MEMORANDUM

To: Mayor and City Council

From: Ken Gibb, Community Development Director

Copy: Jon Nelson, City Manager

Date: March 11, 2011

Subject: Brooklane Heights Conceptual and Detailed Development Plan and Tentative Subdivision Plat (PLD06-00018, SUB06-00006), Storm Water Design.

I. Issue

City Council review of this matter is limited to issues related to the proposed stormwater design. The Brooklane Heights Conceptual and Detailed Development Plan, and Tentative Subdivision Plat land use application has received conditional approval by the City Council (Order Numbers 2007-111, 2009-007, and 2010-007). Each of the Council decisions to approve the application were appealed to LUBA. The first and second decisions were remanded by LUBA to the City Council. The third decision, which modified conditions of approval numbers 20 and 27 to respond to the LUBA remand of Order #2009-007, was affirmed by LUBA **(Exhibits III - VIII)**, thereby upholding the City Council decision to approve, with conditions, the Brooklane Heights land use application.

In summary, Condition of Approval 20 of the latest City Council decision (Order 2010-007), requires the applicant to submit materials, to be reviewed during a public hearing process, that demonstrate that the proposed water quality facilities are consistent with Comprehensive Plan policy 4.11.12, and comply with criteria outlined in Appendix F of the Corvallis Storm Water Master Plan and criteria outlined in the King County, Washington, Surface Water Design Manual. Condition 27 of Order 2010-007 requires areas not previously approved to be graded, to be reviewed through a public hearing process to determine if the grading is consistent with Comprehensive Plan policy 4.6.7, regarding hillside development.

In response to Conditions of Approval 20 and 27, the applicant has submitted stormwater facility plans, and grading plans limited to work associated with the proposed stormwater facilities. (Grading in any other area not previously approved must be reviewed through a future public hearing process for compliance with Policy 4.6.7 prior to issuance of grading permits in those areas.) Because City Council Order 2010-007 approved the Conceptual and Detailed Development Plan, and Tentative Subdivision Plat application, this memorandum only provides analysis of the stormwater facility plans, and associated grading, for compliance with Conditions of Approval 20 and 27. Likewise, the City Council is asked to review the proposed stormwater facility plans for the limited purpose of

determining if the plans comply with Conditions of Approval 20 and 27 of City Council Order 2010-007.

II. Background

The site is a 25.88 acre property that is currently undeveloped, except for an underground sanitary sewer line that runs along the western and southwestern boundary, and a small gravel access road that enters the site near its southwest corner. The site is located northwest of Brooklane Drive, northeast of Agate Avenue, east of Fairmont Drive, and south of Whiteside Drive. The site is identified as Tax Lot 1000 on Benton County Assessor's Map 12-5-10 C. The property is owned by Stephen J. Schaberg. The Planned Development application was submitted in 2006, prior to adoption of the current 2006 Land Development Code, and is subject to the 1993 Land Development Code, as amended. The 1993 LDC required Planned Development applications to be reviewed for compliance with the new Comprehensive Plan policies, which were not fully implemented by the 1993 Code language. Those policies include policies 4.6.7 and 4.11.12, the two policies the applicant must demonstrate consistency with per Conditions of Approval 20 and 27 of City Council Order 2010-007.

As outlined below, the application has been reviewed three times by the City Council. On each occasion the Council approved the application with conditions, and each Council decision was appealed to the Land Use Board of Appeals (LUBA). The first two Council decisions were remanded, the third Council decision was affirmed **(Exhibits III-VIII)**.

Case History Summary

- June 20, 2007 - The Planning Commission deliberated and voted to deny the application. A notice of decision was signed on June 22, 2007.

- July 5, 2007 – Applicant, Stephen Schaberg, filed an appeal of the Planning Commission's decision.

- September 4, 2007 - The City Council overturned the Planning Commission's decision, thereby approving the proposal, with conditions (Order No. 2007-111) **(Exhibit VIII)**.

LUBA 1

- October 9, 2007 - The City received a Notice of Intent to Appeal the City Council decision to LUBA. The decision was appealed by Anne Davies, Attorney, on behalf of Petitioners, Arthur and Barbara Boucot, et. al. (Boucot et. al vs City of Corvallis, LUBA No. 2007-200)

- May 30, 2008 - LUBA issued a Final Order and Opinion. LUBA determined that the City had not made adequate findings in support of the proposal with respect to two of the assignments of error raised in opposition, and portions of two other assignments of error **(Exhibit VII)**.

- February 2, 2009 – The City Council reviewed and addressed the remand issues and approved the application subject to adoption of Formal Findings. Formal Findings were adopted and signed on March 2, 2009 (Order No. 2009-007) **(Exhibit VI)**.

LUBA 2

- March 31, 2009 - The City received a notice that the decision to approve the application was being appealed a second time to LUBA (Morre et. al vs City of Corvallis, LUBA No. 2009-042).

- October 29, 2009 - LUBA remanded the case after determining that the City failed to make adequate findings that the individual lot grading and stormwater treatment plans satisfied applicable review criteria in the Comprehensive Plan **(Exhibit V)**.

- December 16, 2009 - The applicant submitted a letter to the Planning Division asking the City to act on the remand. This correspondence was received by the Planning Division on approximately December 21, 2009.

- January 4, 2010 – The City Council scheduled a hearing for February 1, 2010, to consider the specific issues in the LUBA remand. The Council's decision was based on information already in the record (no new information was submitted or considered). Because the Council's decision was based on information already in the record, the Council opened a public hearing on the remand issues only to give the opportunity for the public to rebut Councilor declarations. Written and oral testimony were not accepted.

- February 1, 2010 - The City Council held a public hearing and approved the Planned Development application, with conditions, including revisions to previously approved Conditions of Approval 20 and 27. This decision (Order 2010-007) upheld the two previous Council decisions to approve the subject application **(Exhibit IV)**.

- February 23, 2010 - City Staff received a Notice of Intent to Appeal the Council decision to LUBA.

LUBA 3

- July 15, 2010 - LUBA issued a Final Opinion and Order affirming the Council decision to approve the application, subject to revised Conditions of Approval 20 and 27 **(Exhibit III)**.

- March 1, 2011 - The applicant submitted a document titled *Brooklane Heights Storm Water Analysis and Design Corvallis, Oregon* that contains the applicant's response to Conditions of Approval 20 and 27 **(Exhibit II)**.

Background specific to Conditions of Approval 20 and 27, as revised by the City Council, and Comprehensive Plan policies 4.6.7 and 4.11.12, as well as these Conditions and Policies, is provided below.

Case History Related to Conditions 20 and 27

In October, 2009, LUBA remanded the City Council decision in Order 2009-007 regarding the Brooklane Heights application because it found the Council did not make adequate findings regarding Corvallis Comprehensive Plan (CCP) policies 4.6.7 and 4.11.12. LUBA also found that the City was wrongly deferring consideration of compliance with these policies to a future review process that would not provide public notice or opportunity for public input **(Exhibit V)**. As discussed in more detail below, these remand issues were specific to individual lot grading plans and stormwater drainage plans.

Condition 20 - Stormwater Quality and Drainage

In its 2009 decision, the City Council approved the proposed stormwater drainage and treatment plans subject to Condition of Approval 19, which required the applicant to design stormwater facilities consistent with the City's Stormwater Master Plan (SWMP). The Council found that if constructed to the standards in the adopted SWMP, the storm water facilities would be consistent with CCP 4.11.12, one of the two review criteria currently at issue. Compliance with the SWMP would be determined through review of Public Improvement by Private Contractor (PIPC) permit applications. This would occur outside of the public hearing process because PIPC permit applications are reviewed and decided upon administratively. However, in this case, LUBA determined that,

> "because the city deferred a finding of compliance with 4.11.12 to a future proceeding involving a determination regarding compliance with the SWMP standards, and failed to ensure that future proceeding will be a public proceeding, those findings are inadequate. On remand, the city must clarify that a future proceeding to determine compliance with the SWMP standards will be subject to public participation" **(Exhibit V.16)**.

Based on the above direction in the LUBA remand, the City Council, via Order 2010-007, revised Condition of Approval 20 to require review of storm water facilities for consistency with Corvallis Comprehensive Plan (CCP) 4.11.12 through a public hearing process. The applicant has submitted materials for review by the City Council that are intended to demonstrate consistency with CCP 4.11.12, and applicable criteria in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual.

Condition of Approval 20 and CCP 4.11.12

Condition of Approval 20 as revised in City Council Order 2010-007, and CCP 4.11.12 are provided below. The full Notice of Disposition for Council Order 2010-007 is provided in **Exhibit IV**.

Condition of Approval 20

20. **Public Water Quality Facility Design & Maintenance** - The applicant shall submit the information required in this condition of approval. This information shall be reviewed for consistency with Comprehensive Plan Policy 4.11.12 and approved through a City Council Public Hearing review process prior to issuance of PIPC permits.

As part of the plans for public improvements the applicant shall provide engineered calculations for storm water quality facilities demonstrating compliance with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting water quality requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The water quality analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons.

All water quality facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for two years after acceptance by the City. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the warranty for storm water quality facilities is terminated.

The design for the public water quality facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.

CCP 4.11.12

4.11.12 Development upslope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands.

Condition 27 - Individual Lot Grading Plans

Grading is necessary to install the proposed stormwater facilities, including a required access drive to the proposed detention vault south of Badger Place **(Exhibit II.11)**.

In 2009, via Order 2009-007, the City Council approved a two phase approach to site grading **(Exhibit VI)**. First, some portions of the site, including the locations of streets and utilities would be mass graded. Mass grading would prepare the site for streets and utilities, and would create flat pads on certain lots for building construction **(Exhibit VI.4)**. During the second phase of the grading plan, individual lots that were not included in the areas to be mass graded would be prepared to accommodate custom building designs.

In 2009, the City Council evaluated the grading plan for compliance with CCP 4.6.7, and found that, through application of Conditions of Approval 22 and 27, the grading plan was consistent with this review criterion. Condition of approval 27 required all areas not mass graded to comply with the Hillside Development Standards in 2006 LDC Section 4.5.80.03. The determination of compliance with 2006 LDC Section 4.5.80.03 would occur when applications to develop individual lots (non-mass graded) were submitted. Council found that because LDC Section 4.5.80.03 provided clear and objective standards, Staff discretion would not need to be exercised in determining compliance, and consequently, a public hearing would not be required.

LUBA was not convinced by this finding. LUBA remanded the 2009 Council decision stating that the City should have made a determination that the proposed individual lot grading complied with CCP 4.6.7, provided there was substantial evidence in the record to support this determination. LUBA also stated that just because standards are nondiscretionary does not mean that compliance with those standards can be deferred to a future, non-public, decision making process, when the standards are otherwise applicable to an application that requires a public hearing. Even if nondiscretionary standards could be excepted from consideration during a public review process, LUBA found that the Council findings did not adequately explain why the applicable standards in 2006 LDC Chapter 4.5 are clear and objective **(Exhibit V.8)**.

Based on the direction given in the LUBA remand, the City Council revised Condition of Approval 27 by removing the requirement to comply with standards for hillside development in the 2006 LDC, and to include the requirement that the applicant "obtain approval by the City Council through a public hearing review process, detailing how the grading plan(s) for development on individual lots are consistent with Comprehensive Plan Policy 4.6.7" (Condition 27, Order 2010-007; **Exhibit IV**).

Condition of Approval 27 and CCP 4.6.7

Condition of Approval 27 as revised in Council Order 2010-007 and CCP 4.6.7 are provided below.

Condition of Approval 27

27. **Lot Grading and Structures** -Mass grading shall be limited to the areas shown on the grading plan identified as Drawing X – Brooklane Heights Grading and Tree Preservation Plan, and Drawing Y – Brooklane Heights Cut/Fill Analysis (Exhibits D.1, 2). Cuts and fills in the areas permitted to be mass graded shall not exceed the measurements shown in Drawing Y. All mass graded areas, as shown in Drawing Y shall be engineered and constructed such that retaining walls are neither required nor used.

Prior to grading and excavation activities in areas not approved for mass grading, as shown in Drawing Y (Exhibit D.2), the applicant shall obtain approval by the City Council through a public hearing review process, detailing how the grading plan(s) for development on individual lots are consistent with Comprehensive Plan Policy 4.6.7.

CCP 4.6.7

4.6.7 In areas where development is permitted, standards in the Land Development Code for hillside areas will achieve the following:

A. Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development.

B. Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities.

C. Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees.

D. Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments.

E. Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated.

F. Design developments and utilize construction techniques that minimize erosion and surface water runoff.

G. Demonstrate a concern for the view of the hills as well as the view from the hills.

H. Provide landscaping that enhances the identified open space resources.

I. Design developments that consider landscaping management that will minimize the threat of fire on improved property spreading to wildland habitat.

Case History Conclusion
On appeal, LUBA upheld the Council decision expressed in Order 2010-007, which modified Conditions of Approval 20 and 27 to require a public hearing process for work related to proposed storm water facilities and grading on areas not previously approved (non-mass graded areas). The applicant has submitted detailed plans regarding the design of public storm water detention and water quality facilities. The applicant has also submitted grading plans for installing the storm water facilities, including for the access off of Badger Place to an underground stormwater detention tank **(Exhibit II)**. All other areas not previously approved to be graded, will be reviewed during a separate, future, public hearing process to determine compliance with CCP 4.6.7, as required by Condition 27 of Order 2010-007.

III. Discussion

The Discussion section of this report is divided in three parts: Proposal Summary, Analysis of Compliance with Condition of Approval 20, and Analysis of Condition of Approval 27. The Proposal Summary provides an overview of the proposed storm water quality and detention facilities, including related grading activities. The other two sections include discussion and analysis regarding the compliance of the proposed water quality facilities and associated grading with the requirements of Conditions of Approval 20 and 27. Analysis in these sections considers the proposal's compliance with applicable review criteria in Appendix F of the Storm Water Master Plan, criteria outlined in the King County, Washington, Surface Water Design Manual, and consistency with Comprehensive Plan policies 4.6.7 and 4.11.12, the two policies referenced in Conditions of Approval 20 and 27 of Order 2010-007, which addressed the LUBA remand of Council Order 2009-007.

The analysis in this section of the report will form the basis for the overall Staff conclusions regarding compliance with Conditions of Approval 20 and 27, and recommendations for Council consideration.

Proposal Summary
In response to Conditions of Approval 20 and 27 of City Council Order 2010-007 the applicant has submitted stormwater management plans and grading plans associated with the installation and access of the stormwater facilities. The proposed plans include three components: stormwater conveyance, stormwater detention vaults, and stormwater quality facilities. Conveyance pipes would be located in the northeast portion of Wolverine Drive, Buckeye Place, and Badger Place. Pipes would also be installed below the lots on the south side of Buckeye Place and Badger Place, and between Wolverine Drive and the private alley abutting the south side of the subject site. A large detention vault is proposed below Badger Place in Tract B, where a detention pond was previously approved. Smaller vaults are proposed in Wolverine Drive near the northeast corner of the site and at the intersection of Wolverine and Brooklane Drives. Water quality facilities are located with each of the detention vaults **(Exhibit II.6-17)**.

To demonstrate compliance with Conditions of Approval 20 and 27, the stormwater plans first approved by the City Council have been modified by the applicant and include much greater detail; similar to what is expected for PIPC Permit applications. The most noticeable difference in the current plan compared to what was most recently approved, is that the two detention ponds originally proposed along Badger Place have been replaced with a single below ground detention vault, and the wide swale in the northeast corner of the site has been replaced with an underground pipe **(Exhibit II.6, 33)**, that doesn't require the open channel. The design and function of the proposed detention vault complies with applicable standards in the Stormwater Master Plan, however, it requires removal of 14 trees originally planned for preservation. Similarly, one tree in the northeast corner of the site originally planned to be preserved would be removed to install the underground conveyance pipe. The removed trees are proposed to be mitigated by planting 14 new trees near the detention vault **(Exhibit II.15)**. Tree removal will be discussed later in this report under the section addressing Comprehensive Plan policy 4.6.7.

Proposed grading is limited to what is needed to install the storm lines, detention tanks, water quality facilities, and an access serving the large detention tank abutting Badger Place. The 1993 LDC, as amended, does not have standards that limit cuts and fills. In previous decisions regarding the Conceptual and Detailed Development Plan, CCP 4.6.7 was the criterion used by the City Council to evaluate cuts and fills. Consistent with the previous use of this policy and Condition of Approval 27, CCP 4.6.7 will be used as a criteria to evaluate the grading proposed to install stormwater facilities.

As described in more detail in the application materials and in the analysis, below, stormwater would be directed to streets or drainage channels which would convey the water to one of three below grade vaults which would detain and treat the water prior to its release into existing public stormwater facilities, where it would be directed to the wetland, southeast of Brooklane Drive.

The balance of this report evaluates the proposal's compliance with Conditions of Approval 20 and 27, including compliance with applicable City standards and CCP 4.11.12 and 4.6.7, which are specifically referenced in Conditions 20 and 27.

Analysis of Condition of Approval 20

The following analyzes the application materials for compliance with Condition of Approval 20. Evaluation first focuses on the proposal's compliance with applicable standards in the Corvallis Stormwater Master Plan, and second by evaluating the proposal for consistency with CCP 4.11.12.

Overview

Comp Plan policy 4.11.12 states *"Development up slope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands."* The applicants have submitted a stormwater plan for the Brooklane Heights development. The plans and calculations submitted show compliance with the City's Land Development Code (LDC)

and with the City's Stormwater Master Plan, specifically Appendix F of the Master Plan. In showing compliance with the City's requirements, the applicants have demonstrated that they will be retaining the existing drainage patterns to the wetlands located below the site by providing post-development drainage outlets at the same locations the pre-developed site drains to. With the implementation of both stormwater detention and water quality, the post-development stormwater runoff rate from the site will be held to the pre-developed rate, up to the 10-year, 24 hour storm as required by the Storm Water Master Plan. Stormwater flow up to and including the City's 0.9 inch, 24 hour, stormwater quality design storm will also be filtered by Storm Filter vault water quality facilities in order to minimize detrimental changes in water quality.

The City's LDC 4.0.80.e specifies that all public utility installations required with development shall conform to the City's adopted facilities master plans **(Exhibit I)**. In the case of stormwater, the City's Storm Water Master Plan, adopted September 2002, and its Appendix F contain the City's associated design standards.

Stormwater Conveyance

The site is located within the Marys River drainage basin. Drainage patterns on the existing site are generally from the northwest to the southeast. Stormwater flowing to the southeast is collected in a series of existing private ditches and public stormwater inlets located on the northern edge of Brooklane Park Estates, which abuts much of the south boundary of the subject site. The public storm system within Brooklane Park Estates was installed when Brooklane Park Estates subdivision was developed. Stormwater from the applicant's site that passes through Brooklane Park Estates is released at pre-developed rates into a wetland area to the south and southeast of Brooklane Park Estates, and eventually reaches the Marys River **(Exhibit II.13)**.

The partially approved and proposed development on the applicant's site will collect stormwater from roads, backyard drains, and drainage ways through open and piped systems. The systems will drain though stormwater detention and water quality facilities before making connections to the existing piped public system located within Brooklane Park Estates.

The site can be broken into three distinct drainage basins that can be seen on the applicant's submitted Sheet 1.7 and 1.9 **(Exhibits II.8, 10):** a western basin that drains a portion of Track A and the southern portion of Wolverine Drive from Badger Place to Brooklane Drive; a Central Basin that drains Track B, a portion of Track C, Badger Place, Buckeye Place, and Wolverine Drive from Badger Place to the top of the hill; and an eastern basin that drains a portion of Track C and Wolverine Drive from the top of the hill to the limits of the development at the northeast. The conveyance systems proposed for the site can be seen on the applicant's submitted sheet 1.7 **(Exhibit II.11)**.

The western basin stormwater conveyance system is proposed to consist of gutters; catch basins; a public piped system within Wolverine Drive; a detention vault; a connection to the

existing storm system in Brooklane Drive; and storm filter vault on the existing storm line in Brooklane Drive.

The central basin stormwater conveyance system is proposed to consist of gutters; catch basins; a piped system within Buckeye Place that drains to open drainageways; a piped system in a portion of Wolverine Drive and Badger Place that drains to the central detention vault; the open drainageways that drain to the central detention vault; a private back-yard pipe serving the lots below Buckeye Place that drains to the open drainageway; private back-yard pipes serving the lots below Badger Place that drain into the central detention vault; a storm filter vault, and a connection to the existing public system that drains through Brooklane Park Estates.

The eastern basin stormwater conveyance system is proposed to consist of gutters; catch basins; a piped system within the eastern portion of Wolverine Drive; a detention vault; a storm filter vault; and a piped connection to the existing public system that drains through Brooklane Park Estates.

The open drainageways mentioned above are proposed to consist of "V" shaped, rock lined channels **(Exhibit II.12)**. The channels have been designed in accordance with King County's Surface Water Design Manual (SWDM), Open Channels Section 4.4.1. Calculations for capacity and velocity within the designed channels can be found in the applicants submitted *Brooklane Heights Storm Water Analysis & Design*, Section 9 Runoff Conveyance Analysis. Concurrent with the final plat, the open channels shall be placed in Drainageway Easements. The easement shall be per 1993 LDC 4.5.80.d.3, with a minimum easement width equal to the drainage channel width plus 1.5 times the width, plus 5 ft on each side of the channel. Channel width + 2((1.5 x channel width) + 5') = 12' + 2((1.5 x 12') + 5') = 58 ft **(Condition 3)**.

The private back-yard storm drainage pipes mentioned above are proposed to consist of 12 inch PVC pipes that will convey storm drainage from below the lots that are located below public streets, Buckeye Place and Badger Place. The lots being served by these private storm drainage pipes are all located along public streets that have a public storm drainage system located within them. The City considers the access these lots have to the public system to be serving the lots, as required in LDC 4.0.80.a. The private pipes are an additional facility that the developers are providing to the lots and not subject to the requirements of 4.0.80.a **(Exhibit I)**.

Per Appendix F of the City's Stormwater Master Plan, conveyance facilities shall be designed for capacity, size, grades, and separation. Capacity is discussed in the following paragraph. The size requirements list a minimum pipe size of 12 inches for mains and 10 inches for laterals. All pipe sizes shown in the submitted *Brooklane Heights Stormwater Design Analysis* and shown on the submitted plan sheets comply with the minimum pipe size requirements. The grade requirement stipulates that all pipes shall be designed at a grade to produce a mean velocity of at least 2 fps when flowing full. In Section 9, Runoff

Conveyance Analysis, of the submitted *Brooklane Heights Stormwater Design Analysis* calculations are included that demonstrate compliance with the minimum velocity requirement. The separation requirement only allows the combination of sanitary and storm sewer in areas of the City with existing combined systems. The proposed stormwater conveyance system is separated from the sewer system and complies with this requirement.

Per Appendix F of the City's Stormwater Master Plan, stormwater conveyance systems shall be designed to convey and contain the peak runoff flow from the 10-year design event. No surcharging of the system is allowed for the 10-year storm event. Conveyance system capacity shall be determined using the Rational Method. The applicant has provided design calculations in the submitted *Brooklane Heights Stormwater Design Analysis.* Section 9, Runoff Conveyance Analysis, provides the 10-year Rational Method calculations and corresponding pipe and open channel flow capacities that demonstrate compliance with the City's requirements **(Exhibit II.164)**.

In addition, the 10-year conveyance design shall be supplemented with an overland conveyance component demonstrating the safe passage of the 100-year, 24-hour SCS type 1A storm event. The overland component shall not be allowed to flow through or inundate existing buildings. The applicant has provided design calculations in the submitted *Brooklane Heights Stormwater Design Analysis*. Section 10, SBUH Hydrograph Analysis, provides hydrographs for the west, central, and east connection points up to the 100-year flows **(Exhibit II.220)**. The flows shown are less than the capacities of the pipes and open channels. These hydrographs demonstrate compliance with the City's requirements. The overland component that is allowed in Appendix F is not required as the hydrographs show the pipes will flow the designed 100-year flows without surcharge to the piped system.

As shown above, the piped and open channel systems comply with both the 10-year and 100-year flow requirements. The hydraulics of the flow control device in the detention vaults were also checked for compliance with 10-year and 100-year flows. Section 12, Flow Control Hydraulics of the *Brooklane Heights Stormwater Analysis & Design,* submitted by the applicants, provides calculations showing the flow control riser and the weir on top of the riser have the capacity to pass the 10-year Rational Method flows as well as the 100-year SBUH hydrograph flows **(Exhibit II.256)**. The design of the Storm Filter water quality vault allows for pipes connected to the structure, flowing at full design capacity, to pass through the structure. The Runoff Conveyance Analysis, Section 9 of the *Brooklane Heights Stormwater Analysis & Design*, shows that the pipes associated with the water quality facilities have capacity for the designed flows **(Exhibit II.164)**. These calculations show compliance with the stormwater conveyance requirements through the detention and water quality facilities.

It should be noted that the calculated 100-year flows are lower than the 10-year flows. This is a result of the different methods used to calculate each flow scenario. Per Appendix F

of the City's Stormwater Master Plan, 10-year flows are to be calculated with the Rational Method for areas less than 25 acres and 100-year flows are to be calculated with a hydrograph method for all areas. The Rational Method is known for being excessively conservative and is the reason the City chose to specify its use. Use of the Rational Method adds a factor of safety to the City's conveyance system. Hydrograph methods, such as the Natural Resource Conservation Service (NRCS) TR-55 or the Santa Barbara Urban Hydrograph (SBUH) method, chosen by the applicants, are known to be more accurate for actual flows expected from a site.

Stormwater Detention

Condition 19 from Order 2010-007, PLD06-00018, SUB06-00006, was modified because detention vaults are being used instead of detention ponds, and to ensure compliance with Comprehensive Plan policy 4.11.12. Please see **Condition 4**.

Land Development Code Section 4.5.90.b.1 requires development projects that create impervious surfaces in excess of 25,000 ft^2 to implement stormwater detention or retention and that detention facilities shall be designed to maximize infiltration. Per Appendix F of the City's Stormwater Master Plan, when required, stormwater detention facilities shall be designed to capture runoff so the run-off rates from the site after development do not exceed the pre-developed conditions, based on the 2-year through 10-year, 24-hour design storms. Appendix F of the City's Stormwater Master Plan contains the standards for detention facilities. Detention facilities shall be designed in accordance with criteria as established in the *King County, Washington Surface Water Design Manual,* September 1998 or the most recent final version; parking areas should not be used as detention facilities except for larger storm events; detention of storm water shall be limited to a single facility, rather than a series of smaller detention facilities, whenever possible; and the detention facility must be designed to safely pass storms up to the 100-year, 24-hour event.

Stormwater detention facilities shall be designed to capture runoff so the run-off rates from the site after development do not exceed the pre-developed conditions, based on the 2-year through 10-year, 24-hour design storms. Detention facilities shall be designed in accordance with the criteria as established in the most recent version of the King County Surface Water Design Manual. At this time, the January 9, 2009 edition is the most current Surface Water Design Manual. The City will assume maintenance responsibility two years after final construction approval by the City and upon passing an inspection by City inspectors to ensure the facility has been properly maintained and the facility is operating as designed. The site developer/owner shall provide a maintenance bond to the City that shall remain in effect until the facilities are accepted by the City and the warranty period is terminated **(Condition 4)**.

While LDC 4.5.90.b.1 requires detention facilities to maximize infiltration, Appendix F of the City's Stormwater Master Plan states that infiltration shall not be allowed in areas with slopes over 10%. The applicant's site is largely covered with areas of slopes over 10%. In addition, the applicant's Geotechnical Report recommends lining the detention ponds

to minimize stormwater infiltration "to decrease the risk of seepage and/or piping that could undermine the slopes or create localized instabilities". The applicant has proposed to construct subsurface detention vaults for storage of stormwater in excess of the pre-developed 2-year through 10-year flows. Detention vaults comply with the Requirements of Appendix F and the recommendations of the Geotechnical Report.

Per Appendix F of the City's Stormwater Master Plan, stormwater detention facilities shall be designed to capture runoff so the run-off rates from the site after development do not exceed the pre-developed conditions, based on the 2-year through 10-year, 24-hour design storms. The applicants have submitted calculations in the *Brooklane Heights Storm Water Analysis & Design*, Section 10, SBUH Hydrograph Analysis and Section 12, Flow Control Hydraulics. These sections contain hydrographs and flow control structure hydraulics that show how the proposed development complies with the detention requirements for 2-year through 10-year flow conditions such that post-development flows do not exceed pre-development flows under the above conditions.

The proposed detention facilities are designed to the most recent version of King County's Storm Water Design Manual for Detention Vaults (SWDM 5.3.3). The applicants have submitted calculations in the *Brooklane Heights Storm Water Analysis & Design*, Section 10, SBUH Hydrograph Analysis and Section 12, Flow Control Hydraulics and plan sheets 1.7, 1.8, 1.10, 1.11, 1.12, and 1.14 that show where the detention vaults are proposed to be located and configured **(Exhibits II.220, 256, and 11-17)**. These submittals show how the proposed detention facilities meet the facility design requirements of King County's most recent Surface Water Design Manual.

Per Appendix F, the use of parking areas for stormwater detention is not allowed except for larger storm events. The proposed detention vaults are not associated with parking so the requirement has been met.

Per Appendix F, detention of storm water shall be limited to a single facility, rather than a series of smaller detention facilities, whenever possible. The applicant's site is located across a broad hillside. The existing drainage patterns on the site drain to multiple points. It is not practical or desirable to change the natural drainage patterns to facilitate a single detention facility. Each of the sites drainage basins are proposed to have a single detention vault associated with each separate conveyance system. Designing the system this way assures each outlet from the site complies with the post-development flow requirements, as opposed to over detaining on one portion of the site, and not detaining on another. The applicants have shown compliance with this requirement by providing a single facility for each basin.

As shown in the Conveyance section, the applicants have shown compliance with the requirement to safely pass storms up to the 100-year 24 hour storm event per Appendix F requirements.

Stormwater Treatment

Land Development Code Section 4.0.80.e specifies that all public utility installations required with development shall conform to the City's adopted facilities master plans. In the case of stormwater, the City's Storm Water Master Plan, adopted September 2002, and its Appendix F contain the City's associated design standards. Per Appendix F, all new development and redevelopment are required to construct water quality facilities to reduce the contaminants entering the storm collection and surface water systems. The stormwater facilities shall be designed to remove 70 percent of the total suspended solids (TSS) entering the facility during the water quality design storm. For purposes of implementing appendix F, the City Engineer has adopted and established the storm water quality design storm event as 0.9 inches of rain in a 24 period, using the NRCS Type 1A distribution curve. Appendix F of the City's Stormwater Master Plan contains the standards for water quality facilities. Water Quality facilities shall be designed in accordance with criteria as established in the *King County, Washington Surface Water Design Manual,* September 1998 or the most recent final version. Acceptable water quality facilities include vegetated swales, water quality ponds, sedimentation ponds, water quality inlets, and infiltration facilities. The use of infiltration facilities is recommended where soil and slope conditions permit the use of this type of facility and the facilities do no have an adverse impact to adjacent or downhill properties; the use of multiple water quality facilities may be required to meet the performance standard. Chapter 6 of the King County Manual identifies seven types of treatment facilities that will meet the performance standards. Water quality facilities must be designed to safely pass without damage to the facility flows in excess of the water quality design storm up to the 100-year, 24-hour event. For some facilities, a bypass system will be required.

Stormwater quality facilities shall be designed to remove 70 percent of the total suspended solids (TSS) entering the facility during the water quality design storm of 0.9 inches in 24 hours, using the NRCS Type 1A distribution curve. Water Quality facilities shall be designed in accordance with the criteria as established in the most recent version of the King County Surface Water Design Manual. The City will assume maintenance responsibility two years after final construction approval by the City and upon passing an inspection by City inspectors to ensure the facility has been properly maintained and the facility is operating as designed. The site developer/owner shall provide a maintenance bond to the City that shall remain in effect until the facilities are accepted by the City and the warranty period is terminated **(Condition 5)**.

Per Appendix F of the City's Stormwater Master Plan, Water Quality facilities shall be designed in accordance with criteria as established in the *King County, Washington Surface Water Design Manual,* September 1998 or the most recent final version. The applicants have proposed the use of storm filter vaults. The storm filter vaults are a King County SWDM media filtration facility. According to the King County SWDM 6.1.1 (the basic water quality design menu), the water quality facilities, including the storm filter vault, are designed to remove a minimum of 80% of the total suspended solids entering the facility during the water quality design storm flows. Separate storm filter vaults have been proposed for each of the three drainage basins on the site. Design calculations are

provided in the submitted *Brooklane Heights Storm Water Analysis & Design*, Section 13, Contech Stormfilter. The capacity of the storm filter vaults are largely dependent on the number and type of filter cartridges. The design calculations show the calculations for the water quality design storm flows through each of the three facilities and the selection of number and type of filter cartridges to satisfy the flow requirements. The use of a media filtration facility requires pre-settlement prior to the water quality facility per King County's SWDM 6.5.1. The applicants are providing the pre-settlement in the base of the detention vaults. The detention vaults are designed to have dead storage in the bottom, below the outlet invert that is more than 75% of the mean annual storm runoff volume. A letter from the applicant on January 10, 2011 describes their method of calculating the mean annual storm volume for our area as the mean annual storm does not appear to be published for our area **(Exhibit II.312)**. The designs and calculations provided by the applicants have shown they are proposing water quality facilities in accordance with the most recent version of the King County SWDM.

Per Appendix F, acceptable water quality facilities include vegetated swales, water quality ponds, sedimentation ponds, water quality inlets, and infiltration facilities. As discussed above, the applicants have chosen storm filter vaults from King County's SWDM. The storm filter vaults are essentially a modified water quality inlet that adds filter cartridges to enhance the ability to remove suspended solids from the water quality design flows. The use of the storm filter vaults meets this requirement.

Per Appendix F, the use of infiltration facilities is recommended where soil and slope conditions permit the use of this type of facility and the facilities do not have an adverse impact on adjacent or downhill properties. This is a recommended standard in Appendix F, not a requirement. The applicant's Geotechnical Report, included in Section 6 of the *Brooklane Heights Storm Water Analysis & Design* specifically addresses infiltration by recommending facility liners to limit infiltration in order "to decrease the risk of seepage and/or piping that could undermine the slopes or create localized instabilities". The proposed facilities comply with the recommendation of the Geotechnical Report.

Per Appendix F, the use of multiple water quality facilities may be required to meet the performance standard. Chapter 6 of the King County Manual identifies seven types of treatment facilities that will meet the performance standards. As discussed above, the applicants have selected an approved King County facility that exceeds the City's water quality standard. A single facility in each basin satisfies the standard.

Per Appendix F, water quality facilities must be designed to safely pass without damage to the facility flows in excess of the water quality design storm up to the 100-year, 24-hour event. As shown in the Conveyance section, the applicants have shown compliance with the requirement to safely pass storms up to the 100-year 24 hour storm event per Appendix F requirements.

Access

Per Appendix F, water quality and detention facilities must be located on a site dedicated for public use. Access tracts, easements or permanent right-of-ways are required when the facilities do not abut the public right-of-way. The minimum width of an access easement is 15 feet. All-weather road(s) shall provide maintenance vehicle access to the facility and the control structures **(Condition 6)**. Additionally the City's Off Street Parking and Access Standards as well as King County's SWDM have standards for accesses. The applicants have submitted plan sheets 1.7, 1.10, 1.11, 1.12, and 1.14 that show access to the City's and King County's standards for all proposed facilities **(Exhibits II.11-17)**. All public drainage facilities that are located outside of the right-of-way have been shown within proposed easements in accordance with LDC 4.0.110 and LDC 4.5.80.d.3 **(Exhibit I)**. The application shows compliance with the City's access requirements.

CCP 4.11.12 Analysis

Condition of Approval 20 in City Council Order 2010-007 requires the applicant to submit stormwater quality plans to be reviewed during a public hearing process for consistency with CCP 4.11.12. The following analyzes the proposed stormwater facilities for consistency with Comprehensive Plan policy 4.11.12.

4.11.12 Development upslope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands.

The Brooklane Heights development site is located on a hillside northwest of Brooklane Drive. The area abutting the site to the north and west is developed with low density residential neighborhoods. Adjacent to the south of the subject site, Brooklane Drive is developed with single detached homes. Southeast of these homes and Brooklane Drive, is a wetland area. Currently storm water run-off from the subject site flows to a drainage ditch at the base of the hill, north of the abutting private alley. From that point, it is directed through public storm lines and into the wetland **(Exhibit II.13)**.

Currently water from the site is not treated or detained. As part of the Brooklane Heights development, the applicant proposes to install water quality and detention facilities. Stormwater on the site will be directed into stormwater pipes and overland drainage areas to underground detention vaults. After being treated to standards in the Corvallis Stormwater Master Plan, the water will enter existing public storm lines and be released in a wetland below the site, on the east side of Brooklane Drive.

As discussed above, the proposed design satisfies applicable criteria from Appendix F of the Storm Water Master Plan, and criteria in the King County, Washington, Surface Water Design Manual as required by Condition of Approval 27. As explained below, the proposed facilities are also consistent with CCP 4.11.12 because the proposed facilities will minimize interference with water patterns discharging to wetlands and would minimize detrimental changes in water quality discharging into wetlands.

Water Patterns

The Stormwater Conveyance section of this report provides a detailed explanation of the water patterns on the site, and how water will be directed post-development. In summary, the topography of the site creates three drainage areas which the applicant refers to as the West, Central and East basins. The western portion of Wolverine Drive generally follows the west basin, and water on this portion of the site will drain into existing streets such as Wolverine Drive, where it will flow into pipes and be directed to the detention vault under Wolverine Drive, near Brooklane Drive. The Central basin, which according to the applicant, contains a spring, will be preserved for overland flow using a constructed swale. **Condition of Approval 3** requires this swale to be within a drainage easement, which helps ensure existing drainage patterns in this area will be preserved. Water from the center of the site, Buckeye Place, and lots along Buckeye Place will be directed into the Central basin where it will flow through the improved swale to the large detention vault south of Badger Place. The East basin, which is in the northeast corner of the site was originally planned to be developed with a constructed swale. In the most recently submitted materials this swale is proposed to be replaced with an underground pipe. In both instances, the water would be directed to existing public facilities installed with the abutting Brooklane Park Estates development, and into the adjacent wetland. Using a pipe rather than a constructed swale minimizes the area disturbed by grading, while effectively directing stormwater runoff to the public stormwater system.

In short, stormwater will be conveyed through constructed facilities following the natural topography of the site, into one of three detention facilities, where it will be treated before entering an existing public system and eventually directed to the wetland area on the east side of Brooklane Drive. Placing streets, constructed swales, and pipes within areas that naturally collect runoff helps to maintain natural drainage patterns of the development site, thereby minimizing interference with water patterns discharging to wetlands. This is consistent with CCP 4.11.12.

The proposed stormwater facilities include three detention vaults, which are described in more detail in the Stormwater Detention section of this report. As explained in that section of the report, the detention vaults are designed so that post development water runoff rates from the site match pre-development rates for two through ten year 24-hour storm events **(Condition of Approval 4)**. By installing a stormwater facility that matches pre-development stormwater runoff rates, the proposal minimizes interference with water patterns discharging into wetlands, consistent with CCP 4.11.12..

All water from the development site will be directed into existing stormwater lines which drain at 2 points into the wetland east of Brooklane Drive **(Exhibit II.13)**. No new outfall points are proposed or required. By using existing pipes, rather than installing new pipes in new locations, the locations of water entering the wetland will not be changed by the proposal. For this reason the proposed development minimizes interference with water patterns discharging into wetlands, consistent with CCP 4.11.12.

Water Quality
Detrimental changes in water quality discharging into wetlands will be minimized through the use of water quality treatment facilities installed with each of the three proposed detention vaults. The water quality treatment plan includes three components: pre-settling facilities integrated with each of the detention vaults, flow control structures in the detention vaults, and a media based filtration system. The specifics of the water quality treatment are provided in the application materials and in the Stormwater Treatment section of this report. In summary, these facilities will result in the removal of at least 70% of Total Suspended Solids (TSS) entering the water quality facilities **(Condition of Approval 5)**. By removing at least 70% of Total Suspended Solids from stormwater, the proposed water quality facilities will minimize detrimental changes in water quality discharging into wetlands.

Condition of Approval 20 also requires the design for water quality facilities to include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. As proposed, landscaping is not required to ensure the proper functioning of the water quality facilities as these facilities will all be sub-surface. Landscaping is proposed around the largest detention vault to conform to CCP 4.6.7. Discussion of this landscaping occurs in the following section of this report.

Conclusion on CCP 4.11.12
Comprehensive Plan policy 4.11.12 does not require new development upslope of wetlands to avoid changes to pre-development water patterns and water quality. Rather, this policy requires new development to *minimize* interference with pre-development water patterns and to *minimize* detrimental changes in water quality. As explained above, the proposed facilities minimize interference with water patterns in three ways. The facilities:

1) Incorporate and use the site's natural topography and drainage basins;
2) Include three detention vaults designed so that post-development run-off rates match pre-development rates for the two through ten year 24-hour storm events; and
3) Use the existing public storm system, avoiding the relocation or installation of new outfall points into the wetland area.

Consistent with CCP 4.11.12, the proposal minimizes detrimental changes in water quality by removing 70% of Total Suspended Solids from stormwater before it is released into wetlands.

Conclusions Regarding Condition of Approval 20
Based on the above discussion, the proposal complies with Condition of Approval 20 for the following five reasons:

1. The applicant submitted information required by Condition of Approval 20;

2. This information is to be reviewed through a public hearing process to determine consistency with CCP 4.11.12. The preceding analysis finds that the proposed stormwater facilities are consistent with CCP 4.11.12;

3. The applicant has submitted plans that show the proposed stormwater quality facilities comply with criteria in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. The submitted materials include a water quality analysis that contains a discussion on the feasibility of implementing infiltration during both the wet and dry seasons;

4. The applicant proposes to dedicate all water quality facilities that are part of the public storm drainage system to the City, and per Condition 20 will enter into a maintenance agreement as specified in Condition 20; and

5. The proposed public water quality facilities are underground systems that do not require landscaping to ensure their proper functioning.

Analysis of Condition of Approval 27

Prior approvals of the Brooklane Heights Conceptual and Detailed Development Plan and Tentative Subdivision Plat approved mass grading on much of the site, including all streets and detention pond areas **(Exhibit II.33)**. Condition of Approval 27 in City Council Order 2010-007 required the applicant to submit grading plans for individual lots and other non-mass graded areas to be reviewed during a public hearing process for consistency with CCP 4.6.7. Grading is required to install the proposed stormwater facilities. Parts of these facilities are outside of the previously approved mass-graded areas and require review during a public hearing process for consistency with CCP 4.6.7. Areas where grading is required for the current proposal, but are outside of the mass-graded areas include the constructed swale east of Buckeye Place and north of Badger Place, portions of Tract B where the large detention vault is proposed, the access to the detention vault within Tract B, connecting segments of the previously approved swale in the northeast corner of the site (this swale is now proposed to be a below ground pipe), and portions of storm lines running through the southern edge of the lots below Badger Place. Other than these areas, the proposed pipes, vaults, and water quality units would be placed within streets where mass-grading has already been approved **(Exhibit II.11)**.

The following provides an overview of the grading associated with the proposed stormwater facilities and evaluates the grading and stormwater facilities for consistency with Comprehensive Plan policy 4.6.7

Overview

Grading associated with this stormwater plan differs in a few areas from the previously approved mass grading plan. Specifically the open channel drainageways between Buckeye Place and Badger Place are larger than previously approved in order to allow a higher level of protection from erosion. The detention pond on the north side of Badger Place has been removed, and the detention pond on the south side of Badger Place has

been changed into a detention vault. The remainder of the stormwater plan is proposing to locate facilities within the Right of Way or in areas where the finished grade over the utilities will comply with the previously approved mass grading plan.

The open channels are proposed to be constructed with gabion rock blankets. The design for the gabion blankets is provided in the *Brooklane Heights Storm Water Analysis & Design*, Section 14, Channel Stabilization System and Section 9, Runoff Conveyance Analysis. The finished side slopes of the channels are 3h:1v, in compliance with the Geotechnical recommendations of a maximum of 2h:1v. Grading around the central detention vault is proposed to have a maximum slope of 2h:1v according to the submitted plan sheets 1.7, 1.11, and 1.14, also in compliance with the Geotechnical recommendations.

Tract B Detention Vault

The greatest amount of earthwork would occur in Tract B to install the underground detention vault and vehicular access leading to the vault from Badger Place. Previous City Council decisions approved the construction of two stormwater detention ponds, one on each side of Badger Place. In the current proposal, the detention ponds would be replaced with a single 8,000 sq ft detention tank. Most of the tank would be below grade except for portions of the tank's top which would be even with grade and would be used as a vehicle turn-around and access point to the tank's interior. Fill would primarily be used around the tank to bring the finished grade level with the tank's top **(Exhibits II.13, 17)**.

Fourteen Significant trees (>8" diameter trunks) previously planned to be preserved around the originally approved detention ponds would be removed to install the detention vault. The loss of these trees is proposed to be mitigated by planting 14 trees around or near the vault **(Exhibit II.15)**. Fill is proposed on the south side of the vault, which would run for approximately 40 ft at a 2:1 slope. The slope is proposed to be planted with several rows of large shrubs. The shrubs are expected to screen the vault along with a 6-ft tall, black, vinyl, chainlink fence that would be installed around the vault and access **(Exhibit II. 17)**.

Vehicle access is required to the detention vault for maintenance purposes. One is proposed along the east side of the vault, within Tract B, that is accessed from Badger Place. The access would be 12-ft wide and paved. It's maximum grade of the access would be 15% **(Exhibits II.11, 17)**.

