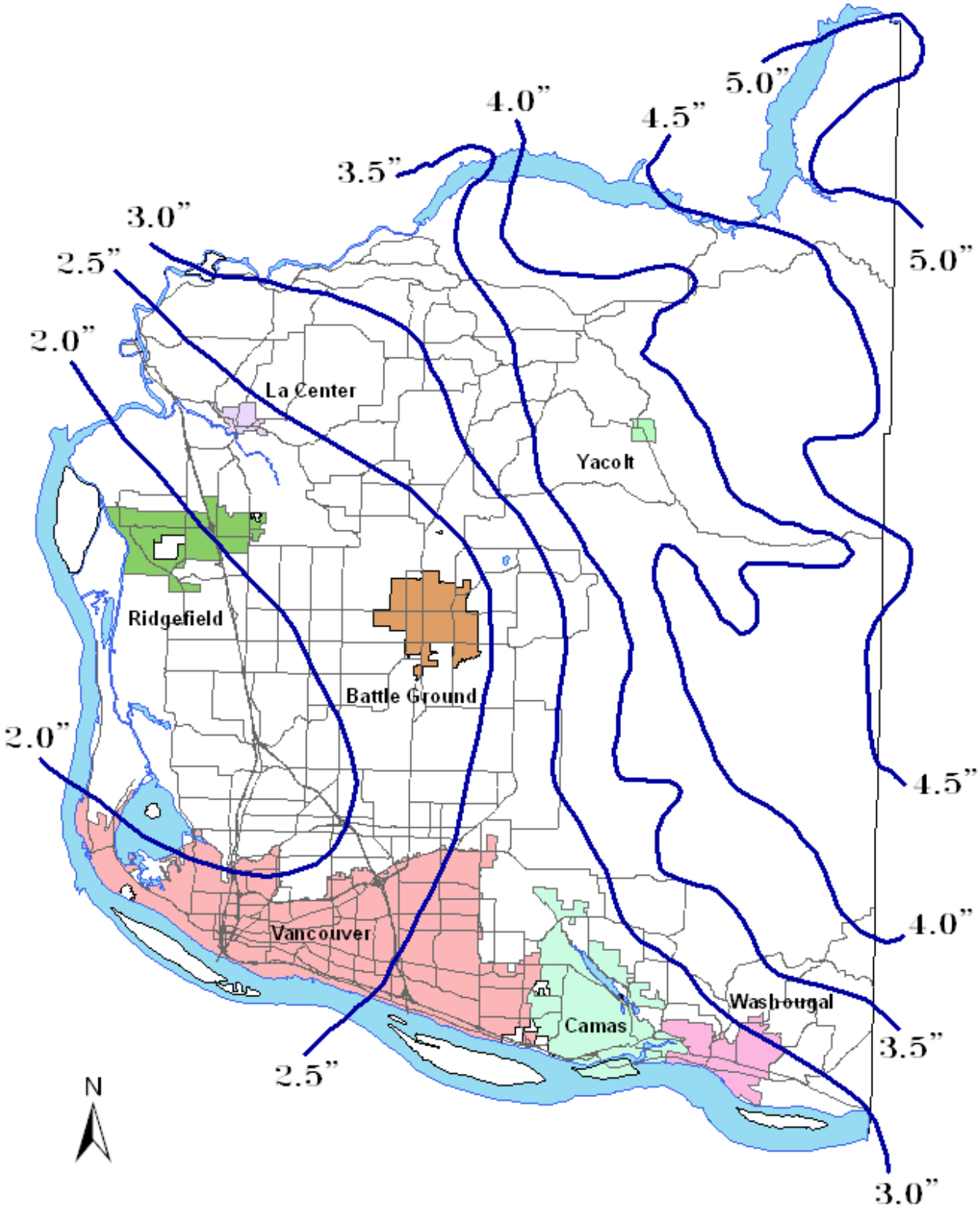


Figure A-3: 10-Year, 24-Hour Clark County Isopluvial Map

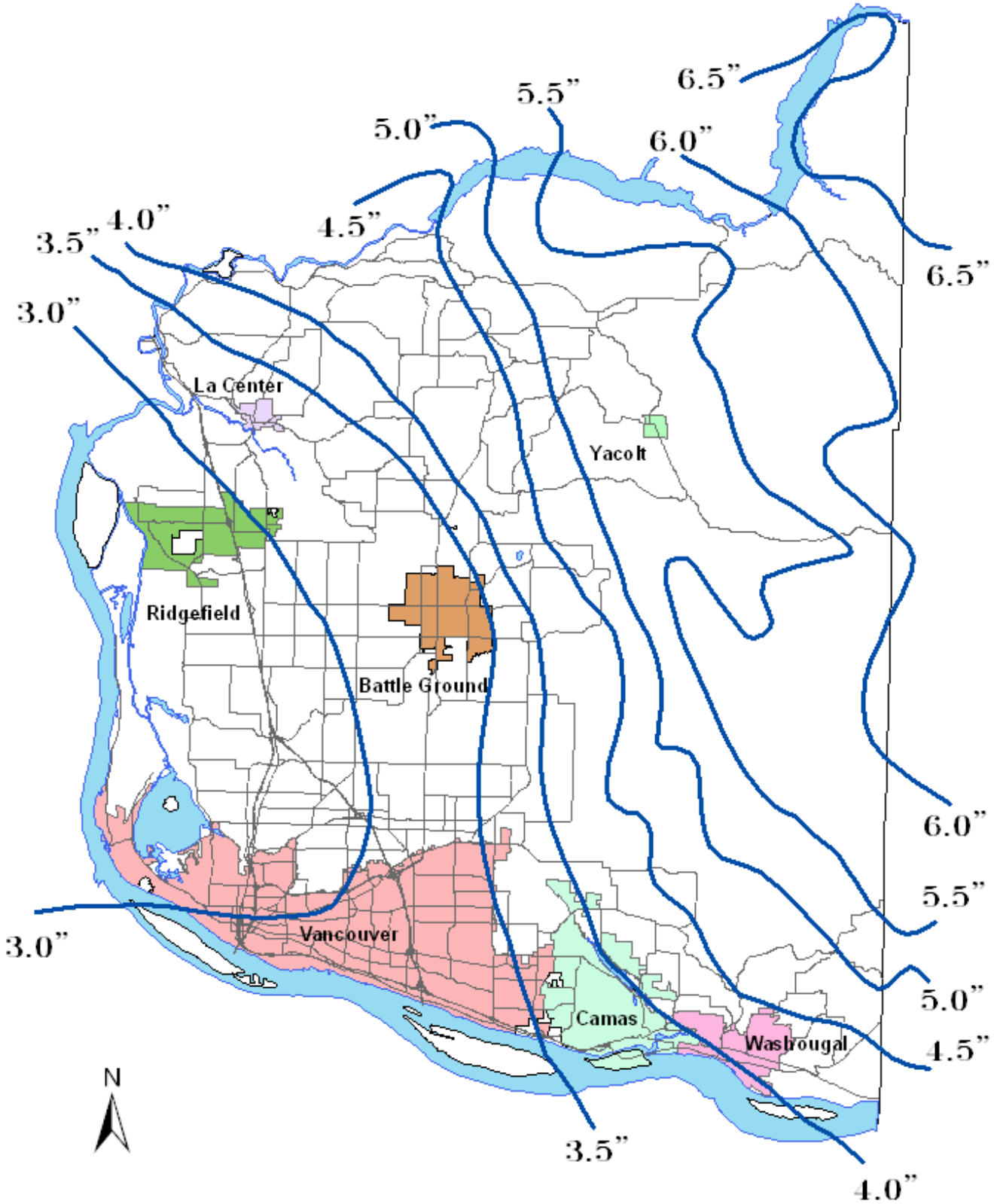


Figure A-4: 25-Year, 24-Hour Clark County Isopluvial Map

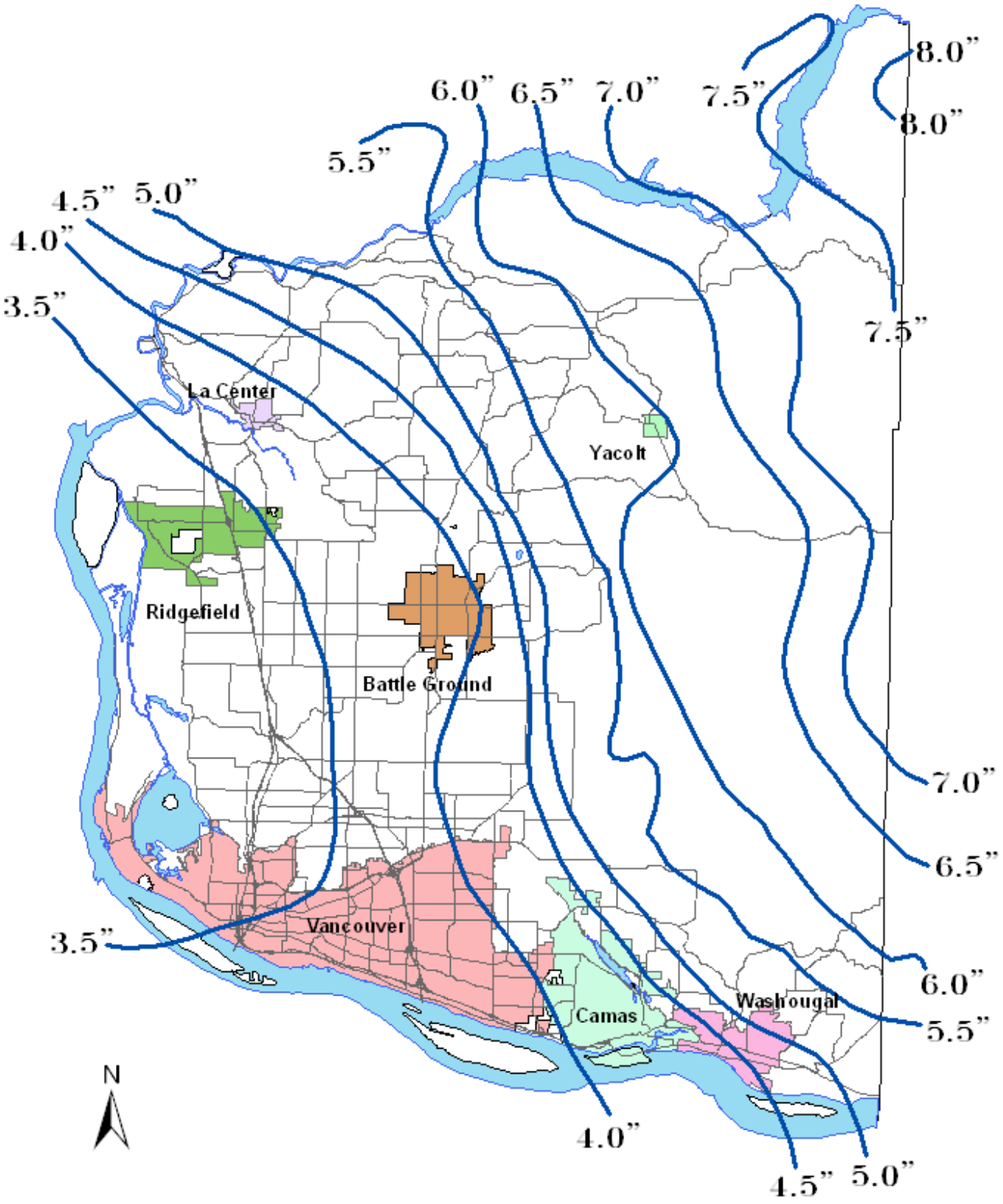


Figure A-5: 100-Year, 24-Hour Clark County Isopluvial Map

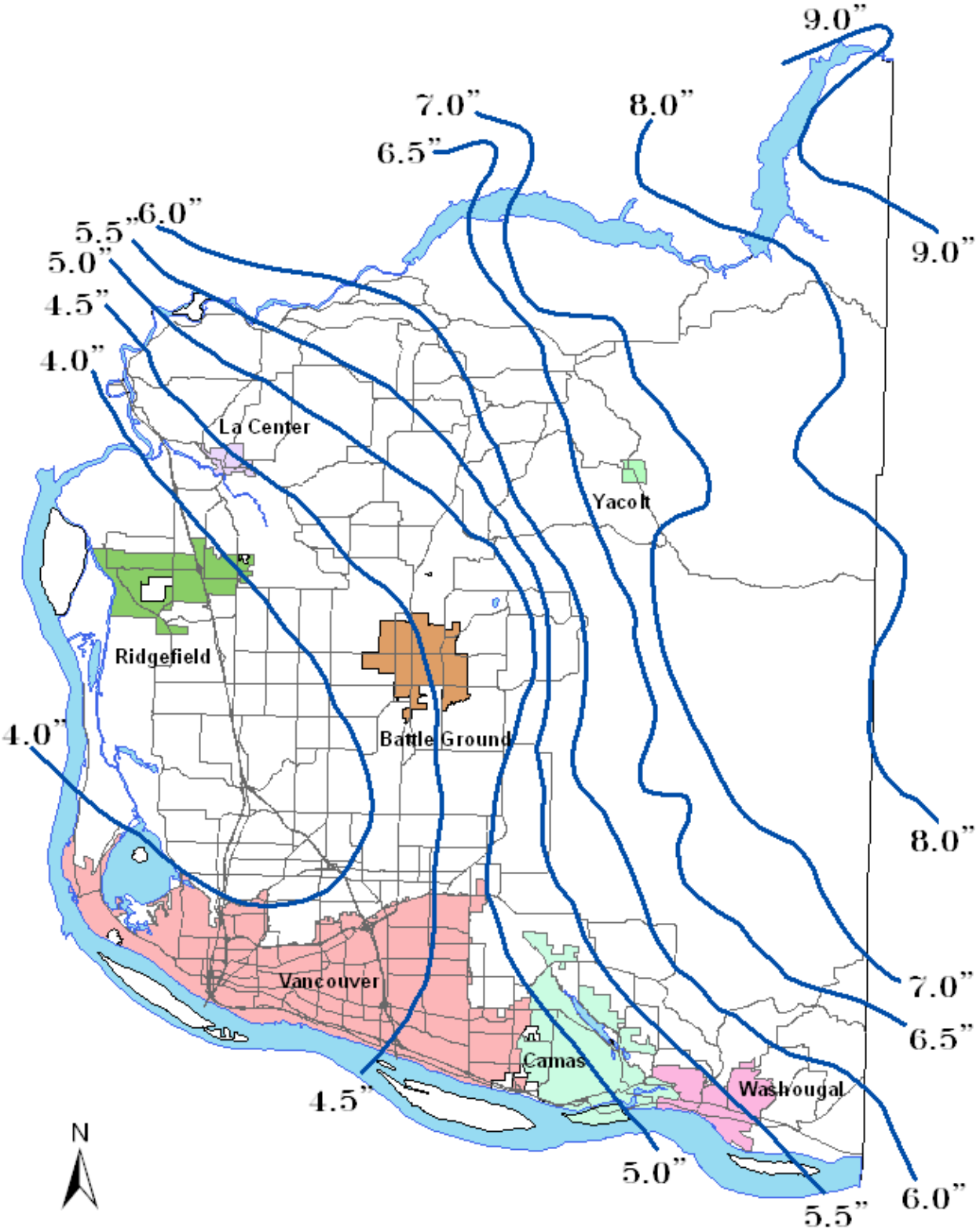


Table A-3: Runoff Curve Numbers

