

Technical Memorandum #9



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Subject: Detention volume comparison between single-event and Continuous Flow Modeling with and without LID.
Project 14505
No.:

Introduction

This memo describes the results of a study comparing detention pond sizes calculated in accordance with the current Clark County Code to pond sizes calculated in accordance with the Department of Ecology's flow duration standard.

The current Clark County Code (CCC) refers to the 1992 Puget Sound Manual which utilizes a single-event methodology to size detention ponds. The post-development peak flows must match existing condition peak flows at half the two to the two, ten to the ten, and 100 to the 100-year, 24-hour events. Current CCC also requires existing conditions to be modeled as the least developed condition in the past 30 years.

The Ecology Manual utilizes a flow-duration standard based on HSPF modeling. Ecology developed the *Western Washington Hydrology Model* version 3 (WWHM3) which uses HSPF to generate a continuous flow model based on 50 years of rainfall data. The software compares pre and post development flows durations and determines compliance based on the percent of time the duration is met or not met (see Vol III, page 2-9). Ecology requires pre-developed conditions to be modeled as they were prior to settlement. Pre-settlement conditions are assumed to be undisturbed forest condition (unless otherwise proven).

Three developments were evaluated for this study. Two of the developments have been constructed in Clark County, and the third is a hypothetical development. The constructed developments include *Bridge Creek Village* (single family residential) and *99th Street Development* (commercial). The hypothetical development is a modified version of *Bridge Creek Village*; modifications include increasing lot sizes to 7,500 square-feet.

Summary of Results

Modeling results for the three developments show that meeting Ecology’s flow duration standard results in significantly larger detention pond sizes than meeting Clark County’s current Code. Without the use of LID facilities, pond size increases ranged from 2.8 to 4.3 times larger for the developments modeled in this study. The characteristics with the greatest influence on pond size increases include project site soil infiltration rates, the increase of effective impervious area resulting from the development, and the pre-development site conditions. Pre-development site conditions with little to no runoff result in very large detention ponds due to the amount of post-development runoff that must be stored to meet the duration standard.

Low impact development (LID) facilities were also modeled using WWHM3 to evaluate pond size reductions as a result of incorporating LID into the modeled developments. Various LID options were modeled and results show pond sizes can be reduced with the use of LID. When using LID, the amount of space available for the facilities is important. This is especially true for sites with soils that have limiting infiltration rates, or on sites relying on infiltration to consume all runoff without detention.

Table 1 lists the pond sizes calculated for the three developments based on Clark County’s current code and Ecology’s flow duration standards, with and without LID.

Table 1 Pond Size Comparison			
Development	Current CCC	Ecology Flow Duration Standards – No LID	Ecology Flow Duration Standards – With LID
Bridge Creek (as constructed)	0.50 acres (4-ft depth)	1.42 acres (4-ft depth)	0.40 acres (4-ft depth)
Bridge Creek (modified)	0.24 acres (5-ft depth)	1.04 acres (7-ft depth)	0.55 acres (7-ft depth)
99 th Street	600 LF 72-inch pipe	2244 LF 72-inch pipe	802 LF 72-inch pipe

Table 1 shows that for the specific developments and assumptions used in this study, the incorporation of LID facilities is successful at reducing pond sizes. Please see the attached technical report for a detailed description of the models evaluated for this study.

Attachment - Technical Report

Bridge Creek Village as Constructed

Bridge Creek Village is a 58 lot, single family residential development constructed on 6.3 acres of flat land (0-5% slope) with Hydrologic Soil Group (HSG) B soils. The water table was evaluated at the project site and is recorded in a geotechnical report to be approximately 4 feet below grade.

Infiltration facilities were not used on this site due to the limited depth of soil over the water table as infiltration facilities required 3 feet of separation between the invert of the facility and the surface of the water table at the time of the development.

Current CCC Pond Sizing (from project Stormwater Report)

Prior to the site being developed the land cover consisted of a wooded area with underbrush. These conditions were modeled for the entire site using a single event, unit hydrograph method (SCS method) for pre-developed conditions.

Post developed conditions resulted in approximately 53% of the site becoming impervious. The site was constructed with a wetpond to provide both detention and water quality treatment volumes.