Tract C Swales and Storm Line

Grading would also be required to construct the swales and make the stormwater pipe connections within Tract C, on the east side of the Buckeye Place cul de sac. The proposed swales are shown in **(Exhibit II.12)**. The swales would be 24-ft wide with side slopes of 3:1 and a 6-ft wide channel flow regime. The swales would be constructed with gabion "eco mattresses" to prevent soil erosion and stabilize channel banks. As discussed earlier, these swales generally follow the natural topography of the site, and convey water from Buckeye Place and areas within the center of the site.

As shown in **Exhibit II.33**, grading was previously approved to install a swale in the northeast corner of the site, similar to the swale proposed off of Buckeye Place. Rather than construct a swale in this location, the applicant proposes to install a below ground storm line that would pipe water from Wolverine Drive into the public stormwater system that currently begins at the south side of the subject site, abutting the north side of the private alley also south of the site. Installing the pipe would result in the removal of a Significant Tree, which likely would have had to have been removed if the swale were constructed. To mitigate for the loss of this tree, **Condition of Approval 7** requires the applicant to plant two large canopy, native species trees in the general vicinity of the proposed pipe.

Other Storm Lines

In addition to the above work, storm lines are proposed along the bottom of the lots on the south side of Badger Place. Installation of these lines requires some digging, but the finished grade would not change, and the applicant's drawings indicate that significant trees would not be impacted.

CCP 4.6.7 Analysis

Prior City Council review of the Conceptual and Detailed Development Plan found the application was consistent with CCP 4.6.7, except for non-mass graded areas. Therefore, the following analysis only considers grading associated with proposed stormwater facilities that fall outside of previously approved mass graded areas as required by Condition of Approval 27. All other grading not previously approved, such as grading on certain lots, will be required to be reviewed through a future public hearing process to determine consistency with CCP 4.6.7.

The first sentence of CCP 4.6.7 states, *"In areas where development is permitted, standards in the Land Development Code for hillside areas will achieve the following:"* and lists nine objectives that the Land Development Code should accomplish with respect to hillside development. These policy objectives were used as review criteria because the application was submitted under the 1993 LDC, which did not contain specific criteria for hillside development. Each objective of CCP 4.6.7 is provided below, followed by analysis of the proposal's compliance with each objective. Policy 4.6.7 is also provided in **Exhibit I**.

CCP 4.6.7.A

A. Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development.

The Tract B swales would be located in a natural depression. Locating the swales in this location respects the natural topography of the hillside and takes advantage of existing hydrological flows. The applicant has submitted multiple geotechnical reports that show that the soils and geological structure of the site are stable, with a low potential for landslides or instability, as long as the geotechnical report's recommendations are

followed. As discussed previously in this report, the proposed swale and stormwater facilities are consistent with the geotechnical reports.

The Tract B detention vault, including the required access drive, are located between two lots included in the approved mass grading plans. After grading, these lots will be at an elevation of approximately 280 ft and will slope towards the area for the detention vault, which has a low point of approximately 255 ft. The vault will be placed in this lower elevation area between the two lots, and will be designed so that the top of the vault will be at an elevation of about 270 ft. The greatest amount of fill (approximately 15 ft) would be placed on the south side of the vault, and some fill material would be placed between Badger Place and the north edge of the vault for road fill. The vault and access initially require a larger area to be disturbed than would be required for the originally approved detention ponds. However, at completion, the entire vault will be below grade except for it's top, which will be even with finished grade and will serve as a vehicle turn around and access point into the vault **(Exhibits II.11, 17)**.

The storm lines proposed in the lots south of Badger Place, extending from Buckeye Place, and in the northeast corner of the site require ground disturbance to install the pipes. Once installed, the finished grade will be the same as the previously approved grading plan.

Impacts to the site's natural topography are minimized by placing the stormwater facilities below ground, and re-vegetating over storm lines. The site's natural hydrological flows are incorporated into the stormwater system by placing the Tract C swales in a naturally occurring depression and by returning the soil over storm lines to match previously existing grades. According to the geotechnical report, the soils and geology of the site are stable. The proposed large detention vault conforms with the recommendations of the geotechnical report, ensuring hillside stability after development. For these reasons, the proposal is consistent with CCP 4.6.7.A.

CCP 4.6.7.B

B. Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities.

The Brooklane Heights site is on a hillside. The subject site does not reach to the hill's upper portions, which have been previously developed with single family homes. Consequently, the proposed stormwater facilities have no impact on ridgelines. All proposed stormwater facilities except for part of the Tract B detention vault would be underground, causing no visual impact to slopes or ridgelines. The detention vault and access in Tract B would be installed near the bottom of the hill, but could potentially be visible from some off-site locations, and the removal of 14 Significant trees to construct the vault and drive would cause some change to the appearance of the hill. To mitigate for the tree removal and the detention vault's potential visual impact, the applicant proposes to plant 14 trees around and near the vault **(Exhibit II.15)**. Additionally, fill will be placed at a 2:1 slope south of the vault and planted with several rows of shrubs that are expected to reach a mature height of at least 6-ft. The mitigation trees and the landscaping south

of the vault will screen off-site views of the vault and buffer views of the access drive **(Exhibits II.11, 15, and 17)**. Given the above, the proposed stormwater facilities preserve the most visually significant slopes and ridgelines, consistent with CCP 4.6.7.B.

CCP 4.6.7.C

C. Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees.

The most significant natural features on the site are tree groves and Significant Trees (>8-in diameter trunks) which include some specimen trees. Previous applications approved by the City Council stated that site contains approximately 454 Significant trees, and approximately 400, or 88%, would be preserved. Most Significant trees are within open space tracts that will not be developed except to install the proposed stormwater facilities. The tracts account for 42%, or 11 acres of the 26 acre site. The proposed stormwater facilities require the removal of 15 trees, including 14 near the large detention vault. One Significant tree, in the northeast corner of the site, originally expected to be preserved is proposed to be removed to install the storm line between Wolverine Drive and the private alley abutting the south side of the development site **(Exhibit II.16)**. This tree would very likely have had to have been removed under the approved plans which included a 15-ft wide swale in the same area. **Condition of Approval 7** requires two large canopy, native trees to be planted near the storm line in the northeast part of the site to mitigate the loss of the tree. Consistent with the approved site plan, the protected tree groves on the site will continue to be preserved. As proposed and conditioned, removed trees will be replaced with new trees, and the majority of Significant Trees (85%) on the site will be preserved. The subject site contains open grassy areas, some of which abut tree groves or contain trees. The stormwater facilities would have minimal impacts on the presence or health of these grassy areas as swales would be constructed in existing drainage areas, and storm lines would be buried with the finished grade, revegetated, and returned to current grade.

As proposed and conditioned, the tree groves on the site will be preserved, removed trees will be replaced with mitigation trees, and only minor impacts from grading associated with stormwater facilities will occur to grassy areas containing trees or near wooded areas. As such, the proposed stormwater facilities preserve the site's most significant natural features, consistent with CCP 4.6.7.C.

CCP 4.6.7.D

D. Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments.

Past Council decisions have found that the project as a whole is consistent with CCP 4.6.7.D, including the location of streets and mass graded areas. The location of approved streets, which follow natural contours, and areas for mass grading are not proposed to change. Some cuts and fills are required to install the proposed stormwater facilities. The Tract C swales near Buckeye Place follow the site's natural contours, as does the Tract C storm line in the northeast corner of the site. Cuts associated with the storm line in Tract

C are less than required to install the previously approved 15-ft wide swale. Installation of the large Tract B detention vault and access drive requires fill with lesser amounts of digging. Once installed, the vault will be entirely below ground except for its top, which will be used as a vehicle turn-around area. All other stormwater facilities will be placed in streets where mass grading has been approved, or if outside of approved mass graded areas, cuts will be returned to existing grade. As proposed, the grading associated with the stormwater facilities is aligned with the natural contours of the site's terrain, minimizing cuts and fills.

CCP 4.6.7.E

E. Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated.

Some soil disturbance and removal of vegetation is necessary to install properly functioning systems that will manage stormwater on the site. The applicant's proposal minimizes soil disturbance by replacing the previously approved, 15-ft wide swale in the northeast corner of the site, with an underground pipe **(Exhibits II.16, 33)**. The pipe requires significantly less ground disturbance to install. All storm lines will be below ground, and the finished grade will match existing grade. Fill is required around the large detention vault and access. The fill will either be paved over in the case of the driveway, or revegetated, thereby minimizing disturbances to soil. Fifteen trees are proposed to be removed, including 14 trees near the Tract B detention vault. As proposed and conditioned, these trees would be replaced with 16 trees.

The applicant proposes to construct the stormwater systems during summer months to minimize the potential for sediment and sediment laden waters from being created.

Given the above, the proposal is consistent with CCP 4.6.7.E.

CCP 4.6.7.F

F. Design developments and utilize construction techniques that minimize erosion and surface water runoff.

The stormwater facilities are required to comply with City and State erosion control standards through the NPDES 1200-C construction permit. Complying with these standards ensures that sediment and sediment filled water do not leave the site during and after construction. Typical erosion control methods required to comply with City and State erosion control standards include use of silt fences, silt screens around drainage structures, vegetation, and mulching slopes. These techniques, noted by the applicant, will minimize erosion caused by installing the stormwater facilities. Once installed, the stormwater facilities will minimize surface water runoff, and will detain and treat stormwater runoff in a manner that complies with applicable standards in the Corvallis Stormwater Master Plan. Given the above, the proposed stormwater facilities will be constructed in a way that minimizes erosion, and once installed, will minimize surface water runoff and related soil erosion, consistent with CCP 4.6.7.F.

CC 4.6.7.G

G. Demonstrate a concern for the view of the hills as well as the view from the hills.

Tree groves are the most distinctive features of the subject site. Under the approved plans, these groves and a majority of trees would be protected by placing them within open space tracts. Areas of the site without tree groves would be developed with streets and single detached homes. The proposed stormwater facilities would be placed below ground and would not affect views of, or from the hill. The top of the large detention vault would be level with finished grade and it, and the access drive, would be visible from certain locations on the development site and possibly from certain areas off site. The visual impact of the top of this vault and access drive would be equivalent to views of a driveway serving one of the proposed houses. This impact would be reduced by the existing tree canopy below the vault, the proposed landscaping south of the vault, and the mitigation trees proposed to be planted around the vault. Consistent with CCP 4.6.7.G, the placement of the vault below ground, and surrounded by existing or proposed vegetation demonstrate a concern of views to and from the hill.

Installing the storm line in the northeast corner of the site requires one tree to be removed, *but as conditioned two new trees will be planted in this area.* The drainage swale in Tract B follows natural contours and depressions, minimizing its visual impact on the site **(Exhibits A.11, 13)**. These two components of the stormwater plan also demonstrate a concern for the view of, and from the hill, consistent with CCP 4.6.7.G.

CCP 4.6.7.H

H. Provide landscaping that enhances the identified open space resources.

The open space resources on the site are within open space tracts, which are characterized by tree groves. The tracts would not be developed except for stormwater facilities. The tree groves and significant trees in the tracts are proposed to be preserved, except for trees that need to be removed to install stormwater facilities. To mitigate for the 15 trees that would be removed to install the stormwater facilities (14 near detention vault and 1 in Tract C), the applicant proposes to plant 14 trees, and **Condition of Approval 7** would require two additional trees to be planted. Large shrubs are proposed to be planted on the slope south of the large detention vault **(Exhibit II.17)**. As proposed and conditioned, the trees and shrubs would enhance the development site and open space resources, consistent with CCP 4.6.7.H.

CCP 4.6.7.I

I. *Design developments that consider landscaping management that will minimize the threat of fire on improved property spreading to wildland habitat.*

Irrigated landscaping is proposed around the large detention vault in Tract B, and as conditioned, two native species trees would be planted in Tract C near the northeast corner of the site. Other than this, the proposed detention facilities would not be landscaped. The

proposed landscaping will not increase the risk of fire on an improved property spreading to wildland habitat. Consequently, the proposal conforms to CCP 4.6.7.I.

CCP Review Conclusions

As described above, and in detail in the application materials, the proposed stormwater facilities and associated grading respect the natural topography of the site; protect significant aspects of the hillside, such as tree groves and views, and minimize erosion, surface water runoff, and soil disturbances. Thus, the proposal is consistent with CCP 4.6.7.

Conclusions Regarding Condition of Approval 27

Based on the above analysis, the proposal complies with Condition of Approval 27 for the following reasons:

1. The applicant has not proposed to change the areas previously approved by City Council to be mass graded. Approved Mass graded areas are shown most clearly in Drawing Y - Brooklane Heights Cut/Fill Analysis **(Exhibit II.33)**;

2. The applicant proposes grading outside of areas not approved for mass grading and has submitted information regarding this proposal to be reviewed through a public hearing process to determine consistency with CCP 4.6.7;

3. The above analysis finds that the proposed grading outside of areas approved for mass grading is limited to what is necessary to install stormwater facilities, and this grading and the stormwater facilities are consistent with CCP 4.6.7.

LDC Standards

Conditions of approval 20 and 27 implicitly require compliance with certain standards in LDC Chapter 4.0 - Improvements Required with Development, LDC Chapter 4.5 - Flood Control, Storm Drainage, Riparian, and Wetland Provisions, and LDC Chapter 4.2 - Landscaping, Buffering, and Screening (LDC 1993 as Amended). Compliance with applicable provisions in Chapter 4.0 and 4.5 is addressed in this report under the Stormwater Conveyance, Stormwater Detention, Stormwater Treatment, and Access sections. Analysis in these sections finds that as proposed, and conditioned, the proposal complies with applicable LDC standards in Chapters 4.0 and 4.5 **(Exhibit I)**.

Land Development Code Chapter 4.2 requires Significant trees to be preserved to the greatest extent practicable. As discussed previously, most of the site's trees are within Tracts not proposed for development. Significant trees proposed to be removed with the current application are only those that would be directly impacted by installation of the stormwater facilities. Thus, the proposal complies with the requirement to preserve significant trees to the greatest extent practicable. Further analysis of this issue is found in this report under the section addressing consistency with CCP 4.6.7.C.

As proposed, and conditioned, the proposal to install stormwater facilities, including associated grading, complies with applicable standards in the 1993 LDC, as Amended.

IV. Conclusions and Recommended Actions

Conclusions

City Council Order 2010-007 approved the Brooklane Heights Conceptual and Detailed Development Plan and Tentative Subdivision Plat, subject to conditions of approval. Condition 20 requires plans for public water quality facilities to be reviewed through a public hearing process to determine compliance with standards in the Corvallis Stormwater Master Plan, and to determine consistency with CCP 4.11.12. Analysis of the application materials in this report find that the proposal complies with the requirements of Condition of Approval 20.

Condition of Approval 27 in Order 2010-007, identifies areas where mass grading is approved, and requires grading in other areas to be reviewed through a public hearing process to demonstrate consistency with CCP 4.6.7. To install the proposed stormwater facilities, some grading is required outside of the areas approved for mass grading. Grading proposed in the current application that is outside of the areas approved for mass grading, is limited to what is necessary to install stormwater facilities. Analysis of grading to install these facilities finds that the proposed grading is consistent with CCP 4.6.7, and is, therefore, consistent with Condition of Approval 27. All areas not previously approved to be mass graded, or approved to be graded through the current application, are required by Condition of Approval 27 to be reviewed through a future public hearing process to determine consistency with CCP 4.6.7.

To ensure consistency with 1993 LDC standards, **Condition of Approval 3** is recommended for the current application. **Condition 3**, which requires a drainageway easement over the proposed swale, also helps maintain existing water drainage patterns, consistent with CCP 4.11.12.

Condition of Approval 19 in City Council Order 2010-007 refers to detention ponds which are no longer proposed. To avoid confusion during plan review and to ensure compliance with CCP 4.11.12, **Condition of Approval 4** is recommended for the current application. This Condition ensures that the proposed stormwater facilities detain water so that post development stormwater run-off rates match pre-development rates for the 2-year through 10-year 24-hour design storm. This minimizes interference in water patterns discharging to wetlands, consistent with CCP 4.11.12.

Condition of Approval 5 requires stormwater quality facilities to remove at least 70% of Total Suspended Solids from stormwater entering water quality facilities, thereby minimizing detrimental changes in water quality for waters discharging into wetlands, consistent with CCP 4.11.12.

Condition of Approval 7 requires two large canopy, native trees to be planted near the Tract C storm line to mitigate for the tree to be removed. Planting these trees ensures the proposal complies with CCP 4.6.7, specifically with respect to preserving trees, providing landscaping, and protecting views of the hillside.

Recommended Actions
The City Council has three options with respect to the proposal:

Option 1: Approve the application subject to recommended conditions of approval;

Option 2: Approve the application with new, and/or revised conditions;

Option 3: Deny the application.

The analysis in this report concludes that the proposal, as conditioned, complies with the requirements of Conditions of Approval 20 and 27. As such, Option 1 is recommended. If the City Council pursues option 1, the following motion is suggested:

Motion
I move to approve the proposed stormwater facilities and associated grading for the Brooklane Heights Conceptual and Detailed Development Plan, and Tentative Subdivision Plat (PLD06-00018, SUB06-00006) as Conditioned in the March 11, 2011, Staff memorandum to the City Council, subject to conditions of approval and adoption of Formal Findings. This motion is based on analysis provided in the March 11, 2011 Staff memorandum to City Council, and findings made during City Council deliberations on this matter.

V. Recommended Conditions of Approval

1. **Consistency with Plans** - Development shall comply with the applicant's narrative and plans in **Exhibit II**, except as modified by the conditions of approval below. Development shall also comply with all previous conditions of approval for the proposed development, unless modified by the conditions of approval below.

2. **Public Improvements** - Any plans for public improvements referenced within the application or this staff report shall not be considered final engineered public improvement plans. Prior to issuance of any structural or site utility construction permits, the applicant shall obtain approval of, and permits for, engineered plans for public improvements from the City's Engineering Division. The applicant shall submit necessary engineered plans and studies for public storm drainage facilities. Public improvement plan submittals will be reviewed and approved by the City Engineer under the procedures outlined in Land Development Code Section 4.0.90.

3. **Drainageway Easement** - Concurrent with the final plat, the open channels shall be placed in Drainageway Easements. The easement shall be per LDC 4.5.80.d.3 with a minimum easement width equal to the drainage channel width plus 1.5 times the width plus 5 ft on each side of the channel. Channel width + 2((1.5 x channel width) + 5') = 12' + 2((1.5 x 12') + 5') = 58 ft.

4. **Stormwater Detention** - Stormwater detention facilities shall be designed in accordance with Appendix F of the City's Stormwater Master Plan. Stormwater detention facilities shall be designed to capture runoff so the run-off rates from the site after development do not exceed the pre-developed conditions, based on the 2-year through 10-year, 24-hour design storms. Detention facilities shall be designed in accordance with the criteria as established in the most recent version of the King County Surface Water Design Manual. The City will assume maintenance responsibility two years after final construction approval by the City and upon passing an inspection by City inspectors to ensure the facility has been properly maintained and the facility is operating as designed. The site developer/owner shall provide a maintenance bond to the City that shall remain in effect until the facilities are accepted by the City and the warranty period is terminated.

5. **Stormwater Quality** - Stormwater quality facilities shall be designed in accordance with Appendix F of the City's Stormwater Master Plan. Stormwater quality facilities shall be designed to remove 70 percent of the total suspended solids (TSS) entering the facility during the water quality design storm of 0.9 inches in 24 hours, using the NRCS Type 1A distribution curve. Water Quality facilities shall be designed in accordance with the criteria as established in the most recent version of the King County Surface Water Design Manual. The City will assume maintenance responsibility two years after final construction approval by the City and upon passing an inspection by City inspectors to ensure the facility has been properly maintained and the facility is operating as designed. The site developer/owner shall provide a maintenance bond to the City that shall remain in effect until the facilities are accepted by the City and the warranty period is terminated.

6. **Utility Easements** - Concurrent with the final plat, all public utilities, facilities, and access to facilities that are located outside of public Right of Way shall have permanent easements placed around them. The minimum width of an access easement is 15 feet. All-weather road(s) shall provide maintenance vehicle access to the facilities and the control structures.

7. **Tree Mitigation** - The applicant shall plant 14 trees around the large detention vault in Tract B as shown in drawing 1.11 of the application **(Exhibit II.15)**. Two large canopy, native trees shall be planted near the Tract C storm line in the northeast

corner of the site. Prior to planting, the precise location and species of mitigation trees shall be reviewed and approved by the City's Urban Forester.

VI. Exhibits

I. Staff Identified Review Criteria

II. Application Materials
- Brooklane Heights Storm Water Analysis and Design, Corvallis Oregon, received March 1, 2011;
- Stormwater Facility Site Plans and Drawings
- February 10, 2011, Correspondence addressing applicable Comprehensive Plan policies;
- January 10, 2011, correspondence addressing stormwater facility design.

III. LUBA Final Order and Opinion, No. 2010-014

IV. City Council Order, No. 2010-007

V. LUBA Final Order and Opinion, No. 2009-042

VI. City Council Order, No. 2009-007

VII. LUBA Final Order and Opinion, No 2007-200

VIII. City Council Order, No. 2007-111

Review and Concur

Jon Nelson, City Manager

Staff Identified Review Criteria

The following criteria have been identified by City Staff as applicable to the proposal to install stormwater facilities and perform related grading for the Brooklane Heights Conceptual and Detailed Development Plan and Tentative Subdivision Plat (PLD06-00018, SUB06-00006).

LDC Chapter 4.0 - Improvements Required With Development

Section 4.0.80 - PUBLIC UTILITY EXTENSIONS

a. All development sites shall be provided with public water, sanitary sewer, storm drainage, and street lights.

b. Where necessary to serve property as specified in "a" above, required public utility installations shall be constructed concurrent with development.

c. Off-site public utility extensions necessary to fully serve a development site and adjacent properties shall be constructed concurrent with development.

d. To provide for orderly development of adjacent properties, public utilities installed concurrent with development of a site shall be extended through the site to the edge of adjacent property(ies).

e. All public utility installations required with development shall conform to the City's adopted facilities master plans.

Section 4.0.90 - PUBLIC IMPROVEMENT PROCEDURES

It is in the best interests of the community to ensure public improvements installed in conjunction with development are constructed in accordance with all applicable City policies, standards, procedures, and ordinances. Therefore, prior to commencement of installation of public water, sanitary sewer, storm drainage, streetlights, street, bicycle, or pedestrian improvements for any development site, developers shall contact the City Engineer to receive information regarding adopted procedures governing plan submittal, plan review and approval, permit requirements, inspection and testing requirements, progress of the work, and provision of easements, dedications, and as-built drawings for installation of public improvements. All work shall proceed in accordance with those adopted procedures, and all applicable City policies, standards, and ordinances.

Whenever any work is being done contrary to the provisions of this Code, the Director may order the work stopped by notice in writing served on the persons engaged in performing the work or causing the work to be performed. The work shall stop until authorized by the Director to proceed with the work or with corrective action to remedy substandard work already completed.

Section 4.0.110 - LAND FOR PUBLIC PURPOSES

a. Easements for public sanitary sewer, water, storm drain, streetlight, pedestrian and bicycle facilities shall be provided whenever these facilities are located outside a public right-of-way in accordance with the following:

    2. The minimum easement width for a single utility is 15 ft. The minimum easement width for two adjacent utilities is 20 ft. The easement width shall be centered on the utility to the greatest extent practicable. Wider easements may be required for unusually deep facilities.

c. Where a development site is traversed by a drainageway or water course, drainageway improvements in accordance with the Corvallis Drainage Master Plan and a drainageway dedication in accordance with the requirements of Chapter 4.5 shall be provided to the City.

e. Where existing rights-of-way and/or easements within or adjacent to development sites are nonexistent or of insufficient width, dedications may be required. The need for and widths of those dedications shall be determined by the City Engineer.

LDC Chapter 4.2 - Landscaping, Buffering, and Screening

Section 4.2.20 - GENERAL PROVISIONS

c. Significant plant and tree specimens should be preserved to the greatest extent practicable and integrated into the design of a development. Trees of 8-in. or greater diameter measured at a height of 4 ft above grade and shrubs (excluding blackberries, poison oak, and similar noxious vegetation) over 3 ft in height are considered significant. Plants to be saved and methods of protection shall be indicated on the detailed planting plan submitted for approval. Existing trees may be considered preserved only if no cutting, filling, or compaction of the soil takes place between the trunk of the tree and the area 5 ft outside the tree's dripline. In addition, the tree shall be protected from damage during construction by a construction fence located 5 ft outside the dripline.

LDC Chapter 4.5 - Flood Control, Storm Drainage, Riparian, and Wetland Provisions

Section 4.5.80 - DRAINAGEWAY EASEMENTS AND DEDICATIONS

Development can have a number of impacts on the drainage system and its associated water quality. These potential impacts include, but are not limited to, increases in the amount of surface water runoff, decreases in the time for stormwater destined for drainageways to reach peak flow, increases in water temperature, and increases in the quantity and types of pollutants that may enter drainageways. To the greatest extent practicable, the drainageways within the City are intended to function as a wholistic natural system that includes both fish-bearing streams and other streams whose flow is recognized to have direct impacts on these fish-bearing streams. To ensure that unnecessary negative impacts to this system are minimized and to provide and maintain adequate stormwater facilities, new development, expansion of existing development, or redevelopment proposed on land abutting or containing an open, natural drainageway, shall require granting of an easement, under the conditions described in “a” of this section, over lands suitable for conveying storm waters and for maintaining and operating an effective open drainageway system. The easement is intended to satisfy the purposes cited in Section 4.5.10 above and shall be reviewed and approved by the City Engineer.

d. **Easement Width:** When an easement is required (see Figure 4.5-1), the appropriate width shall be determined as follows:

3. For streams not indicated on Figure 4.5-1 as fish-bearing, the easement area shall include the drainage channel plus additional width as determined by the following formula:

WFTOB = 1.5x + 5 ft

WFTOB = **W**idth **F**rom **T**op **O**f **B**ank (*i.e.,* width of the easement area needed on each side of a drainageway channel).

x = Width of channel from top of bank to top of bank as determined by the City Engineer, or 30 ft, whichever is less.

Section 4.5.90 - STORMWATER DETENTION & RETENTION MEASURES

a. To reduce the risk of causing downstream properties to become flooded and to help maintain or restore the properly functioning conditions of receiving waters, new development, expansions to existing development, or redevelopment shall be required to provide stormwater detention and retention in accordance with "b" of this section.

b. When detention and/or retention are required

1. Development Projects that create impervious surfaces (roads, driveways, parking lots, walks, patios, and roofs) in excess of 25,000 square feet are required to implement stormwater detention and/or retention measures as specified in the Corvallis Design Criteria Manual. Detention facilities shall be designed to maximize stormwater infiltration.

Comprehensive Plan Policies

4.6.7 In areas where development is permitted, standards in the Land Development Code for hillside areas will achieve the following:

A. Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development.

B. Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities.

C. Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees.

D. Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments.

E. Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated.

F. Design developments and utilize construction techniques that minimize erosion and surface water runoff.

G. Demonstrate a concern for the view of the hills as well as the view from the hills.

H. Provide landscaping that enhances the identified open space resources.

I. Design developments that consider landscaping management that will minimize the threat of fire on improved property spreading to wildland habitat.

4.11.12 Development upslope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands.

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

Prepared for:

Oakmont Development, LLC

Corvallis, OR 97333

METOLIUS CONSULTING

"Natural solutions in a changing environment"

Prepared by:

Metolius Consulting

Scott A. Wright, P.E.

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Corvallis, OR 97333

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BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 1
Stormwater Design Report

S T O R M W A T E R D E S I G N R E P O R T

Brooklane Heights Subdivision

Corvallis, Oregon

Prepared for

Oakmont Development, LLC
Corvallis, Oregon

1 EXISTING DRAINAGE PATTERNS
1:9 Scale: 1" = 100'

Prepared by

METOLIUS CONSULTING

"Natural solutions in a changing environment"

November 2010

CC EXHIBIT II - 4

BACKGROUND

Approval of a Conceptual and Detailed Development Plan and a Tentative Subdivision Plat to create 45 lots and 4 common tracts was granted by the Corvallis City Council on February 3, 2010. The City Council's Notice of Disposition, Order 2010-007, includes certain Conditions of Approval to be implemented by the applicant in order to proceed with the development plan. This report addresses Condition 20. Public Water Quality Facility Design & Maintenance, which requires a direct review by the City Council with a public hearing.

20. Public Water Quality Facility Design & Maintenance -The applicant shall submit the information required in this condition of approval. This information shall be reviewed for consistency with Comprehensive Plan Policy 4.11.12 and approved through a City Council Public Hearing review process prior to issuance of PIPC permits.

As part of the plans for public improvements the applicant shall provide engineered calculations for storm water quality facilities demonstrating compliance with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting water quality requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The water quality analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons.

All water quality facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for two years after acceptance by the City. The maintenance agreement shall be executed prior to acceptance of publtc improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County~· Washington Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the warranty for storm water quality facilities is terminated.

The design for the public water quality facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established ,prior to any paving activity on the development site.

APPROACH

This report is a design summary of the storm water master plan for Brooklane Heights subdivision. The storm water master plan is represented graphically on a series of drawings accompanying this report. The approach has two primary objectives: 1) design a functional, serviceable stormwater management system; and 2) demonstrate its compliance with the City of Corvallis Stormwater Master Plan (SWMP).

The drawings presented with this report are not final construction drawings. Once the project's storm water master plan has been accepted by City of Corvallis, the applicant's engineer then can proceed with the integration of approved storm water components with the comprehensive grading and infrastructure plans for Brooklane Heights Subdivision.

Detailed engineering calculations and technical resource documents accompany this report in a bound notebook. Because the water quantity management and water quality management systems are integrated, descriptions of each are included. The principal components of an engineered surface water management system are conveyance, storage (detention) and quality (treatment). Operations and maintenance of the proposed physical components are addressed as well.

Throughout the engineering documents, frequent technical references are provided to demonstrate compliance with established standards of the City of Corvallis Stormwater Master Plan (SWMP).

CORVALLIS DESIGN STANDARDS

Appendix F - Technical Memorandum No. 4, Recommendations to Development Standards, November 10, 1999 is used as the primary reference document for stormwater analysis and design in Corvallis. Appendix F is found in the Corvallis Stormwater Master Plan. The SWMP has been adopted by the City of Corvallis as part of its Comprehensive Plan. Technical compliance with the SWMP therefore assures compliance with the City's Comprehensive Plan. Considering the history of the land use review process for this project, the stormwater design will be based entirely on current SWMP standards, which are referenced throughout the design documents.

As an interim measure, the Corvallis SWMP recommended the use of applicable portions of the King County Washington Surface Water Design Manual (KCSWDM) as a technical engineering guide for the analysis and design of stormwater facilities. References to the KCSWDM standard are provided throughout the drawings and engineering calculation set.

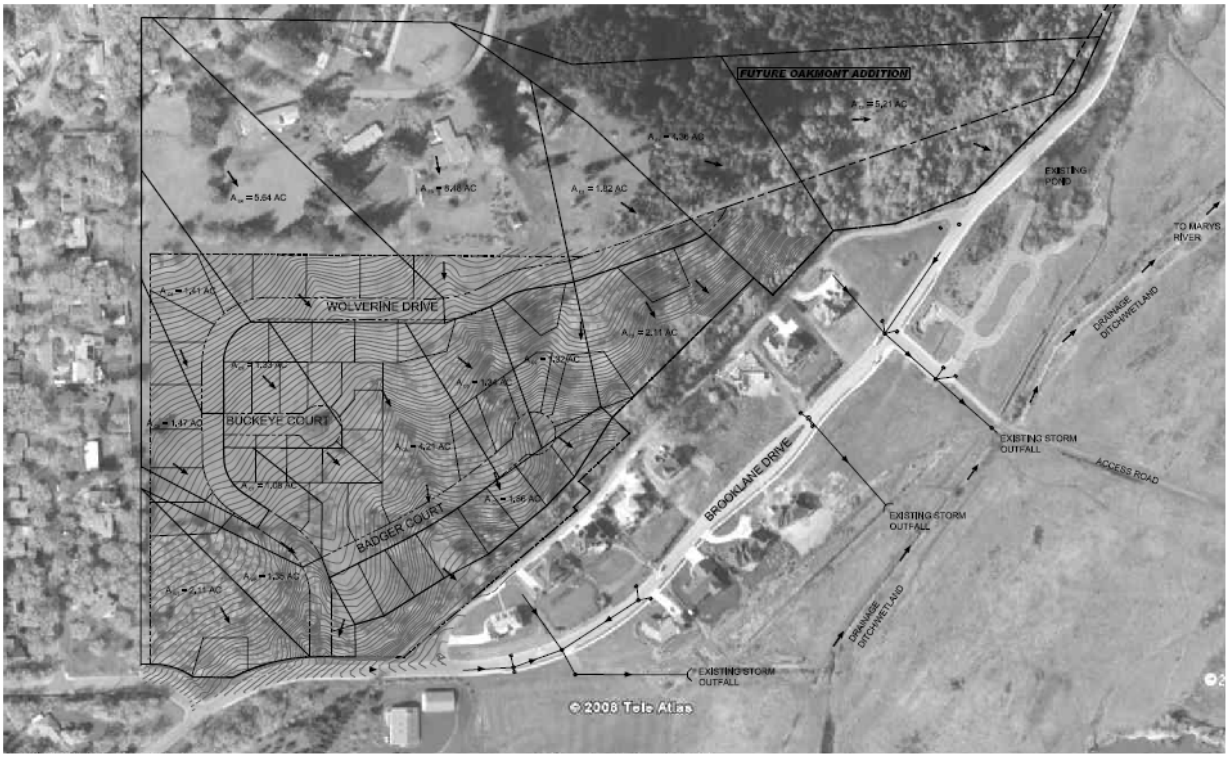
The Rational Method recommended in Technical Memorandum No. 4 is used for conveyance design. The conveyance system is designed for a 100-year frequency 24-hour design storm, exceeding the 10-year frequency recommended requirement. Conveyance components include a short reach of an existing natural swale, constructed swales, City standard inlets and manholes, and a conventional piped conveyance system with a minimum pipe diameter of 12 inches.

The Santa Barbara Urban Hydrograph (SBUH) method recommended in Technical Memorandum No. 4 is used for detention and water quality design. The detention system is designed to capture and temporarily store rainfall runoff so that post-developed flow rates do not exceed pre-development flow rates for the 2-year, 5-year and 10-year frequency design storms. The water quality design is designed to capture and treat the post-developed runoff from a 0.9-inch, 24-hour rainfall event. (Stormwater Quality Facility Design Storm, Bruce Moser, City of Corvallis, December 15, 2003).

EXISTING CONDITIONS

The contributing runoff area includes the Brooklane Heights land proposed for new development, a portion of the Oakmont Addition proposed for new development and a portion of existing residential development on Country Club Hill. Developed areas are all low density housing. Undeveloped land typically is covered with meadow grass, oak and evergreen trees.

The existing City stormwater collection system has been extended to the Brooklane Heights property at three points along Brooklane Drive. In this report and drawings these existing connections are referred to as the West, Central and East drainage basins.



1 / 1.9 SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

The three drainage basins, further divided into sub-basins for analysis and design, are shown graphically on Drawing 1.9, pictured above.

DEVELOPED CONDITIONS

Brooklane Heights is proposed to be developed as low density residential housing. Development is concentrated within the Central basin, with little new development of the West and East basins. Portions of the existing Country Club Hill housing development located up slope from Brooklane Heights are assumed to remain static. Oakmont Addition is assumed to be fully developed as planned.

NATIVE SOILS - INFILTRATION FEASIBILITY

The USDA's Natural Resources Conservation Service (NRCS) provides full access to soil surveys throughout Oregon, including Benton County (OR606). In runoff analyses, soils data are used to help determine the SCS Curve Number (CN). The NRCS identifies the soils on this site as Map Symbol 167 – Willakenzie-Wellsdale complex 12 to 20 percent south slopes, Hydrologic Group B. The typical soil profile is loam to clay loam, overlaying shallow weathered bedrock. Saturated hydraulic conductivity is very low, 1.40-4.00 micrometers/second. These poorly-drained clayey soils, combined with the site's relatively steep slopes, generate rainfall runoff conditions that are unsuitable for the implementation of groundwater infiltration as a storm water management alternative for an urbanized residential hillside.

STORMWATER CONVEYANCE DESIGN

For analysis and design purposes, each of the three aforementioned basins, West, Central and East, are further divided into sub-basins associated with planned stormwater collection points (curb inlets) in the approved roadway configuration. Using the Rational Method and Intensity-Duration-Frequency Curves (I-D-F) synthesized from SWMP design storms, conveyance system piping was designed for each aggregation of sub-basins within a reach. Located near the top of the hillside, accumulated runoff in Brooklane Heights is relatively small. All of the conveyance piping is sized to meet the City minimum standard of 12-inch diameter. The largest downstream collectors are 15-inch diameter pipes. This is a relatively small conveyance system.

The small west basin drains into existing or new streets and is served with piped conveyance. An existing natural conveyance, which includes a spring, is preserved for runoff in the Central basin. The East basin includes piping and features a constructed swale for it final reach. The conveyance system is shown on the Brooklane Heights Stormwater Master Plan, including pipe size, estimated 10-year storm flows and pipe capacities. Detailed engineering calculations can be found in the accompanying design notebook.

STORMWATER DETENTION DESIGN

Detention facilities are proposed at the downstream end of each of the three basins. Hillside topography, combined with the applicant's plan to preserve natural features, led to the design decision to utilize underground reinforced concrete detention vaults for each of the three basins. These KCSWDM structures provide the maximum storage with the minimum site footprint and limited visual exposure. And, long-term public maintenance costs are kept at a minimum. An additional water quality benefit is the avoidance of thermal pollution and nutrient growth often associated with open ponds.

For the smaller west and east basins, these facilities are linear concrete tanks, located in or near the street ROW in areas already planned for grading. The larger tank required for the Central basin is proposed to be located at the toe of the existing hillside, within Tract B open space. The tank has been geometrically configured to avoid disturbance of trees identified for preservation. Privately installed and maintained landscaping is proposed for this facility to enhance its appearance to new homeowners in Brooklane Heights.

Using SBUH hydrograph methodology, SCS Type 1A storm hyetographs and SWMP design storms, peak flows and volumes were calculated for 2-year, 5-year and 10-year frequency storm events for pre-development and post-development land uses. Detention volumes were calculated for the post-developed 2-year, 5-year and 10-year frequency storm events. Using a flow control structure recommended in the KCSWDM, detention discharge for each of the three basin facilities was limited to pre-development levels. In addition to meeting minimum requirements, the system includes capacity for limiting 100-year storm events to pre-development runoff for the new subdivision. And, the detention system provides flow-through capacity for all upstream runoff generated from a 100-year 24-hour storm event.

STORMWATER QUALITY DESIGN

Water quality facilities are proposed for each of the three basins. Pre-settling facilities are proposed to be structurally integrated with the underground reinforced concrete detention vaults, following the KCSWDM procedures for design of combined facilities. Design of water quality facilities is adopted directly from the KCSWDM. Flow control structures also can be structurally integrated with the combined detention/settlement vaults. Our plan proposes separate flow control structures fabricated in precast manholes for ease of inspection, operation and maintenance. The flow control structure includes an auxiliary sediment basin and an oil trap to prevent floatable pollutants and roadway generated oil from migrating downstream.

The final component of the treatment train is a media based filtration system. The proprietary Contech StormFilter is a flow-through stormwater filtration system comprised of an underground vault that houses media-filled cartridges. For this site, the appropriate filter media is a combination of zeolite, perlite and granular activated carbon (ZPG). The number and size of ZPG cartridges varies at each site with the water quality flow rate derived from the 0.9-inch, 24-hour design storm, which is the City of Corvallis standard for water quality design. Engineering calculations for sizing treatment facilities can be found in the design notebook.

The KCSWDM requires pre-settling for media based water quality filtration systems. As described above, planned efficiency of the utilization of underground vaults for detention is their dual functional capacity as “wet pools” providing required pre-settling of stored storm water. Engineering calculations demonstrating the adequacy of the proposed detention vaults to meet KCSWDM pre-settling storage volume requirements can be found in the design notebook. This combined use limits the grading requirement and site footprint required for the system. Combined facilities also reduce public O&M costs.

STORMWATER OPERATION & MAINTENANCE

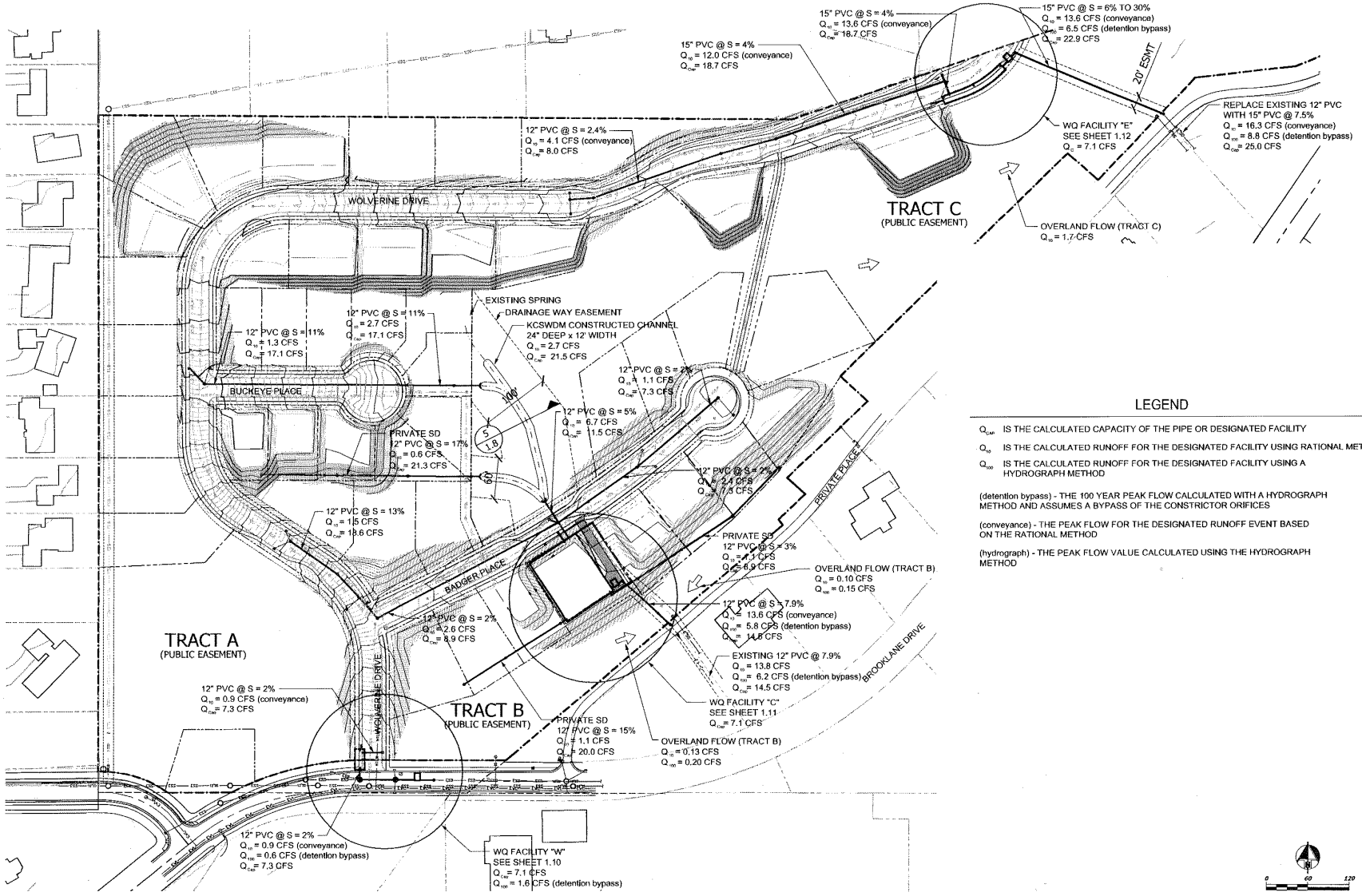
Appendix A of the King County Surface Water Design Manual includes detailed operation and maintenance (O&M) standards for stormwater management facilities, including the proposed proprietary StormFilter ZPG media filtration system. Copies of the applicable O&M standards from the KCSWDM are included in the engineering design notebook for reference.

While not part of this Brooklane Heights Stormwater Master Plan, it should be noted that roadway maintenance operations regularly performed by City of Corvallis Public Works Department include stormwater BMP's. Vacuum assisted street sweeping, seasonal leaf pickup and curb inlet cleaning are significant contributions to the City's demonstrated efforts toward clean water objectives.