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP			
		A	**B**	**C**	**D**
Cultivated land (1):	winter condition	86	91	94	95
Mountain open areas: grasslands	low growing brush and	74	82	89	92
Meadow or pastures:		65	78	85	89
Wood or forest land:	undisturbed	42	64	76	81
Wood or forest land:	young second growth or brush	55	72	81	86
Orchard:	with cover crop	81	88	92	94
Open spaces, lawns, parks, golf courses, cemeteries, landscaping:					
Good condition:	grass cover on over 75% of the area	68	80	86	90
Fair condition:	grass cover on 50-75% of the area	77	85	90	92
Gravel roads & parking lots:		76	85	89	91
Dirt roads & parking lots:		72	82	87	89
Impervious surfaces, pavement, roofs etc.		98	98	98	98
Open water bodies:		100	100	100	100
Single family residential (2):					
Dwelling Unit/Gross Acre	% Impervious (3)	Separate curve number shall be selected for pervious & impervious portions of the site or basin			
1.0 DU/GA	15				
1.5 DU/GA	20				
2.0 DU/GA	25				
2.5 DU/GA	30				
3.0 DU/GA	34				
3.5 DU/GA	38				
4.0 DU/GA	42				
4.5 DU/GA	46				
5.0 DU/GA	48				
5.5 DU/GA	50				
6.0 DU/GA	52				
6.5 DU/GA	54				
7.0 DU/GA	56				
PUD's, condos, apartments, commercial businesses & industrial areas	% impervious must be computed				