The areas as modeled using the single event method for post developed conditions follow:

- Roofs: 1.45 acres
- Pavement: 1.74 acres
- Pond: 0.30 acres
- Lawn: 2.81 acres

A wetpond was constructed on site with a live storage volume of about 2 acre-feet (approximately 0.5 acres, 4-ft deep). This does not include the treatment storage provided in the bottom of the wetpond.

Ecology's Flow Duration Pond Sizing without LID

The entire site was modeled as *C, Forest, Flat* for pre-development conditions.

For modeling post-development conditions in WWHM3 without LID, site areas were modeled as follows:

- C, Lawn, Flat: 2.96 acres
- Parking Lot, Flat: 3.34 acres

The WWHM3 Autopond feature was used to size a detention pond meeting Ecology’s flow duration standards. Autopond calculated a pond size of 1.42 acres, with a 4-ft depth (including freeboard).

Ecology’s Flow Duration Pond Sizing with LID

Due to high groundwater and unfavorable conditions for infiltration, the entire site was modeled as *C, Forest, Flat* for pre-development conditions. For post-development conditions the LID facility modeled included pervious pavement for driveways and sidewalks. In addition, each lot was assumed to contain a 10-foot by 10-foot rain garden. These rain gardens were modeled as an equivalent composite rain garden measuring 76 ft x 76 ft. The rain garden was modeled as a trapezoidal pond with 1.8-feet of effective depth, an infiltration rate of 0.5 inches/hour, and a riser weir overflow.

To model the post-development site in WWHM3 using LID facilities, site areas were modeled as follows:

- C, Lawn, Flat: 2.96 acres
- C Lawn, Flat (to model pervious pavement for driveways and sidewalks): 1.0-acre
- Roof tops, Flat (to model roofs: 1.34 acres routed to rain garden).
- Roads, Flat: 1.0-acre

WWHM3 was used to size a detention pond manually meeting Ecology’s flow duration standards. A detention pond was calculated with a size of 0.40 acres and a depth of 4-feet (including freeboard).

Table A1 compares the results of the Bridge Creek Village, as constructed, detention pond sizes.

Table A1 Bridge Creek Village as Constructed Detention Pond Size Comparison		
Design Method	Top Area (acres)	Depth (ft) Includes Freeboard
Current CCC	0.50	4.0
Ecology’s Flow-Duration w/out LID	1.42	4.0
Ecology’s Flow-Duration w/LID	0.40	4.0

Modified Bridge Creek Village

To represent a residential development constructed in HSG C soils with more pervious area than Bridge Creek Village as constructed, the Bridge Creek development was modified. The lot sizes were increased from an average of 3,000 square feet to 7,500 square feet and the soils were modeled as glacial till (HSG C). These modifications resulted in a total project area of 11.39 acres.

Current CCC Pond Sizing

The Santa Barbara Urban Hydrograph (SBUH) method was used to model the modified Bridge Creek Development with the *Hydraflow Hydrograph* software. Prior to the site being developed the land cover consisted of a wooded area with underbrush. These conditions were modeled using the SBUH method for the entire site under pre-development conditions.

The areas as modeled using the SBUH method for post-development conditions follow:

- Impervious: 6.0 acres
- Lawn: 5.39 acres

A detention pond was then sized in accordance with the current CCC. The optimum pond size was calculated to be 0.24 acres, with a 5-ft depth (including freeboard).

Ecology's Flow Duration Pond Sizing without LID

The entire site was modeled as *C, Forest, Flat* for pre-development conditions.

For post-development conditions without the use of LID, the site areas were modeled as follows:

- Roofs: 4.0 acres
- Streets: 1.0-acre
- Driveways and sidewalks: 1.0-acre
- C, Lawn, Flat: 5.39 acres

The Autopond feature was then used to size a detention pond meeting Ecology's flow duration standards. Autopond calculated a pond size of 1.04 acres, with a depth of 7-feet (including freeboard).

Ecology's Flow Duration Pond Sizing with LID

The entire site was modeled as *C, Forest, Flat* for pre-development conditions.

For post-development conditions, pervious pavement was modeled for sidewalks and driveways, and the runoff from 1.25 acres of impervious roof area was directed to and completely infiltrated by rain gardens with 10ft x 10ft bottom areas on each lot. These rain gardens were modeled as an equivalent composite rain garden measuring 76 ft x 76 ft. The rain garden was modeled as a trapezoidal pond with 1.8-feet of effective depth, an infiltration rate of 0.5 inches/hour, and a riser weir overflow. The amount of roof area routed to the modeled rain garden was limited to the

amount the rain garden could completely infiltrate resulting in no overflow. This area was calculated to be 1.25 acres by WWHM3. This area was not included in the basin used to size the detention pond.