Respectfully submitted,

Scott Wright, P.E.
Project Manager

Enc: Calculation Notebook "Brooklane Heights Storm Water Analysis & Design"
Drawings 1.7 – 1.14 "Brooklane Heights Stormwater Master Plan"



LEGEND

Q_{CAP} IS THE CALCULATED CAPACITY OF THE PIPE OR DESIGNATED FACILITY

Q_{10} IS THE CALCULATED RUNOFF FOR THE DESIGNATED FACILITY USING RATIONAL METHOD

Q_{100} IS THE CALCULATED RUNOFF FOR THE DESIGNATED FACILITY USING A HYDROGRAPH METHOD

(detention bypass) - THE 100 YEAR PEAK FLOW CALCULATED WITH A HYDROGRAPH METHOD AND ASSUMES A BYPASS OF THE CONSTRICTOR ORIFICES

(conveyance) - THE PEAK FLOW FOR THE DESIGNATED RUNOFF EVENT BASED ON THE RATIONAL METHOD

(hydrograph) - THE PEAK FLOW VALUE CALCULATED USING THE HYDROGRAPH METHOD

METOLIUS CONSULTING

STORMWATER MASTER PLAN
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER
OREGON
SCOTT A. WEIGHT
RENEWAL 6/30/12

REVISION	DATE
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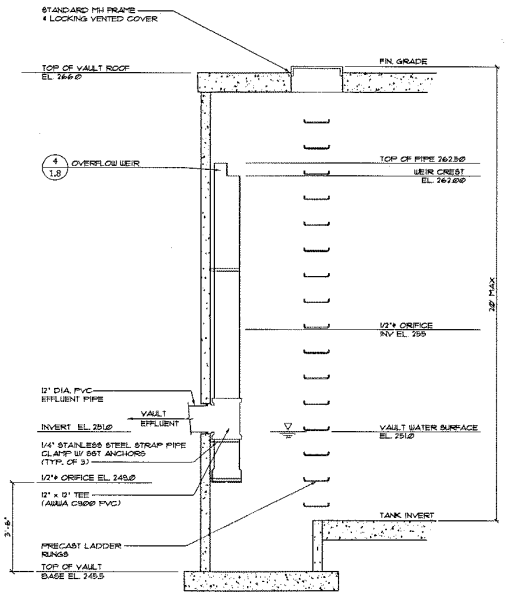
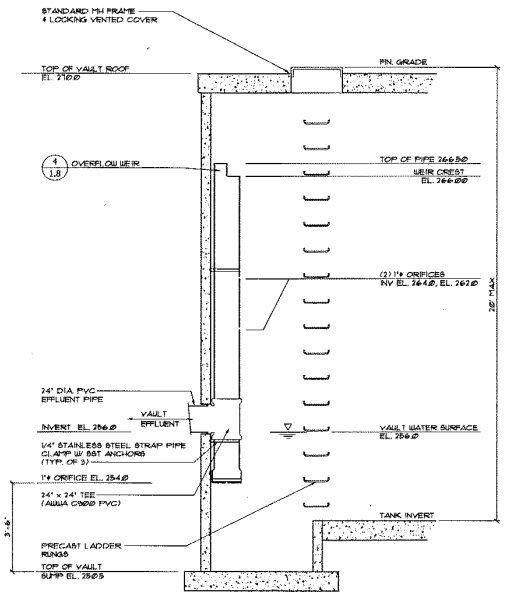
DRAWING NUMBER
1.7
DRAWING - nf -

CC EXHIBIT II - 11



1 1.8 KCSWDM FLOW CONTROL STANDPIPE - WEST DETENTION VAULT
SCALE: N.T.S.



2 1.8 KCSWDM FLOW CONTROL STANDPIPE - CENTRAL DETENTION VAULT
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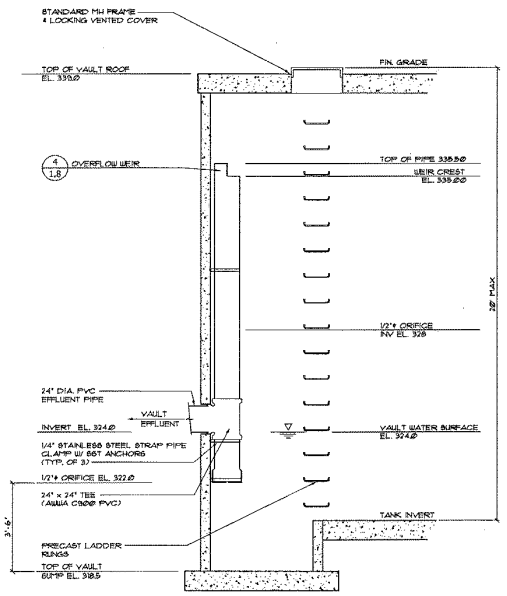
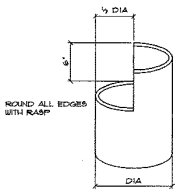
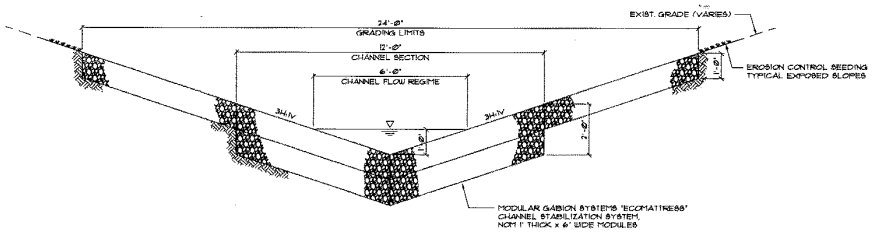


3 1.8 KCSWDM FLOW CONTROL STANDPIPE - EAST DETENTION VAULT
SCALE: N.T.S.



4 1.8 WEIR DETAIL
SCALE: 1-1/2" = 1'-0"



5 1.8 GABION STABILIZED CHANNEL SECTION
SCALE: 1/2" = 1'-0"

METOLIUS CONSULTING

STORMWATER QUALITY DETAILS
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER
OREGON
SCOTT A. WRIGHT
RENEWAL 6/30/12

REVISION	DATE
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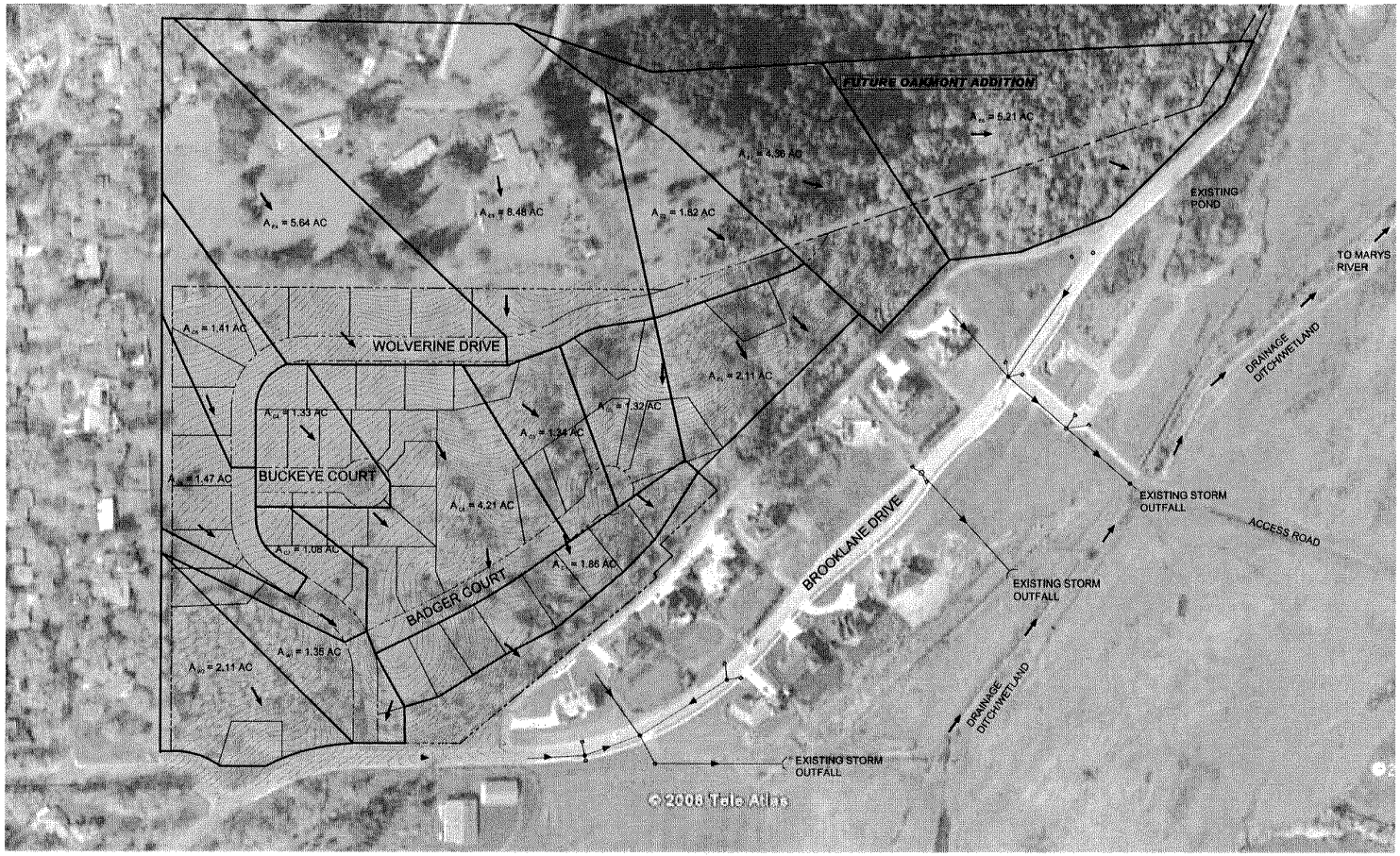

1 / 1.9 **SURFACE DRAINAGE PATTERNS**
Scale: 1" = 100'

CC EXHIBIT II - 13

METOLIUS CONSULTING

SURFACE DRAINAGE PATTERNS
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER
OREGON
RENEWAL 6/30/12

REVISION	DATE
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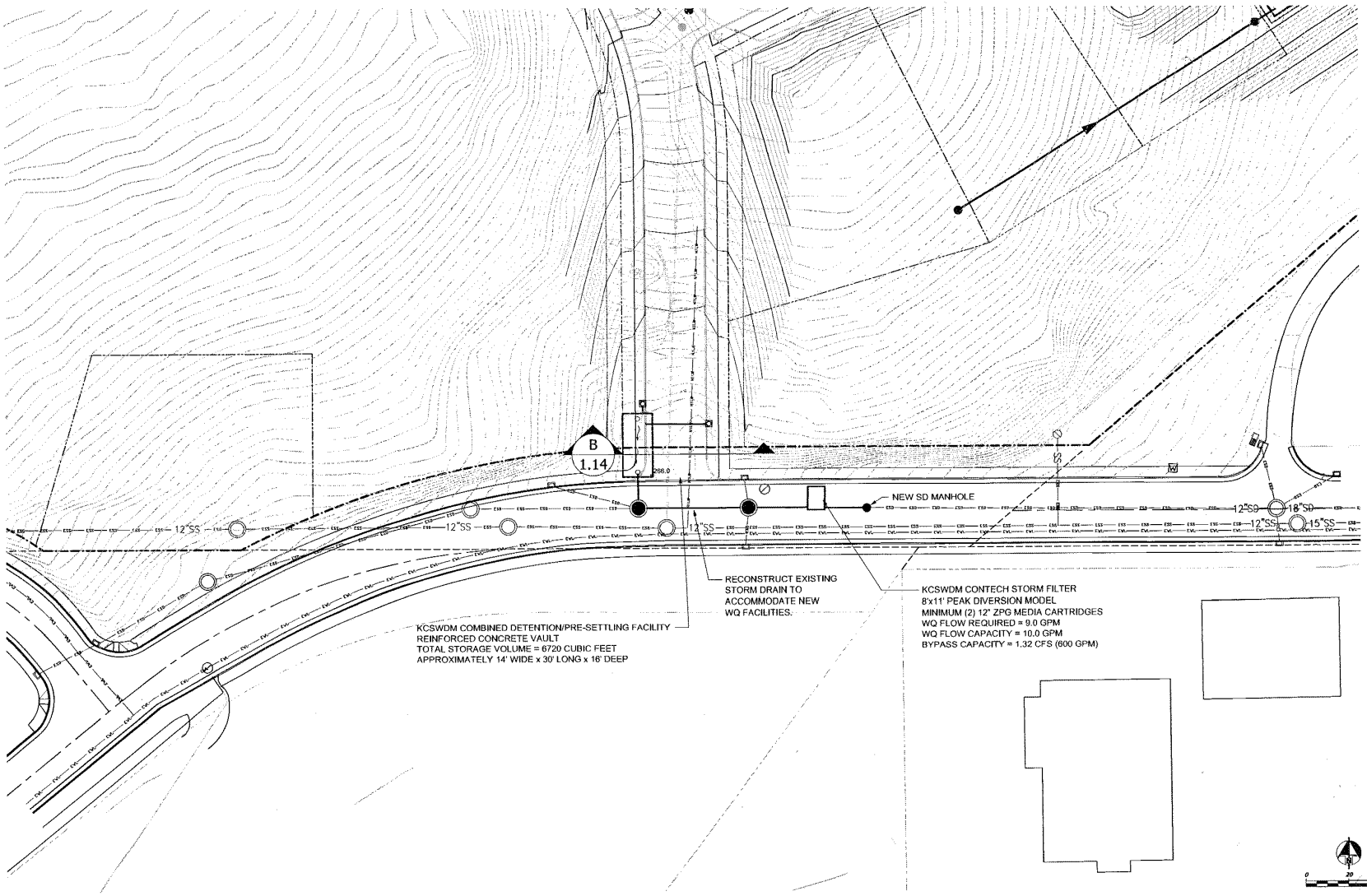
EXHIBIT II - 13



METOLIUS CONSULTING

WATER QUALITY FACILITY "W"
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER
OREGON
SCOTT A. WRIGHT
RENEWAL 6/30/12

REVISION	DATE
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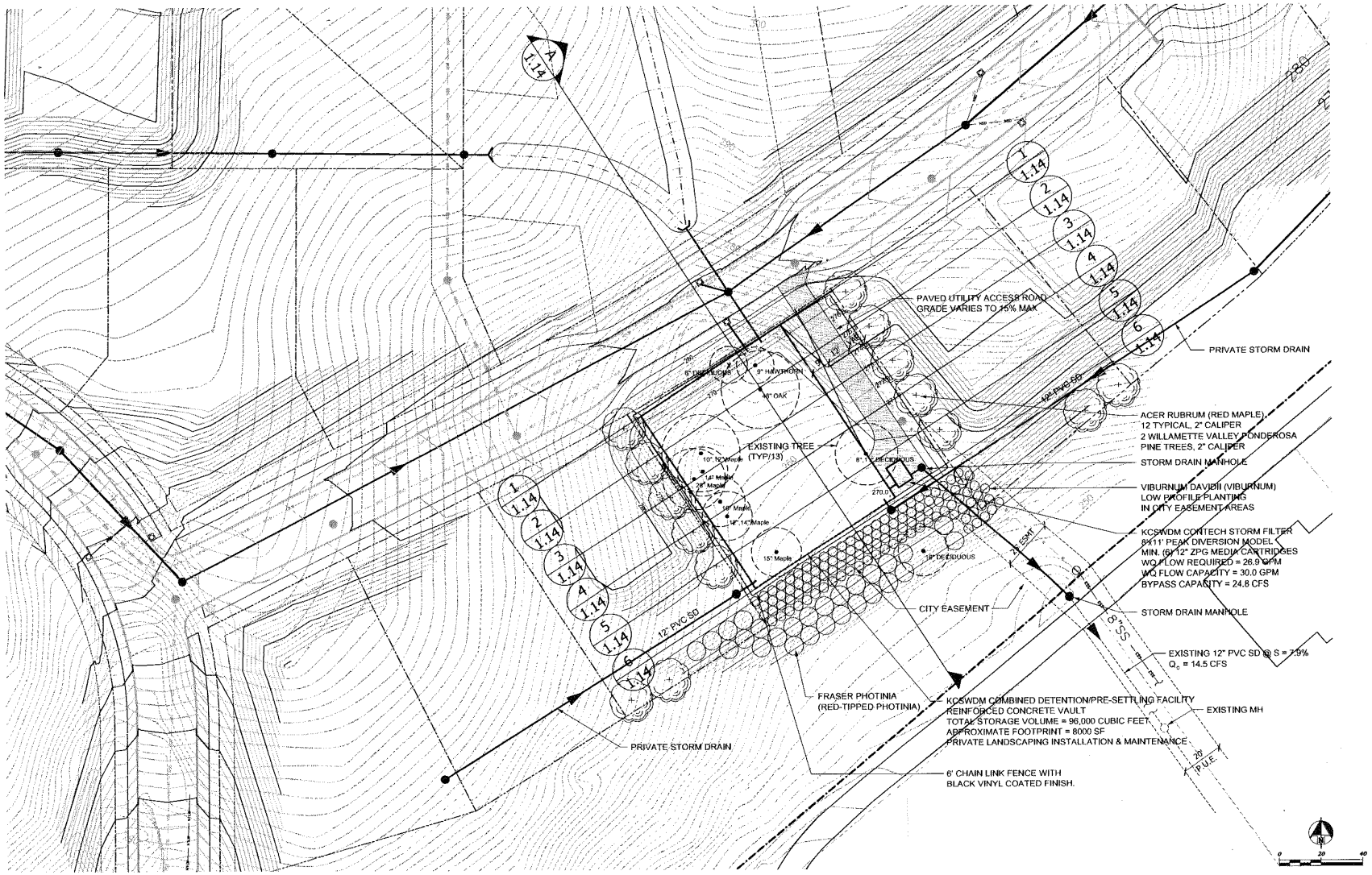
DRAWING - of -

CC EXHIBIT II - 14



CC EXHIBIT II - 15

METOLIUS CONSULTING

WATER QUALITY FACILITY "C"
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER
OREGON
SCOTT A. WRIGHT
RENEWAL 6/30/12

REVISION	DATE
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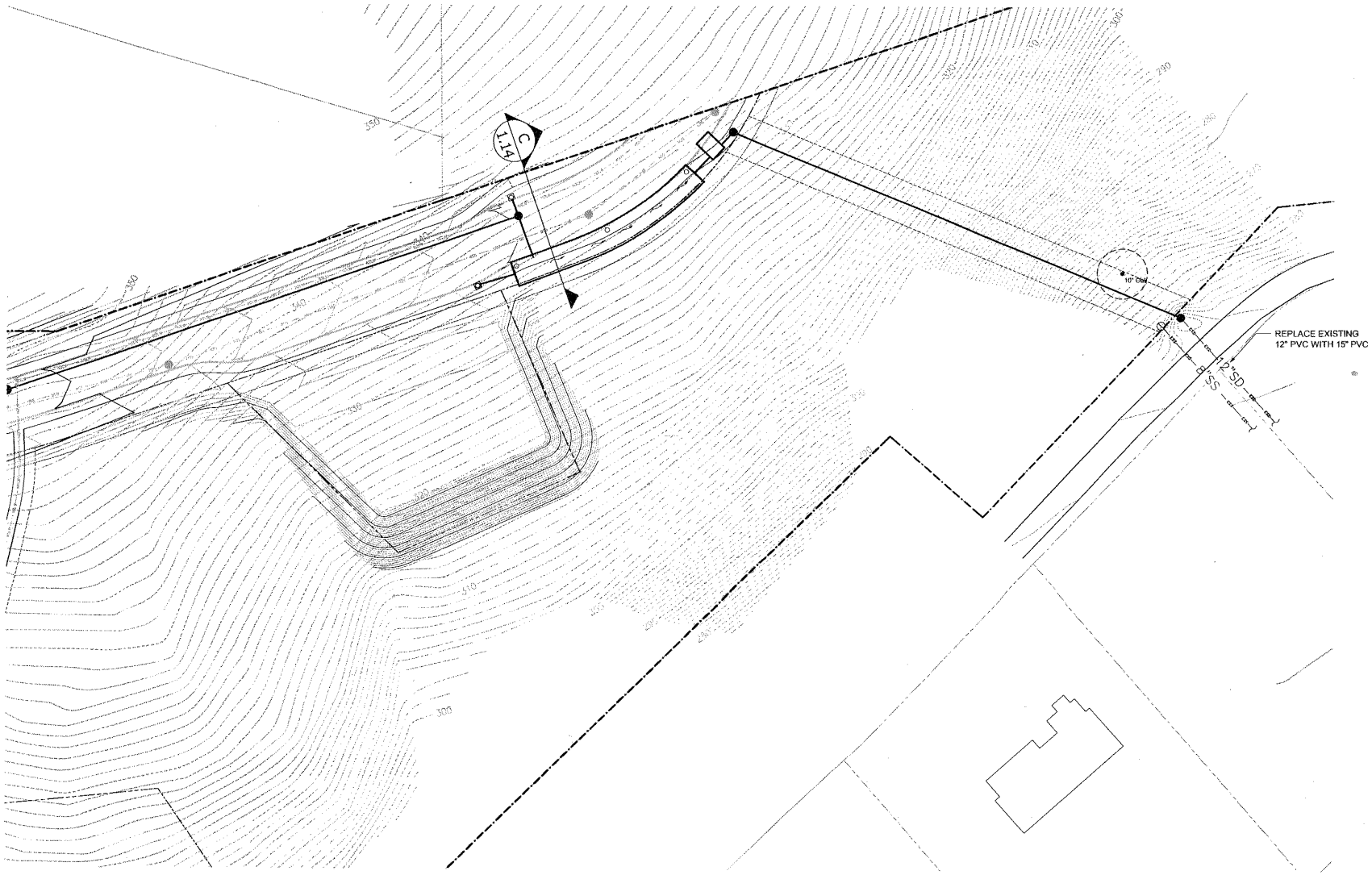
DRAWING - of -



CC EXHIBIT II - 16

METOLIUS CONSULTING

WATER QUALITY FACILITY "E"
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER
OREGON
SCOTT A. WRIGHT
RENEWAL 6/30/12

REVISION	DATE
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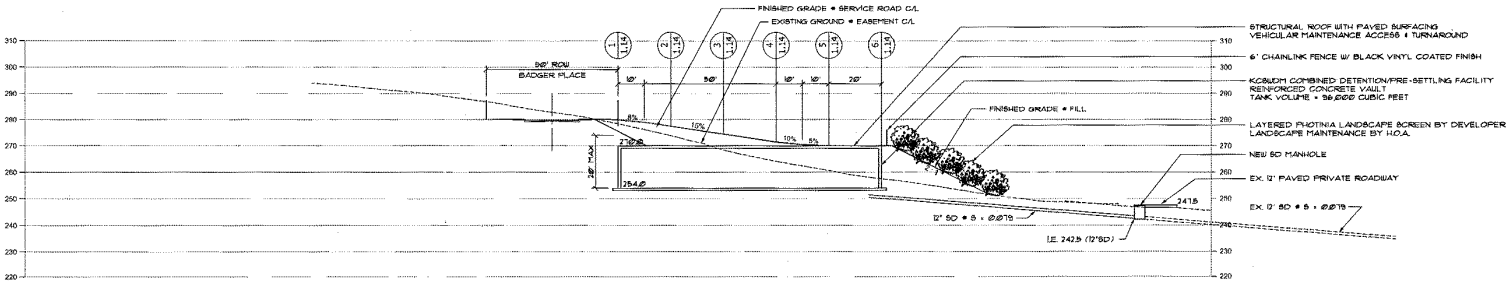
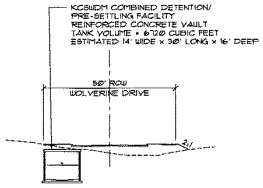
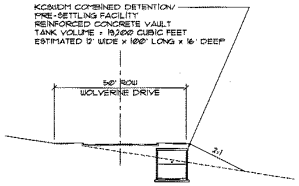


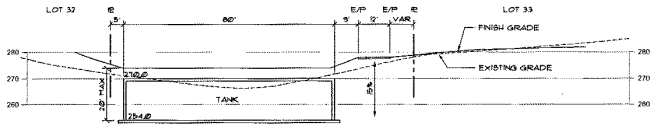
A 1.14 SECTION WITH DETENTION VAULT
SCALE: 1" = 20'



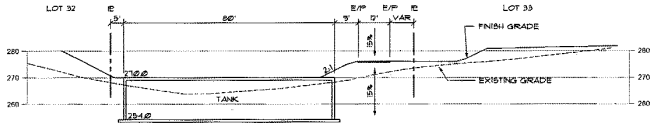
B 1.14 STORMWATER DETENTION VAULT
SCALE: 1" = 20'



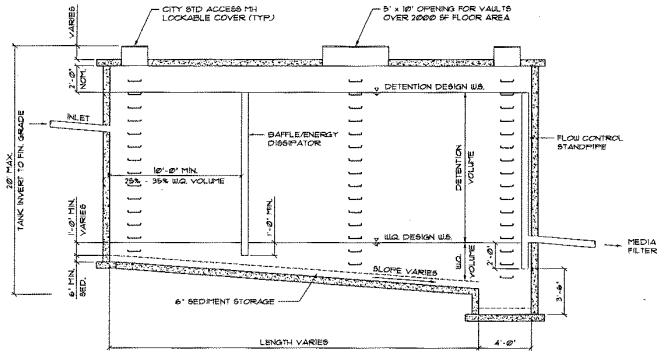
C 1.14 STORMWATER LINEAR DETENTION VAULT
SCALE: 1" = 20'



1 1.14 SECTION @ NORTH WALL OF TANK
SCALE: 1" = 20'

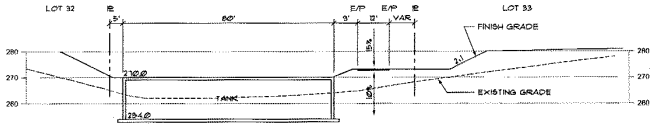


2 1.14 SECTION @ 20' SOUTH OF NORTH WALL
SCALE: 1" = 20'

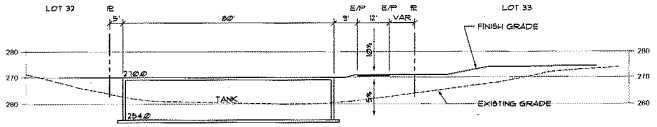


D 1.14 KCSWDM COMBINED DETENTION/PRE-SETTLING VAULT (TYP.)
SCALE: N.T.S.

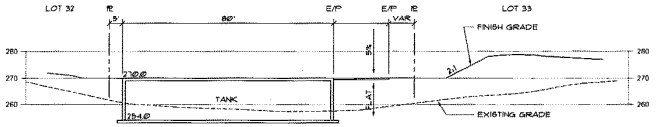
NOTE: ALL VAULTS SHALL MEET KCSWDM STANDARDS



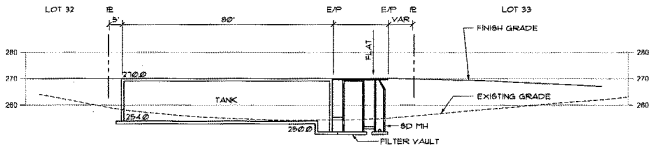
3 1.14 SECTION @ 40' SOUTH
SCALE: 1" = 20'



4 1.14 SECTION @ 60' SOUTH
SCALE: 1" = 20'



5 1.14 SECTION @ 80' SOUTH
SCALE: 1" = 20'



6 1.14 SECTION @ SOUTH WALL OF TANK
SCALE: 1" = 20'

METOLIUS CONSULTING

FACILITY SECTIONS
BROOKLANE HEIGHTS SWMP
BROOKLANE DEVELOPMENT, CORVALLIS, OREGON

REGISTERED PROFESSIONAL ENGINEER OREGON SCOTT A. WEIGHT
RENEWAL 6/30/12

REVISION	DATE
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DRAWING NUMBER
1.14
DRAWING - of -

EXHIBIT II - 17

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 2
Land Use Approvals

CITY COUNCIL
NOTICE OF DISPOSITION

ORDER: 2010-007

CASE: **Brooklane Heights Planned Development**
(PLD06-00018, SUB06-00006)

REQUEST: Approval of a Conceptual and Detailed Development Plan and Tentative Subdivision Plat to create 45 residential lots and 4 common tracts on 25.88 acres of land, and to vary from certain Land Development Code standards.

On September 4, 2007, the City Council approved the subject application, with conditions. This decision was appealed to the Oregon Land Use Board of Appeals (LUBA), and LUBA remanded the decision. On February 2, 2009, the City Council reviewed the remand issues and approved the application, with conditions. This decision was also appealed to LUBA, and the decision was remanded. On February 1, 2010, the City Council considered the remand issues, and approved the application, with conditions, including revisions to Conditions of Approval 20 and 27.

APPLICANT/OWNER: Stephen Schaberg
2535 SW Whiteside Drive
Corvallis, Oregon 97333

LOCATION: The 25.88 acre site is located northwest of Brooklane Drive and north of Agate Avenue, east of Fairmont Drive, and south of Whiteside Drive. The site consists of one parcel which is identified on Benton County Assessor's Map 12-5-01 C as Tax Lot 1000.

On February 1, 2010, the City Council held a duly-advertised public hearing to consider the issues remanded by LUBA. The public hearing was opened to allow the public the opportunity to rebut Councilor declarations, after which, the public hearing was closed. The Council deliberated on the matter, and voted to approve the Conceptual and Detailed Development Plan and Tentative Subdivision Plat requests, with conditions, including revisions to previously approved Conditions of Approval 20 and 27. This decision upheld the two previous Council decisions to approve the subject application.

If you wish to appeal these decisions, an appeal must be filed with the State Land Use Board of Appeals within 21 days from the date of the decision.

The proposal, staff report, hearing minutes, memoranda to City Council, and findings and conclusions may be reviewed at the Community Development Department, Planning Division, City Hall, 501 SW Madison Avenue.

Charles C. Tomlinson
Mayor, City of Corvallis

Signed: February 3, 2010
Appeal Deadline: February 24, 2010

Expiration Date(s) (If Not Appealed): February 24, 2013
(Conceptual and Detailed Development Plan)

February 24, 2012
(Tentative Subdivision Plat)

If an appeal is not filed by the appeal deadline, the Conceptual and Detailed Development Plan shall be valid for three years. If the applicant has not begun construction of the development or its phases within this period, the approval shall expire on February 24, 2013. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to two additional years if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

If an appeal is not filed by the appeal deadline, the Tentative Subdivision Plat shall be valid for two years. If the applicant has not submitted a final subdivision plat within two years (with appropriate assurances for improvements, if applicable), the approval shall expire on February 24, 2012. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to one additional year if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

Attachments:

- Revised Conditions of Approval (Pages 3-12 of this Disposition)
- Excerpts of Approved Plans (Tentative Subdivision Plat, Revised Grading and Tree Preservation Plan, Cut/Fill Analysis)

CONDITIONS OF APPROVAL

The City Council applied the following conditions to the approval of the Brooklane Heights Conceptual and Detailed Development Plan, and Tentative Subdivision Plat (PLD06-00018, SUB06-00006). Condition numbers 20 and 27, which were approved via the previous Council decision (Order 2009-00007), were revised by the Council on February 1, 2010. These conditions are written below as approved by the City Council.

1. **Consistency with Plans** – Development shall comply with the narrative and plans identified in or referenced in **Attachment IX** of the August 10, 2007, Memorandum to the City Council from Community Development Director, Ken Gibb, except as modified by the conditions below or unless a requested modification otherwise meets the criteria for a Planned Development Modification and/or a Tentative Plat Modification. Such changes may be processed in accordance with Chapters 2.4 and 2.5 of the Land Development Code.

   A Home Owners Association (HOA) shall be established and shall be subject to the requirements stated in the following Conditions of Approval.

2. **Secondary Access** - Per LDC section 4.0.70.c.3, development of lots shall be limited to Lot 1, and 18 additional lots on a street segment not to exceed 600 feet, or 150 feet beyond an emergency turn-around until secondary access, as proposed, is achieved. If development occurs on the 600 foot street segment, prior to development of secondary access, the street terminus shall be constructed with turn-arounds to accommodate emergency vehicles. The turn-around area shall comply with applicable Oregon Uniform Fire Codes, or as specified by the Corvallis Fire Marshall.

3. **Landscaping Construction and Maintenance** – The following landscaping provisions shall apply to overall development of the site:

   Landscape Construction Documents – Prior to issuance of PIPC permits, the applicant shall submit to the Community Development Director, a Detailed Landscape Plan for this site that contains a specific planting plan (including correct plant names in the Latin format), construction plans, irrigation plans, details, and specifications for all required landscaped areas on the site in sufficient detail to show the relationship between required landscaping and public utilities, franchise utilities, driveways, and other streetscape elements such as light poles, signs and mailboxes. Where conflicts arise between landscaping and streetscape elements and public facilities, flexibility in the location of trees may be permitted. However, a reduction in the number of required streets trees shall not be permitted unless modified through a Planned Development Modification approval.

   Plantings shall comply with LDC Section 4.2 and other conditions of this approval. Required street trees shall have at least a 1½-inch trunk diameter at the time of installation and shall be chosen from the list of species provided in LDC Section 4.2.60, or as approved by the Community Development Director. The plans must have been

reviewed and approved prior to installation of landscape materials.

The landscape plans shall address the following additional requirements:

Landscape Installation and Maintenance – Street trees and ground cover in planter strips in Brooklane Drive shall be installed with PIPC improvements, except for street trees adjacent to Lot 1. Street trees and ground cover in planter strips fronting Lot 1 shall be installed prior to issuance of Final Inspection for Lot 1. Street trees and ground cover in planter strips in other proposed local streets shall be installed on lot frontages as individual lots are developed, and shall be installed prior to Final Inspection for homes on the associated lot. Street trees on Wolverine Drive northeast of lot 13 shall be installed prior to Final Inspection for lot 45.

The locations of all required trees will be shown on all site plans submitted for public improvement design. A maintenance plan for all plantings shall be provided prior to the City's on-site approval of the landscape installation. This plan shall provide measures to assure all new plantings attain the minimum 90 percent ground cover required by LDC Section 4.2.20 within three years from the date of installation approval.

Security for Landscape Installation and Maintenance – Prior to the approval of the landscaping plan, a Performance Bond (or other LDC-approved financial security) will be provided to the City to secure installation of all required landscaping along new local streets and within Tracts. Prior to Final Plat approval, A 3-year maintenance Bond (or other LDC-approved financial security) shall be provided to the City to cover 50 percent of the costs for landscape materials and labor (plus costs for administration) associated with landscaping installed along all new local streets and Tracts.

Home Owners' Association Landscape Maintenance Responsibilities – After completion of the required three-year maintenance period, the Home Owners' Association created for this subdivision will be responsible for the perpetual maintenance of any landscaping and management of wooded areas within in Tracts. Prior to final plat approval, the applicant shall submit for approval by the Community Development Director, the Home Owners' Association's Codes, Covenants and Restrictions (CC&Rs) and or bylaws. The Homeowners' Association's CC&R's or bylaws shall include all language from this Condition of Approval.

4. **Erosion Control** - Prior to issuance of excavation and grading permits, the applicant shall obtain erosion control permits. Where required by Development Services staff, the applicant shall install an erosion control and re-vegetation product capable of functioning on a 2:1 slope, that will result in 90% vegetation coverage within 3 years, without using irrigation.

5. **Tree Preservation and Planting** – Prior to issuance of any permits, the applicant shall submit a report by a certified arborist that identifies all significant trees proposed to be removed in this application. Identified trees shall include those identified in the arborist report submitted with the subject application (Attachments S and R.55 of the May 25, 2007, staff report to the Planning Commission) trees impacted by construction of the

pedestrian path between Badger Place and Wolverine Drive, trees impacted by construction of the stormwater swale in the north portion of the site, and trees potentially impacted by construction and use of the detention ponds in Tracts B and C.

Unless approved for removal through this application , trees in Tracts A, B, C, an D, as identified in the approved Revised Tentative Subdivision Plat shall be preserved unless a tree is determined to be a hazard tree, or its removal is necessary to protect the health and longevity of an Oregon White Oak tree. Prior to removal of any tree a certified aborist's report shall be submitted to the Community Development Department for review, and trees shall only be removed if the City's Urban Forester concurs with the analysis and recommendations in the arborist's report.

Regarding the pedestrian path, stormwater swale, and ponds, the arborist's report shall detail methods to preserve as many significant trees as possible in or adjacent to these site components. The applicant shall follow tree preservation methods outlined by the arborist. Unless already approved for removal, (any) significant trees may be removed only if a certified arborist recommends removal and the City Forester concurs with the arborist's recommendation.

The arborist's report shall also illustrate all trees approved/proposed to be preserved. To ensure protection of trees, there shall be no cutting, filling, trenching, nor compaction of the soil under tree canopies and to a minimum distance of 5 feet outside the canopy's dripline, consistent with Section 4.2.20.c of the Land Development Code. To assure this protection, a minimum 5-foot high construction fence (constructed of metal chain link, and supported by metal posts sunk into the ground) shall be installed 5 feet outside the canopy's dripline for all trees to be preserved, prior to any excavation and grading of the development site. An exception may occur upon inspection and a recommendation by a certified arborist.

Existing trees, including trees on adjacent properties with driplines within 10 feet of the subject site, and construction protection fences shall be illustrated on all site plans submitted for excavation, erosion control, PIPC, and building permits. Tree protection plans shall be submitted to the City for review and approval, and tree preservation fencing shall be installed and inspected, prior to issuance of any excavation and grading, erosion control, PIPC, or building permits.

6. **Wetland Determination** - Prior to issuance of PIPC permits, the applicant shall submit a wetland determination report indicating the presence of wetlands. If wetlands are found to be present on the site, prior to issuance of excavation and grading permits, the applicant shall submit documentation from the Department of State Lands verifying that the site development and wetland mitigation plans comply with all applicable local, state, and federal wetland regulations.

7 **Archaeological Resources** - Prior to issuance of excavation and grading permits, the applicant shall have the site surveyed by a State Historic Preservation Office (SHPO) qualified archaeologist to determine the presence of archaeological resources on the site, in addition to those identified as site 35-BE-67. The archaeologist shall submit

findings and recommendations regarding site development to the applicant/developer, Corvallis Development Services Division, and SHPO for review. The applicant shall comply with all State and Federal regulations pertaining to archaeological, cultural, and historic materials. Prior to issuance of grading and excavation permits and any earth disturbing activities the applicant shall submit a letter from the SHPO verifying that the proposed development complies with applicable State and Federal regulations relative to archaeological, cultural, and historic materials. During construction of the site, the applicant shall continue to comply with applicable regulations.

8. **Public Improvement Plans** - Any plans for public improvements referenced within the application or this staff report shall not be considered final engineered public improvement plans. Prior to issuance of any structural or site utility construction permits, the applicant shall obtain approval of, and permits for, engineered plans for public improvements from the City's Engineering Division. The applicant shall submit necessary engineered plans and studies for public utility and transportation systems to ensure that adequate street, water, sewer, storm drainage and street lighting improvements are provided. Final utility alignments (including locations for detention facilities) that maximize separation from adjacent utilities and street trees shall be engineered with the plans for public improvements in accordance with all applicable LDC criteria and City, DEQ and Oregon Health Division requirements for utility separations Public improvement plan submittals will be reviewed and approved by the City Engineer under the procedures outlined in Land Development Code Section 4.0.90. **Note:** Land Development Code Section 4.0.70 has been amended to establish street lights as public utilities. Under the revised Code Section, developers shall provide an engineered design for street light installation; obtain appropriate electrical permits from the Development Services Division; and install the street light system concurrent with public improvements.

9 **Right-of-Way Dedication** - As part of Phase I, additional ROW shall be dedicated along SW Brooklane Drive in order to achieve the minimum half street standard width of 33 ft from the original ROW centerline.

Also as part of Phase I, 50 ft of ROW shall be dedicated in Tract D to allow the proposed Oakmont Addition to construct Hawkeye Avenue between the Oakmont Addition subdivision and SW Brooklane Drive.

In addition, an environmental assessment for all land to be dedicated must be completed in accordance with LDC Section 4.0.110.h.

10. **Frontage Improvements** - At the time of development, curbside sidewalk shall be installed along the north side of SW Brooklane Drive between SW Agate Avenue and the private alley located along the northwest portion of Brooklane Park Estates. The sidewalk will connect to existing sidewalk located at SW Agate Avenue to the west. Curb cuts will be provided on both sides of SW Brooklane Drive just west of the private alley described above. New and existing curb cuts shall be constructed or re-constructed to meet current ADA standards.

11. **Public Improvements** - Prior to Final Plat approval the applicant shall construct or secure all public improvements within the subject site.

12. **Vision Clearance** - The City's Off-Street Parking and Access Standards require a vision clearance triangle be maintained between an elevation of 2 feet and 8 feet above the roadway height for all intersecting streets. The legs of the vision clearance triangle shall be determined from table 3 of the City of Corvallis Off-Street Parking and Access Standards. Site plans showing an unobstructed vision clearance triangle as outlined shall be submitted concurrent with application for public improvement permits.

13. **Construction Traffic Plan** - Prior to issuance of excavation and grading permits, the applicant shall prepare a detailed construction traffic plan that outlines proposed hours of operation, route maps, and direction of travel for loaded and empty trucks. This plan shall prohibit construction traffic from using Local Streets as classified in the 1996 Corvallis Transportation Plan. Additionally, construction traffic on the new section of SW Brooklane Drive shall be limited to vehicles of less than 12,000 lbs loaded weight. The construction traffic plan shall be submitted to the City of Corvallis, Development Review for review and approval.

14. **Public Sidewalk/Landscape Strip Improvements** - At the time of development, park strips and setback sidewalks shall be constructed adjacent to Tracts A, B, and C. All other park strips and setback sidewalks will be constructed when individual lots are developed as specified in the LDC 4.0.40.a.3.b.

15. **Transit Improvements** - The applicant shall place a bus shelter easement and provide a flat, graded pad, adjacent to the Brooklane Drive ROW. The location should be selected in cooperation with City of Corvallis, Transportation Division.

16. **Looped Waterline** - City standards are to loop all waterlines to eliminate dead-end runs. The waterline in Buckeye Place shall be looped. When the waterline leaves the ROW, it shall installed in an utility easement. A 15 ft utility easement will be required with a single utility, and a 20 ft utility easement will be required if two utilities run parallel to each other.

17. **Deed Restrictions for Pressure Reducing Valves** - In order to ensure that future owners of lots 33 thru 36 are aware of the need to install pressure reducing valves (PRV), and as part of the building permit process, the developer shall record deed restrictions outlining this need against lots 33 thru 36 concurrent with the final plat. All costs related to PRV installation and maintenance shall be borne by the property owners.

18. **Public Drainage** - All public storm drainage facilities located outside of ROW shall be placed in public drainage easements. This includes pipes, water quality manholes, drainageways, swales, and detention ponds. The minimum required easement width is 15 ft for a single utility and 20 ft for two utilities, or, for drainageways, the 1.5X + 5 LDC 4.5.80 (d)(3) formula. The easement must fully encompass drainageways, swales,

and detention ponds. All weather accesses must also be provided to the water detention facilities.

19. **Public Detention Facility Design & Maintenance Agreement** - The design of the storm water detention facilities shall incorporate all recommendations of the March 16, 2007, Geotechnical report that was conducted by Foundation Engineering, Inc. The geomembrane liner recommended in the Geotechnical report shall be placed on a slope of 3(h):1(v), or flatter and it shall be covered with at least 12 inches of soil. The detention pond shall remain in the same location and footprint as shown on the submitted Utility Plan. Any alteration to the placement of the pond and its associated structural features may require a Planned Development Modification.

    As part of the plans for public improvements the applicant shall provide engineered calculations for pre-development and post-development peak storm water run-off flows, and demonstrate that the storm drainage facilities are designed to match pre and post development flows based on the 2-year, 5-year, and 10-year storm events. The detention facilities shall be designed consistent with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting detention requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The detention analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons.

    The design for the public detention facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the detention facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.

    All detention facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for one year after build-out of all portions of the site that drain to the facilities. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington, Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the detention facilities are accepted by the City.

20. **Public Water Quality Facility Design & Maintenance** - The applicant shall submit the information required in this condition of approval. This information shall be reviewed for consistency with Comprehensive Plan Policy 4.11.12 and approved through a City Council Public Hearing review process prior to issuance of PIPC permits.

As part of the plans for public improvements the applicant shall provide engineered calculations for storm water quality facilities demonstrating compliance with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting water quality requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The water quality analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons.

All water quality facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for two years after acceptance by the City. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the warranty for storm water quality facilities is terminate.

The design for the public water quality facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.

21. **Tree Protection on Private Lots** - Homes on lots 1, 2, 5, 13, 24, and 43 shall be designed to minimize impacts to trees. Prior to issuance of permits for excavation and grading for home construction, a minimum 5-foot high, metal, chain-link construction fence, supported by metal poles sunk into the ground, shall be installed 5-feet outside the tree canopy driplines. If an alteration proposed by a certified arborist is reviewed and approved by City staff, an exception to this fencing location standard may occur.

22. **House Size Deed Restrictions** - Concurrent with final plat approval, the applicant shall record the following deed restrictions: Dwelling unit size on lots 19-29 shall not exceed 1,200 square feet. Buildings on Lots 2-13 and 44 and 45 shall be limited to one story above grade, with the option to construct daylight basements. The roof pitch of all buildings on all lots shall not exceed a 6:12 (rise:run) ratio. Cuts within any building footprint may exceed eight feet.

23. **Tentative Subdivision Plat and Grading Plans** - The approved Tentative Subdivision Plat shall be the revised Plat submitted with the July 5, 2007, appeal letter (Attachment I.6 of the August 10, 2007, Staff Memorandum to the City Council). The approved grading plan shall be the revised grading plan submitted with the July 5, 2007, appeal

letter (Attachments I.7, 8 of the August 10, 2007, Staff Memorandum to the City Council).

24. **Cul-de-Sac Length** - As reflected in the revised Tentative Subdivision Plat submitted on July 5, 2007, the length of cul-de-sacs shall be limited to 600 feet.

25. **Trail Width** - The width of the paved portion of the pedestrian and bicycle trail between Badger Place and Wolverine Drive shall be 8 feet.

26. **Off-Site Drainage** - Prior to final plat approval, the applicant shall develop a storm water drainage plan that ensures site surface drainage is captured in area drains before it crosses the Brooklane Park Estates alleyway. If new off-site area drains are required above the alleyway, the applicant will utilize the existing utility easements, which were specifically designed for storm drainage and sanitary sewer, and will construct such facilities to discourage storm water from crossing the alleyway.