Table A-4: Hydrologic Soils Groups

Map Symbol	Soil Name	Hydrologic Group
BpB	BEAR PRARIE	B
BpC	BEAR PRARIE	B
CnB	CINEBAR	B
CnD	CINEBAR	B
CnE	CINEBAR	B
CnG	CINEBAR	B
CrE	CINEBAR	B
CrG	CINEBAR	B
CsF	CISPUS	B
CtA	CLOQUATO	B
CvA	COVE	D
CwA	COVE	D
DoB	DOLLAR	C
Fn	FILL LAND	In-situ
GeB	GEE	C
GeD	GEE	C
GeE	GEE	C
GeF	GEE	C
GuB	GUMBOOT	D
HcB	HESSON	C
HcD	HELLSON	C
HcE	HESSON	C
HcF	HESSON	C
HgB	HESSON	C
HgD	HESSON	C
HhE	HESSON	C
HIA	HILLSBORO	B
HIB	HILLSBORO	B
HIC	HILLSBORO	B
HID	HILLSBORO	B
HIE	HILLSBORO	B
HIF	HILLSBORO	B
HoA	HILLSBORO	B
HoB	HILLSBORO	B
HoC	HILLSBORO	B
HoD	HILLSBORO	B
HoE	HILLSBORO	B
HoG	HILLSBORO	B
HsB	HILLSBORO	B

Table A-4: Hydrologic Soils Groups (cont.)

Map Symbol	Soil Name	Hydrologic Group
HtA	HOCKINSON	D
HuB	HOCKINSON	D
HvA	HOCKINSON	D
KeC	KINNEY	B
KeE	KINNEY	B
KeF	KINNEY	B
KnF	KINNEY	B
LaE	LARCHMOUNT	B
LaG	LARCHMOUNT	B
LcG	LARCHMOUNT	B
LeB	LAUREN	B
LgB	LAUREN	B
LgD	LAUREN	B
LgF	LAUREN	B
LIB	LAUREN	B
LrC	LAUREN	C
LrF	LAUREN	C
McB	McBEE	C
MeA	McBEE	C
MIA	McBEE	C
MnA	MINNIECE	D
MnD	MINNIECE	D
MoA	MINNIECE VARIANT	D
MsB	MOSSYROCK	B
NbA	NEWBERG	B
NbB	NEWBERG	B
OdB	ODNE	D
OeD	OLEQUA	B
OeE	OLEQUA	B
OeF	OLEQUA	B
OhD	OLEQUA VARIANT	C
OhF	OLEQUA VARIANT	C
OIB	OLYMPIC	B
OID	OLYMPIC	B
OIE	OLYMPIC	B
OIF	OLYMPIC	B
OmE	OLYMPIC	B
OmF	OLYMPIC	B
OpC	OLYMPIC VARIANT	C

Table A-4: Hydrologic Soils Groups (cont.)

Map Symbol	Soil Name	Hydrologic Group
OpE	OLYMPIC VARIANT	C
OpG	OLYMPIC VARIANT	C
OrC	OLYMPIC VARIANT	C
PhB	PILCHUCK	C
PoB	POWELL	C
PoD	POWELL	C
PoE	POWELL	C
PuA	PUYALLUP	B
Ra	RIVERWASH	D
Rc	RIVERWASH	D
Rk	ROCK LAND	D
Ro	ROUGH BROKEN LAND	A
SaC	SALKUM	B
SIB	SARA	D
SID	SARA	D
SIF	SARA	D
SmA	SAUVIE	B
SmB	SAUVIE	B
SnA	SAUVIE	D
SpB	SAUVIE	B
Sr	SEMIAHMOO	C
Su	SEMIAHMOO VARIANT	D
SvA	SIFTON	B
ThA	TISCH	D
VaB	VADER	B
VaC	VADER	B
WaA	WASHOUGAL	B
WgB	WASHOUGAL	B
WgE	WASHOUGAL	B
WhF	WASHOUGAL	B
WnB	WIND RIVER VARIANT	B
WnD	WIND RIVER VARIANT	B
WnG	WIND RIVER VARIANT	B
WrB	WIND RIVER VARIANT	B
WrF	WIND RIVER VARIANT	B
YaA	YACOLT	B
YaC	YACOLT	B
YcB	YACOLT	B