For post-development conditions with the use of LID, the site was modeled as follows:

- C, Lawn, Flat: 5.39 acres
- C, Lawn, Flat: 1.0-acre (to model pervious pavement for driveways and sidewalks)
- Routed to rain garden and not used in detention pond sizing: 1.25-acres (from roofs)
- Roofs, Flat: 2.75 acres (remaining roof area)
- Roads, Flat: 1.0-acre

The Autopond feature was used to size a detention pond meeting Ecology’s flow duration standards. Autopond calculated a pond size of 0.55 acres, with a depth of 7-feet (including freeboard).

Table A2 compares the results of the modified Bridge Creek detention pond sizes.

Table A2 Modified Bridge Creek Village Detention Pond Size Comparison		
Design Method	Top Area (acres)	Depth (ft) Includes Freeboard
Current CCC	0.24	5.0
Ecology’s Flow-Duration w/out LID	1.04	7.0
Ecology’s Flow-Duration w/LID	0.55	7.0

Table A2 shows that for the modified Bridge Creek Village development the use of LID facilities and applying flow-duration criteria with a continuous flow model results in a larger pond than using the current CCC, and a smaller pond than using Ecology’s flow duration standards without LID. This shows that even in poorly drained till soils, the use of LID modeled in accordance with Ecology is successful at reducing detention pond sizes compared to the same standards not using LID.

99th Street Development

The 99th Street Development consists of two commercial buildings and a parking lot constructed on 2.63 acres of flat land (0-5% slope) with Hillsboro Series soils. Hillsboro Series soils are listed as HSG B, however experience with these soils shows that they are poorly drained. For this reason they were modeled as HSG C soils in WWHM3 for this study.

Current CCC Pond Sizing

Prior to development site cover consisted of grass with a few trees and one residence with a gravel road. The stormwater management plan for this project modeled these conditions to determine the peak pre-development flow using a unit hydrograph method. An underground storage tank consisting of 600 feet of 72-inch diameter pipe was constructed as the detention facility for this development. A water quality manhole with filters was installed downstream of the tank to provide treatment.

Ecology's Flow Duration Pond Sizing without LID

The entire site was modeled as *C, Forest, Flat* in WWHM3 for pre-development conditions. Post-development conditions resulted in approximately 89% of the site becoming impervious. The post-development site areas were modeled as follows:

- Roof Area, Flat: 0.51 acres
- Parking Lot, Flat: 1.37 acres
- Sidewalk, Flat: .18 acres
- C, Lawn, Flat: 0.57 acres

The Autopond feature was then used to size a detention pond meeting Ecology's flow duration standards. Autopond calculated a pond volume of 63,469 cubic feet. This would require a storage tank consisting of 2,245 feet of 72-inch diameter pipe.

Ecology's Flow Duration Pond Sizing with LID

The entire site was modeled as *C, Forest, Flat* in WWHM3 for pre-development conditions. The WWHM3 model with LID was programmed with the parking lot and sidewalks constructed with permeable pavement over the existing underlying soil. The overflow from the pervious pavement was accounted for in the sizing of the detention pond by the model. Pervious pavement was modeled as *C, Lawn, Flat*.

The Autopond feature was used to size a detention pond meeting Ecology's flow duration standards. Autopond calculated a pond volume of 22,693 cubic feet. This would require a storage tank consisting of 803 feet of 72-inch diameter pipe.

Table A3 compares the results of the 99th Street Development detention pond sizes.

Table A3 99 th Street Development Detention Pond Size Comparison		
Design Method	Volume (ft ³)	Feet of 72-inch Pipe
Current CCC	16,964	600
Ecology's Flow-Duration w/out LID	63,469	2,245
Ecology's Flow-Duration	22,693	803

w/LID		
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Table A3 shows the use of LID is very beneficial for reducing the volume of the detention tank for the 99th Street Development. Further study of the 99th Street Development may allow for other LID features to be constructed that would result in the detention volume approaching, or even becoming smaller than the volume calculated in accordance with Clark County's current Code.