27. **Lot Grading and Structures** -Mass grading shall be limited to the areas shown on the grading plan identified as Drawing X – Brooklane Heights Grading and Tree Preservation Plan, and Drawing Y – Brooklane Heights Cut/Fill Analysis (Exhibits D.1, 2). Cuts and fills in the areas permitted to be mass graded shall not exceed the measurements shown in Drawing Y. All mass graded areas, as shown in Drawing Y shall be engineered and constructed such that retaining walls are neither required nor used.

    Prior to grading and excavation activities in areas not approved for mass grading, as shown in Drawing Y (Exhibit D.2), the applicant shall obtain approval by the City Council through a public hearing review process, detailing how the grading plan(s) for development on individual lots are consistent with Comprehensive Plan Policy 4.6.7.

28. **Maintenance Obligations** - Individual homeowners shall be prohibited from applying pesticides, herbicides, fungicides, or fertilizers to their property. For the entire subdivision, the Homeowners Association (HOA) shall hire a Licensed Commercial Operator to apply any and all pesticides or herbicides on the site. The commercial operator shall be licensed by the Oregon Department of Agriculture, with licenses in the categories of Ornamental and Turf/Herbicide and Ornamental and Turf/Herbicide and Fungicide, or other applicable categories, with the appropriate insurance for that license. The Licensed Commercial Operator is to practice Integrated Pest Management as defined in Oregon Revised Statute 634.650. The use of any pesticide material that contains any of the top ten leachable ingredients, as identified by the Oregon Department of Agriculture, Department of Environmental Quality, and/or USGS for Oregon is strictly prohibited. Prior to recordation of the final plat, the applicant shall submit for review and approval by the Planning Division manager draft CC&Rs for the development that provide notice to homeowners of this condition of approval. The CC&Rs shall clearly state that the obligation for maintenance of all tracts within the subdivision will be held by the HOA.

DEVELOPMENT RELATED CONCERNS

A. **Mailbox Locations** - Mailbox locations shall be coordinated between the developer and the Post Office as part of the public improvements construction process.

B. **Excavation and Grading Plans** - Prior to issuance of any construction permits, the applicant shall submit an excavation and grading plan, including erosion control methods, to the City's Development Services Department for review and approval.

C. **Other Permits** - Prior to issuance of any construction permits, the applicant shall be required to obtain a National Pollutant Discharge Elimination System (NPDES) permit if construction activity will disturb, through clearing, grading, and/or excavation, one acre of the site. Additionally, any permits required by other agencies such as the Division of State Lands; Army Corps of Engineers; Railroads; County; or Oregon Department of Transportation, shall be approved and submitted to the City prior to issuance of any City permits.

D. **Infrastructure Cost Recovery** - Where it is determined that there will be Infrastructure Cost Recovery payments from past public improvements the developer shall pay their required share of the costs prior to receiving any building permits in accordance with Corvallis Municipal Code 2.18.040.

E. **Franchise Utility Plans** - Prior to issuance of public improvement permits, the applicant shall submit, as part of the public improvement plan set, an overall site utility plan that shows existing and proposed franchise utility locations, including vaults, poles, and pedestals. The proposed franchise utilities shall conform to requirements outlined in Land Development Code Section 4.0.100 - Franchise Utility Installations, including provision of appropriate public utility easements.

F. **Streetscape Plan** - As part of the public improvement plans, the applicant shall include a "streetscape" plan that incorporates the following features: composite utility plan; street lights; proposed driveway locations; vision clearance triangles for each intersection; street striping and signing (in conformance with the MUTCD); and proposed street tree locations.

G. **Development Standards** - Construction of homes on the site will be subject to the development standards of the 2006 LDC, including, but not limited RS-5 Development Standards and development standards in Article IV, to, Chapter 4.10-Pedestrian Oriented Design Standards, Chapter 4.11-Minimum Assured

Development Area, and Chapter 4.12-Significant Vegetation Provisions

H. **Spring** - Application materials reference a spring that is believed to be located in the East Drainage. Development on the site should be designed with consideration given to the spring and its potential impacts to future buildings and infrastructure.

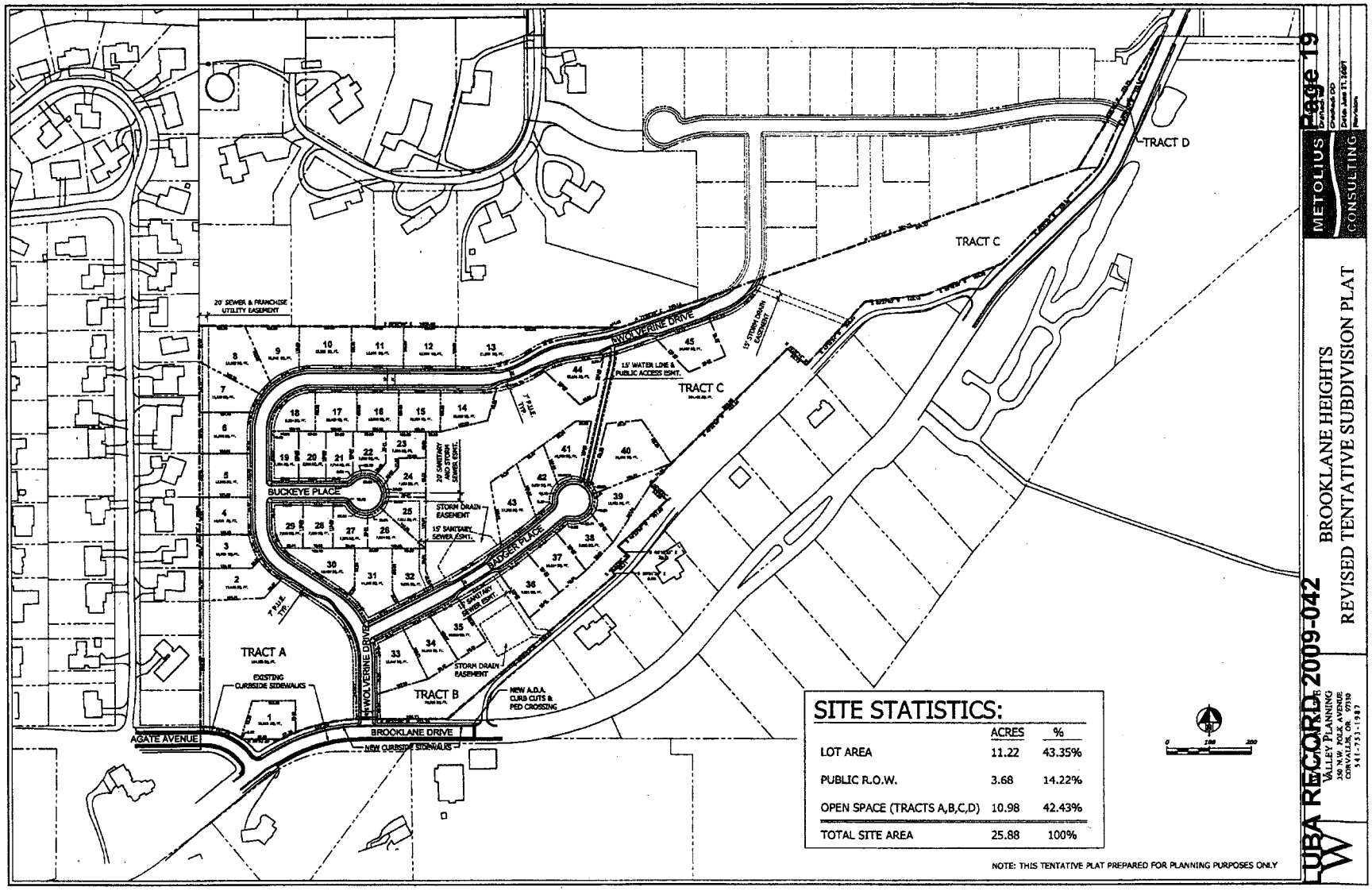

Exhibit B.3
CC EXHIBIT II - 31

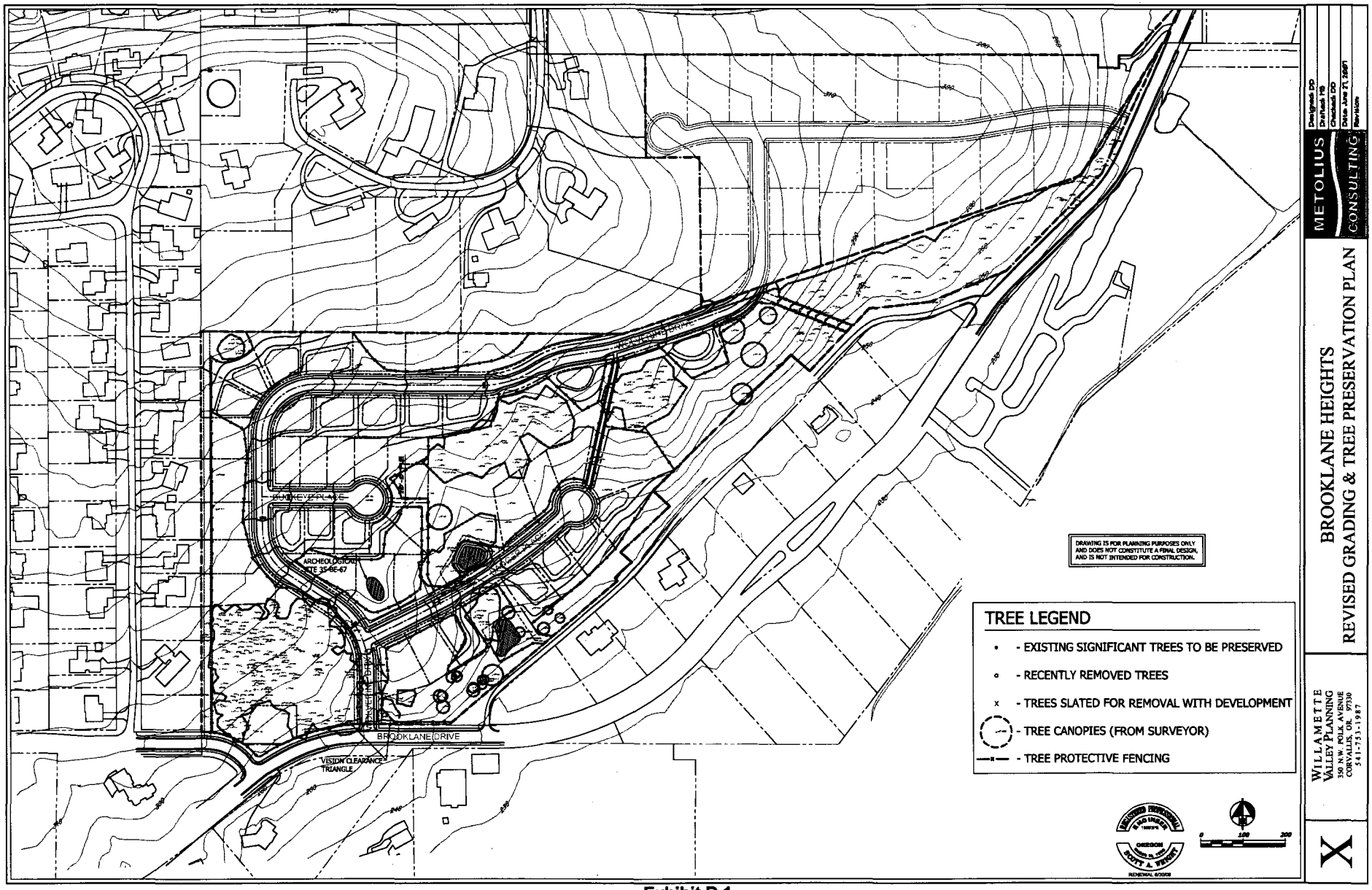

Exhibit D.1

CC EXHIBIT II - 32

FAIRHAVEN DRIVE
WOLVERINE DRIVE
BUCKEYE PLACE
BROOKLANE DRIVE
ARCHEOLOGICAL SITE 35-BB-61
VISION CLEARANCE TRIANGLE
DRAWING IS FOR PLANNING PURPOSES ONLY AND DOES NOT CONSTITUTE A FINAL DESIGN, AND IS NOT INTENDED FOR CONSTRUCTION.
CUT/FILL LEGEND
0' - 10' CUT
10' - 20' CUT
0' - 10' FILL
10' - 20' FILL
0 100 200
METOLIUS CONSULTING
Designed: DD
Drafted: TB
Checked: DD
Date: June 21, 2007
Revision
BROOKLANE HEIGHTS
CUT/FILL ANALYSIS
WILLAMETTE VALLEY PLANNING
330 N.W. POLK AVENUE
CORVALLIS, OR. 97330
541-753-1987

Exhibit D.2

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 3
Corvallis Design Standards

MEMORANDUM

TO: Greg Gescher, CP&P Supervisor

FROM: Bruce Moser, Project Manager

DATE: December 15, 2003

SUBJECT: **Stormwater Quality Facility Design Storm**

This memo reviews the stormwater quality design storm event for the City of Corvallis, and recommends using a NRCS Type 1A storm event of 0.9 inch in 24 hours.

Background

NPDES Phase 1 and 2 Stormwater regulations require agencies to implement stormwater quality treatment by the use of best management practices. NPDES Phase 1 and 2 Permits do not include a specific requirement for meeting a design storm and treatment level. The State of Oregon DEQ has not established stormwater quality criteria for NPDES Phase 1 for receiving streams that are not water quality limited (TMDLs have not been established).

The Corvallis SWMP includes the requirement to retrofit all existing stormwater outfalls with water quality facilities, and to require new development to install stormwater quality facilities. The SWMP includes Technical Memorandum No. 3, dated Nov. 10, 1999, in which Brown&Caldwell staff recommended that the City of Corvallis use 2/3's of the 2 year, 24 hour rainfall event, or 1.67 inches for 24 hours for the stormwater treatment design storm event. This level of treatment exceeds the level other agencies in Oregon are currently using.

Discussion

Agencies in Oregon that have NPDES stormwater permits have established differing criteria for the stormwater quality design storm event to capture and treat. Agencies have reviewed local rainfall data to determine the level of storm event to capture that represents a percentage of the total rainfall. This methodology is based on the assumption that the majority of pollutants are mobilized and transported prior to the peak of a large rainfall event. Several stormwater quality studies have substantiated this assumption.

The process for review of rainfall data involves review of historical rainfall events to establish a level of 24 hour precipitation that represents a given percentage of the total volume of rainfall. The City of Portland has established design criteria of 95% of total stormwater runoff is to be treated to remove 70% of Total Suspended Solids (TSS). The design storm to capture has been established as 0.83 inches in 24 hours, using NRCS Type 1A curve. The City of Eugene has established the design criteria of 90% of total stormwater runoff to be treated, but the TSS removal criteria is not mentioned. City of Eugene staff assume that a properly designed stormwater quality BMP will remove 80% of TSS. City of Eugene has established the design storm as 0.21 inches in one hour for on-line facilities, and 0.12 inches in one hour for off-line facilities. This is based on using 1.0 inch

in 24 hour as the design storm, using the NRCS Type 1A curve. The on-line facilities have a greater design storm based on the assumption that the effectiveness of an on-line facility will be impacted by flow when compared to an off-line facility.

Establishing Stormwater Quality Treatment Design Storm Event for Corvallis

The design rainfall event and treatment level is not currently identified under existing or anticipated regulatory requirements for the City of Corvallis. The SWMP does not specify treatment levels, but community input frequently referenced the water quality requirements that larger Oregon cities were meeting. A reasonable expectation for the implementation of stormwater quality facilities in Corvallis would be meeting community standards established in other Oregon cities that require stormwater treatment.

The stormwater receiving streams in Corvallis do not have established TMDL's, and none are anticipated to be implemented in the foreseeable future. In addition, the EPA Implementation Plan for Corvallis has not established a water quality treatment requirement with the exception of water temperature.

The methodology for developing the storm event for design treatment levels for the City of Corvallis uses review of historical daily rainfall over the last 42 years from the Hyslop rainfall gage (located 4 miles north of Corvallis) to determine the 24 hour event that would provide 90% capture for treatment. The 42 year historical data was tabulated to establish the average yearly rainfall of 43.20 inches. The amount of yearly rainfall that equals 90% of this yearly rainfall is 38.87 inches. The next step of the methodology was to established a daily rainfall amount that collectively meets the 38.88 inches over the 42 years of data. The historical rainfall data was input to a spreadsheet "if, then" command to record all daily rainfall less than or equal to 0.9 inches. Rainfall greater than 0.9 inches was converted to 0.9 inches for the 24 hour period. The data was again tabulated and averaged to determine the yearly average rainfall amount, which was calculated to be 38.99 inches. This level nearly matches the target the yearly average for 90% rainfall of 38.88 inches.

The following table compares the annual average rainfall and design storm events for Portland, Corvallis, and Eugene.

City	Portland	Corvallis	Eugene
Annual Ave. Rainfall (inches)	37.07	43.20	50.90
24 Hr. Design Storm (inch/24 hour)	0.83	0.90	1.00

Recommendation

Based on review of other agency design storm methodology and review of local rainfall data, the stormwater quality design storm event for the City of Corvallis is recommended to be 0.9 inches in 24 hours, using the NRCS Type 1A distribution curve.

X:\Divisions\Engineering\Capital Planning&Projects\Projects\Stormwater Master Plan Projects\Stormwater Quality Design Criteria\memo on stormwater quality design storm event.wpd

APPENDIX F
TECHNICAL MEMORANDUM NO. 4

Recommendations to Development Standards

TECHNICAL MEMORANDUM No. 4

November 10, 1999 53-15989

TO: Bruce Moser,
City of Corvallis

FROM: James Hansen,
Brown and Caldwell

PROJECT: City of Corvallis
Recommendations to Development Standards

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Operation and Maintenance Requirements 4
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Introduction

This technical memorandum was prepared to assist the City of Corvallis with updating of the existing stormwater development standards. The recommendations provided below should be considered as interim measures that should be implemented until a more detailed evaluation can be performed later in the stormwater master planning process. However, the interim recommendations will improve the City's ability to manage both stormwater quantity and quality from new development or redevelopment.

A more detailed analysis of the development standards should be based on citywide definition of the stormwater problems and potential solutions as determined from the master planning process. The adoption of new development standards will have a major impact on future stormwater management within the city. The standards will impact many different interest groups, including citizens, environmental groups, developers, builders, realtors, engineers, landscape architects, and city staff. City departments affected by the standards include planning, engineering, development assistance, legal, and operations/maintenance. Private and public representatives should participate in the development of the modified development standards, policies, and ordinances in order to develop an effective stormwater management program.

Major Categories of Development Standards

The major categories of stormwater development standards addressed by this technical memorandum include:

1. Design storm and method
2. Detention policy
3. Water quality policy
4. Acceptable types of water management facilities
5. Operation and maintenance requirements

The above noted categories are discussed in the following sections and are represented in the recommended design standards at the end of this document.

Design Storm and Method

Pipe sizing. The Design Criteria Manual requires the use of the Rational Method for a 10-year storm event. Most cities use either a 10-year or a 25-year design storm for sizing drainage facilities. The decision is based on the level of flood protection desired by the community along with the cost of providing the additional level of protection. Modifying the design criteria with a longer return period (i.e., 25-year) design storm would create a situation where the collection systems in the newly developed areas of the city would have greater capacity than older downstream sections of the system, thus creating greater downstream flooding situations in both open channels and pipes. We recommend that the city stay with the 10-year design storm using the Rational Method for most conveyance facilities.

We recommend that additional guidance be provided with the use of the Rational Method. The method should not be used for drainage areas larger than 25 acres or have times of concentration that exceed 100 minutes. A hydrograph technique should be used for either of these situations. Flow routes should be identified for storms larger than the 10-year, up to and including the 100-year storm. The City should adopt or establish runoff coefficients and an intensity-duration-frequency curve for use on projects within the City's jurisdiction. This approach would help provide consistency in the design of stormwater facilities.

Detention Facilities. The design storm for detention facilities should be based on the 10-year return event with 24-hour duration based on the standard SCS type 1A rainfall distribution. A hydrograph approach provides the most accurate rainfall model for this analysis. The SCS TR-55/20 method or the Santa Barbara Urban Hydrograph (SBUH) method are recommended options. We understand that most of the Corvallis development community uses the SCS method rather than the SBUH method; therefore, use the SCS method as the approved city standard. We do not recommend the use of the Rational Method for designing detention facilities.

Water Quality Facilities. The design storm for water quality facilities should be based on two-thirds of the two year storm with a 24-hour duration. This is similar to the design storm used by King County and is slightly more conservative than the storms used by City of Portland and the Unified Sewerage Agency. The more conservative approach will better prepare the city for future TMDL, NPDES Phase II and Endangered Species Act requirements. Water quality facilities should be designed using a hydrograph technique as recommended for detention facilities.

Detention Policy

The existing level of development throughout the city has altered the natural drainage characteristics of the major surface water systems. These streams are under stress due to an increase in the volume and duration of stormwater runoff. In addition, some of the older piped collection systems and culverts are becoming undersized as additional development generates increased flows and durations. Detention and other types of stormwater management techniques are required to prevent these problems from getting worse.

Water Quality Policy

Urban development creates a wide range of stormwater management related problems, including higher flow rates and increased water pollution. Surface water collects a variety of pollutants as it travels through the drainage system, including nutrients, suspended solids, organic matter, bacteria, hydrocarbons, trace metals, pesticides, thermal pollution and trash and debris. Water quality facilities constructed in new and redeveloped areas will help lessen the negative impacts associated with increased urban development.

Acceptable Types of Water Management Facilities

Our letter dated May 13, 1999 identified five facility types that should be considered for immediate use for new development or redevelopment, including detention ponds, water quality ponds, sedimentation ponds, vegetated swales, and water quality inlets. The King County Manual should be used as guidance for the basis of design of these facilities. The City should consider the adoption of the other treatment facilities identified in the manual. A toolbox of acceptable facilities would allow developers to customize the design of detention and water quality systems to best meet the constraints of the site.

The City should consider developing a guidance manual for the design of stormwater quantity and quality facilities. A custom manual would address the specific needs of the Corvallis community. A manual specifically prepared for the City of Corvallis would provide the greatest ease of use for City staff and design professionals in the community. A minimum of $75k would be required to produce such a manual. The total effort required would be dependent on the level of detail provided by the manual. Several of the manuals in use throughout the northwest cost many times that to produce.

Operation and Maintenance Requirements

Detention and water quality facilities require routine maintenance to ensure the desired performance of the facility. The efficiency of most types of water quality facilities will drop significantly in the absence of routine maintenance. The maintenance requirements identified in the King County Manual should be followed for these facilities. Inspection of major stormwater facilities, including detention ponds, water quality ponds, vegetated swales, trash racks, etc. should be conducted annually. The City should develop and manage an inspection program to ensure that the maintenance is being performed for both public and privately owned facilities. The cost of the inspection program needs to be determined and an appropriate funding mechanism established for implementing the inspection program.

Support of the inspection program needs to be written into City code. The code needs to be modified to provide for enforcement actions to address maintenance deficiencies for privately owned facilities. Using the King County model, the City would perform the maintenance and charge the owner if the owner did not perform the required maintenance within a specified timeframe.

Facility access is a major complaint of many municipalities charged with maintaining storm water facilities. Where possible an all-weather access road should be provided to the site. This requirement is particularly important for those facilities requiring routine maintenance, such as, detention and water quality facilities. The City shall ensure during design review that adequate access to the facility is provided through a maintenance easement or other form of permanent legal transfer of the right-of-access to the City.

Proposed Changes to the Design Criteria Manual

The following sections represent interim replacement or additional sections to the existing *Design Criteria Manual for Public Improvements*. The changes affect Section IV. STORM DRAINAGE. Only the subsections shown below are modified.

IV. STORM DRAINAGE

B. Design Criteria

1. <u>Conveyance Facilities</u>

   a. Capacity

      1) Conveyance facilities shall be designed to convey and contain the peak runoff flow from the 10-year design event. No surcharging of the system is allowed for the 10-year storm event. Conveyance system capacity shall be determined for most conveyance facilities using the Rational Method.

A hydrograph technique shall be used for designing facilities draining areas larger than 25 acres or for sites that have a time of concentration longer than 100 minutes. Acceptable hydrograph techniques include the Soil Conservation Service (SCS) TR-55 or TR-20 methods. The SCS Type 1A rainfall distribution for the 10-year, 24-hour storm shall be used with the hydrograph techniques.

2) The 10-year design shall be supplemented with an overland conveyance component demonstrating the safe passage of the 100-year, 24-hour SCS type 1A storm event. The overland component shall not be allowed to flow through or inundate existing buildings.

3) Sufficient capacity shall be designed into the system to account for the future growth potential of the area served as identified in the Comprehensive Plan.

b. Sizing

1) Minimum pipe size for storm drain mains is twelve (12) inches.
2) Minimum pipe size for lines leading from curb inlets or catch basins to the main lines is ten (10) inches.

c. Grades

1) All storm drains shall be designed at a grade that will produce a mean velocity when flowing full or half-full of at least two (2) feet per second.

d. Separation

1) New combined sanitary sewer and storm drain systems will only be permitted in the existing combined sewer areas of the city.

2. Detention Facilities

a. The maximum design storm for detention facilities shall be based on the 10-year return event with 24-hour duration based on the standard SCS Type 1A rainfall distribution. The Soil Conservation Service (SCS) TR-55 or TR-20 are recommended. The use of alternative hydrograph methods may be allowed, but require pre-approval by the City. The use of alternative techniques may require additional development review time. The use of the Rational Method for designing detention facilities is not permitted.

3. Water Quality Facilities

a. The design storm for water quality facilities (vegetated swales, water quality ponds, sedimentation ponds, water quality vaults, etc.) shall be based on two-thirds of the 2-year, 24-hour SCS Type 1A design storm. The analysis and design shall be based on a hydrograph method. The Soil Conservation Service (SCS) TR-55 or TR-20 are recommended. The use

of alternative hydrograph methods may be allowed, but require pre-approval by the City. The use of alternative techniques may require additional development review time. The use of the Rational Method for designing water quality facilities is not permitted.

K. Detention Facilities

1. When Required

All new development and redevelopment shall require detention unless specifically exempted from this requirement. When required, stormwater detention facilities shall be designed to capture run-off so the run-off rates from the site after development do not exceed the predeveloped conditions, based on the 2-year through 10-year, 24-hour design storms.

2. Exemptions

a. Detention is not required for sites draining directly into Mary's River or the Willamette River.

b. Detention is not required if infiltration methods can be demonstrated to be feasible. A soil map or geotechnical report is required to document the infiltration rates of the soils in the area of the proposed infiltration facility. Infiltration shall not be allowed in areas with slopes over 10 percent.

c. Detention is not required for single family residences not developed as part of a planned development.

d. Detention is not required for areas specifically identified as exempt (not requiring detention) in the Corvallis Stormwater Master Plan.

3. Standards

a. Detention facilities shall be designed in accordance with criteria as established in the *King County, Washington Surface Water Design Manual,* September 1998 or the most recent final version.

b. Parking areas should not be used as detention facilities except for larger storm events. Up to 6-inches of water depth is allowed to be detained in parking areas for storm events larger than the 10 year return event.

c. Detention of storm water shall be limited to a single facility, rather than a series of smaller detention facilities, whenever possible. Detention facilities may be designed as combination detention and water quality facilities. Detention facilities may be designed "in-line" with water quality facilities.

d. The detention facility must be designed to safely pass storms up to the 100-year, 24-hour event.

4. Access and Maintenance Responsibility

a. Detention facilities must be located on a site dedicated for public use. Access tracts, easements or permanent right-of-ways are required when the facilities do not abut the public right-of-way. The minimum width of an access easement is 15 feet. All-weather road(s) shall provide maintenance vehicle access to the facility and the control structures.

b. The City will assume maintenance and operation responsibility for detention facilities within the improved public right-of-way for any residential subdivision with two or more lots, and any similar development or redevelopment where at least two-thirds of the developed contributing area is from single family or duplex residential structures on individual lots. Detention facilities for the above mentioned land uses shall be located in a tract or right-of-way dedicated to the City.

c. The City does not accept maintenance responsibility for private storm water conveyance, detention, or water quality systems. Private systems include single family residential (not associated with a subdivision or multiple lot residential development), multifamily development, industrial, or commercial and all redevelopment for the above mentioned land uses.

d. Maintenance requirements for stormwater facilities are identified in the King County Manual. A maintenance plan shall be submitted to the City for approval along with the design and analysis calculations prepared for the construction permit application.

e. For public facilities, the City will assume maintenance responsibility two years after final construction approval by the City and upon passing an inspection by City inspectors to ensure the facility has been properly maintained, the vegetation clearly established, and the facility is operating as designed. The site developer/owner shall provide a maintenance bond to the City that shall remain in effect until the facilities are accepted by the City.

f. The City reserves the right to perform maintenance on private facilities if those facilities are found to have the potential to have a negative impact on public facilities or water quality. The City will charge the owner for all expenses incurred from City performed maintenance.

L. Water Quality Facilities

1. When Required

All new development and redevelopment are required to construct quality facilities to reduce the contaminants entering the storm collection and surface water systems. The stormwater facilities shall be designed to remove 70 percent of the total suspended solids (TSS) entering the facility during the water quality design storm. This policy may require the use of a combination of water quality facilities to achieve the designed removal rate.

2. Standards

   a. Water quality facilities shall be designed in accordance with criteria as established in the *King County, Washington Surface Water Design Manual,* September 1998 or the most recent final version.

   b. Acceptable water quality facilities include vegetated swales, water quality ponds, sedimentation ponds, water quality inlets, and infiltration facilities.

   c. The use of infiltration facilities is recommended where soil and slope conditions permit the use of this type of facility and the facilities do no have an adverse impact to adjacent or downhill properties.

   d. The use of multiple water quality facilities may be required to meet the performance standard. Chapter 6 of the King County Manual identifies seven types of treatment facilities that will meet the performance standards.

   e. Water quality facilities must be designed to safely pass without damage to the facility flows in excess of the water quality design storm up to the 100-year, 24-hour event. For some facilities, a bypass system will be required.

3. Access and Maintenance Responsibility

   a. Water quality facility access tracts, easements or permanent right-of-ways are required when the facilities do not abut the public right-of-way. All-weather road(s) shall provide access to the facility and the control structure as required for vehicular maintenance access.

   b. The City will assume maintenance and operation responsibility for water quality facilities within the improved public right-of-way for any residential subdivision with two or more lots, and any similar development or redevelopment where at least two-thirds of the developed contributing area is from single family or duplex residential structures on individual lots. Water quality facilities for the above mentioned land uses shall be located in a tract or right-of-way dedicated to the City.

   c. The City does not accept maintenance responsibility for private storm water quality systems. Private systems include single family residential (not associated with a subdivision or multiple lot residential development), multifamily development, industrial, or commercial and all redevelopment for the above mentioned land uses.

   d. Maintenance requirements for the facilities are identified in the King County Manual. A maintenance plan shall be submitted to the City for approval along with the design and analysis calculations prepared for the construction permit application. The maintenance plan shall describe the maintenance activity and frequency of execution.

e. For public facilities, the City will assume maintenance responsibility two years after final construction approval by the City and upon passing a City inspection to ensure the facility has been properly maintained and is operating as designed. The site developer/owner shall provide a maintenance bond to the City that shall remain in effect until the facilities are accepted by the City.

f. The City reserves the right to perform maintenance on private facilities if those facilities are found to have the potential to have a negative impact on public facilities or water quality. The City will charge the owner for all expenses incurred from City performed maintenance.

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 4
Maps & Topographic Data

Stormwater Facility Map

Current as of Jan 29, 2007

M30-68 M32-68 M34-68

M30-71 M34-71

M30-74 M32-74 M34-74

CORVALLIS
GIS Services
Public Works Department

MAP SHEET
M32-71

1" : 200'

Stormwater Facility Map

Current as of Jan 29, 2007

Storm
Combo
OSU
Private
Abandoned

Stormwater Facility Map

Current as of Jan 29, 2007

CC EXHIBIT II-90

Stormwater Facility Map

Current as of Jan 29, 2007

Storm
Combo
OSU
Private
Abandoned

1" : 200'

MAP SHEET
M32-74

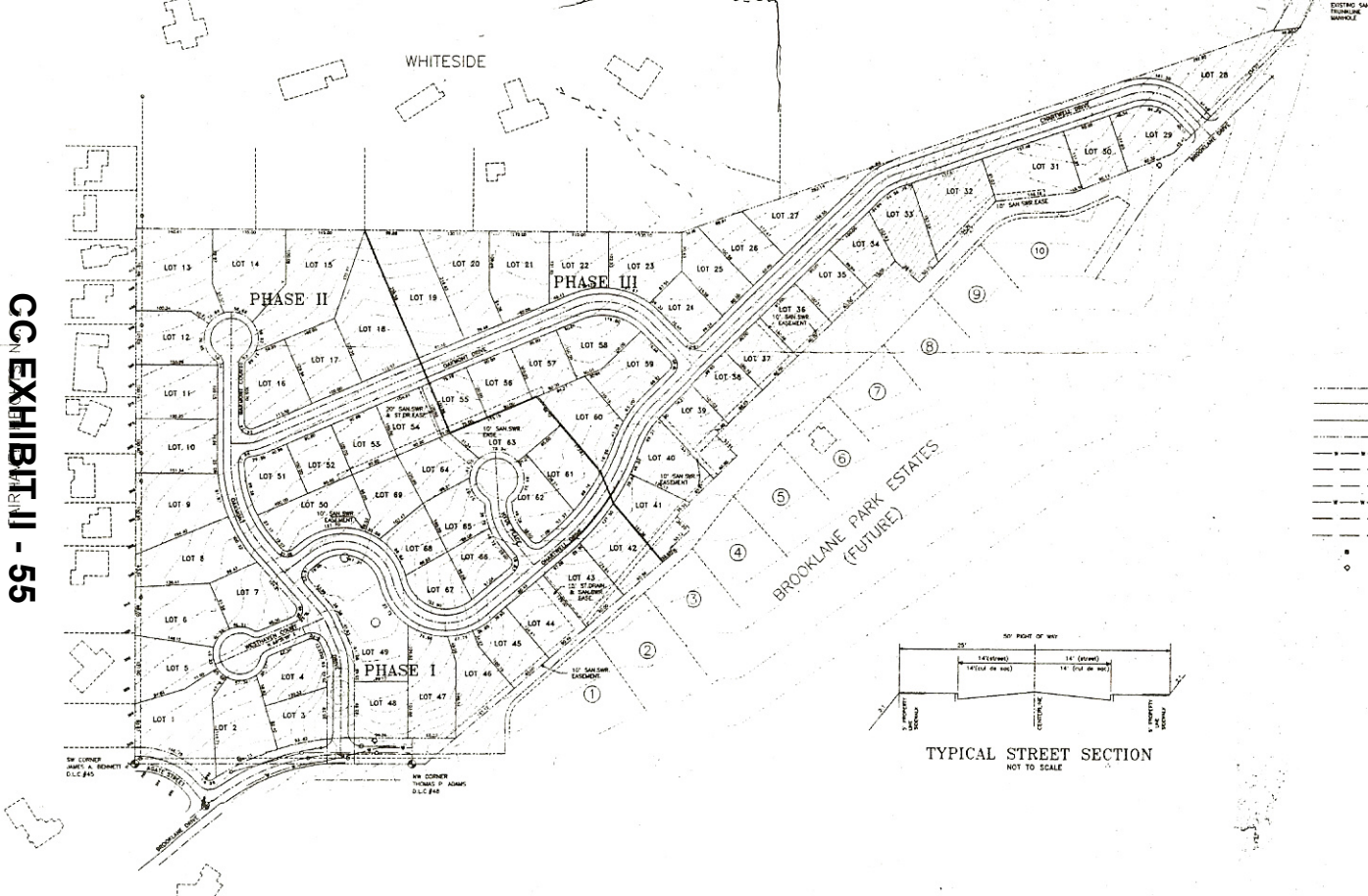
GIS Services
Public Works Department

CC EXHIBIT II - 31

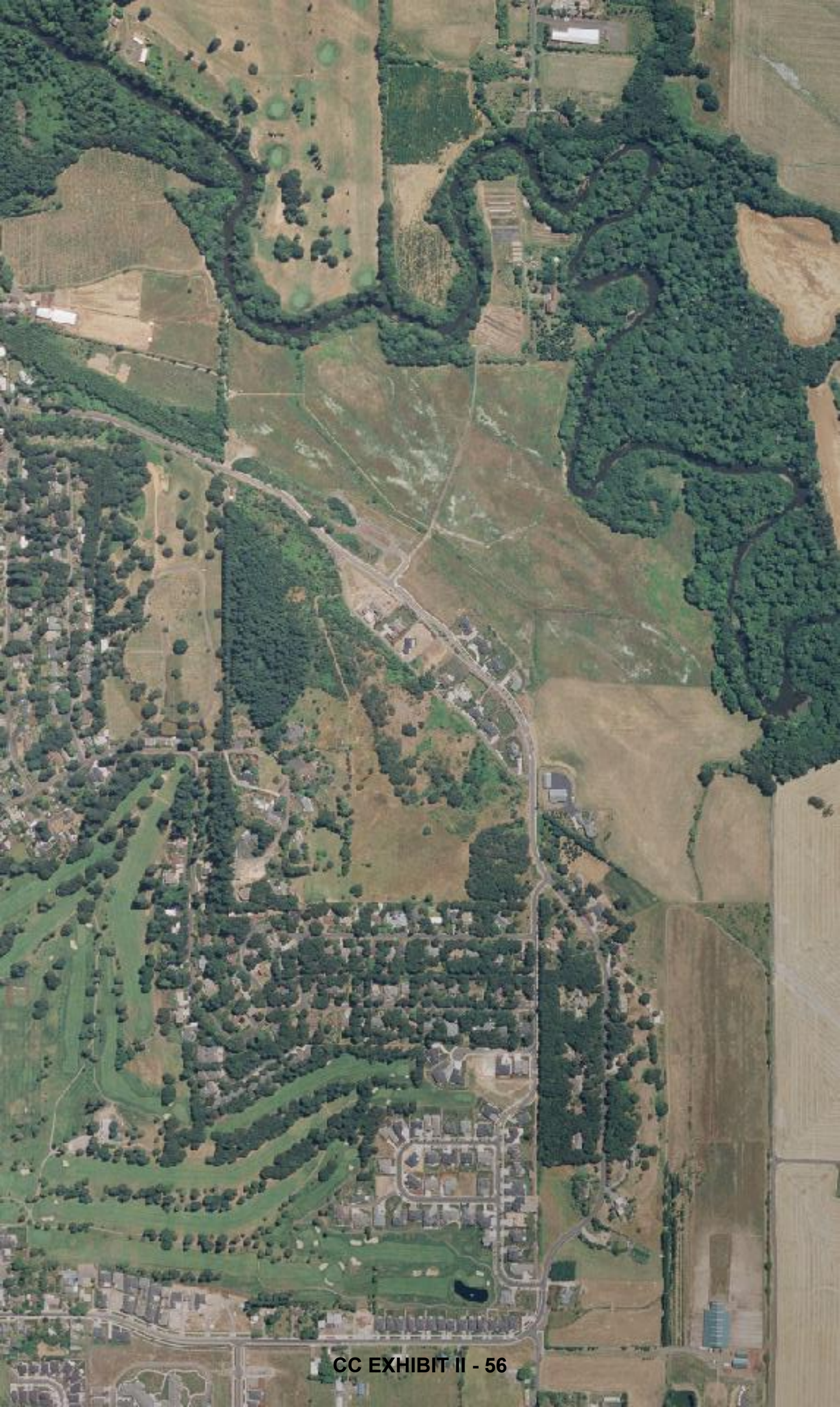
CC EXHIBIT II - 52

CC EXHIBIT II - 53

CC EXHIBIT II - 54



CC EXHIBIT II - 55



BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

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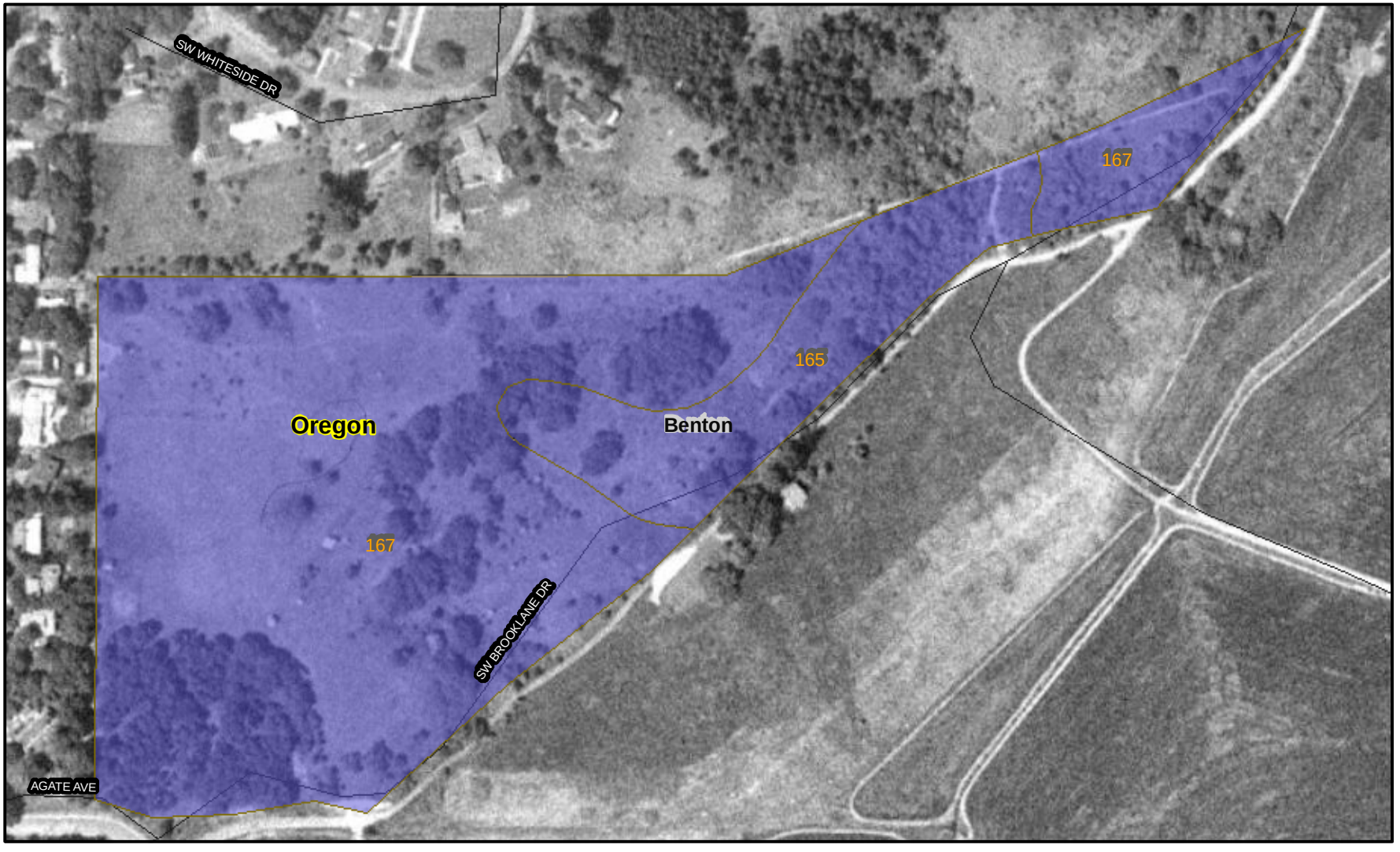
Section 5
NRCS Soils Hydrologic Data

HYDROLOGIC GROUP RATING FOR BENTON COUNTY, OREGON



Meters
0 35 70 140

Feet
0 100 200 400 600 800

MAP LEGEND

Hydrologic Group

{Dominant Condition, <}

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available
- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 10

Soil Survey Area: Benton County, Oregon
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
5/7/1994

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

CC EXHIBIT II - 59

Tables - Hydrologic Group

Summary by Map Unit - Benton County, Oregon

Soil Survey Area Map Unit Symbol	Map Unit Name	Rating	Total Acres in AOI	Percent of AOI
165	Willakenzie loam, 20 to 30 percent slopes	B	4.2	16.4
167	Willakenzie-Wellsdale complex, 12 to 20 percent south slopes	B	21.4	83.6

Description - Hydrologic Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are placed into four groups A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Definitions of the classes are as follows:

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only soils that are rated D in their natural condition are assigned to dual classes.

Parameter Summary - Hydrologic Group

Aggregation Method: Dominant Condition

Component Percent Cutoff:

Tie-break Rule: Lower

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

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Section 6
Geotechnical Reports

Geotechnical Investigation

Brooklane Heights and
Oakmont Addition

Corvallis, Oregon

Prepared for:

TC2 Investments, LLC
Corvallis, Oregon

May 20, 2008

Professional Geotechnical Services

Foundation Engineering, Inc.

Foundation Engineering, Inc.
Professional Geotechnical Services

Scott Sanders
TC2 Investments, LLC
4411 SW Golf View Drive
Corvallis, Oregon 97333

May 20, 2008

Brooklane Heights and Oakmont Addition
Geotechnical Investigation
Corvallis, Oregon

Project 2081024

Dear Mr. Sanders:

We have completed the requested geotechnical investigation for the above-referenced project. Our report includes a description of our work, a discussion of the site conditions, a summary of laboratory testing and a discussion of engineering analyses. Recommendations for site preparation, foundation design and construction, and pavement construction are enclosed.

It has been a pleasure assisting you with this phase of your project. Please do not hesitate to contact us if you have any questions or if you require further assistance.

Sincerely,

FOUNDATION ENGINEERING, INC.

David L. Running, P.E., G.E.
Project Manager

DLR/jd
enclosure

REGISTERED PROFESSIONAL ENGINEER
62647PE
OREGON
NOV. 9, 1999
DAVID L. RUNNING

Expires: 12/31/10

Portland • Corvallis
820 NW Cornell Avenue • Corvallis, Oregon 97330-4517 • Bus. (541) 757-7645 • Fax (541) 757-7650

GEOTECHNICAL INVESTIGATION
BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

BACKGROUND

Two residential subdivisions are planned for a ±36.3-acre parcel in Corvallis, Oregon. The site is located in steeply (10 to 30%) sloping terrain on the northwest side of Brooklane Drive. The location is shown on Figure 1A (Appendix A). The proposed site layout for Brooklane Heights and Oakmont Addition are shown on Figures 2A and 3A (Appendix A), respectively.

The proposed grading plans indicate cuts and fills up to ±23 feet are planned for Brooklane Heights. Cuts up to ±20 feet and fills up to ±6 feet are planned for Oakmont Addition. Retaining walls will be constructed at several locations. We understand most retaining structures will be rockery walls 4 feet or less in height. A storm water detention pond will be constructed at the northeast corner of Oakmont Addition, next to the existing City of Corvallis pump station. A second pond will be constructed within an existing drainage in the southwest portion of Brooklane Heights.

Foundation Engineering, Inc. (FEI) completed a preliminary geotechnical investigation for the project in 2005. The focus of that investigation was to record the depth of practical (digging) refusal in the bedrock and provide information for others to assess the feasibility of deep cuts at the site. A reconnaissance-level geologic hazard study of the site was also completed to address the City of Corvallis standards for development on steeply-sloped areas. The findings of that work were summarized in a report dated January 25, 2006.

FEI completed a supplemental geotechnical investigation at the site in 2007 to evaluate the subsurface conditions for proposed improvements in existing drainages in the southwest portion of Brooklane Heights. The findings of that work were summarized in a letter report dated March 16, 2007.

FEI's current scope of work is to provide design and construction recommendations for site-grading, pavements, residential foundations, retaining walls, and storm water detention ponds. This work scope is consistent with the recommendations for additional work in our 2006 report. Information from our previous site investigations is included in this report. References to our previous reports are made where appropriate.

TC2 Investments, LLC (TC2) is the project developer. Metolius Consulting (Metolius) is providing civil engineering services for the project. FEI was retained by TC2 to provide geotechnical services for the project. Our scope of work for this phase was outlined in a proposal dated March 31, 2008, and was authorized by a signed Professional/Technical Services agreement dated April 1, 2008.

FIELD EXPLORATION

A summary of the field explorations for our various phases of work is provided below. The test pit locations are shown on Figures 2A and 3A (Appendix A). These locations were determined by pacing and are approximate only.

Preliminary Geotechnical Investigation - 2006

Twelve exploratory test pits (TP-1 through TP-12) were dug at the site on November 15, 2005, using a John Deere 490E tracked excavator. The purpose of the exploration was to determine the subsurface profile and examine the soil and rock variability.

The test pits extended to maximum depths ranging from ±2 to 15 feet. Torvane measurements were made on the test pit sidewalls, where practical to estimate the shear strength of the soils. All of the explorations terminated in bedrock. The John Deere 490E excavator encountered practical digging refusal on sandstone at several locations at ±1 to 4.5 feet below the bedrock surface. The subsurface profiles, sampling depths and strength measurements are summarized on the appended test pit logs (Appendix B).

Supplemental Geotechnical Investigation - 2007

Six exploratory test pits (TP-1A through TP-6A) were dug at the site on February 23, 2007, using a CAT 312C tracked excavator. Five of the explorations were completed to better characterize the subsurface profile within the East Drainage, where detention ponds and the Badger Place road embankment were planned. One test pit was dug in the West Drainage near the proposed alignment of Wolverine Drive.

The test pits extended to maximum depths ranging from ±1.5 to 11 feet. Torvane measurements were made on the test pit sidewalls where practical to estimate the shear strength of the soils. All of the explorations terminated in bedrock. The CAT 312C excavator encountered practical digging refusal in TP-5A and TP-6A at ±1 to 3.5 feet below the bedrock surface. The subsurface profiles, sampling depths and strength measurements are summarized on the appended test pit logs (Appendix B).

Supplemental Geotechnical Investigation - 2008

Six exploratory test pits (TP-1B through TP-6B) were dug at the site on April 3, 2008, using a Komatsu PC150LC tracked excavator. The explorations were completed to supplement the previous subsurface investigations and obtain samples for laboratory testing.

The test pits extended to maximum depths ranging from ±4 to 19 feet. Torvane measurements were made on the test pit sidewalls to estimate the shear strength of the soils. Most of the test pits extended to bedrock. The Komatsu PC150LC excavator encountered practical digging refusal in TP-3B and TP-4B at ±5 to 7 feet below the bedrock surface. Samples were retained for possible laboratory testing. The subsurface profiles, sampling depths and strength measurements are summarized on the appended test pit logs (Appendix B).

Three additional test pits and two borings were planned as part of the supplemental investigation. However, the fieldwork was halted prior to completion due to possible archeological conflicts. It is assumed this work will be completed at a later date.

SITE CONDITIONS

Topography and Vegetation

The parcel contains a south to southeast-facing, steep to moderate slope. According to the provided topographic map, the elevation ranges from ±El. 230 at the northeast corner to ±El. 410 at the northwest property corner. Two drainages are located in the southwest portion of the property. These features are illustrated by the topographic contours on Figure 2A (Appendix A) and are referenced as the West Drainage and East Drainage in this report.

The northwest portion of the property is the most open and contains tall grass with few scattered trees. The central portion of the property contains steeper slopes with several sandstone outcrops, trees (oak and fir), scotch broom, blackberry bushes, and low-ground scrub vegetation including poison oak. Similar vegetation was observed in the Oakmont Addition during our investigations in 2006 and 2007. This portion of the property was cleared prior to our 2008 investigation.

Subsurface Conditions

A general description of the soil and rock conditions encountered in the test pits is provided below. More detailed descriptions of conditions encountered in individual test pits are summarized on the logs (Appendix B).

Brooklane Heights. TP-1, TP-2, TP-3, TP-5, TP-6, TP-3B, TP-4B and TP-5B were dug in the western uphill portion of Brooklane Heights. The explorations typically encountered ±2.5 to greater than 16 feet of residual soil underlain by sandstone. The residual soil consists of brown to orange-brown, medium stiff to stiff, medium plasticity, clayey silt. The sandstone is decomposed to moderately weathered, and iron and manganese-stained. TP-1 and TP-3 were terminated in extremely weak (R0) sandstone at depths of ±15 feet, the maximum reach of the excavator. TP-2, TP-5 and TP-6 were terminated in extremely weak to very weak (R0 to R1) sandstone at ±6.5 to 9.5 feet. TP-5B encountered residual soil to ±16 feet (the limit of the exploration).

TP-4, TP-7, TP-8 and TP-9 were dug along the southeast portion of the site, in the area of steep slopes and/or rock outcrops. The test pits encountered ±0.5 to 4.0 feet of residual soil underlain by sandstone. The test pits were terminated in very weak to weak (R1 to R2), moderately to slightly weathered sandstone at ±2 to 7 feet.

TP-1A was dug in the West Drainage, near the proposed Wolverine Drive, and encountered a few inches of roots and sod underlain by extremely weak to very weak (R0 to R1) sandstone. The sandstone is grey to orange-brown and moderately weathered to decomposed.

TP-3A, TP-4A and TP-5A were dug in the East Drainage along the planned alignment of the proposed Badger Place embankment. TP-3A and TP-5A were dug on the side slopes of the drainage swale at the west and east ends of the planned embankment, respectively. TP-3A encountered medium stiff to stiff, brown, medium plasticity,

clayey silt to ±3 feet, followed by stiff silt with trace sand to ±4 feet. Sandstone was encountered below ±4 feet, extending to ±4.5 feet (the limits of the exploration). TP-5A encountered ±6 inches of medium stiff, brown, clayey silt (topsoil) followed by sandstone.

TP-4A was dug near the bottom of the East Drainage, towards the center of the planned embankment. TP-4A encountered ±6 feet of brown, medium plasticity, clayey silt. The silt is soft to a depth of 3 feet and then becomes stiff. Stiff, brown to grey, low to medium plasticity clay with trace rock fragments was encountered from ±6 to 8 feet. Sandstone was encountered from ±8 to 10 feet (the limits of the exploration).

TP-2A was dug within the lower-lying portion of the East Drainage. Soft to medium stiff, dark brown, medium plasticity, clayey silt was encountered to a depth of ±2.5 feet, followed by soft, light brown, medium plasticity, silty clay to ±7 feet. Stiff, brown to grey clay with trace rock fragments extended from ±7 to 10 feet and was underlain by extremely weak (R0) sandstone that extended to the bottom of the test pit (±11 feet).

TP-6A was dug within the East Drainage, in the vicinity of the proposed detention pond. The test pit encountered ±6 inches of medium stiff, brown, clayey silt (topsoil) followed by sandstone.

TP-6B was excavated near a spring in upper portion of the East Drainage. The test pit encountered ±2 feet of medium plasticity silt topsoil followed by extremely weak to very weak (R0 to R1) sandstone. The excavation was terminated in extremely weak (R0) sandstone at ±4 feet due to possible archaeological conflicts.

Oakmont Addition. TP-1B and TP-2B were excavated in the northwest portion of the site near the proposed roadway alignment. TP-1B encountered residual soil to a depth of ±19 feet (the limit of the exploration). TP-2B encountered ±3.5 feet of residual soil followed by extremely weak to very weak (R0 to R1) sandstone. TP-2B was also terminated at a depth of ±19 feet.

TP-10 through TP-12 were dug along the southeast portion of the site, in the area of steep slopes and/or rock outcrops. The test pits encountered ±0.5 to 4.0 feet of residual soil underlain by sandstone. The test pits were terminated in very weak to weak (R1 to R2), moderately to slightly weathered sandstone at depths of ±2 to 7 feet.

Ground Water

No ground water infiltration or seepage was encountered in any of the test pits dug on November 15, 2005. However, the residual soils were damp to moist and some of the joints in the sandstone also appeared to be moist. During our December 6, 2005, reconnaissance, we observed an active spring, wet conditions, and/or standing water at various locations in the East Drainage. The West Drainage appeared moist to wet with no visible surface water or flowing water.

On February 23, 2007, we noted water flowing in the East Drainage and relatively wet ground conditions in the low-lying area adjacent to the drainage. TP-2A and TP-4A, dug near the bottom of the drainage, encountered infiltration at depths of ±1.5 feet and ±3 feet, respectively. The infiltration rate in those test pits ranged from moderate to rapid. Slow seepage was also noted at ±5.5 feet in TP-1A.

During our April 3, 2008 exploration, rapid seepage was observed in TP-1B at ±16 feet. Slow seepage was observed in TP-5B at ±2 feet and in TP-6B between ±3 and 4 feet. No infiltration was observed in any of the other test pits. Wet conditions and/or standing water was noted at various locations in the East Drainage.

LABORATORY TESTING

The laboratory work included natural water content and Atterberg limits tests to classify the foundation soils and estimate their overall engineering properties. Results of these tests are summarized on Table 1C (Appendix C). Moisture-density (ASTM D698) and California Bearing Ratio (CBR) tests were also completed on bulk samples from TP-5B to establish compaction characteristics of the pavement subgrade. The results of these tests are summarized in Figures 1C and 2C (Appendix C).

DISCUSSION OF GEOTECHNICAL ISSUES

Slope Stability

A brief discussion of slope stability is provided below. More detailed discussions are provided in our 2006 and 2007 reports.

Our subsurface investigation suggests the site is typically mantled with a thin layer of topsoil underlain by medium stiff to stiff residual soil that grades to bedrock at relatively shallow depths. The presence of a thin soil mantle and shallow bedrock typically precludes the formation of large-scale, deep rotational failures. Failures in these slope conditions are generally limited to shallow, surficial events known as debris flows.

The Corvallis Natural Hazards Map designates two locations on the site as "high landslide risk" areas. However, during our site reconnaissance, we determined that these mapped hazard areas represent natural drainages. Our reconnaissance noted no visible movement, instability or existing scarps within the drainages or elsewhere on the property. The ground surface along the drainages is vegetated, and tree trunks within the property were generally straight. The drainage swales were predominantly moist to wet at the time of our site investigation, with flowing water and standing water at some locations in the East Drainage. No other seeps or springs were observed on the site.

Based on our observations, we have concluded there is a low potential for landslides or instability of natural slopes due to the absence of identifiable landslide features, the lack of seeps or springs (except for existing drainages), and the presence of relatively stiff residual soil and shallow bedrock beneath mature slopes.

Cuts and Fills

Cuts will likely expose residual soil underlain by decomposed to highly weathered sandstone. Relatively deep utility trenching will be required in some areas. Trenching through extremely weak to very weak (R0 to R1) sandstone should be anticipated. Weak (R2) rock may also be encountered in some areas.

The strength and weathering of the bedrock varies with location and depth. Consequently, difficulty excavating the rock should be expected to vary with location. Three different excavators were used in our field explorations. A John Deere JD490E excavator encountered practical digging refusal at ±1 to 4.5 feet below the bedrock surface. A CAT 312C excavator encountered practical digging refusal at ±1 to 3.5 feet below the bedrock surface. A Komatsu PC150LC excavator encountered practical digging refusal at ±5 to 7 feet below the bedrock surface.

Deep cuts and utility excavations made in very weak to weak (R1 to R2), shallow sandstone will either require heavier equipment than the excavators used for our explorations, pre-drilling and splitting or use of a hydraulic ram. We anticipate blasting is not a feasible option due to nearby residences. Contractors bidding on the work should be provided a copy of this report to qualitatively evaluate the difficulty of the excavations for their own estimates and to select the most appropriate method of excavation.

Fill material for embankment construction may be generated from cuts. Fill that includes high plasticity clay or silt should not be used as subgrade for roads or placed beneath structures. Fill should be placed on terrain that is properly stripped. Fill placement in areas steeper than 5:1 (H:V) will require benching and a key trench into stiff residual soil or bedrock. A standard benching detail for embankment construction is shown on Figure 4A (Appendix A). We recommend overbuilding the slopes and subsequently trimming the fill to allow adequate compaction at the face of the finish slope. Fill should be density tested frequently to verify the required compaction.

The proposed grading will require building an embankment across the East Drainage. At that location it will be necessary to add a drain to the toe of the embankment to intercept seepage. A benching detail including a toe drain is shown on Figure 5A (Appendix A).

It is possible that concentrated seepage or springs may develop in cut slopes at isolated locations. If so, a slope drain may be required to collect the moisture and reduce the risk of localized slope instability. The need for slope drains and details for their construction should be established by FEI once the cuts are exposed.

Site Drainage

The observed iron-staining of the surficial soils suggests that rainfall perches within a few feet of the ground surface during the wet portion of the year. It is difficult to predict where seepage may be encountered during construction. However, ground water infiltration should be anticipated in deep cuts and excavations.

Permanent mitigation of seeps and springs, which daylight along the face of cut slopes may be required as they are encountered during construction to reduce the risk of localized slope instability. Run-off from streets should be directed to the nearest storm drain or drainage swale. We recommend perimeter-footing drains be placed around the homes to reduce the risk of weakening the foundation soils due to repeated wetting and drying.

Shallow ground water can accumulate in granular trench backfill. In long segments of trenches extending down sloping terrain, the water can develop significant pressure that can be detrimental to pavements. Therefore, drainage should be provided for utility trenches extending down slope roadways. Drainage may consist of filter-fabric wrapped sections of perforated drain pipe placed at appropriate intervals and discharging into manholes.

Topsoil

The topsoil is typically ±6 inches to 2 feet thick and is comprised of blocky-structured, soft to medium stiff, medium plasticity, clayey silt. Topsoil that is relatively free of organic debris may be moisture-conditioned and reused as subgrade beneath the proposed roads. However, this recommendation is predicated on dry-weather construction.

Plastic Soils

The plasticity of the residual soil varies with location and depth. Our test pits encountered predominantly low to medium plasticity soils. However, medium to high plasticity soils may also be encountered at some locations. Such soils typically have moderate to high potential to shrink and swell with seasonal changes in moisture content. Shrinkage or swelling of the subgrade could cause cracking and distress in slabs, foundations and structures if not properly mitigated.

Satisfactory performance of the residential foundations will depend on proper mitigation of any high plasticity soils and foundation drainage to reduce fluctuations in the moisture content of the foundation soils. High plasticity soils encountered beneath foundations and slabs should be completely removed if practical. We recommend that a representative of FEI be present during the initial site grading to identify high plasticity soils. We should also observe the foundation subgrade for individual residences to help identify if expansive soils are present and determine the limits of the required overexcavation.

ENGINEERING ANALYSIS

Bearing Capacity for Residential Foundations

Torvane measurements in the residual soils indicated undrained shear strengths ranging from ±0.3 tsf to >1.0 tsf and we noted that the residual soil was typically medium stiff to stiff at the time of our explorations. An allowable bearing pressure was calculated assuming an undrained soil shear strength of 0.35 tsf. The calculations suggest an allowable bearing pressure of 1,500 psf with a typical factor of safety of 3. This analysis assumes that foundations will be placed at

least 24 inches below the ground surface. In addition, we assumed the footings will bear on a minimum of 6 inches of compacted crushed rock (Select Fill) extending a minimum of 6 inches outside the footprint of the footing. Foundations should not be constructed on soft soils or high plasticity soils.

Settlement

Based on the stiffness of the soil, the shallow depth to rock and the assumed footing loads, we anticipate that settlement due to consolidation of the foundation soils will be relatively small (i.e., ½-inch or less). Larger foundation movements may occur due to shrinking and swelling if high plasticity soils are left beneath foundations and slabs.

Basement Walls

Lateral earth pressures for basement retaining walls were estimated assuming at-rest (K_0) conditions. An equivalent fluid density of 55 pcf is recommended for wall design based on the assumed rigidity of the wall and the method of backfill compaction. We recommend that temporary cuts for wall construction be no steeper than ½:1 (H:V). However, this recommendation will have to be verified at the time of construction based on the soil conditions exposed on the cut slopes. In some cases, flatter slopes may be required.

Recommendations assume the walls will be backfilled with compacted Select Fill. Additionally, it is assumed that an appropriate drainage system will be installed behind the wall to alleviate the build up of hydrostatic pressure. Figure 6A (Appendix A) provides a schematic of the assumed basement wall construction.

Rockery Retaining Walls

We understand rockery walls (typically 4 feet tall or shorter) may be constructed associated with the site grading work. The actual heights and locations were not established at the time this report was prepared. Therefore, we have limited our work to providing general recommendations. We assume the actual design of rockery walls will be by others.

Figure 7A (Appendix A) provides a typical wall section of the major wall elements. The base of the rock wall should be embedded a minimum of 12 inches below the finish grade for walls at the toe of a slope. For walls constructed on a slope, where the ground in front of the wall is sloping away, the embedment depth should be increased to 24 inches and, where practical, extend to weathered bedrock. Walls should be designed and constructed with a batter no steeper than 1:6 (H:V). The walls should be backfilled with open-graded, angular, crushed rock (typically 4 to 6-inch rock is used). A filter fabric should be provided on the cut slope behind the backfill and a foundation drain should be provided near the base of the wall as shown on Figure 7A.

Site fill that will be retained by the rockery wall should be constructed by placing the material in lifts (<8 inches loose thickness) adjusting the moisture content to near optimum values and compacting the material to a minimum of 95% relative

compaction as defined by ASTM D 698. The fill at the wall location should initially be overbuilt at a 1.5:1 (H:V) slope extending ±3 feet beyond the top of the wall and trimmed back at the time of wall construction. Table 1 summarizes the recommended distance from the face of the wall to the toe of the temporary fill slope for a range of wall heights.

Table 1. Distance from Wall Facing to the Toe of the Temporary Fill Slope.

Wall Height (ft)	Toe of Wall to Toe of Fill Slope (ft)
4	9
6	12
8	15

We recommend designing walls using an allowable bearing pressure of 1,500 psf. This bearing pressure assumes a typical factor of safety of 3. Settlement of the wall facing is expected to be less than ½ inch.

Appropriate lateral earth pressures for rockery walls will depend upon the height of the walls and the materials they support. We understand the rockery walls may be tiered to construct slopes with a series of benches. Surcharge loads from upslope walls should be considered where tiered walls are constructed closer than ±6 feet apart. FEI is available to provide additional recommendations for these walls if needed as the design progresses. We assume that information would be provided as an addendum to this report.

Pavement Analysis and Design

Detailed traffic information was not available for the development at the time this report was prepared. Therefore, pavement design was completed with assumed traffic. Based on the proposed number of lots (i.e., 42 lots at Brooklane Heights and 24 lots at Oakmont Addition), we assumed a daily traffic of ±360 cars and light pickup trucks, ±5 medium size delivery trucks and/or service vehicles and up to 1 heavy truck per day. We also included construction traffic at the beginning of the development including 5 concrete trucks, 10 dump trucks, and 10 material delivery trucks per lot. A total of 3 moving vans were assumed per lot over the 20-year design period. We assumed that traffic would be divided evenly between the two ingress/egress points. Our calculations suggest a total of 72,000 equivalent single (18-kip) axle loadings (ESAL's) is appropriate for a 20-year design life.

We assumed a reliability of 85%, a standard deviation of 0.45, and initial and terminal serviceability ratings of 4.2 and 2.0, respectively. The minimum AC thickness was established based on the AASHTO 1993 method using the assumed traffic and a resilient modulus (M_r) of 20,000 psi for the base course. A laboratory CBR value of 1.8 was calculated for a bulk sample from TP-5B. A resilient

modulus (M_r) value of 3,000 psi was selected for our pavement analysis based on available correlations and an assumed CBR value of 2. We calculated a required structural number (S_N) of 2.96 for the overall pavement section.

A structural strength coefficient of 0.42 and a drainage coefficient of 1.0 was assumed for the AC. A structural strength coefficient of 0.14 and a drainage coefficient of 0.8 was assumed for the base rock. Our analysis indicates the new streets should have a minimum flexible pavement section consisting of a nominal 3.5 inches of AC over 13.5 inches of base rock consisting of Select Fill. The minimum pavement section assumes the streets will be built on a firm, non-yielding subgrade prepared as recommended herein and any high plasticity, expansive soils encountered at the subgrade level will be removed.

A 20-year design life was assumed for the analysis. However, grinding and a nominal 2-inch overlay should be planned at about 12 years. The Asphalt Institute (TAI) recommends overlaying flexible pavements when 60% of the structure life is used. Research has shown that overlaying pavements at that time is more cost-effective than a full-depth repair after the pavement has failed. The pavement should be inspected by an experienced engineer every 5 to 7 years to determine its condition and need for rehabilitation.

The subgrade soils are sensitive to moisture, will soften when wet, and pump under construction traffic. Wet weather construction will likely require subgrade stabilization in the form of additional base rock (or granular subbase) and a geotextile. We should be contacted to provide wet weather construction recommendations if the earthwork and roadway construction is delayed into the winter months.

RECOMMENDATIONS

The following recommendations assume the earthwork will be completed during dry weather. Excavations will be difficult during wet weather due to water infiltration and stabilization of the subgrade. In addition, compaction of the on-site soils will be impractical during wet weather and may require substitution with a higher quality imported material. The contractor may still experience pumping problems in the summer if the surficial soils have not adequately dried. Therefore, we recommend an on-site conference with the contractor prior to the grading work to review the site conditions.

Material and Compaction Recommendations

1. Select Fill as defined in this report should consist of 1 or ¾-inch minus, clean (i.e., less than 5% passing the #200 U.S. Sieve), well-graded, crushed gravel or rock. We should be provided a sample of the intended fill for approval, prior to delivery to the site.

2. On-Site Fill should consist of low to medium plasticity silt, clay, rock, or mixtures of the above that are free of high plasticity clay, organics or construction debris. Unless approved by FEI, silts or clays should not be placed under foundation areas or under settlement-sensitive structures.

3. Stabilization Rock should consist of 6-inch minus, durable, angular, crushed rock, which is free-draining and does not contain clay, organic matter, or debris. Uncrushed (bar-run) gravels are not acceptable as Stabilization Rock.

4. Drain Rock should consist of 2-inch minus, clean (less than 2% passing the #200 sieve), open-graded gravel or rock.

5. Filter Fabric should consist of a non-woven geotextile with a grab tensile strength greater than 200 lb., an apparent opening size (AOS) of between #70 and 100 (US Sieve) and a permitivity greater than 0.1 sec^{-1}.

6. Separation Geotextile should have Mean Average Roll Value (MARV) strength and hydraulic properties meeting the requirements of an AASHTO M 288-05 Class 2 geotextile. The geotextile should have a permitivity greater than 0.25 $sec.^{-1}$ and an Apparent Opening Size (AOS) less than 0.6 mm. We should be provided a specification sheet on the selected geotextile for approval prior to delivery to the site.

7. Compact the subgrade and all imported fill to 95% relative compaction. The maximum dry density of ASTM D 698 should be used as the standard for estimating relative compaction. Fine-grained soils may require moisture-conditioning prior to compaction to adjust the natural moisture content to within ±2% of its optimum value. Moisture-conditioning may include ripping and aeration for soils too wet of optimum or ripping and wetting if the soils are too dry of optimum.

   Field density tests should be run frequently to confirm adequate compaction of the subgrade and imported fills. The subgrade and granular fills that contain aggregates too coarse for density testing should be proof-rolled using a loaded, 10-yd^3 dump truck or other approved vehicle. The proof-roll should be observed by an FEI representative. Areas of pumping or deflection observed beneath the truck wheels may be reworked, or overexcavated and replaced with compacted Select Fill or Stabilization Rock and proof-rolled again. Weathered sandstone exposed at the subgrade level should not be compacted.

8. Place and compact all fill in loose lifts not exceeding 12 inches. Thinner lifts may be required if light or hand-operated equipment is used.

9. Overexcavate all test pits that extend under homes and pavements. Replace the test pit backfill with compacted Select Fill.

10. Shore all excavations to protect workers from sloughing or caving soils according Oregon OSHA requirements. Soils encountered in the test pits typically met the OSHA standard for Type B soils. However, where seepage is encountered and on slopes, trenches should be shored assuming OSHA Type C soils. OR OSHA recommendations assume

maximum temporary cut slopes of 1:1 (H:V) for Type B soils and 1.5:1 (H:V) for Type C soils. Short-term steeper cuts (up to ½:1 (H:V)) may be feasible in the stiff soils or weathered bedrock during dry weather. The actual maximum cut slopes will have to be evaluated in the field at the time of construction.

Trenches should be pumped dry prior to placing the backfill. Trench backfill that extends beneath homes, pavements and hardscapes should consist of compacted Select Fill. Native backfill may be used in other areas.

Ground water can accumulate in granular trench backfill in long segments of trenches extending down sloping terrain or roads. For trenches extending down slope, provide drainage for the trench backfill. Drainage may consist of filter-fabric wrapped sections of perforated drain pipe placed at appropriate intervals and discharging into new manholes.

11. Provide contractors with a copy of this report to review recommendations for foundation construction and the soil and rock conditions encountered in the test pits. We should be provided an opportunity to meet with the contractor prior to construction to discuss the site conditions and the contractor's approach to site preparation.

Embankment Construction

Recommendations for excavation, preparation of fill areas and fill placement are outlined below for embankment construction. Compaction may not be practical if the soils are too wet of optimum. Therefore, the site work should not be attempted during wet weather and should be delayed until the subgrade soils are sufficiently dry or until weather permits efficient aeration. We recommend that the work be conducted only during dry weather as follows:

12. Strip the existing ground ±3 to 6 inches, or as required to remove roots and sod. Deeper excavations may be required to remove larger tree roots. Dispose of all strippings outside of construction areas.

13. Compact the subgrade to a depth of at least 12 inches. Embankments constructed in sloping terrain should be benched into the slope as shown on Figure 4A. Embankments constructed across the East Drainage should include a toe drain as shown on Figure 5A

14. Maintain the moisture in the subgrade to prevent excessive drying and cracking. Immediately backfill the prepared subgrade with On-Site Fill or Stabilization Rock and compact as specified in Item 7.

15. Overexcavate and replace any pumping soils with compacted Stabilization Rock, Select Fill or drier On-Site Fill.

16. Subgrade stabilization (where required) should include placement of a Separation Geotextile over relatively undisturbed subgrade. An initial ±12 to 18-inch thick lift of Stabilization Rock should be spread over the geotextile prior to any compaction of the fill.

17. Construct permanent cut and fill slopes no steeper than 2:1 (H:V).

18. Periods of wet weather or isolated showers may prevent adequate compaction of the fine-grained On-Site Fill. Therefore, if showers occur, the work may have to be delayed or a higher quality material may be required to allow the work to continue in these conditions. In addition, surficial fill that softens due to exposure to wet weather may have to be aerated and recompacted or excavated and replaced.

19. The finished grades should be seeded, watered and maintained as soon as possible following earthwork to provide mature vegetation prior to the onset of wet weather and reduce the risk of erosion.

Site Preparation for Foundation Construction

It is assumed that daylight basements or stepped foundations will be typical for residential construction within the development. We recommend that FEI be present to confirm the minimum embedment depth of footings, in particular those on the downhill portion of the site, where basement excavations will "daylight". Individual home sites should be evaluated by FEI to confirm the absence of expansive soils or unexpected ground water, and the need for subslab drainage.

We recommend that the foundation area under new residences be prepared during dry weather as follows:

20. Strip the existing ground ±3 to 6 inches, or as required to remove roots and sod. Deeper excavations may be required to remove larger tree roots. Dispose of all strippings outside of construction areas.

21. Site grading for residential construction should be limited to full cut or fill benches to provide uniform foundation support. Constructing residences on combination cut and fill benches should be avoided. The appropriate set back for residential foundations from fill slopes depends on the height of the embankments and quality of the fill material. We recommend that all foundation setbacks for new residences be confirmed in the field by FEI.

22. Appropriate temporary cut slopes for basements will have to be evaluated at the time of construction. Temporary cuts should be no steeper than ½:1 (H:V). Concentrated seepage from the slope will tend to destabilize the slope. Therefore, grading should direct surface water away from the slopes.

23. Excavate to the planned grades for slabs and footings using a hoe equipped with a smooth bucket to reduce subgrade disturbance. The excavations should be deep enough to accommodate a ±6-inch

granular leveling pad of compacted Select Fill beneath the footings and slabs. The Select Fill should extend at least 6 inches outside the edges of the footings. The Select Fill may be eliminated if the footings bear on weathered bedrock.

24. High plasticity soils may be encountered in some areas. If practical, foundation excavations should extend deep enough to bypass the plastic soils. Where deep deposits of plastic soils are encountered, these materials should be overexcavated as required to provide at least 24 inches of Select Fill between the bottom of the footing and the subgrade. The excavations should be backfilled with compacted Select Fill. The footing excavations should be evaluated by an FEI representative prior to backfilling.

25. Compact building pad Select Fill as specified in Item 7. Staging construction traffic on the completed pad will increase the risk of subgrade disturbance and is not recommended.

26. Design all continuous wall footings and isolated column footings using an allowable bearing pressure of 1,500 psf. This value assumes that all footing excavations will terminate in medium stiff, residual soil or in decomposed to highly weathered bedrock.

27. Assume the walls could experience maximum total and differential settlements of ½ inch and ¼ inch, respectively. These values assume the foundations would be designed and constructed as recommended herein.

28. Provide a minimum footing width of 18 inches for continuous wall footings and isolated column footings. Place the base of all exterior footings at least 24 inches below the finished grade or paved surface. Shallower embedment may be used for interior footings that are poured monolithically with the slab. Construct footings along slopes with a minimum 5 feet of horizontal distance between the edge of the footing and the face of the slope as shown on Figure 5A (to be confirmed in the field by FEI).

29. Use Select Fill for backfill behind basement walls. Wall backfill should be compacted using a light, hand-operated compactor. Use an equivalent fluid density of 55 pcf to represent lateral earth pressure for the design of basement walls.

30. Grade the ground surface surrounding all buildings to promote runoff away from the foundations.

Rockery Wall Construction

We anticipate that rockery walls will be constructed using large diameter boulders individually selected and placed to create steep rock-faced slopes. Wall locations, sizes and lengths are not currently known. General recommendations for wall

design and construction are summarized below. These recommendations are provided for general planning and preliminary layout of rockery walls. It is assumed that others will provide the actual design of the walls.

31. Design and construct the walls as shown in Figure 7A (Appendix A). Batter the walls no steeper than 1:6 (H:V).

32. In areas where rockery walls will retain fill, the fill slopes should be overbuilt to 1.5:1 (H:V) at least 3 feet beyond the facing at the top of the wall and subsequently trimmed back prior to constructing the rockery walls. Recommended distances between the toe of the wall and the toe of the temporary cut slope are shown on Table 1.

33. Use appropriate sized boulders to construct the walls. The size of the boulders will depend upon the wall height. Use relatively clean, open-graded, angular crushed rock to backfill the walls. Line the cut slope with Filter Fabric prior to backfilling as shown on Figure 7A.

34. Embed the base of the rock wall a minimum of 12 inches below the finish grade for the walls at the toe of the slope. Increase the minimum embedment depth to 24 inches for walls constructed with a slope below the toe of the wall.

35. Excavate for the wall foundation using a hoe equipped with a smooth bucket to reduce subgrade disturbance. The excavations should be deep enough to accommodate a ±6-inch granular leveling pad of compacted Select Fill beneath the wall.

36. Design the walls using an allowable bearing pressure of 1,500 psf. This value assumes that all footing excavations will terminate in medium stiff, residual soil or in decomposed to highly weathered bedrock.

Foundation and Wall Drainage

We recommend that drainage for the site be constructed as follows.

37. Install foundation drains along the perimeter of the buildings as shown on Figure 6A. The drains should consist of 3 or 4-inch diameter, perforated or slotted, PVC pipe. The flowline of the pipe should be set near the bottom of the foundation at least 18 inches below the ground surface. The pipe should be bedded in at least 4 inches of Drain Rock. The entire mass of Drain Rock should be wrapped in a filter fabric that laps at least 12 inches at the top.

38. Install drains behind the rockery walls. The drain should consist of a 4-inch diameter, perforated or slotted PVC pipe. The flowline of the pipe should be set near the base of the wall. The pipe should be bedded in at least 4 inches of Drain Rock and the wall should be backfilled with open-graded, angular crushed rock. A filter fabric should be placed over the cut slope (as shown on Figure 7A) to reduce the risk of fine-grained soils intruding into the granular backfill.

39. Provide clean-outs at appropriate locations for future maintenance of the drainage systems.

40. Discharge the drains by gravity flow into the nearest storm drain, if practical. Otherwise, discharge the water into the nearest natural drainage. Roof drains may be discharged onto the property at least ±15 feet away from the foundations. If roof drains discharge onto sloping ground, provide an energy dissipater at the outlet to reduce surface erosion. Roof drains should not be connected to foundation drains.

Pavement Construction

41. Strip the ground surface as required to remove roots and sod. Dispose of all strippings outside of construction areas.

42. Prepare, compact and density test the subgrade as specified in Item 7. Compaction should be verified for both native soils and embankment fill.

43. Proof-roll the completed subgrade to identify any soft or pumping areas. Overexcavate and replace any pumping subgrade with compacted Select Fill. High plasticity soils should also be overexcavated and replaced with compacted Select Fill or Granular Site Fill to a minimum depth of 24 inches below the finished grade.

44. Maintain the moisture in the compacted subgrade to prevent excessive drying and cracking. Immediately cover the subgrade with compacted Select Fill.

45. Provide a minimum flexible pavement section of 3.5 inches of AC over 13.5 inches of base rock (Select Fill). Compact the base rock as specified in Item 7.

46. Compact the AC to a minimum of 91% relative compaction according to the theoretical maximum density calculated from the Rice specific gravity.

DESIGN REVIEW/CONSTRUCTION OBSERVATION/TESTING

We should be provided the opportunity to review all drawings and specifications that pertain to site preparation, foundation construction and pavements. Site preparation will require field confirmation of foundation soils and road subgrade, as well as proper mitigation of high plasticity soils or unexpected ground water, where present. Mitigation of any subgrade pumping will also require engineering review and judgment. That judgment should be provided by one of our representatives. Frequent field density tests should be run on all engineered fill, subgrade and base rock. We recommend that we be retained to provide the necessary construction observations.

VARIATION OF SUBSURFACE CONDITIONS, USE OF THIS REPORT AND WARRANTY

The analysis, conclusions and recommendations contained herein are based on the assumption that the soil profiles and the ground water levels encountered in the test pits are representative of the overall site conditions. The above recommendations assume that we will have the opportunity to review final drawings and be present during construction to confirm assumed foundation conditions. No changes in the enclosed recommendations should be made without our approval. We will assume no responsibility or liability for any engineering judgment, inspection or testing performed by others.

This report was prepared for the exclusive use of TC2 Investments, LLC, Metolius Consulting and their design consultants for Brooklane Heights and Oakmont Addition in Corvallis, Oregon. Information contained herein should not be used for other sites or for unanticipated construction without our written consent. This report is intended for planning and design purposes. Contractors using this information to estimate construction quantities or costs do so at their own risk. Our services do not include any survey or assessment of potential surface contamination or contamination of the soil or ground water by hazardous or toxic materials. We assume that those services, if needed, have been completed by others.

Climate conditions in western Oregon typically consist of wet weather for almost half of the year (typically between mid-October and late May). The recommendations for site preparation and foundation drainage are not intended to represent any warranty (expressed or implied) against the growth of mold, mildew or other organisms that grow in a humid or moist environment.

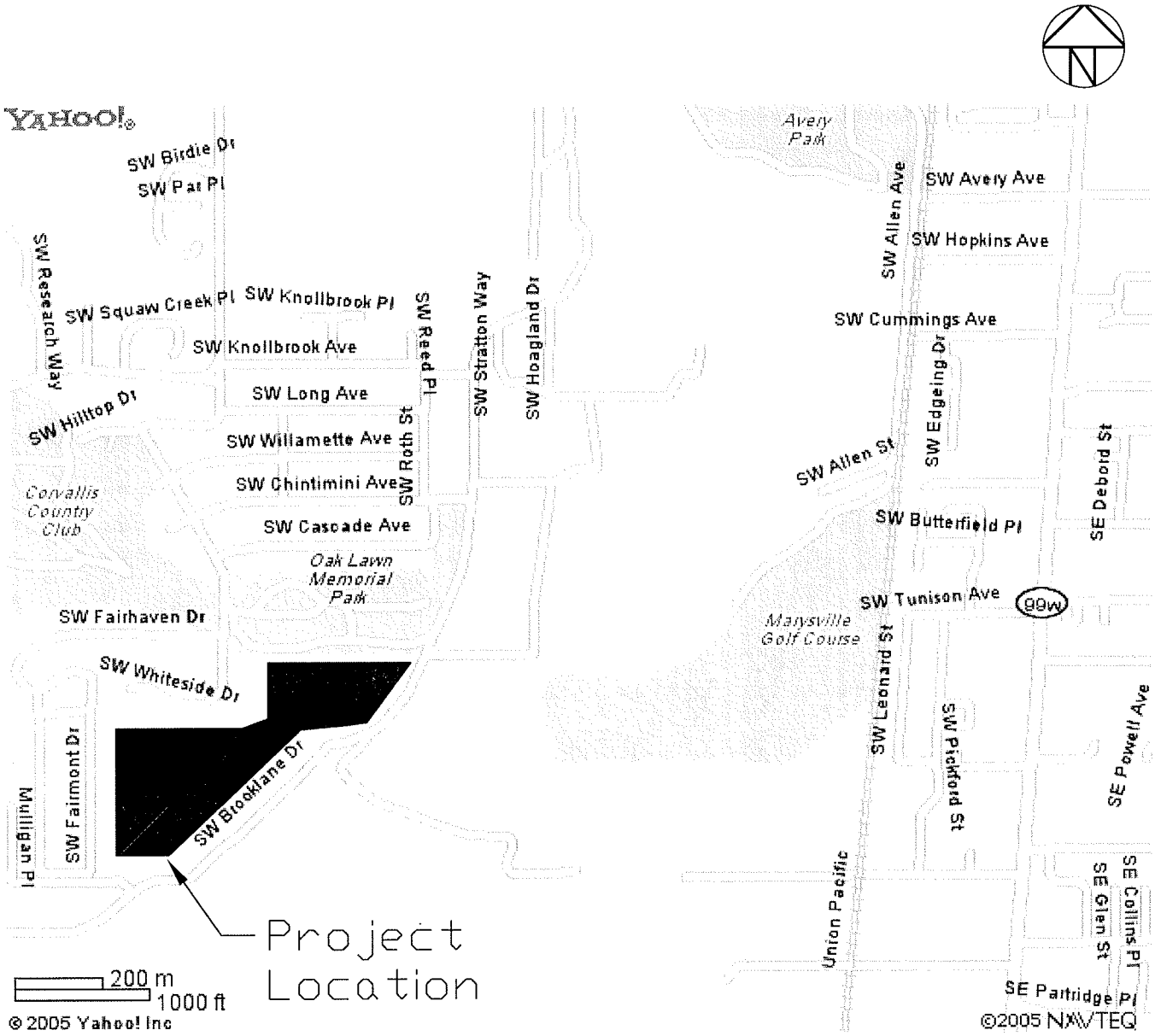
Our work was done in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

Appendix A

Figures

Professional
Geotechnical
Services

Foundation Engineering, Inc.



DATE MAY 2008
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REVIS. _____
PROJECT NO.
2081024

FOUNDATION ENGINEERING INC.
PROFESSIONAL GEOTECHNICAL SERVICES
820 NW CORNELL AVENUE
CORVALLIS, OR 97330-4517
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VICINITY MAP

BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO.
1A

TRACT C

TRACT A

WEST DRAINAGE

TRACT B

EAST DRAINAGE

FENCE AND SIDEWALK ENCROACHMENT

FENCE ENCROACHMENT

20'-0" PUE

SCALE: 1" = 120'

0 60 120 240

LEGEND

- TP-1 TEST PITS DUG BY FEI NOVEMBER 15, 2005
- TP-1A TEST PITS DUG BY FEI FEBRUARY 23, 2007
- TP-1B TEST PITS DUG BY FEI APRIL 3, 2008

NOTES:
1. TEST PIT LOCATIONS WERE ESTABLISHED BY PACING AND VISUAL REFERENCE AND ARE APPROXIMATE ONLY.
2. SEE REPORT FOR A DISCUSSION OF SUBSURFACE CONDITIONS.
3. BASE MAP WAS PROVIDED BY METOLIUS CONSULTING.

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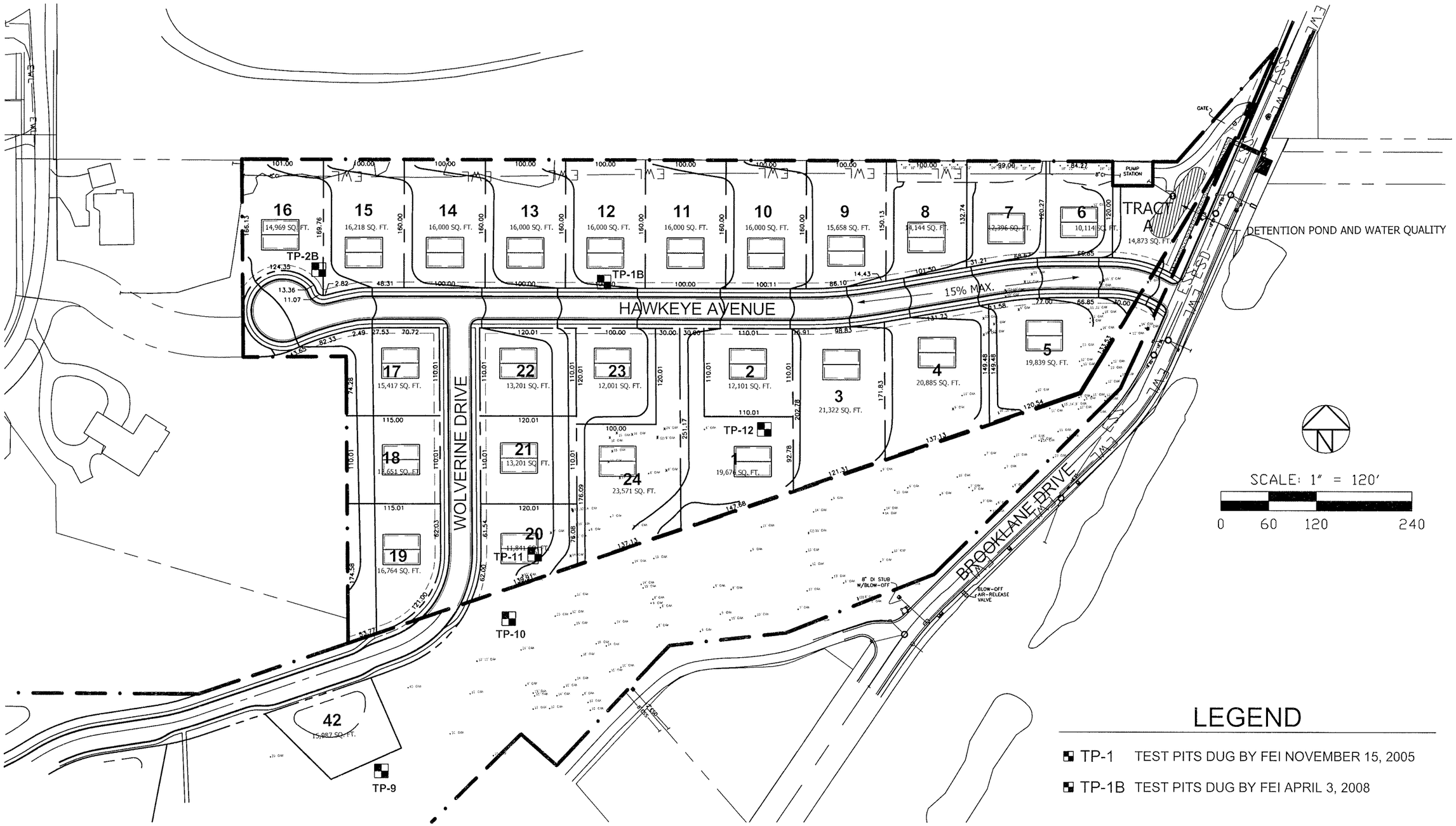
SITE LAYOUT & TEST PIT LOCATIONS
BROOKLANE HEIGHTS
BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO. 2A



NOTES:
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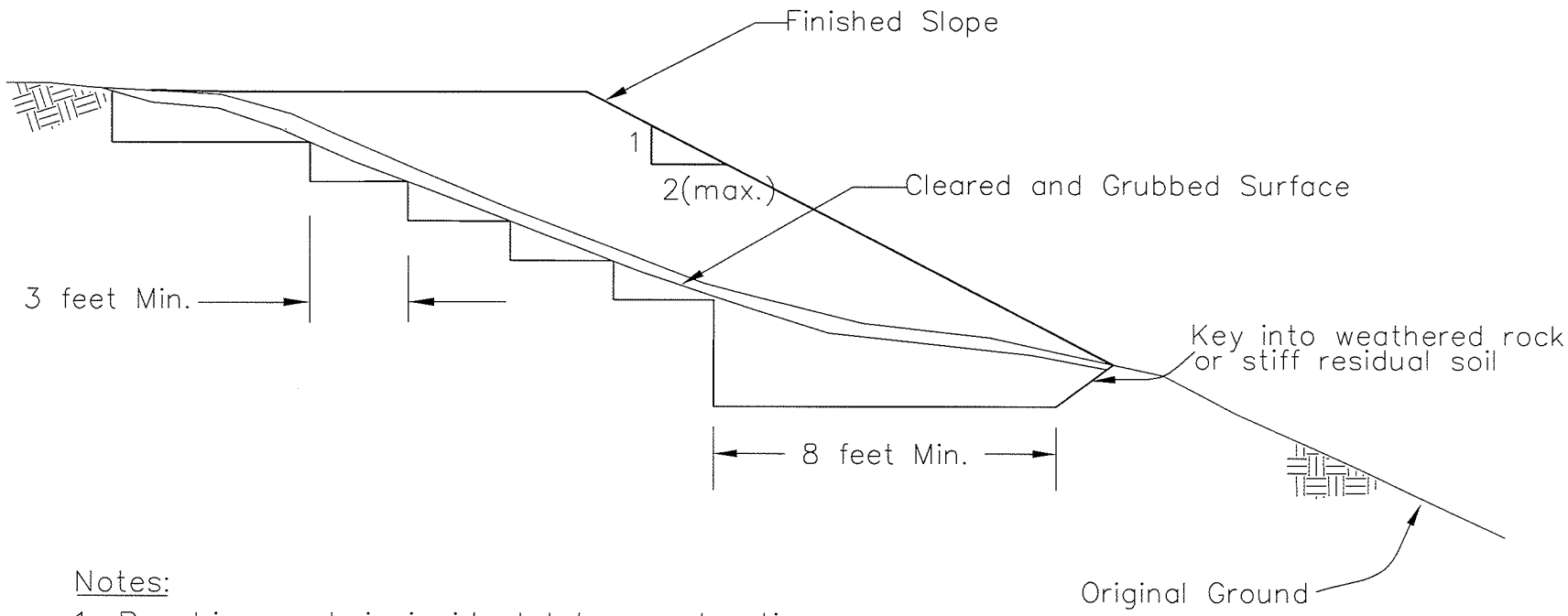
SITE LAYOUT & TEST PIT LOCATIONS
OAKMONT ADDITION
BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO. 3A



Notes:

1. Benching work is incidental to construction.
2. Bench all new fill into existing ground.
3. Individual lifts should be constructed at slopes 10(h):1(v) or flatter.
4. See report for discussion of embankment soils.

Not to Scale

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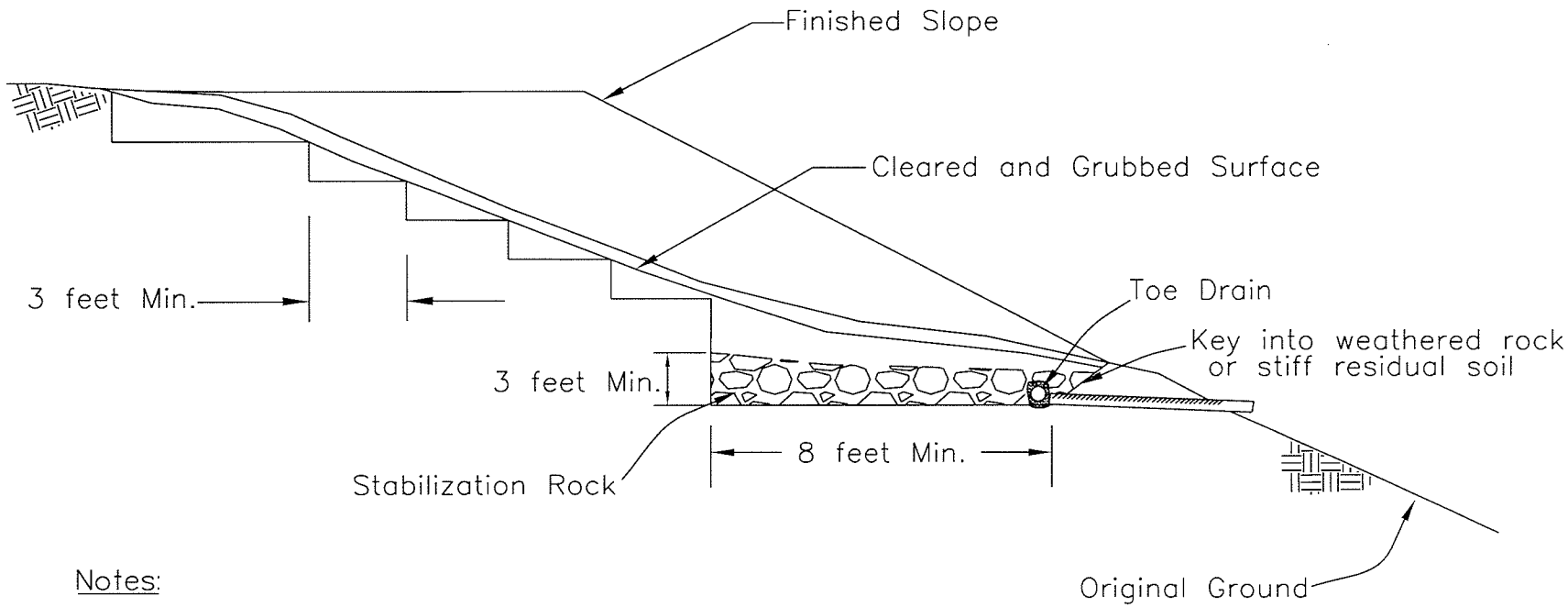
STANDARD BENCHING DETAIL

BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO.
4A



Notes:

1. Benching work is incidental to construction.
2. Bench all new fill into existing ground.
3. Individual lifts should be constructed at slopes 10(h):1(v) or flatter.
4. See report for discussion of embankment soils, Stabilization Rock and toe drain.

Not to Scale

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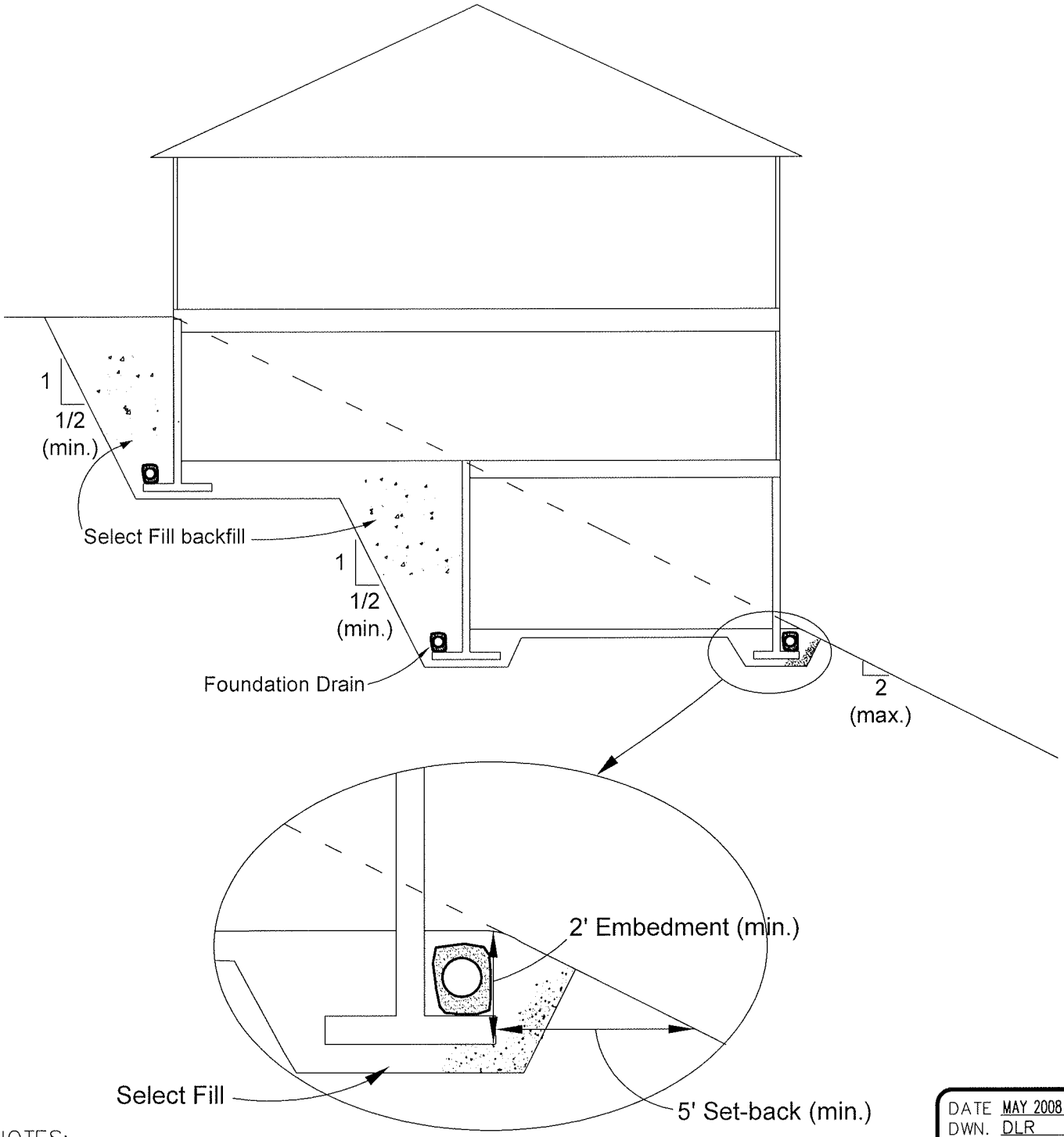
BENCHING DETAIL WITH TOE DRAIN

BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO.
5A



NOTES:
1. SEE REPORT FOR DETAILS OF FOUNDATION DRAIN CONSTRUCTION AND MATERIAL SPECIFICATIONS.
2. MAXIMUM CUT SLOPES WILL NEED TO BE VERIFIED IN THE FIELD.

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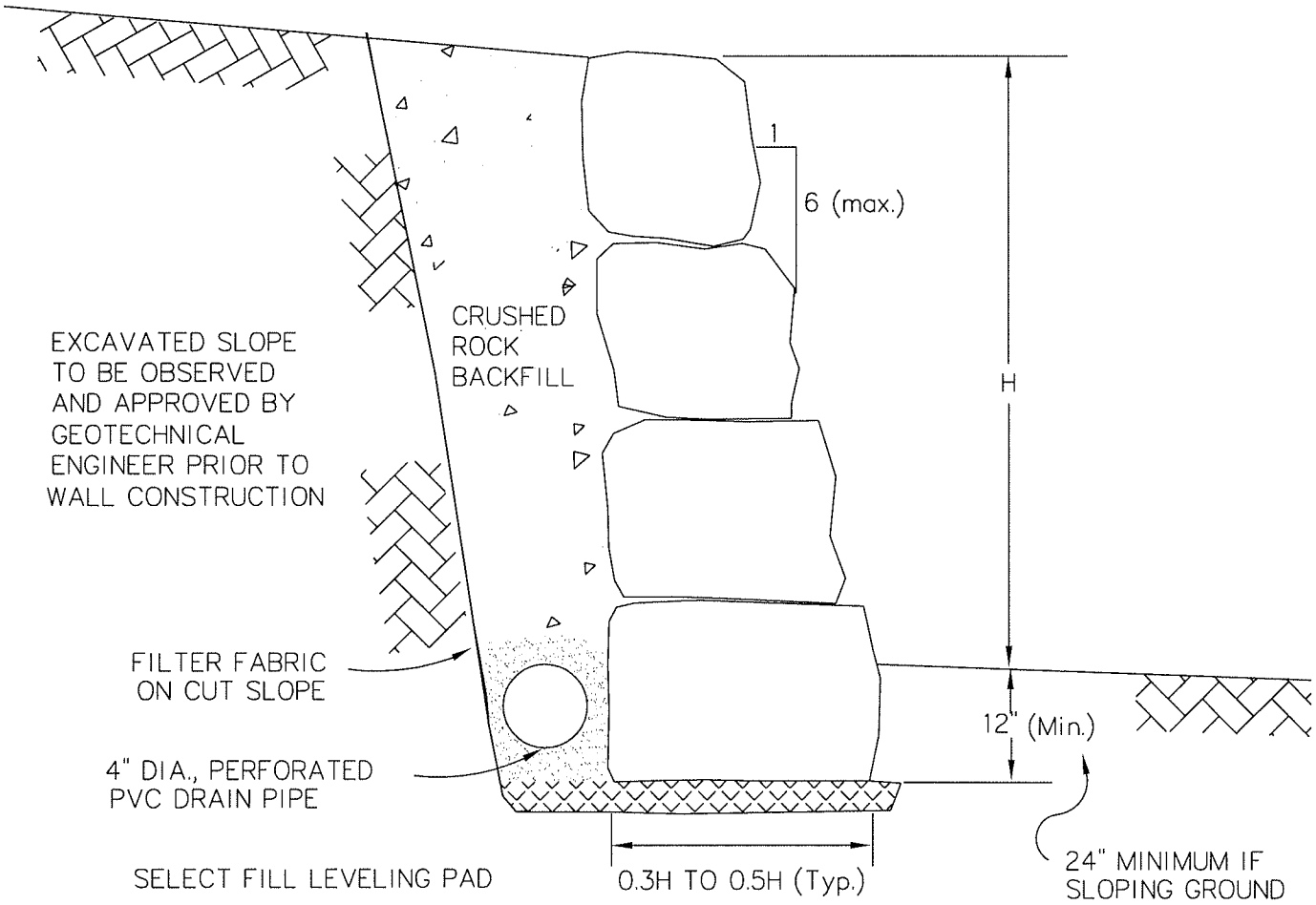
TYP. FOOTING DETAIL/SLOPE EXCAVATION

BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO.
6A



NOTES:
1. DRAWING IS SCHEMATIC ONLY AND IS NOT TO SCALE.
2. REQUIRED ROCK SIZES WILL DEPEND UPON THE WALL HEIGHT.
3. ACTUAL DESIGN BY OTHERS.

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TYPICAL ROCKERY WALL DETAIL

BROOKLANE HEIGHTS AND OAKMONT ADDITION
CORVALLIS, OREGON

FIGURE NO.
7A

Appendix B

Test Pit Logs

Professional
Geotechnical
Services

Foundation Engineering, Inc.

DISTINCTION BETWEEN FIELD LOGS AND FINAL LOGS

A field log is prepared for each boring or test pit by our field representative. The log contains information concerning sampling depths and the presence of various materials such as gravel, cobbles, and fill, and observations of ground water. It also contains our interpretation of the soil conditions between samples. The final logs presented in this report represent our interpretation of the contents of the field logs and the results of the laboratory examinations and tests. Our recommendations are based on the contents of the final logs and the information contained therein and not on the field logs.

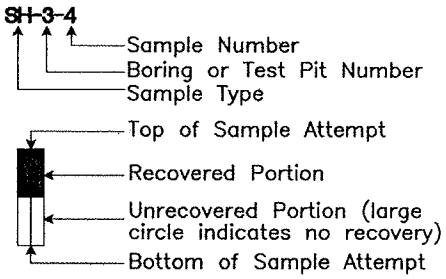
VARIATION IN SOILS BETWEEN TEST PITS AND BORINGS

The final log and related information depict subsurface conditions only at the specific location and on the date indicated. Those using the information contained herein should be aware that soil conditions at other locations or on other dates may differ. Actual foundation or subgrade conditions should be confirmed by us during construction.

TRANSITION BETWEEN SOIL OR ROCK TYPES

The lines designating the interface between soil, fill or rock on the final logs and on subsurface profiles presented in the report are determined by interpolation and are therefore approximate. The transition between the materials may be abrupt or gradual. Only at boring or test pit locations should profiles be considered as reasonably accurate and then only to the degree implied by the notes thereon.

SAMPLE OR TEST SYMBOLS



S – Grab Samples
SS – Standard Penetration Test Sample (split–spoon)
SH – Thin–walled Shelby Tube Sample
C – Core Sample
CS – Continuous Sample

▲ Standard Penetration Test Resistance equals the number of blows a 140 lb. weight falling 30 in. is required to drive a standard split–spoon sampler 1 ft. Practical refusal is equal to 50 or more blows per 6 in. of sampler penetration.

● Water Content (%).

UNIFIED SOIL CLASSIFICATION SYMBOLS

G – Gravel	W – Well Graded
S – Sand	P – Poorly Graded
M – Silt	L – Low Plasticity
C – Clay	H – High Plasticity
Pt – Peat	O – Organic

FIELD SHEAR STRENGTH TEST

Shear strength measurements on test pit side walls, blocks of soil or Shelby tube samples are typically made with Torvane or pocket penetrometer devices.

TYPICAL SOIL/ROCK SYMBOLS

Sand	Silt
Clay	Gravel
Basalt	Siltstone

WATER TABLE

▼ Water Table Location

(1/31/00) Date of Measurement

Piezometer Tip Location (if used)

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SYMBOL KEY

BORING AND TEST PIT LOGS

Explanation of Common Terms Used in Soil Descriptions

Field Identification	Cohesive Soils			Granular Soils	
	SPT	S_u^* (tsf)	Term	SPT	Term
Easily penetrated several inches by fist.	0 – 1	< 0.125	Very Soft	0 – 4	Very Loose
Easily penetrated several inches by thumb.	2 – 4	0.125–0.25	Soft	5 – 10	Loose
Can be penetrated several inches by thumb with moderate effort.	5 – 8	0.25 – 0.50	Medium Stiff (Firm)	11 – 30	Medium Dense
Readily indented by thumb but penetrated only with great effort.	9 – 15	0.50 – 1.0	Stiff	31 – 50	Dense
Readily indented by thumbnail.	16 – 30	1.0 – 2.0	Very Stiff	> 50	Very Dense
Indented with difficulty by thumbnail.	31 – 60	> 2.0	Hard		

* Undrained shear strength

Term	Soil Moisture Field Description
Dry	Absence of moisture. Dusty. Dry to the touch.
Damp	Soil has moisture. Cohesive soils are below plastic limit and usually moldable.
Moist	Grains appear darkened, but no visible water. Silt/clay will clump. Sand will bulk. Soils are often at or near plastic limit.
Wet	Visible water on larger grain surfaces. Sand and cohesionless silt exhibit dilatancy. Cohesive silt/clay can be readily remolded. Soil leaves wetness on the hand when squeezed. "Wet" indicates that the soil is wetter than the optimum moisture content and above the plastic limit.

Term	PI	Plasticity Field Test
Nonplastic	0 – 3	Cannot be rolled into a thread.
Low Plasticity	3 – 15	Can be rolled into a thread with some difficulty.
Medium Plasticity	15 – 30	Easily rolled into thread.
High Plasticity	> 30	Easily rolled and rerolled into thread.

Term	Soil Structure Criteria
Stratified	Alternating layers at least 1 inch thick – describe variation.
Laminated	Alternating layers at less than 1 inch thick – describe variation.
Fissured	Contains shears and partings along planes of weakness.
Slickensides	Partings appear glossy or striated.
Blocky	Breaks into lumps – crumbly.
Lensed	Contains pockets of different soils – describe variation.

Term	Soil Cementation Criteria
Weak	Breaks under light finger pressure.
Moderate	Breaks under hard finger pressure.
Strong	Will not break with finger pressure.

FOUNDATION ENGINEERING INC.
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COMMON TERMS
SOIL DESCRIPTIONS

Explanation of Common Terms Used in Rock Descriptions

Field Identification		UCS (psi)	UCS (MPa)	Strength (Hardness)
Indented by thumbnail.	R0	< 100	0.25–1.0	Extremely Weak (Extremely Soft)
Crumbles under firm blows with geological hammer, can be peeled by a pocket knife.	R1	100–1000	1.0–5.0	Very Weak (Very Soft)
Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with geological hammer.	R2	1000–4000	5.0–25	Weak (Soft)
Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow of geological hammer.	R3	4000–8000	25–50	Medium Strong (Medium Hard)
Specimen requires more than one blow of geological hammer to fracture it.	R4	8000–16000	50–100	Strong (Hard)
Specimen requires many blows of geological hammer to fracture it.	R5	16000–36000	100–250	Very Strong (Very Hard)
Specimen can only be chipped with geological hammer.	R6	> 36000	> 250	Extremely Strong (Extremely Hard)

Term	Weathering Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric.
Moderately Weathered	Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Highly Weathered	Rock can be excavated with geologist's pick. All dicontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Spacing (meters)	Spacing (feet)	Spacing Term	Bedding/Foliation
< 0.06	< 2 in.	Very Close	Very Thin
0.06 – 0.30	2 in. – 1 ft.	Close	Thin
0.30 – 0.90	1 ft. – 3 ft.	Moderately Close	Medium
0.90 – 3.0	3 ft. – 10 ft.	Wide	Thick
> 3.0	> 10 ft.	Very Wide	Very Thick (Massive)

Vesicle Term	Volume
Some	3 – 20%
Highly	20 – 50%
Scoria	> 50%

Stratification Term	Description
Lamination	< 1 cm thick beds
Fissile	Preferred break along laminations
Parting	Preferred break direction
Foliation	Metamorphic layering of minerals

RQD %	Designation	RQD %	Designation
0 – 25	Very Poor	75 – 90	Good
25 – 50	Poor	90 – 100	Excellent
50 – 75	Fair		

Rock Quality Designation (RQD) is the percent of a core run with intact lengths greater than 0.1 m excluding breaks caused by drilling.

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COMMON TERMS
ROCK DESCRIPTIONS

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and weeds.	1-							Medium stiff, clayey SILT; light brown, damp to moist, medium plasticity, semi-blocky structure, (topsoil/residual soil).
Fine roots extend to ±1.5 feet.	2-							
	3-							
	4-					0.50		
	5-					0.60		Medium stiff to stiff, clayey SILT; light brown to orange-brown, iron and manganese-stained, damp to moist, medium plasticity, relict structure, (residual soil). Gravel-sized sandstone corestones noted below ±6 feet.
	6-							
	7-							
	8-							
	9-							
Slightly harder digging noted below ±9 feet.	10—							Cobble to boulder-sized sandstone corestones noted below ±9 feet.
	11-							
	12-							
	13-							
	14-							
No ground water encountered to the limit of excavation.	15-							Extremely weak (R0) SANDSTONE; light brown to orange-brown, iron and manganese-stained, decomposed to highly weathered, fine sand, (Spencer Formation).
	16-							BOTTOM OF TEST PIT

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 1

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and weeds.	1-							Medium stiff, clayey SILT; light brown to orange-brown, damp to moist, medium plasticity, semi-blocky structure, (topsoil/residual soil).
Fine roots extend to ±1 foot and along bedrock contact.	2-							
	3-	S-2-1						Extremely weak to very weak (R0 to R1) SANDSTONE; light brown, highly weathered, fine sand, micaceous, very close to close joints. Joints are irregular, rough, closed with some iron and manganese-staining, (Spencer Formation).
	4-							
	5-							
	6-							
Digging refusal encountered at ±7 feet.	7-							
No ground water encountered to the limit of excavation.	8-							BOTTOM OF TEST PIT
	9-							
	10—							
	11-							
	12-							
	13-							
	14-							
	15-							
	16-							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 2

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and weeds. Fine roots extend to ±6 inches.	1-							Medium stiff SILT, trace to some clay; brown, damp, low to medium plasticity, (topsoil).
	2-					0.65		Stiff, clayey SILT, scattered roots; light brown to orange-brown, damp to moist, medium plasticity, (residual soil). Becomes very stiff and grey mottled orange below ±2.7 feet.
	3-							
	4-							
	5-					>1.0		Relict structure noted below ±5 feet.
	6-							
	7-							
	8-							
	9-							
	10—	S-3-1						Extremely weak (R0) SANDSTONE; light brown, iron and manganese-stained, close joints, fine sand, silty and micaceous, (Spencer Formation).
	11-							
	12-							
	13-							Less staining and becomes light brown-grey, moderately weathered below ±12.5 feet.
	14-	S-3-2						
No ground water encountered to the limit of excavation.	15-							
	16-							BOTTOM OF TEST PIT

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 3

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass, scotch broom, blackberries and wild rose.	1-							Medium stiff SILT, trace to some clay, scattered roots; brown, damp, medium plasticity, (topsoil/residual soil).
	2-					0.85		Medium stiff to stiff to stiff SILT, some clay; orange-brown, iron-stained, damp, low to medium plasticity, relict structure, (residual soil to decomposed rock).
	3-							
	4-							Extremely weak to very weak (R0 to R1) SANDSTONE; light brown to orange, iron stained, highly weathered, fine sand, close joints. Joints are irregular, rough, closed with some manganese-staining, (Spencer Formation).
	5-							
	6-							
Digging refusal encountered at ±7 feet.	7-	S-4-1						
No ground water encountered to the limit of excavation.	8-							Becomes very weak (R1), orange-grey with iron and manganese-staining and highly to moderately weathered below ±6 feet.
	9-							BOTTOM OF TEST PIT
	10—							
	11-							
	12-							
	13-							
	14-							
	15-							
	16-							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 4

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass.	1-					0.30		Medium stiff SILT, some to trace clay, scattered roots; dark brown to brown, damp, medium plasticity, (topsoil/residual soil).
	2-							Stiff to very stiff SILT, some clay; light brown, damp, low plasticity, relict structure, (residual soil).
	3-							
	4-							Extremely weak (R0) SANDSTONE; light brown, damp, iron-stained, decomposed to highly weathered, very close to close joints. Joints are irregular, rough, closed, (Spencer Formation).
	5-							
Digging refusal encountered at ±6.5 feet.	6-							
No ground water encountered to the limit of excavation.	7-							Becomes very weak (R1), grey and moderately weathered below ±5 feet.
	8-							BOTTOM OF TEST PIT
	9-							
	10–							
	11-							
	12-							
	13-							
	14-							
	15-							
	16-							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 5

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass.	1-							Medium stiff SILT, trace clay; brown, damp to moist, medium plasticity, (topsoil).
Fine roots extend to ±6 inches.	2-					0.35		
	3-	S-6-1						Medium stiff SILT, trace to some clay, scattered roots; brown, dry to moist, low to medium plasticity, (residual soil).
	4-							
	5-							Stiff to very stiff SILT, some clay; brown, damp to moist, medium plasticity, relict structure, (residual soil).
	6-							
	7-							
Digging refusal encountered at ±8.5 feet.	8-	S-6-2						Extremely weak to very weak (R0 to R1) SANDSTONE; orange-brown to grey, iron and manganese-stained, highly to moderately weathered, manganese-stained joints, fine sand, (Spencer Formation).
No ground water encountered to the limit of excavation.	9-							
	10–							BOTTOM OF TEST PIT
	11-							
	12-							
	13-							
	14-							
	15-							
	16-							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 6

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and oak leaves.		S-7-1						Soft to medium stiff SILT, some to trace clay; dark brown, medium plasticity, (topsoil).
Fine roots extend to ±1 foot.	1-	S-7-2						Very weak to weak (R1 to R2) SANDSTONE; green-grey, moderately to slightly weathered, fine sand, close joints. Joints are irregular, smooth to rough, closed, (Spencer Formation).
Digging refusal encountered at ±2 feet.	2-							BOTTOM OF TEST PIT
No ground water encountered to the limit of excavation.	3-							
	4-							
	5-							
	6-							
	7-							
	8-							
	9-							
	10-							
	11-							
	12-							
	13-							
	14-							
	15-							
	16-							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 7

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and weeds.	1-							Soft to medium stiff SILT, some clay, scattered roots; dark brown, damp to moist, medium plasticity, (topsoil).
	2-							Very weak to weak (R1 to R2) SANDSTONE; dark grey moderately to slightly weathered, fine to medium sand, close joints. Joints are irregular to planar, smooth to rough, closed with some manganese-staining, (Spencer Formation).
Digging refusal encountered at ±3 feet.		S-8-1						
No ground water encountered to the limit of excavation.	3-							BOTTOM OF TEST PIT
	4-							
	5-							
	6-							
	7-							
	8-							
	9-							
	10-							
	11-							
	12-							
	13-							
	14-							
	15-							
	16-							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 8

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass, scotch broom and blackberries.	1							Soft to medium stiff SILT, abundant fine roots; brown to dark brown, damp, medium plasticity, (topsoil).
	2							Very weak to weak (R1 to R2) SANDSTONE; light brown, moderately weathered, fine sand, close joints. Joints are irregular to planar, smooth to rough, closed with some manganese-staining, (Spencer Formation).
Digging refusal encountered at ±3.5 feet.	3	S-9-1						
No ground water encountered to the limit of excavation.	4							BOTTOM OF TEST PIT
	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP- 9

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: scotch broom and wild rose.	1							Medium stiff SILT, trace to some clay, scattered roots; brown to orange-brown, damp to moist, low to medium plasticity, (topsoil/residual soil).
	2							
	3							Very weak (R1) SANDSTONE; light brown, moderately weathered, fine sand, very close to close joints. Joints are irregular, rough, closed with some manganese-staining, (Spencer Formation).
	4							
Digging refusal encountered at ±5.5 feet.	5	S-10-1						
No ground water encountered to the limit of excavation.	6							BOTTOM OF TEST PIT
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP-10

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: blackberries and scotch broom. Digging refusal encountered at ±2 feet. No ground water encountered to the limit of excavation.	1- 2- 3- 4- 5- 6- 7- 8- 9- 10-- 11- 12- 13- 14- 15- 16-							Medium stiff SILT, some clay, scattered roots; orange-brown, damp to moist, medium plasticity, (topsoil). Very weak to weak (R1 to R2) SANDSTONE; green-grey, moderately to slightly weathered, fine sand, close to moderately close joints. Joints are irregular, rough, closed with some manganese-staining, (Spencer Formation). BOTTOM OF TEST PIT

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP-11

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: scotch broom, blackberries. Digging refusal encountered at ±7 feet. No ground water encountered to the limit of excavation.	1- 2- 3- 4- 5- 6- 7- 8- 9- 10-- 11- 12- 13- 14- 15- 16-							Soft to medium stiff SILT, some clay, scattered roots; dark brown, moist, medium plasticity, (topsoil). Stiff to very stiff SILT, some clay; light brown, dry to damp, low to medium plasticity, relict structure, (residual soil). Extremely weak (R0) SANDSTONE; light brown, trace iron and manganese-staining, highly to moderately weathered, fine sand, close joints. Joints are irregular, rough, closed with manganese-staining, (Spencer Formation). Becomes very weak (R1) below ±5.5 feet. BOTTOM OF TEST PIT

Project No.: 2051129

Surface Elevation: N/A (Approx.)

Date of Test Pit: November 15, 2005

Test Pit Log: TP-12

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: short grass, blackberry bushes and rock fragments.								ROOTS and SOD.
	1							Extremely weak to very weak (R0 to R1) SANDSTONE; grey to orange-brown, moderately weathered to decomposed, highly fractured, (Spencer Formation).
	2							
	3							
	4							
	5							
Slow seepage noted at ±5.5 feet.	6							BOTTOM OF TEST PIT
	7							
	8							
	9							
	10							
	11							
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-1A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: tall grass and blackberry bushes.	1							Soft to medium stiff, clayey SILT; dark brown, moist, medium plasticity, blocky structure, (topsoil/alluvium).
	2							
Moderate seepage noted at ±3 feet.	3	S-2A-1				0.25		Soft, silty CLAY; light brown, trace iron-staining, wet, medium plasticity, micaceous, (alluvium).
	4							
	5							
	6							
	7							Stiff CLAY, some gravel-sized rock fragments; brown to grey, trace iron-staining, moist to wet, medium plasticity, (residual soil).
	8							
	9							
	10							Extremely weak (R0) SANDSTONE; brown to grey, decomposed to highly weathered, highly fractured, (Spencer Formation).
	11							BOTTOM OF TEST PIT
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-2A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and tall shrubs.	1-							Medium stiff to stiff, clayey SILT; brown, moist, medium plasticity, micaceous, (possible alluvium).
	2-							
	3-							Stiff SILT, trace fine sand; orange, dry to damp, low plasticity, (residual soil).
No ground water encountered to the limit of excavation.	4-							Very weak (R1) SANDSTONE; grey-brown, moderately weathered, very close to moderately close joints, (Spencer Formation).
	5-							BOTTOM OF TEST PIT
	6-							
	7-							
	8-							
	9-							
	10-							
	11-							
	12-							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-3A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and short brush.	1-							Soft, clayey SILT; brown, wet, medium plasticity, (alluvium).
Rapid seepage noted at ±1.5 feet.	2-							
	3-							Stiff, clayey SILT; brown, wet, medium plasticity, (alluvium).
	4-							
	5-							
	6-							Stiff CLAY, some gravel-sized rock fragments; brown to grey, wet, low to medium plasticity, (residual soil).
	7-							
	8-							Extremely weak (R0) SANDSTONE; orange-brown, decomposed to highly weathered, highly fractured, (Spencer Formation).
	9-							
	10-							BOTTOM OF TEST PIT
	11-							
	12-							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-4A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and shrubs.								Medium stiff, clayey SILT, some organics; brown, damp, low plasticity, blocky structure, (topsoil).
Practical refusal encountered at ±1.5 feet.	1							Weak (R2) SANDSTONE; light brown, moderately to highly weathered, very close to moderately close joints, (Spencer Formation).
No ground water encountered to the limit of excavation.	2							BOTTOM OF TEST PIT
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-5A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface:								Medium stiff, clayey SILT, some organics; brown, iron-stained, damp, low plasticity, blocky structure, (topsoil).
	1							Extremely weak (R0) grading to moderately strong (R2) SANDSTONE; grey to brown, decomposed to slightly weathered, very close to moderately close joints, (Spencer Formation).
	2							
	3							
Practical refusal encountered at ±4 feet.	4							BOTTOM OF TEST PIT
No ground water encountered to the limit of excavation.	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-6A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
	1							Soft to medium stiff SILT, some clay; brown, wet, medium plasticity, (topsoil).
	2	S-1B-1				0.43		Soft to stiff SILT, some clay; brown, iron and manganese-stained, moist, medium plasticity, (residual soil).
	3							
	4					0.65		
Bulk samples taken at ±5 to 6 feet.	5	S-1B-2						Becomes light brown, iron and manganese-stained and relict structure at ±4.5 feet.
	6	S-1B-3						
	7	S-1B-4						Very stiff, clayey SILT; red-brown, iron and manganese-stained, moist to wet, medium plasticity, relict structure, (residual soil).
	8							
	9							
	10	S-1B-5						
	11							
	12	S-1B-6						
	13							
	14							
	15							
Rapid seepage noted at ±16 feet.	16	S-1B-7						Becomes medium stiff to stiff, light brown, iron and manganese-stained, and wet at ±16 feet.
	17					0.40		
	18							
	19							
	20							BOTTOM OF TEST PIT

Project No.: 2081024

Surface Elevation: N/A (Approx.)

Date of Test Pit: April 3, 2008

Test Pit Log: TP-1B

Brooklane Heights and Oakmont Addition

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
	1	S-2B-1				0.40		Soft to medium stiff SILT, some clay; brown, moist, medium plasticity, (topsoil).
	2					0.40		Medium stiff to stiff SILT, some clay; brown, moist, medium plasticity, (residual soil).
	3	S-2B-2						
	4	S-2B-3				0.40 0.55		Becomes iron and manganese-stained below ±2 feet. Relict structure noted below ±2.5 feet.
	5							
Moderate to difficult digging encountered below ±6 feet.	6	S-2B-4						Extremely weak (R0) SANDSTONE; light grey to orange, iron-stained, highly weathered to decomposed, fine sand. Becomes manganese-stained below ±5 feet.
	7							
	8							
	9							
	10							
	11							
	12							
Komatsu PC150LC excavator encountered hard digging below ±12.5 feet.	13	S-2B-5						
	14							
	15							
	16	S-2B-6						Becomes extremely weak to very weak (R0 to R1) and highly weathered below ±16 feet.
	17							
	18							
No ground water encountered to the limit of excavation.	19	S-2B-7						Becomes extremely weak (R0) and decomposed at ±18 feet.
	20							BOTTOM OF TEST PIT

Project No.: 2081024

Surface Elevation: N/A (Approx.)

Date of Test Pit: April 3, 2008

Test Pit Log: TP-2B

Brooklane Heights and Oakmont Addition

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Trace fine roots extend to ±18 inches.	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	S-3B-1 S-3B-2				0.40		Medium stiff SILT, some clay and organics; brown, moist, medium plasticity, (topsoil). Medium stiff to stiff, clayey SILT/silty CLAY; brown, moist, medium plasticity, (residual soil). Extremely weak to very weak (R0 to R1) SANDSTONE; grey, manganese-stained, highly weathered, fine sand.
Komatsu PC150LC excavator encountered practical digging refusal at ±8 feet. No seepage or ground water encountered to the limit of excavation.								BOTTOM OF TEST PIT

Project No.: 2081024

Surface Elevation: N/A (Approx.)

Date of Test Pit: April 3, 2008

Test Pit Log: TP-3B

Brooklane Heights and Oakmont Addition

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Fine roots extend to ±2.5 feet.	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	S-4B-1 S-4B-2 S-4B-3						Stiff SILT, some clay; brown, moist, medium plasticity, (topsoil/residual soil). Stiff to very stiff, clayey SILT; brown, iron-stained, moist, medium plasticity, (residual soil). Extremely weak to very weak (R0 to R1) SANDSTONE; brown, iron and manganese-stained, highly weathered, fine sand. Becomes very weak (R1) below ±5 feet.
Komatsu PC150LC excavator encountered practical digging refusal at ±9.5 feet. No seepage or ground water encountered to the limit of excavation.								BOTTOM OF TEST PIT

Project No.: 2081024

Surface Elevation: N/A (Approx.)

Date of Test Pit: April 3, 2008

Test Pit Log: TP-4B

Brooklane Heights and Oakmont Addition

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Slow seepage noted at ±2 feet. Bulk samples taken at ±3.5 to 4.5 feet.	1- 2- 3- 4- 5- 6- 7- 8- 9- 10– 11- 12- 13- 14- 15- 16- 17- 18- 19- 20–	S-5B-1 S-5B-2 S-5B-3				0.50 0.43 0.38		Soft to medium stiff, clayey SILT; brown, moist, medium plasticity, slightly blocky structure, (topsoil). Medium stiff, clayey SILT; brown, moist, medium plasticity, (residual soil). Becomes iron and manganese-stained below ±2 feet. Medium stiff to stiff, clayey SILT; light brown, iron-stained, moist, medium to high plasticity, relict structure, (residual soil). Plasticity decreases with depth. Becomes iron and manganese-stained below ±13 feet. BOTTOM OF TEST PIT

Project No.: 2081024

Surface Elevation: N/A (Approx.)

Date of Test Pit: April 3, 2008

Test Pit Log: TP-5B

Brooklane Heights and Oakmont Addition

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Trace roots extend to ±2 feet. Slow seepage encountered from ±3 to 4 feet.	1- 2- 3- 4- 5- 6- 7- 8- 9- 10– 11- 12- 13- 14- 15- 16- 17- 18- 19- 20–	S-6B-1 S-6B-2						Stiff SILT, some clay; brown, moist, medium plasticity, blocky structure, (topsoil). Extremely weak to very weak (R0 to R1), silty SANDSTONE; grey-light brown, iron and manganese-stained, medium plasticity, highly weathered, fine sand. Extremely weak (R0) SANDSTONE; light grey, iron and manganese-stained, highly weathered to decomposed, fine sand. BOTTOM OF TEST PIT

Project No.: 2081024

Surface Elevation: N/A (Approx.)

Date of Test Pit: April 3, 2008

Test Pit Log: TP-6B

Brooklane Heights and Oakmont Addition

Corvallis, Oregon

Appendix C

Laboratory Test Results

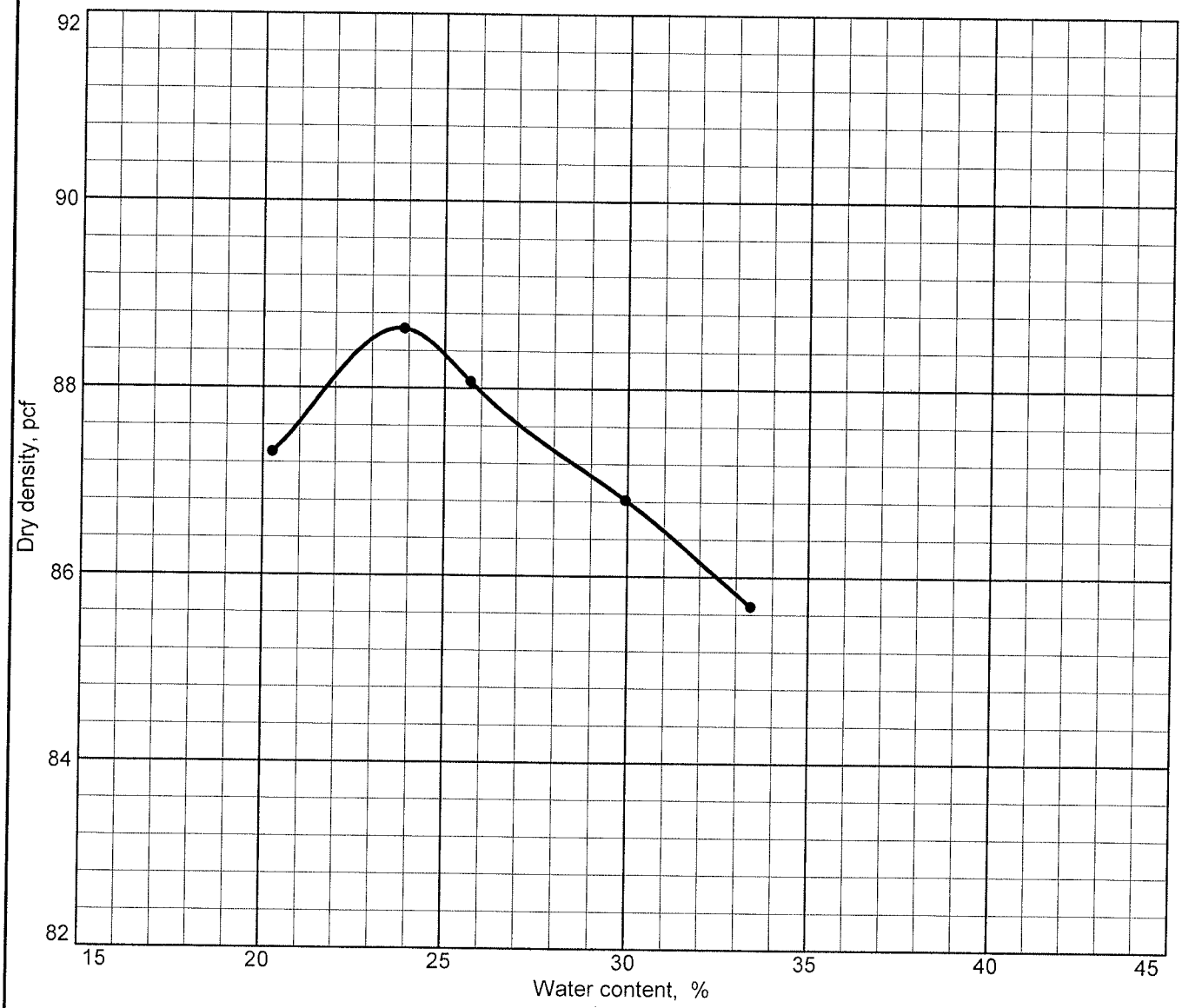
Professional
Geotechnical
Services

Foundation Engineering, Inc.

Table 1C. Natural Water Contents and Atterberg Limits

Sample Number	Sample Depth (ft)	Natural Water Content (percent)	LL	PL	PI	USCS Classification
S-1B-1	1½ - 2	23.1				
S-1B-3	5 - 6	36.0	48	34	14	ML
S-2B-1	1 - 1½	23.8				
S-2B-2	2½ - 3	34.7				
S-3B-1	1½ - 2	19.8	28	19	9	CL
S-4B-1	½ - 1	22.5				
S-5B-2	3½ - 4½	37.7	79	36	43	MH

MOISTURE - DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-00a Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
3.5-4.5'	MH		37.7%		79	43	0.5	

TEST RESULTS

Maximum dry density = 88.6 pcf

Optimum moisture = 23.8 %

MATERIAL DESCRIPTION

Light Brown Clayey SILT

Project No. 2086001-520 **Client:** Foundation Engineering Inc.; Project# 208-1-024

Project: Brooklane Heights & Oakmont Addition Corvallis, Oregon

● **Source:** 3880 **Sample No.:** S-5 B-2 **Elev./Depth:** 3.5-4.5'

Remarks:

Date: 4-17-2008

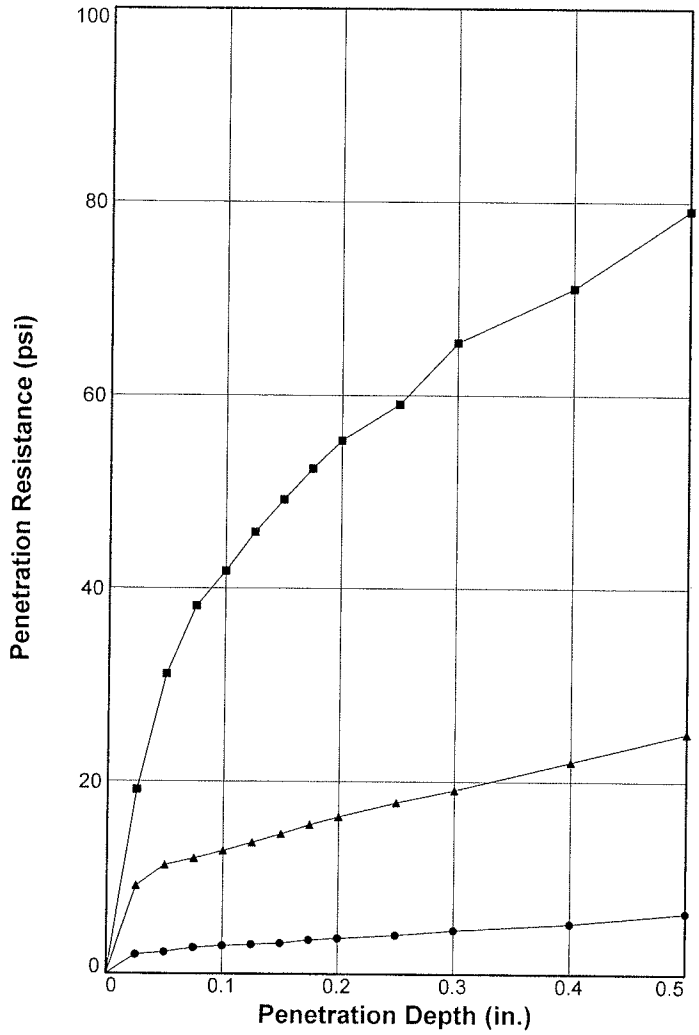
MOISTURE - DENSITY RELATIONSHIP TEST

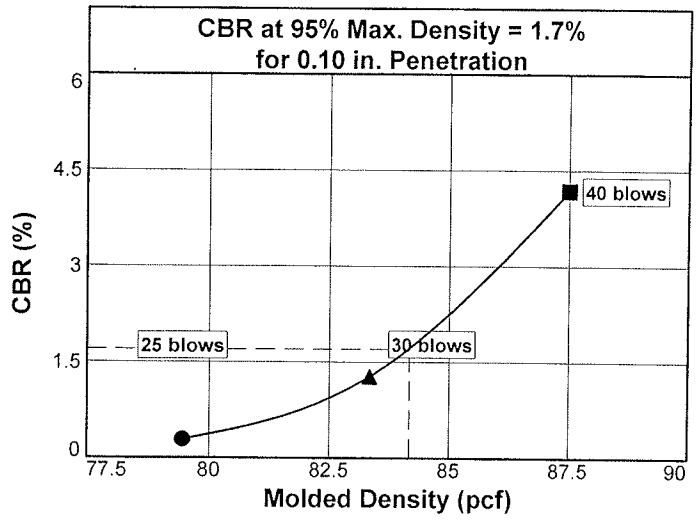
FEI Testing & Inspection, Inc.

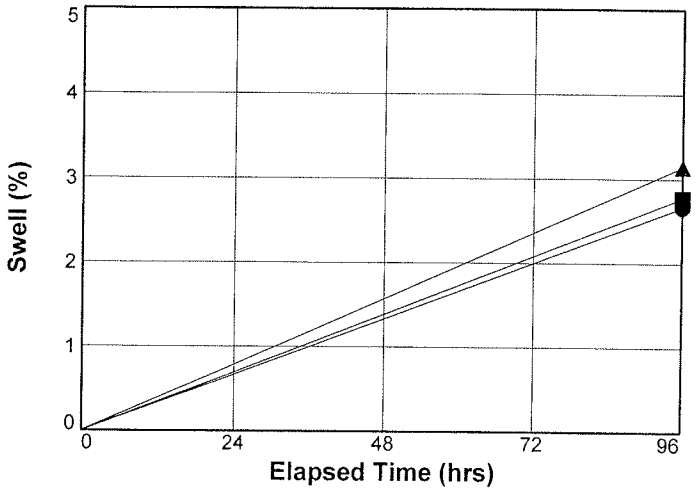
Corvallis, OR

Figure 1C

BEARING RATIO TEST REPORT
ASTM D 1883-05







	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	79.5	89.7	24.4	77.4	87.4	47.0	0.3	0.2	0.000	27	2.7
2 △	83.3	94	25.4	80.8	91.2	41.9	1.3	1.1	0.000	27	3.1
3 □	87.5	98.8	25.2	85.1	96.1	37.8	4.2	3.7	0.000	27	2.8

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Light Brown Clayey SILT	MH	88.6	23.8	79	43

Project No: 2086001-520

Project: Brooklane Heights & Oakmont Addition Corvallis, Oregon

Source of Sample: 3880 **Depth:** 3.5-4.5'

Sample Number: S-5 B-2

Date: 4/23/08

Test Description/Remarks:

BEARING RATIO TEST REPORT
FEI Testing & Inspection, Inc.
Corvallis, OR

Figure 2C

Foundation Engineering, Inc.
Professional Geotechnical Services

Scott Sanders
TC2 Investments, LLC
4411 SW Golf View Drive
Corvallis, Oregon 97333

March 16, 2007

Brooklane Heights Subdivision
Geotechnical Investigation for
Proposed Improvements in Existing Drainages
Corvallis, Oregon

Project 2051129-101

Dear Mr. Sanders:

We have completed the supplemental geotechnical investigation for the above-referenced project. The focus of this investigation was to evaluate the feasibility of proposed improvements (i.e., roadways and water detention basins) within the existing site drainages. This report includes a description of our work, a summary of our findings, and recommendations for design and construction.

BACKGROUND

A ±35-acre parcel is in planning and design stages for residential development. The proposed development is located on the northwest side of Brooklane Drive in Corvallis, Oregon. There are two separate owners for the southwest ±25 acres (Brooklane Heights) and the northeast ±10 acres (Oakmont Addition). Foundation Engineering, Inc. (FEI) previously completed a preliminary geotechnical investigation for the site, summarized in our report dated January 25, 2006.

Our previous investigation identified two mapped hazard areas (designated in The Corvallis Natural Hazards Map) as existing drainages in the south half of the Brooklane Heights portion of the development. We distinguished these features as the West Drainage and East Drainage. At the time that investigation was completed, roadways were planned to cross both drainages. We stated that it should be possible to mitigate risks of slope instability associated with these improvements. We understand two water detention ponds have since been proposed in the East Drainage, immediately north and south of the road embankment (proposed Badger Place). The City of Corvallis has requested additional design details and a feasibility evaluation for the proposed improvements.

Our current work focused on identifying geotechnical issues related to embankment construction within the East Drainage, as well as design and construction of the proposed detention ponds. Our scope of work for this phase was outlined in a proposal dated December 21, 2006, and was authorized by a signed Professional/Technical Services agreement dated February 22, 2007. We anticipate an additional phase will be completed that will address grading for individual lots, recommendations for foundation design and construction, and recommendations for pavement design.

RECENT FIELD EXPLORATION

Several site visits and a subsurface exploration were completed between October and December 2005. Results from this work were included in the preliminary geotechnical report. The recent field work is described below.

A total of six exploratory test pits were dug on February 23, 2007, using a CAT 312C tracked excavator. The test pits extended to maximum depths ranging from ±1.5 to 11 feet. Five of the explorations were completed to better characterize the subsurface profile within the East Drainage where two detention ponds and the Badger Place road embankment are planned. One test pit was dug in the West Drainage near the proposed road alignment for Wolverine Drive. All of the explorations terminated in bedrock. Where practical, Torvane tests were made on the side walls of the test pits to measure the shear strength of the soils above the rock. The soil profile, sampling depths and strength measurements are summarized on the appended test pit logs (Appendix B). The test pits are designated with an 'A' to distinguish them from previous explorations at the site.

The test pit locations are shown on Figure 1A (Appendix A). The locations were determined by pacing and visual reference and are approximate only. The surface and subsurface conditions are discussed below.

SITE CONDITIONS

Topography and Vegetation

The ground surface in the vicinity of the proposed detention ponds varies from gently to moderately sloping. The southernmost portion (where the downhill detention pond is planned) is relatively flat and increases in steepness to the north (where the uphill detention pond is planned). Site drawings indicate that the existing ground surface elevation varies by ±30 feet along the length of the proposed Badger Place. The low elevation point along the proposed road embankment occurs at the middle of the drainage where the road crosses a small channel (in which water was flowing at the time of our exploration). Rock outcrops were noted in the side slopes of the drainage.

Scattered oak and fir trees were observed in the East Drainage and underbrush includes scotch broom, blackberry bushes and low-ground scrub vegetation including poison oak.

Subsurface Soils/Rock

A general description of the soil and rock conditions encountered in the test pits is provided below. A more detailed description of conditions encountered in individual test pits is summarized in the appended logs (Appendix B).

TP-1A was dug in the West Drainage, near the proposed Wolverine Drive, and encountered a few inches of roots and sod underlain by extremely weak to very weak (R0 to R1) sandstone. The sandstone is grey to orange-brown and moderately weathered to decomposed.

TP-3A, TP-4A and TP-5A were dug in the East Drainage along the planned alignment of the proposed Badger Place embankment. TP-3A and TP-5A were dug on the side slopes of the drainage swale at the west and east ends of the planned embankment, respectively. TP-3A encountered medium stiff to stiff, brown, medium plasticity, clayey silt to a depth of ±3 feet, followed by stiff silt with trace sand to ±4 feet. Sandstone was encountered below ±4 feet, extending to ±4.5 feet (the limits of the exploration). TP-5A encountered ±6 inches of medium stiff, brown, clayey silt (topsoil), followed by sandstone. Practical digging refusal was encountered in the sandstone at a depth of ±1.5 feet.

TP-4A was dug near the bottom of the East Drainage, towards the center of the planned embankment. TP-4A encountered ±6 feet of brown, medium plasticity, clayey silt. The silt is soft to a depth of 3 feet and then becomes stiff. Stiff, brown to grey, low to medium plasticity clay with trace rock fragments was encountered from ±6 to 8 feet. Sandstone was encountered from ±8 to 10 feet (the limits of the exploration).

TP-2A was dug within the East Drainage, in the low-lying area near the proposed downhill detention pond. Soft to medium stiff, dark brown, medium plasticity, clayey silt was encountered to a depth of ±2.5 feet, followed by soft, light brown, medium plasticity, silty clay to a depth of ±7 feet. Stiff, brown to grey clay with trace rock fragments extended from ±7 to 10 feet and was underlain by extremely weak (R0) sandstone that extended to the bottom of the test pit (±11 feet).

TP-6A was dug within the East Drainage, in the vicinity of the proposed upslope detention pond. The soil conditions encountered in TP-6A were very similar to TP-5A (i.e., shallow sandstone overlain by a thin layer of topsoil).

Ground Water

During our recent exploration, we noted water flowing in the bottom of the East Drainage and relatively wet ground conditions in the low-lying area adjacent to the drainage. TP-2A and TP-4A, dug near the bottom of the drainage, encountered infiltration at depths of ±1.5 feet and ±3 feet, respectively. The infiltration rate in those test pits ranged from moderate to rapid. Slow seepage was also noted at a depth of ±5.5 feet in TP-1A.

ENGINEERING ANALYSIS AND DISCUSSION OF GEOTECHNICAL CONSIDERATIONS

Metolius Consulting provided FEI with drawings indicating the proposed locations of the roadways and detention ponds, and a cross-section of the proposed road embankment and ponds in the East Drainage.

West Drainage

Grading for the West Drainage will include modest cuts for the construction of Wolverine Drive, and we anticipate that the bulk of the excavation will expose shallow rock. Therefore, we believe the proposed grading plan for the West Drainage should be acceptable. Further engineering analysis and detailed recommendations focus on improvements within the East Drainage as discussed in the following sections.

East Drainage

We understand that significant cuts and fills will be required for improvements within the East Drainage. In general, our explorations encountered shallow rock when digging along the slopes of the drainage. When digging in the lower-lying area, we encountered thicker deposits of silts and clays with varying degrees of saturation and in-situ strength. Therefore, cuts within the East Drainage will expose a variety of soil and rock conditions.

We understand that, to the extent practical, on-site soils will be used for embankment construction. Therefore, we assumed that embankments will primarily be comprised of compacted silts and/or clays. Use of silts and clays for embankment construction will depend on the contractor's ability to moisture-condition the soils. Therefore, construction during wet weather should not be permitted.

Slope Stability

We completed slope stability analyses assuming slope configurations from the cross-section drawing provided by Metolius Consulting. Subsurface conditions were estimated based on the results of our recent explorations at TP-2A, TP-4A and TP-6A because these test pits were dug closest to the cross-sectional line. We interpolated between the test pits to estimate the rock surface. As noted above, our analysis assumed the bulk of the embankment fill would be comprised of compacted silts and clays. We also assumed that any soft soils encountered during construction would be excavated, moisture-conditioned and recompacted, or replaced with higher quality material. A nominal 500 psf surcharge was assumed acting at the top of the larger embankment to represent traffic along Badger Place. Figure 2A (Appendix A) includes the cross-section used for our analysis and the assumed subsurface profile.

The computer program XSTABL was used to generate a series of potential failure surfaces and to determine the minimum factor of safety (FS) for stability of the individual slopes. A circular failure was assumed for the analysis. We performed total and effective stress analysis to model both short-term and long-term stability of the slopes. For total stress analysis, we assumed a nominal undrained shear strength of 1,000 psf to represent the compacted embankment fill and stiff subgrade soils (assuming soft subgrade is excavated as required). For effective stress analysis, we assumed the soil will have an effective friction angle (ϕ') of 30 degrees and negligible cohesion. We assumed that the critical failure plane will not pass through the siltstone.

Minimum factors of safety against slope instability of greater than 3 were estimated for the total stress analyses. Typically, slope stability is not a concern if the factor of safety is greater than 1.5. Therefore, we believe that short-term stability of the berms will not be an issue (i.e., post-construction).

Minimum factors of safety between 1.0 and 1.5 were calculated for some of the slopes in the effective stress analyses. However, the analyses indicated that the potential failure surfaces would be very shallow, suggesting slope movement would be limited to the surficial soils and not a deep-seated rotational failure. We believe that shallow failures could be mitigated with proper erosion control, which may include roughening or stair-stepping the slopes to facilitate landscaping (i.e., seeding and watering). Slopes should be seeded, watered, and maintained concurrently with the site grading (rather than after the work) to provide erosion protection prior to the onset of wet weather.

Exposed sandstone surfaces will be susceptible to raveling and/or slaking when exposed to weather. This surficial raveling does not represent instability of the rock slope. Cutting the rock slopes at shallower angles typically will not lessen the erosion, and may actually increase the volume of debris that is generated if the area of the exposed rock face is increased. Seeding typically produces little growth of vegetation on the sandstone face. Therefore, we anticipate the minor erosion will be a continual maintenance issue.

A ±4-foot high rockery wall is shown in the cross-section at the north edge of the upper detention pond. If desired, FEI can provide consultation for wall design and construction after the limits of the wall are established and grading behind the wall is confirmed. We anticipate that additional work would include digging test pits to confirm the presence of shallow rock at the base of the wall. Some minimum setback (±5 feet) from the top of the slope should be provided to reduce the risk of undermining the wall due to erosion of the subgrade soil/rock.

Embankment Construction

Soft, wet soils were encountered ±3 to 7 feet below the ground surface in the low-lying areas within the East Drainage. Therefore, the contractor should anticipate some excavation and replacement of soils below the base of the embankments. Flowing water should be pumped and/or diverted away from the drainage uphill from the construction to promote aeration of fine-grained soils. Embankment construction should only be attempted during summer months when the ground surface will typically be drier. Pumping soils should be excavated and replaced with Stabilization Rock as outlined in the Recommendations section below. Embankment soils should be relatively free of organics. The use of high plasticity silts and clays as embankment fill is not recommended.

The toe of the fill should be keyed into weathered rock or approved stiff residual soil. A minimum key width of 8 feet is recommended, or as required to allow access for a large compactor. Initial lifts should be placed on relatively level terrain that is properly stripped. We recommend the initial ±3 feet of fill at the base of the key be

comprised of Stabilization Rock. The Stabilization Rock should be tracked in with repeated passes using a dozer, and adequate compaction should be confirmed by field observation. The mass of Stabilization Rock should be wrapped in Filter Fabric to minimize the migration of fine-grained soils into the rock. We also recommend placing a toe drain along the base of the key to collect flow and discharge it away from the base of the embankment.

The subgrade should be prepared by constructing a relatively level bench for placement of additional fill. Benching will likely require some rock excavation. Our field exploration encountered practical refusal using a modest-sized excavator at depths as shallow as ±1.5 feet in the sandstone. However, at most locations the surficial rock was fractured and may allow for deeper excavations.

It is possible that concentrated seepage or springs may develop in cut slopes at isolated locations. If so, a slope drain may be required to collect the moisture and reduce the risk of localized slope instability. The need for slope drains and details for their construction should be established by FEI once the cuts are exposed.

When placing on-site fill (i.e., silts and clays), density tests should be run frequently to verify adequate compaction. We recommend overbuilding the slopes and subsequent trimming to ensure compaction of the face of the finished slope. A schematic of proposed fills on existing slopes is provided on Figure 3A (Appendix A).

Detention Ponds

The new ponds will be constructed upslope from embankment fills. The proposed embankments will be built on sloping ground which is underlain by a sloping rock profile. Likely, ground water flow will preferentially travel along the soil-rock interface at the base of the embankment, which will tend to destabilize the slope. To decrease the risk of seepage and/or piping that could undermine the slopes or create localized instabilities, we recommend lining the ponds. A geomembrane liner is recommended as apposed to a clay liner due to the continual wetting and drying cycles that the ponds will likely experience. Installation of the liner should follow the manufacturer's recommendations. Installation details should include sealing around the pond outlets.

Preliminary grading plans include some pond slopes constructed at 2(h):1(v). Our stability analysis indicates that this slope configuration is possible if the fill is properly compacted. Geomembrane liners (which are adequately anchored) can be placed on slopes 2(h):1(v). However, manufacturers typically recommend placement on 3(h):1(v) slopes. Furthermore, it may be difficult to place and maintain a soil cover over a liner on a 2(h):1(v) slope. Therefore, it would be preferable to build 3(h):1(v) slopes or allow some of the liner to be exposed.

RECOMMENDATIONS

We have prepared the following recommendations for dry weather construction. Excavations will be difficult during wet weather due to water infiltration and the need for additional stabilization of the subgrade. In addition, compaction of on-site fill would be impractical and, therefore, the use of imported granular fill would be required. If wet weather construction is preferred, we should be contacted to revise our recommendations.

Materials and Construction Timing

1. On-site fill should consist of low plasticity silt, sand, rock, or mixtures of the above that are free of plastic clay, organic matter, or construction debris.

2. Stabilization Rock should consist of 6-inch minus, competent, angular, crushed rock, which is free-draining and does not contain clay, organic matter, or debris. Bar-run gravels are not acceptable for use as granular stabilization rock.

3. Drain Rock should consist of 2-inch minus, clean (less than 2% passing the #200 sieve), open-graded gravel or rock.

4. Filter Fabric should consist of a non-woven geotextile with a grab tensile strength greater than 200 lb., an apparent opening size (AOS) of between #70 and 100 (US Sieve) and a permitivity greater than 0.1 sec^{-1}.

5. The geomembrane liner should have a MARV thickness of at least 24 mil and MARV strength properties of at least 50 lb/in tear strength and 700 psi burst strength, respectively. The geomembrane should have long-term UV resistance capability. Installation should follow the manufacturer's specifications. We should be provided a specification sheet on the selected geotextile for approval prior to delivery to the site.

6. Compact all on-site fill in loose lifts not exceeding 12 inches. Thinner lifts may be required if light or hand-operated equipment is used. All fill should be compacted to a minimum of 95% relative compaction, unless otherwise specified. The maximum dry density of ASTM D 698 should be used as the standard for estimating relative compaction, unless otherwise specified. Field density tests should be run frequently to confirm adequate compaction. Field observation will be required to confirm adequate compaction of on-site material that is too variable or rock that is too coarse for conventional field and laboratory testing.

Excavation and Embankment Subgrade Preparation

Recommendations for excavation and preparation of fill areas are outlined below. A schematic of proposed fills on existing slopes is provided on Figure 3A. To reduce problems with ground water infiltration, we recommend the work be completed only during dry weather as follows:

7. Pump and/or divert flowing water away from the drainage uphill from the construction, if required, to facilitate drying the subgrade soils.

8. Strip the existing ground ±4 to 6 inches, or as required to remove roots and sod. Dispose of all strippings outside of construction areas.

9. Remove subgrade with an undrained shear strength of less than 0.5 tsf. The depth and areal extent should be determined by a representative of FEI.

10. Excavate a key trench at the toe of the embankments into weathered rock or approved stiff residual soil. The key should extend deep enough to allow for a minimum 3 feet of compacted Stabilization Rock at the base of the embankment. A minimum key width of ±8 feet is recommended, or as required to allow access for a large compactor.

11. Compact the approved subgrade to a depth of at least 12 inches, unless bedrock is exposed. In areas of embankment construction, the subgrade should be prepared by constructing a relatively level bench for placement of additional fill. Compaction may not be practical if the soils are too wet of optimum. Therefore, the site work should not be attempted during wet weather and should be delayed until the subgrade soils are sufficiently dry or until weather permits efficient aeration.

12. Maintain the moisture in the subgrade to prevent excessive drying and cracking. Immediately backfill the prepared subgrade with on-site fill.

13. Overexcavate and replace any areas of subgrade pumping with compacted Stabilization Fill.

Fill Placement and Compaction

14. Embankment fill should be placed in 12-inch, loose lifts and compacted as recommended. Embankment fill constructed using on-site soil should not include high plasticity clay, organic soils or construction debris. The bottom 3 feet of the embankment keys should be backfilled with Stabilization Rock. Construct permanent cut and fill slopes no steeper than 2(h):1(v). Soil cover over a geomembrane will likely require slopes no steeper than 3(h):1(v). A typical fill section is shown in Figure 3A.

15. Periods of wet weather or isolated showers may prevent adequate compaction of the on-site fill, depending on the quality of the material. Therefore, the work may have to be delayed or a higher quality material may be required to allow the work to continue in these conditions. In addition, the surface of the fill which has been exposed to wet weather conditions may have to be removed or aerated and recompacted.

16. Slopes should be seeded, watered, and maintained concurrently with the site grading (rather than after the work) to provide erosion protection prior to the onset of wet weather.

Toe Drainage

17. Provide a toe drain along the base of the embankment key. The drain should consist of 4-inch diameter or larger, perforated or slotted, PVC pipe wrapped in a Filter Fabric. The pipe should be bedded in at least 12 inches of Drain Rock, and the entire mass of Drain Rock should be wrapped in a similar filter fabric that laps at least 12 inches at the top. The drain pipe should extend the length of the key.

18. Discharge any flow collected from the drain at least 20 feet downslope from the base of the embankment. Provide energy dissipation at the pipe outlet to reduce erosion from continual flow

Detention Ponds

19. Geomembrane-lined slopes should be constructed no steeper than 3(h):1(v), or as recommended by the manufacturer.

20. Geomembrane installation should follow the manufacturer's specifications, which may include placement of cushioning and/or stabilization fill beneath the geomembrane. This fill (if required) should be taken into account for excavation and grading. Installation details should include sealing around the pond outlets.

REVIEW/CONSTRUCTION OBSERVATION/TESTING

We should be provided the opportunity to review all drawings and specifications that pertain to site work, grading and embankment construction. Site work will require field confirmation of subsurface conditions, subgrade and/or on-site soils used as fill. Mitigation of any subgrade pumping or establishing the extent or need for subgrade stabilization will require engineering review and judgment. That judgment should be provided by one of our representatives. Frequent field density tests should be run on all embankment fill. We will be available to provide the necessary geotechnical consultation during construction.

VARIATION OF SUBSURFACE CONDITIONS, USE OF THIS REPORT AND WARRANTY

The analysis, conclusions and recommendations contained herein are based on the assumption that the soil profiles encountered in the test pits are representative of overall site conditions. The above recommendations assume that we will have the opportunity to review final drawings and be present during construction to confirm assumed subsurface conditions. No changes in the enclosed recommendations should be made without our approval. We will assume no responsibility or liability for any engineering judgment, inspection or testing performed by others.

This report was prepared for the exclusive use of TC2 Investments, LLC; Metolius Consulting and design consultants for the proposed improvements in the East and West Drainages in the Brooklane Heights portion of the project in Corvallis, Oregon. Information contained herein should not be used for other sites or for unanticipated construction without our written consent. This report is intended for planning and design purposes. Contractors using this information to estimate construction quantities or costs do so at their own risk. Our services do not include any survey or assessment of potential surface contamination or contamination of the soil or ground water by hazardous or toxic materials. We assume that those services, if needed, have been completed by others.

Our work was done in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

It has been a pleasure assisting you with this phase of your project. Please do not hesitate to call if you have questions or require further assistance.

Sincerely,

FOUNDATION ENGINEERING, INC.

Jonathan C. Huffman
Staff Engineer

Travis C. Munson, P.E.
Staff Engineer

REGISTERED PROFESSIONAL ENGINEER
51530PE
OREGON
Feb. 8, 2000
TRAVIS C. MUNSON
EXPIRES: 12/31/08

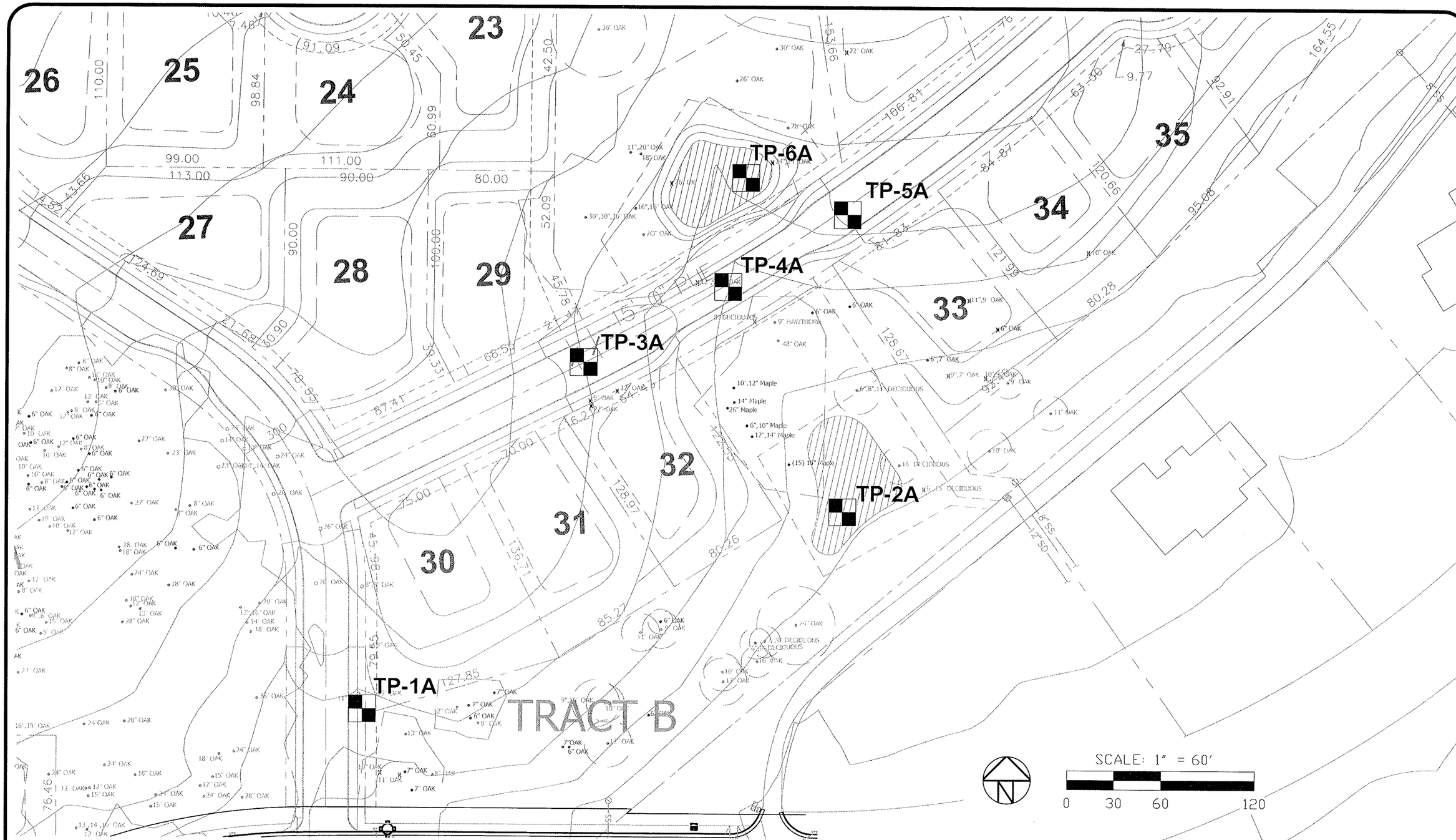
JCH/TCM/cs
Enclosures

Appendix A

Figures

Professional
Geotechnical
Services

Foundation Engineering, Inc.



NOTES:
1. TEST PIT LOCATIONS WERE ESTABLISHED BY PACING AND VISUAL REFERENCE AND ARE APPROXIMATE ONLY.
2. SEE REPORT FOR A DISCUSSION OF SUBSURFACE CONDITIONS.
3. BASE MAP WAS PROVIDED BY METOLIUS CONSULTING.

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DATE MAR 2007
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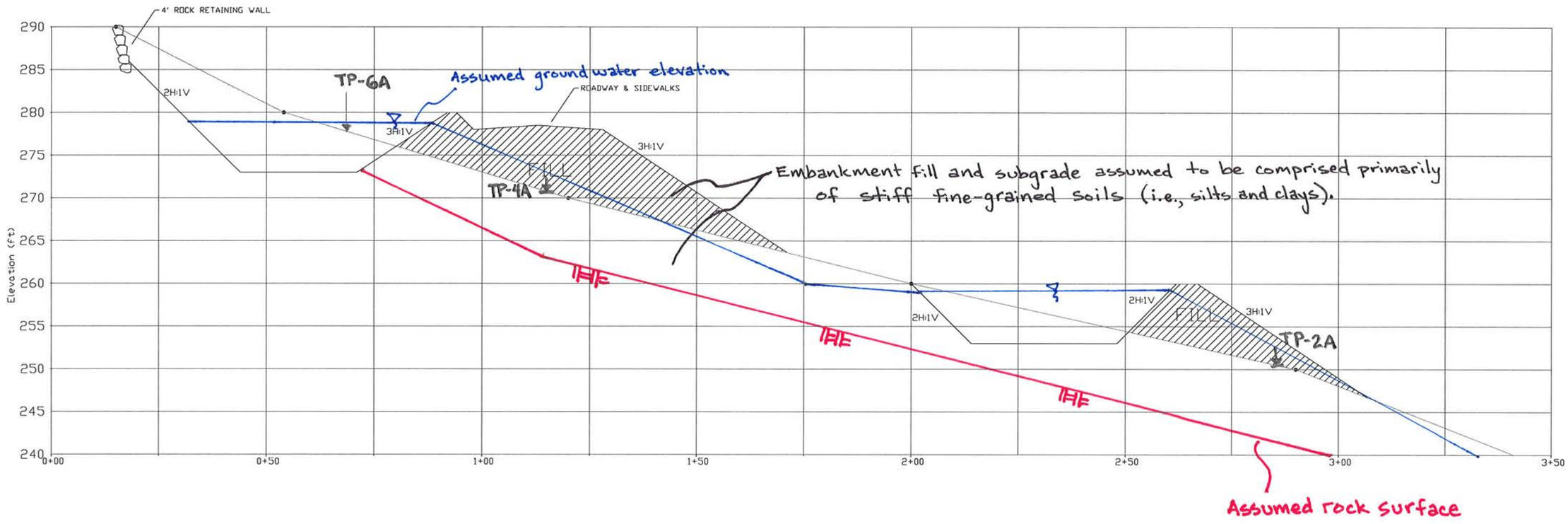
PROJECT NO. 2051129-101

EXPLORATION LOCATIONS

BROOKLANE HEIGHTS
CORVALLIS, OREGON

FIGURE NO. 1A

FILE NAME: Figure1A.dwg



NOTES:

1. CROSS-SECTION WAS PROVIDED BY METOLIUS CONSULTING.
2. ASSUMED SUBSURFACE CONDITIONS ARE BASED ON EXPLORATIONS AT TP-2A, TP-4A AND TP-6A. SOIL CONDITIONS OUTSIDE OF THE TEST PIT LOCATIONS WERE ESTIMATED BY INTERPOLATION.
3. THE CROSS-SECTION AND ASSUMED SOIL CONDITIONS WERE USED FOR SLOPE STABILITY ANALYSIS (SEE REPORT).
4. SEE FIGURE 3A AND REPORT FOR RECOMMENDED BENCHING DETAILS.

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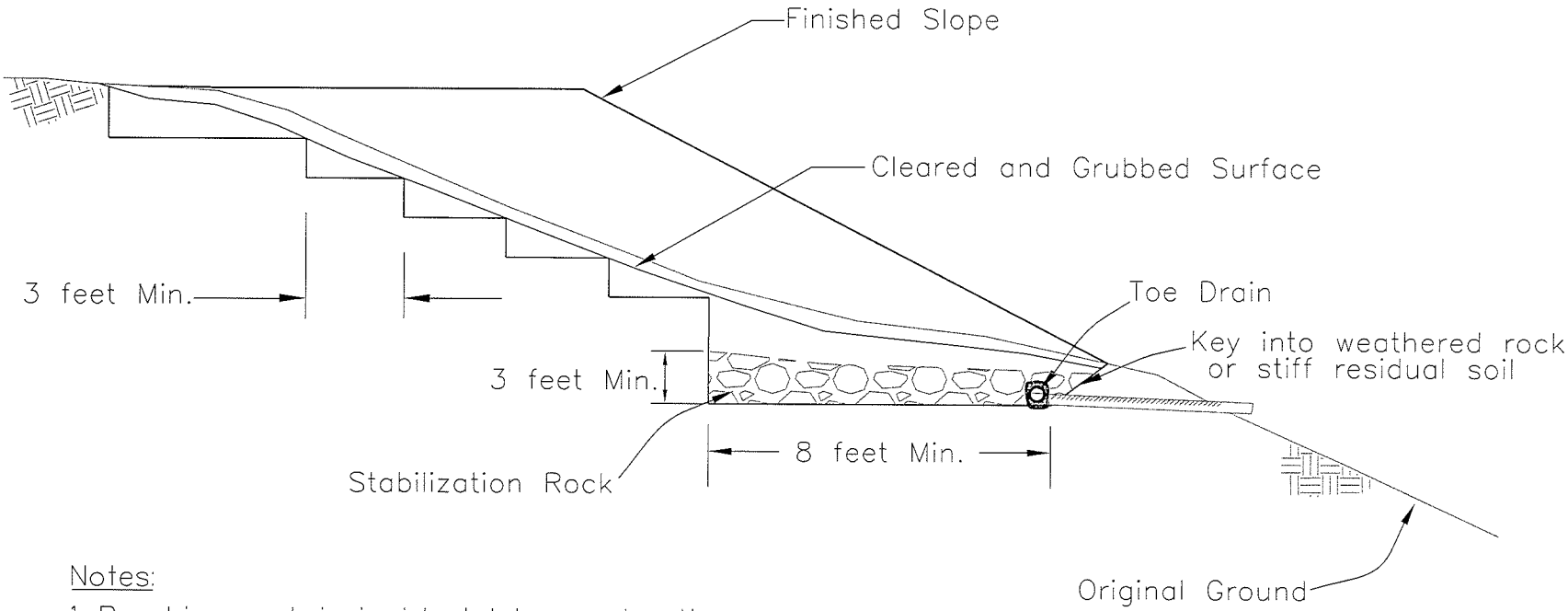
EAST DRAINAGE CROSS-SECTION WITH ASSUMED SOIL PROFILE
BROOKLANE HEIGHTS
CORVALLIS, OREGON

FIGURE NO. 2A

FILE NAME: Figure2A.dwg



Notes:

1. Benching work is incidental to construction.
2. Bench all new fill into existing ground.
3. Individual lifts should be constructed at slopes 10(h):1(v) or flatter.
4. See report for discussion of embankment soils, Stabilization Rock and toe drain.

Not to Scale

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STANDARD BENCHING DETAIL

BROOKLANE HEIGHTS
CORVALLIS, OREGON

FIGURE NO.
3A

FILE NAME:

Appendix B

Test Pit Logs

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DISTINCTION BETWEEN FIELD LOGS AND FINAL LOGS

A field log is prepared for each boring or test pit by our field representative. The log contains information concerning sampling depths and the presence of various materials such as gravel, cobbles, and fill, and observations of ground water. It also contains our interpretation of the soil conditions between samples. The final logs presented in this report represent our interpretation of the contents of the field logs and the results of the laboratory examinations and tests. Our recommendations are based on the contents of the final logs and the information contained therein and not on the field logs.

VARIATION IN SOILS BETWEEN TEST PITS AND BORINGS

The final log and related information depict subsurface conditions only at the specific location and on the date indicated. Those using the information contained herein should be aware that soil conditions at other locations or on other dates may differ. Actual foundation or subgrade conditions should be confirmed by us during construction.

TRANSITION BETWEEN SOIL OR ROCK TYPES

The lines designating the interface between soil, fill or rock on the final logs and on subsurface profiles presented in the report are determined by interpolation and are therefore approximate. The transition between the materials may be abrupt or gradual. Only at boring or test pit locations should profiles be considered as reasonably accurate and then only to the degree implied by the notes thereon.

SAMPLE OR TEST SYMBOLS

SH–3–4

- Sample Number
- Boring or Test Pit Number
- Sample Type

- Top of Sample Attempt
- Recovered Portion
- Unrecovered Portion (large circle indicates no recovery)
- Bottom of Sample Attempt

S – Grab Samples
SS – Standard Penetration Test Sample (split–spoon)
SH – Thin–walled Shelby Tube Sample
C – Core Sample
CS – Continuous Sample

▲ Standard Penetration Test Resistance equals the number of blows a 140 lb. weight falling 30 in. is required to drive a standard split–spoon sampler 1 ft. Practical refusal is equal to 50 or more blows per 6 in. of sampler penetration.

● Water Content (%).

UNIFIED SOIL CLASSIFICATION SYMBOLS

G – Gravel	W – Well Graded
S – Sand	P – Poorly Graded
M – Silt	L – Low Plasticity
C – Clay	H – High Plasticity
Pt – Peat	O – Organic

FIELD SHEAR STRENGTH TEST

Shear strength measurements on test pit side walls, blocks of soil or Shelby tube samples are typically made with Torvane or pocket penetrometer devices.

TYPICAL SOIL/ROCK SYMBOLS

Sand	Silt
Clay	Gravel
Basalt	Siltstone

WATER TABLE

▼ Water Table Location

(1/31/00) Date of Measurement

Piezometer Tip Location (if used)

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SYMBOL KEY
BORING AND TEST PIT LOGS

Explanation of Common Terms Used in Soil Descriptions

Field Identification	Cohesive Soils			Granular Soils	
	SPT	S_u^* (tsf)	Term	SPT	Term
Easily penetrated several inches by fist.	0 – 1	< 0.125	Very Soft	0 – 4	Very Loose
Easily penetrated several inches by thumb.	2 – 4	0.125–0.25	Soft	5 – 10	Loose
Can be penetrated several inches by thumb with moderate effort.	5 – 8	0.25 – 0.50	Medium Stiff (Firm)	11 – 30	Medium Dense
Readily indented by thumb but penetrated only with great effort.	9 – 15	0.50 – 1.0	Stiff	31 – 50	Dense
Readily indented by thumbnail.	16 – 30	1.0 – 2.0	Very Stiff	> 50	Very Dense
Indented with difficulty by thumbnail.	31 – 60	> 2.0	Hard		

* Undrained shear strength

Term	Soil Moisture Field Description
Dry	Absence of moisture. Dusty. Dry to the touch.
Damp	Soil has moisture. Cohesive soils are below plastic limit and usually moldable.
Moist	Grains appear darkened, but no visible water. Silt/clay will clump. Sand will bulk. Soils are often at or near plastic limit.
Wet	Visible water on larger grain surfaces. Sand and cohesionless silt exhibit dilatancy. Cohesive silt/clay can be readily remolded. Soil leaves wetness on the hand when squeezed. "Wet" indicates that the soil is wetter than the optimum moisture content and above the plastic limit.

Term	PI	Plasticity Field Test
Nonplastic	0 – 3	Cannot be rolled into a thread.
Low Plasticity	3 – 15	Can be rolled into a thread with some difficulty.
Medium Plasticity	15 – 30	Easily rolled into thread.
High Plasticity	> 30	Easily rolled and rerolled into thread.

Term	Soil Structure Criteria
Stratified	Alternating layers at least 1 inch thick – describe variation.
Laminated	Alternating layers at less than 1 inch thick – describe variation.
Fissured	Contains shears and partings along planes of weakness.
Slickensides	Partings appear glossy or striated.
Blocky	Breaks into lumps – crumbly.
Lensed	Contains pockets of different soils – describe variation.

Term	Soil Cementation Criteria
Weak	Breaks under light finger pressure.
Moderate	Breaks under hard finger pressure.
Strong	Will not break with finger pressure.

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COMMON TERMS
SOIL DESCRIPTIONS

Explanation of Common Terms Used in Rock Descriptions

Field Identification		UCS (psi)	UCS (MPa)	Strength (Hardness)
Indented by thumbnail.	R0	< 100	0.25–1.0	Extremely Weak (Extremely Soft)
Crumbles under firm blows with geological hammer, can be peeled by a pocket knife.	R1	100–1000	1.0–5.0	Very Weak (Very Soft)
Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with geological hammer.	R2	1000–4000	5.0–25	Weak (Soft)
Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow of geological hammer.	R3	4000–8000	25–50	Medium Strong (Medium Hard)
Specimen requires more than one blow of geological hammer to fracture it.	R4	8000–16000	50–100	Strong (Hard)
Specimen requires many blows of geological hammer to fracture it.	R5	16000–36000	100–250	Very Strong (Very Hard)
Specimen can only be chipped with geological hammer.	R6	> 36000	> 250	Extremely Strong (Extremely Hard)

Term	Weathering Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric.
Moderately Weathered	Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Highly Weathered	Rock can be excavated with geologist's pick. All dicontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Spacing (meters)	Spacing (feet)	Spacing Term	Bedding/Foliation
< 0.06	< 2 in.	Very Close	Very Thin
0.06 – 0.30	2 in. – 1 ft.	Close	Thin
0.30 – 0.90	1 ft. – 3 ft.	Moderately Close	Medium
0.90 – 3.0	3 ft. – 10 ft.	Wide	Thick
> 3.0	> 10 ft.	Very Wide	Very Thick (Massive)

Vesicle Term	Volume
Some	3 – 20%
Highly	20 – 50%
Scoria	> 50%

Stratification Term	Description
Lamination	<0.39 in. thick beds
Fissile	Preferred break along laminations
Parting	Preferred break direction
Foliation	Metamorphic layering of minerals

RQD %	Designation	RQD %	Designation
0 – 25	Very Poor	75 – 90	Good
25 – 50	Poor	90 – 100	Excellent
50 – 75	Fair		

Rock Quality Designation (RQD) is the percent of a core run with intact lengths greater than 4.0 in. excluding breaks caused by drilling.

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COMMON TERMS
ROCK DESCRIPTIONS

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: short grass, blackberry bushes and rock fragments.								ROOTS and SOD.
	1							Extremely weak to very weak (R0 to R1) SANDSTONE; grey to orange-brown, moderately weathered to decomposed, highly fractured, (Spencer Formation).
	2							
	3							
	4							
	5							
Slow seepage noted at ±5.5 feet.	6							BOTTOM OF TEST PIT
	7							
	8							
	9							
	10							
	11							
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-1A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: tall grass and blackberry bushes.								Soft to medium stiff, clayey SILT; dark brown, moist, medium plasticity, blocky structure, (topsoil/alluvium).
	1							
	2							
Moderate seepage noted at ±3 feet.	3	S-2A-1				0.25		Soft, silty CLAY; light brown, trace iron-staining, wet, medium plasticity, micaceous, (alluvium).
	4							
	5							
	6							
	7							Stiff CLAY, some gravel-sized rock fragments; brown to grey, trace iron-staining, moist to wet, medium plasticity, (residual soil).
	8							
	9							
	10							Extremely weak (R0) SANDSTONE; brown to grey, decomposed to highly weathered, highly fractured, (Spencer Formation).
	11							BOTTOM OF TEST PIT
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-2A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and tall shrubs.	1							Medium stiff to stiff, clayey SILT; brown, moist, medium plasticity, micaceous, (possible alluvium).
	2							
	3							Stiff SILT, trace fine sand; orange, dry to damp, low plasticity, (residual soil).
No ground water encountered to the limit of excavation.	4							Very weak (R1) SANDSTONE; grey-brown, moderately weathered, very close to moderately close joints, (Spencer Formation).
	5							BOTTOM OF TEST PIT
	6							
	7							
	8							
	9							
	10							
	11							
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-3A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and short brush.	1							Soft, clayey SILT; brown, wet, medium plasticity, (alluvium).
Rapid seepage noted at ±1.5 feet.	2							
	3							Stiff, clayey SILT; brown, wet, medium plasticity, (alluvium).
	4							
	5							
	6							Stiff CLAY, some gravel-sized rock fragments; brown to grey, wet, low to medium plasticity, (residual soil).
	7							
	8							Extremely weak (R0) SANDSTONE; orange-brown, decomposed to highly weathered, highly fractured, (Spencer Formation).
	9							
	10							BOTTOM OF TEST PIT
	11							
	12							

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-4A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface: grass and shrubs. Practical refusal encountered at ±1.5 feet. No ground water encountered to the limit of excavation.	1 2 3 4 5 6 7 8 9 10 11 12							Medium stiff, clayey SILT, some organics; brown, damp, low plasticity, blocky structure, (topsoil). Weak (R2) SANDSTONE; light brown, moderately to highly weathered, very close to moderately close joints, (Spencer Formation). BOTTOM OF TEST PIT

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-5A

Brooklane Heights

Corvallis, Oregon

Comments	Depth, Feet	Sample #	Location	Class Symbol	Water Table	C, TSF	Symbol	Soil and Rock Description
Surface:	1 2 3 4 5 6 7 8 9 10 11 12							Medium stiff, clayey SILT, some organics; brown, iron-stained, damp, low plasticity, blocky structure, (topsoil). Extremely weak (R0) grading to moderately strong (R2) SANDSTONE; grey to brown, decomposed to slightly weathered, very close to moderately close joints, (Spencer Formation).
Practical refusal encountered at ±4 feet. No ground water encountered to the limit of excavation.								BOTTOM OF TEST PIT

Project No.: 2051129-101

Surface Elevation: N/A (Approx.)

Date of Test Pit: February 23, 2007

Test Pit Log: TP-6A

Brooklane Heights

Corvallis, Oregon

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 7
Corvallis Rainfall Curves

RAINFALL I-D-F CURVES
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Approach

Using NOAA methodology, synthesize rainfall curves using the design rainfall recommended in Section 3.4.1 of the Corvallis Stormwater Master Plan (SWMP), September 2002. The SWMP references the National Oceanic and Atmospheric Administration (NOAA) Atlas X (1973) as a source document for deriving design storms.

Purpose

Rainfall Intensity-Duration-Frequency curves are necessary tools for the estimation of stormwater runoff quantity from design storms.

Hydrologic Design Criteria

1) Use the City of Corvallis Stormwater Master Plan (SWMP), September, 2002 including Technical Memorandum No. 4 (November 10, 1999) found in Appendix F.

2) Calculate SWMP 24-hour Design Storm precipitation with rainfall multiplier.

3) Using the SWMP referenced NOAA rainfall atlas, determine rainfall for 1-hour and 6-hour storms.

4) Evaluate storm return periods (T) of 2, 5, 10, 25 and 100 years.

5) Using the prescribed rainfall data, develop exponential functions for each of the 1-hour, 6-hour and 24-hour rainfall data.

6) Interpolate the functions for storm return periods (T) of 1, 2, 3, 5, 10, 25, 50 and 100 years. .

7) Using NOAA methodology ("Short Duration Rainfall Relations for the Western United States, " Arkell & Richards, NOAA), apply multipliers for short duration rainfall events of 5, 10, 15, 30 and 60 minutes.

8) Evaluate the exponential functions for both short duration and long duration storms.

9) Create a matrix of rainfall intensity values from the derived exponential functions.

10) Develop exponential functions for the 1-year through 100-year storm frequency rainfall rates.

11) Plot the derived Intensity-Duration-Frequency (I-D-F) rainfall curves.

12) From the derived I-D-F curve functions, calculate rainfall for short duration (2-minute through 60-minute) storms.

Design Storms for Corvallis, Oregon

From City of Corvallis Stormwater Master Plan, 3.4.1 Design Storms, precipitation values are as follows

$P_{10} := 3.64$ inches (10-yr return, 24-hr precipitation)

Table 3-1. Design Storm Rainfall Multiplier

Return frequency (years)	2	5	10	25	100
Multiplier	0.7	0.8	1.0	1.1	1.3

Return Periods (yrs) **SWMP Multiplier** **T-year 24-hr Precip (in)**

$$T := \begin{pmatrix} 2 \\ 5 \\ 10 \\ 25 \\ 100 \end{pmatrix} \quad M := \begin{pmatrix} 0.7 \\ 0.8 \\ 1.0 \\ 1.1 \\ 1.3 \end{pmatrix} \quad P := P_{10} \cdot M \quad P = \begin{pmatrix} 2.55 \\ 2.91 \\ 3.64 \\ 4.00 \\ 4.73 \end{pmatrix}$$

NOAA Precipitation for CORVALLIS, Oregon

From inspection of NOAA USDA/SCS Isopluvial Precipitation Maps for **CORVALLIS**, Oregon determine rainfall data for 1-hour and 6-hour storms corresponding to the SWMP 24-hour storm rainfall data.

Return Periods (yrs) **T-yr 1-hr Precip (in)** **T-yr 6-hr Precip (in)** **T-yr 24-hr Precip (in)**

$$T = \begin{pmatrix} 2 \\ 5 \\ 10 \\ 25 \\ 100 \end{pmatrix} \quad P_1h := \begin{pmatrix} 0.58 \\ 0.75 \\ 0.92 \\ 1.14 \\ 1.3 \end{pmatrix} \quad P_6h := \begin{pmatrix} 1.2 \\ 1.5 \\ 1.65 \\ 1.9 \\ 2.2 \end{pmatrix} \quad P_24h := P \quad P_24h = \begin{pmatrix} 2.55 \\ 2.91 \\ 3.64 \\ 4.00 \\ 4.73 \end{pmatrix}$$

Data Smoothing & Interpolation

With the data arrays, simulate a function of the simple form $ax^b + c$

$$Guess := \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$ for coefficents a, b, c

Interpolated Exponential Functions for Rainfall Data

1-hour Precipitation Function:

$$coeff_1 := pwrfit(T, P_1h, Guess)$$

$$coeff_1 = \begin{pmatrix} 160434 \\ 1 \times 10^{-6} \\ -160433 \end{pmatrix}$$

$$P_1(t) := coeff_1_0 \cdot t^{coeff_1_1} + coeff_1_2$$

6-hour Precipitation Function:

$$coeff_6 := pwrfit(T, P_6h, Guess)$$

$$coeff_6 = \begin{pmatrix} 146420 \\ 2 \times 10^{-6} \\ -146419 \end{pmatrix}$$

$$P_6(t) := coeff_6_0 \cdot t^{coeff_6_1} + coeff_6_2$$

24-hour Precipitation Function:

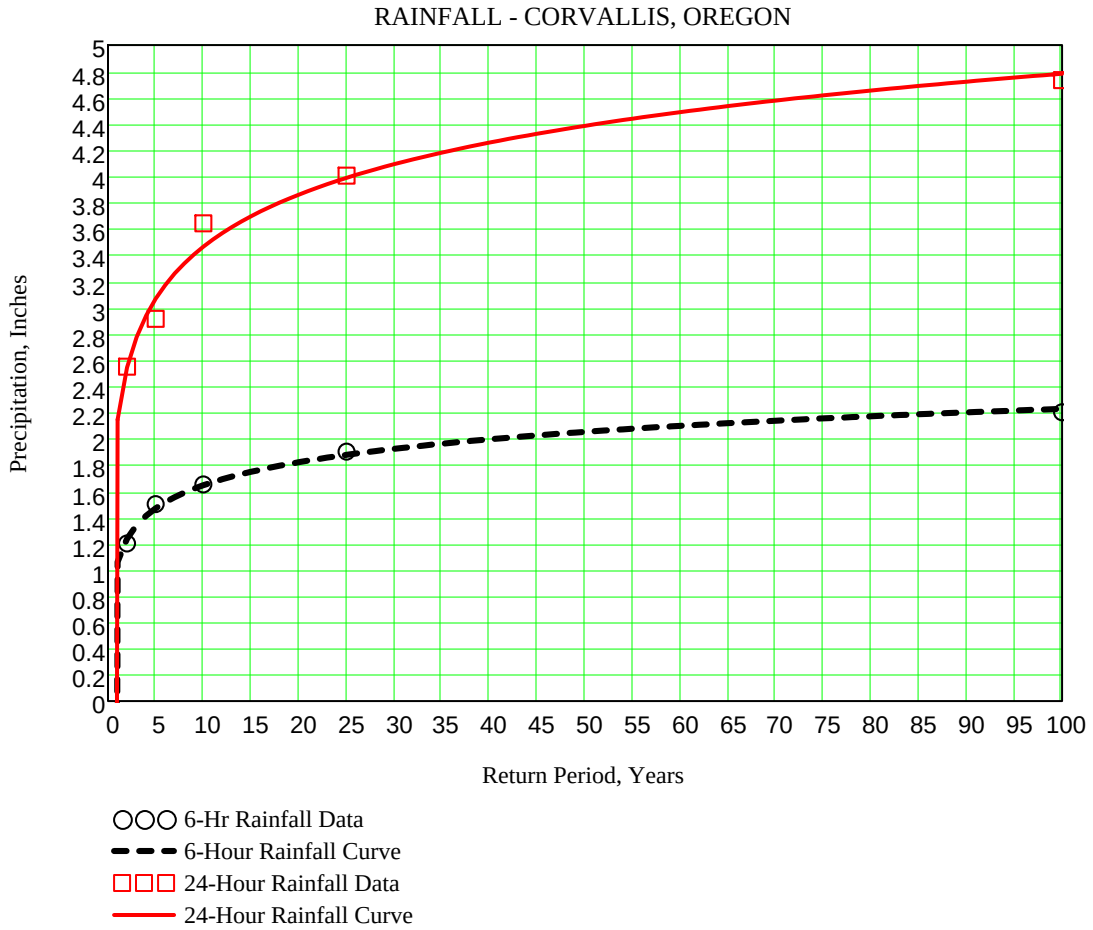
$$coeff_24 := pwrfit(T, P_24h, Guess)$$

$$coeff_24 = \begin{pmatrix} 265362 \\ 2 \times 10^{-6} \\ -265359 \end{pmatrix}$$

$$P_24(t) := coeff_24_0 \cdot t^{coeff_24_1} + coeff_24_2$$

CURVE & DATA PLOTS

Plot the rainfall data and fitted curves over a return period range of $t := 0 .. 100$ years.



Interpolated points of interest

Return Period (years)	6-hr Rainfall (inches)	24-hr Rainfall (inches)
1	1.06	2.14
2	1.24	2.54
3	1.34	2.77
5	1.47	3.07
10	1.64	3.46
25	1.88	3.99
50	2.05	4.38
100	2.23	4.78

$T := \begin{pmatrix} 1 \\ 2 \\ 3 \\ 5 \\ 10 \\ 25 \\ 50 \\ 100 \end{pmatrix}$ $P_6(T) = \begin{pmatrix} 1.06 \\ 1.24 \\ 1.34 \\ 1.47 \\ 1.64 \\ 1.88 \\ 2.05 \\ 2.23 \end{pmatrix}$ $P_24(T) = \begin{pmatrix} 2.14 \\ 2.54 \\ 2.77 \\ 3.07 \\ 3.46 \\ 3.99 \\ 4.38 \\ 4.78 \end{pmatrix}$

Multipliers for Various Durations to One Hour (NOAA "Short Duration Rainfall Relations")

Five minutes	$M_5 := 0.25$	$P_5m := M_5 \cdot P_1(T)$
Ten minutes	$M_{10} := 0.45$	$P_10m := M_{10} \cdot P_1(T)$
Fifteen minutes	$M_{15} := 0.57$	$P_15m := M_{15} \cdot P_1(T)$
Thirty minutes	$M_{30} := 0.79$	$P_30m := M_{30} \cdot P_1(T)$
Sixty minutes	$M_{60} := 1.00$	$P_60m := M_{60} \cdot P_1(T)$

Return Period (years)	5-min Duration Design Storm (inches)	10-min Duration Design Storm (inches)	15-min Duration Design Storm (inches)	30-min Duration Design Storm (inches)
1	0.116	0.209	0.264	0.366
2	0.149	0.268	0.340	0.471
3	0.168	0.303	0.384	0.532
5	0.193	0.347	0.439	0.609
10	0.226	0.406	0.515	0.713
25	0.269	0.485	0.614	0.851
50	0.303	0.545	0.690	0.956
100	0.336	0.604	0.765	1.060

Derived rainfall functions for 1-hour, 6-hour and 24-hour storms

One-hour modified storm	$P_1h := P_1(T)$
Six-hour modified storm	$P_6h := P_6(T)$
Twenty-four hour modified storm	$P_24h := P_24(T)$

Return Period (years)	1-hour Duration Design Storm (inches)	6-hour Duration Design Storm (inches)	24-hour Duration Design Storm (inches)
1	0.46	1.06	2.14
2	0.60	1.24	2.54
3	0.67	1.34	2.77
5	0.77	1.47	3.07
10	0.90	1.64	3.46
25	1.08	1.88	3.99
50	1.21	2.05	4.38
100	1.34	2.23	4.78

Create a matrix of rainfall intensity values (inches/hour)

$RAIN_1 := augment(P_5m \cdot 12, P_10m \cdot 6, P_15m \cdot 4, P_30m \cdot 2)$

$RAIN_2 := augment\left(P_60m, \frac{P_6h}{6}, \frac{P_24h}{24}\right)$

$RAIN := augment(RAIN_1, RAIN_2)$

$$RAIN = \begin{pmatrix} 1.39 & 1.25 & 1.06 & 0.73 & 0.46 & 0.18 & 0.09 \\ 1.79 & 1.61 & 1.36 & 0.94 & 0.60 & 0.21 & 0.11 \\ 2.02 & 1.82 & 1.54 & 1.06 & 0.67 & 0.22 & 0.12 \\ 2.31 & 2.08 & 1.76 & 1.22 & 0.77 & 0.24 & 0.13 \\ 2.71 & 2.44 & 2.06 & 1.43 & 0.90 & 0.27 & 0.14 \\ 3.23 & 2.91 & 2.46 & 1.70 & 1.08 & 0.31 & 0.17 \\ 3.63 & 3.27 & 2.76 & 1.91 & 1.21 & 0.34 & 0.18 \\ 4.03 & 3.62 & 3.06 & 2.12 & 1.34 & 0.37 & 0.20 \end{pmatrix}$$

Separate and invert the arrays of rainfall values for the specified durations

1-year Storm (in/hr)

$P_1 := \left(RAIN^T\right)^{\langle 0 \rangle}$

$$P_1 = \begin{pmatrix} 1.39 \\ 1.25 \\ 1.06 \\ 0.73 \\ 0.46 \\ 0.18 \\ 0.09 \end{pmatrix}$$

2-year Storm (in/hr)

$P_2 := \left(RAIN^T\right)^{\langle 1 \rangle}$

$$P_2 = \begin{pmatrix} 1.79 \\ 1.61 \\ 1.36 \\ 0.94 \\ 0.60 \\ 0.21 \\ 0.11 \end{pmatrix}$$

3-year Storm (in/hr)

$P_3 := \left(RAIN^T\right)^{\langle 2 \rangle}$

$$P_3 = \begin{pmatrix} 2.02 \\ 1.82 \\ 1.54 \\ 1.06 \\ 0.67 \\ 0.22 \\ 0.12 \end{pmatrix}$$

5-year Storm (in/hr)

$P_5 := \left(RAIN^T\right)^{\langle 3 \rangle}$

$$P_5 = \begin{pmatrix} 2.31 \\ 2.08 \\ 1.76 \\ 1.22 \\ 0.77 \\ 0.24 \\ 0.13 \end{pmatrix}$$

10-year Storm (in/hr)

$P_10 := \left(RAIN^T\right)^{\langle 4 \rangle}$

$$P_10 = \begin{pmatrix} 2.71 \\ 2.44 \\ 2.06 \\ 1.43 \\ 0.90 \\ 0.27 \\ 0.14 \end{pmatrix}$$

25-year Storm (in/hr)

$P_25 := \left(RAIN^T\right)^{\langle 5 \rangle}$

$$P_25 = \begin{pmatrix} 3.23 \\ 2.91 \\ 2.46 \\ 1.70 \\ 1.08 \\ 0.31 \\ 0.17 \end{pmatrix}$$

50-year Storm (in/hr)

$P_50 := \left(RAIN^T\right)^{\langle 6 \rangle}$

$$P_50 = \begin{pmatrix} 3.63 \\ 3.27 \\ 2.76 \\ 1.91 \\ 1.21 \\ 0.34 \\ 0.18 \end{pmatrix}$$

100-year Storm (in/hr)

$P_100 := \left(RAIN^T\right)^{\langle 7 \rangle}$

$$P_100 = \begin{pmatrix} 4.03 \\ 3.62 \\ 3.06 \\ 2.12 \\ 1.34 \\ 0.37 \\ 0.20 \end{pmatrix}$$

Express storm durations of interest as an array, in minutes

$$DUR := \begin{pmatrix} 5 \\ 10 \\ 15 \\ 30 \\ 60 \\ 360 \\ 1440 \end{pmatrix}$$

Data Smoothing & Interpolation

With the data arrays, generate an exponential function of the simple form $\mathbf{ax^b + c}$

$$Guess := \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$ for coefficents a, b, c

Interpolated Exponential Functions for Modified Precipitation Rates

100-Yr Return:

$coeff := pwrfit(DUR, P_100, Guess)$ $\quad P_100(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

50-Yr Return:

$coeff := pwrfit(DUR, P_50, Guess)$ $\quad P_50(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

25-Yr Return:

$coeff := pwrfit(DUR, P_25, Guess)$ $\quad P_25(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

10-Yr Return:

$coeff := pwrfit(DUR, P_10, Guess)$ $\quad P_10(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

5-Yr Return:

$coeff := pwrfit(DUR, P_5, Guess)$ $\quad P_5(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

3-Yr Return:

$coeff := pwrfit(DUR, P_3, Guess)$ $\quad P_3(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

2-Yr Return:

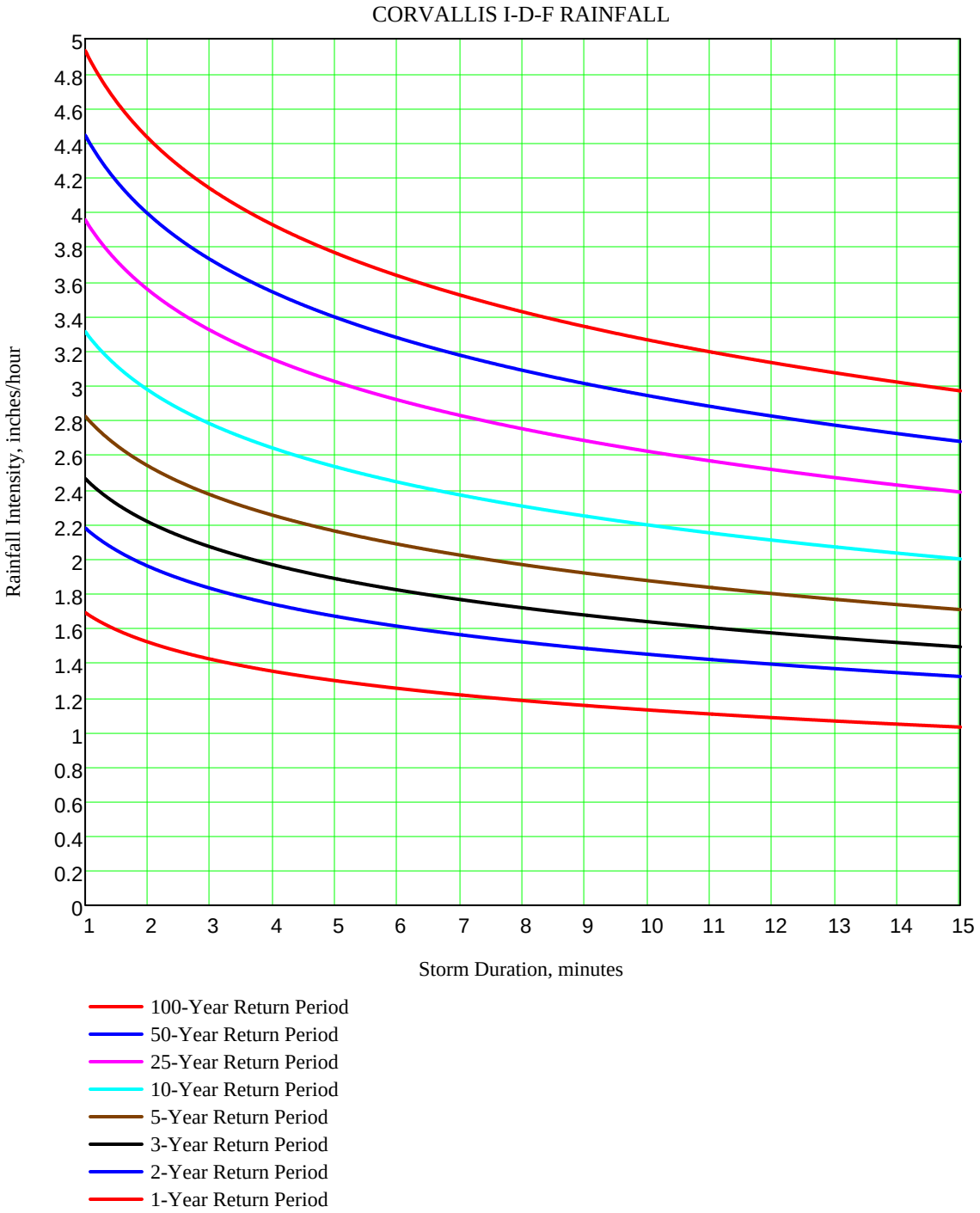
$coeff := pwrfit(DUR, P_2, Guess)$ $\quad P_2(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

1-Yr Return:

$coeff := pwrfit(DUR, P_1, Guess)$ $\quad P_1(t) := coeff_0 \cdot t^{coeff_1} + coeff_2$

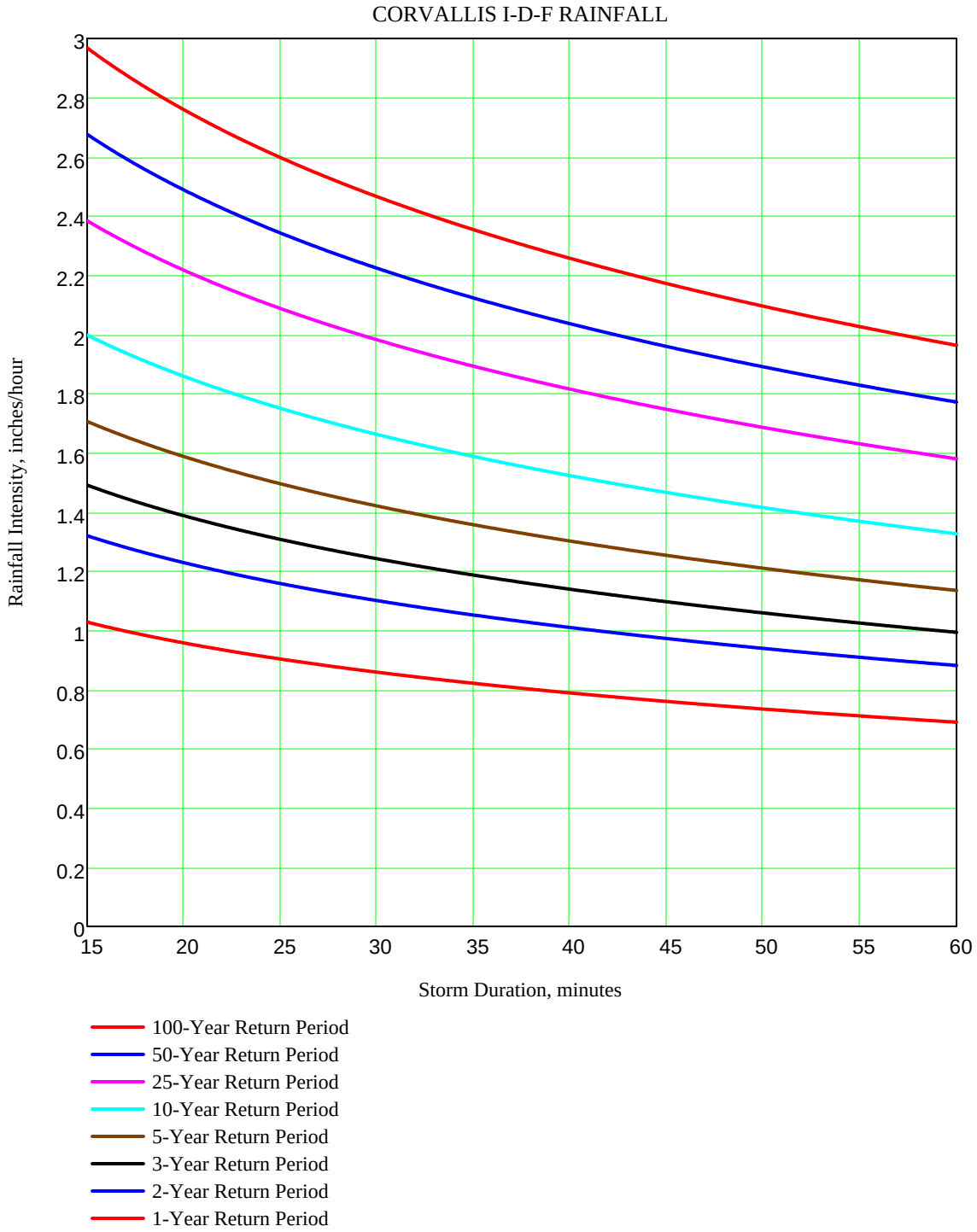
PLOT THE RAINFALL I-D-F CURVES - Graph 1 to 15 Minute Storms

$t := 1, 1.01 .. 15$



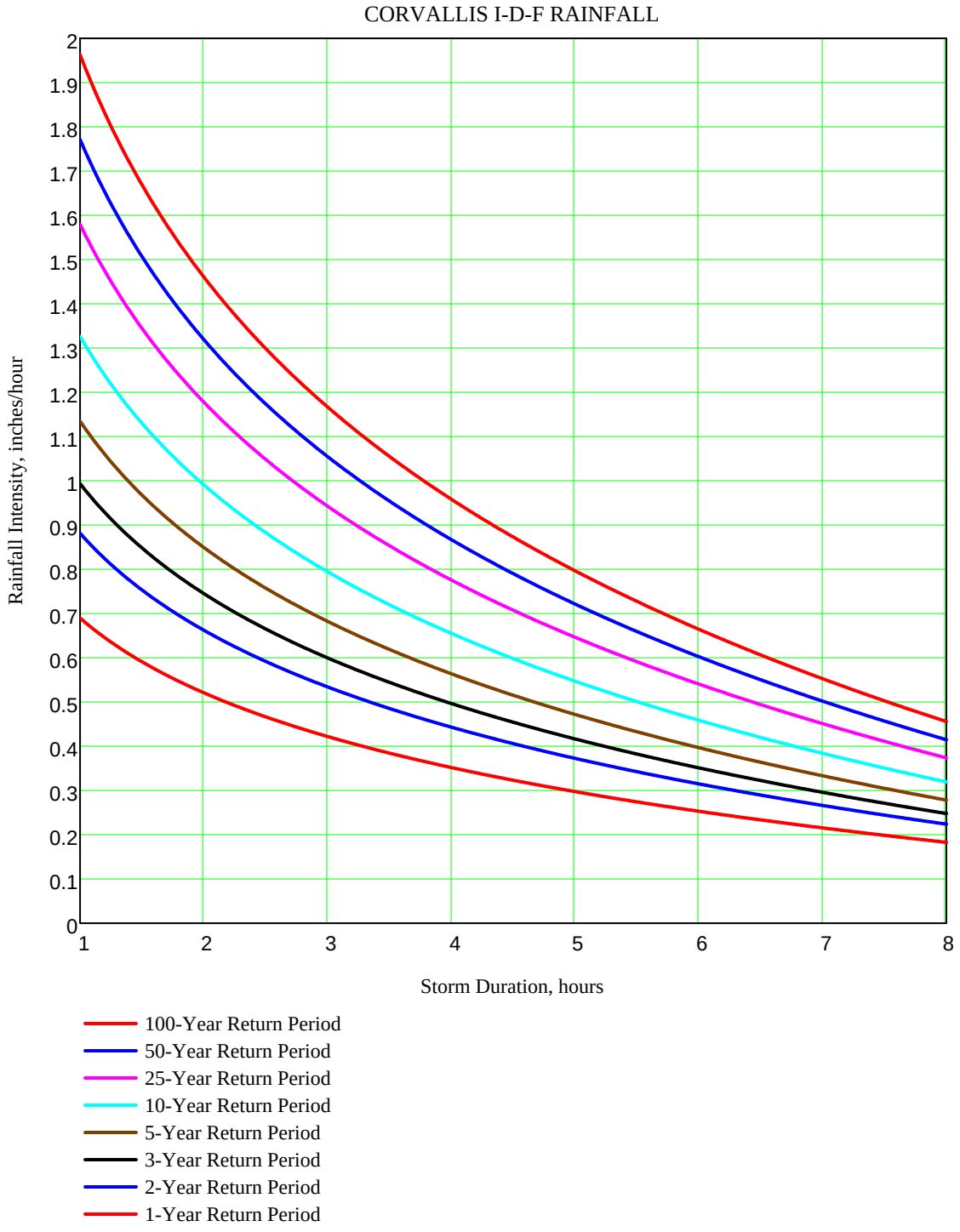
PLOT THE RAINFALL I-D-F CURVES - Graph 15 to 60 Minute Storms

$t := 15, 15.1 .. 60$



PLOT THE RAINFALL I-D-F CURVES - Graph 1 to 8 Hour Storms

$t := 60, 61 .. 480$



I-D-F Rainfall Curves Points of Interest

For storms of durations of 2, of 5, 10, 15, 30 and and 60-minutes

Duration (minutes)	1-year Storm (in/hr)	2-year Storm (in/hr)	3-year Storm (in/hr)
2	1.52	1.96	2.21
5	1.30	1.67	1.88
10	1.13	1.45	1.64
15	1.03	1.32	1.49
30	0.86	1.10	1.24
60	0.69	0.88	0.99

$D := \begin{pmatrix} 2 \\ 5 \\ 10 \\ 15 \\ 30 \\ 60 \end{pmatrix}$ $P_1(D) = \begin{pmatrix} 1.52 \\ 1.30 \\ 1.13 \\ 1.03 \\ 0.86 \\ 0.69 \end{pmatrix}$ $P_2(D) = \begin{pmatrix} 1.96 \\ 1.67 \\ 1.45 \\ 1.32 \\ 1.10 \\ 0.88 \end{pmatrix}$ $P_3(D) = \begin{pmatrix} 2.21 \\ 1.88 \\ 1.64 \\ 1.49 \\ 1.24 \\ 0.99 \end{pmatrix}$

Duration (minutes)	5-year Storm (in/hr)	10-year Storm (in/hr)	25-year Storm (in/hr)
2	2.54	2.97	3.55
5	2.16	2.53	3.02
10	1.87	2.19	2.62
15	1.71	2.00	2.38
30	1.42	1.66	1.98
60	1.13	1.33	1.58

$D = \begin{pmatrix} 2 \\ 5 \\ 10 \\ 15 \\ 30 \\ 60 \end{pmatrix}$ $P_5(D) = \begin{pmatrix} 2.54 \\ 2.16 \\ 1.87 \\ 1.71 \\ 1.42 \\ 1.13 \end{pmatrix}$ $P_10(D) = \begin{pmatrix} 2.97 \\ 2.53 \\ 2.19 \\ 2.00 \\ 1.66 \\ 1.33 \end{pmatrix}$ $P_25(D) = \begin{pmatrix} 3.55 \\ 3.02 \\ 2.62 \\ 2.38 \\ 1.98 \\ 1.58 \end{pmatrix}$

Duration (minutes)	50-year Storm (in/hr)	100-year Storm (in/hr)
2	3.99	4.43
5	3.39	3.76
10	2.94	3.26
15	2.68	2.97
30	2.22	2.47
60	1.77	1.96

$D = \begin{pmatrix} 2 \\ 5 \\ 10 \\ 15 \\ 30 \\ 60 \end{pmatrix}$ $P_50(D) = \begin{pmatrix} 3.99 \\ 3.39 \\ 2.94 \\ 2.68 \\ 2.22 \\ 1.77 \end{pmatrix}$ $P_100(D) = \begin{pmatrix} 4.43 \\ 3.76 \\ 3.26 \\ 2.97 \\ 2.47 \\ 1.96 \end{pmatrix}$

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 8
Stormwater Runoff Analysis

STORMWATER RUNOFF ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Mathcad Reference Document(s)

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Corvallis Rainfall Curves.xmcd

Special Units & Dimensions

$$cfs := \frac{ft^3}{sec}$$

Stormwater System Summary

Catchments: City of Corvallis Public Works Department standard curb inlets with sediment traps.
Piped Conveyance: City of Corvallis Public Works Department standard piped conveyance system.
Channel Conveyance: KCSWDM standard channel conveyance system.
Storage: On site detention system conforming to SWMP Appendix F (Technical Memorandum No. 4).
Treatment: Stormwater Management "StormFilter" flow-through media-filled cartridge filtration system.
Disposal: To existing City of Corvallis public storm drain system.
Overflow: Overflow into Brooklane Drive.
Maintenance: City of Corvallis Public Works Department.

Hydrologic Design Criteria

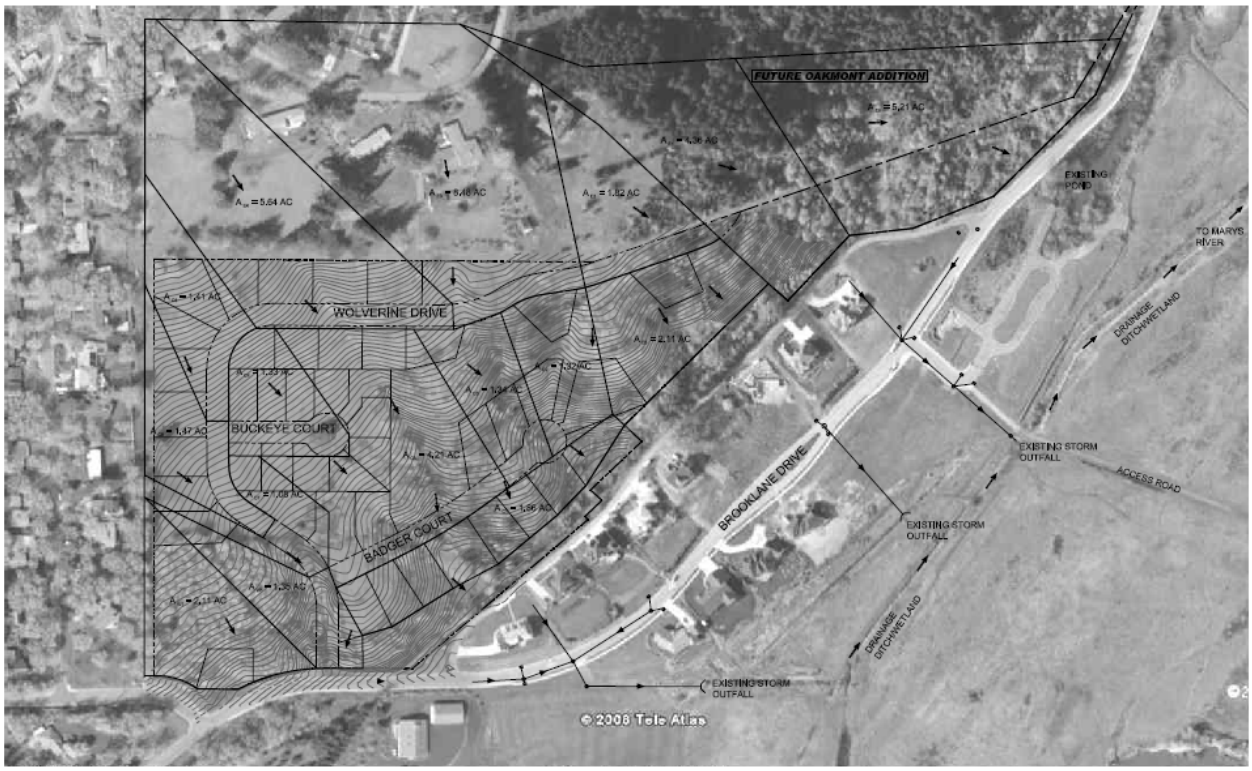
City of Corvallis Corvallis Comprehensive Plan.
City of Corvallis Stormwater Master Plan, September 2002, including Appendix F (Technical Memo No. 4).
King County, Washington Surface Water Design Manual used for guidance (SWMP Technical Memo No. 4).
Time of concentration based on SCS Lag Method (TR-55).
Use Rational Method to design conveyance system for the 10-year, 24-hour design storm event.
Use Rational Method to check conveyance system for the 100-year, 24-hour design storm event.
Use Santa Barbara Urban Hydrographs with SCS Type 1A rainfall distribution for detention system design.
Use SBUH method to design detention system for the 10-year, 24-hour storm event.
Use SBUH method to check detention system bypass for the 100-year, 24-hour storm event.
Design water quality facilites for the 0.9-inch rainfall, 24-hour storm event.

Basin Area Parameters

The project site has three discrete points of stormwater discharge. The "West" basin outfall pipe connects to the existing City storm drain system at the intersection Wolverine Drive and Brooklane Drive. The "Central" basin outfall pipe connects to the existing system north of Brooklane on a private access drive. Likewise, the "East" basin outfall connects to the City system near the easterly end of the private drive. Additionally, the extreme easterly portion of the site drains into the existing City storm drain system in Brooklane Drive.

Smaller sub-basins are identified for sizing elements of the conveyance system. Aggregate basin areas are used as appropriate for design of the detention and water quality facilities respectively.

Drainage Patterns - Basin Map



SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

West Outfall - Contributing Runoff Areas

Quantitative contributing runoff basin sub-areas of subject basin:

Sub-basin W1

Sub-basin W1 comprises the SW corner of the subject basin which drains directly into Wolverine Drive. All runoff from this sub-basin is included in conveyance design, detention design and water quality design.

$A_{W1} := 1.35acre$ $\qquad$ $Area_{W_1} := A_{W1}$

$A_{W_Conveyance_1} := A_{W1}$ $\qquad$ $A_{W_Conveyance_1} = 1.35 \cdot acre$

$A_{W_Detention_1} := A_{W1}$ $\qquad$ $A_{W_Detention_1} = 1.35 \cdot acre$

$A_{W_WQ_1} := A_{W1}$ $\qquad$ $A_{W_WQ_1} = 1.35 \cdot acre$

Sub-basin W2

Sub-basin W2 comprises the extreme SW corner of the parcel which drains directly into Brooklane Drive. Runoff from this sub-area, which drains directly into the City's existing storm drain system, will not be provided with additional conveyance, storage or treatment facilities. This area is dedicated primarily to open space, supporting only one building lot and no streets, thus generates negligible increased stormwater runoff or pollution.

$A_{W2} := 2.11acre$ $\quad$ $Area_{W_2} := A_{W2}$

$A_{W_Conveyance_2} := A_{W2}$ $\quad$ $A_{W_Conveyance_2} = 2.11 \cdot acre$

$A_{W_Detention_2} := 0$ $\quad$ $A_{W_Detention_2} = 0.00 \cdot acre$

$A_{W_WQ_2} := 0$ $\quad$ $A_{W_WQ_2} = 0.00 \cdot acre$

Total Contributing Area of West Outfall Basin for Conveyance Design

$A_{Basin_W_Conveyance} := \sum A_{W_Conveyance}$ $\quad$ $A_{Basin_W_Conveyance} = 3.46 \cdot acre$

Total Contributing Area of West Outfall Basin for Detention Bypass

$A_{Basin_W_Detention_Bypass} := \sum A_{W_Conveyance}$ $\quad$ $A_{Basin_W_Detention_Bypass} = 3.46 \cdot acre$

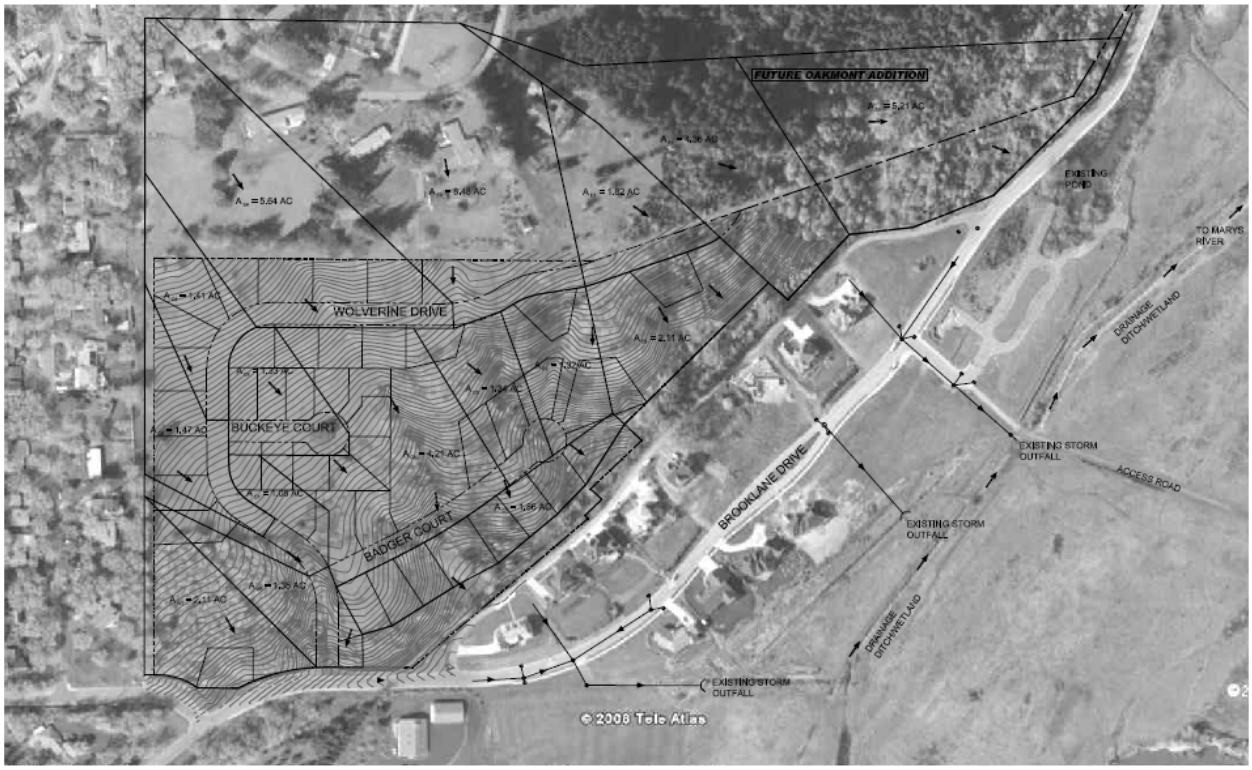
Total Contributing Area of West Outfall Basin for Detention Design

$A_{Basin_W_Detention} := \sum A_{W_Detention}$ $\quad$ $A_{Basin_W_Detention} = 1.35 \cdot acre$

Total Contributing Area of West Outfall Basin for Water Quality Design

$A_{Basin_W_WQ} := \sum A_{W_WQ}$ $\quad$ $A_{Basin_W_WQ} = 1.35 \cdot acre$

Drainage Patterns - Basin Map



SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

Central Outfall - Contributing Runoff Areas

Quantitative contributing runoff basin sub-areas of subject basin:

Sub-basin C0 - Tract B

Sub-basin C0 comprises Tract B open space located immediately above the private drive serving residential lots in Brooklane Heights Estates. There is no direct treatment of runoff from this sub-basin, however there also is no contaminated street runoff contribution. Runoff from this sub-basin drains into an existing conveyance system.

$A_{C0} := 0.96acre$

Sub-basin C1

Sub-basin C1 comprises the tier of lots immediately downslope from Badger Court. A storm drain collector will be located along the southern lot line to collect residential roof and area drains. There is no street runoff tributary to this sub-basin. Because it is located downstream of the proposed detention facility, its runoff volume will be included in the volume served by the detention facility as "compensatory" storage. There is no direct treatment of runoff from this sub-basin, however there also is no contaminated street runoff contribution. Runoff from this sub-basin drains into the new conveyance system.

$A_{C1} := 1.86acre$ $\quad$ $Area_{C_1} := A_{C1}$

$A_{C_Conveyance_1} := A_{C1}$ $\quad$ $A_{C_Conveyance_1} = 1.86 \cdot acre$

$A_{C_Detention_1} := A_{C1}$ $\quad$ $A_{C_Detention_1} = 1.86 \cdot acre$

$A_{C_WQ_1} := 0$ $\quad$ $A_{C_WQ_1} = 0.00$

Sub-basin C2

Sub-basin C2 comprises the area immediately north of the cul-de-sac on Badger Court, extending to the southerly ROW of Wolverine Drive above. Runoff from this basin is included in detention design and water quality design, as well as conveyance.

$A_{C2} := 1.32acre$ $\quad$ $Area_{C_2} := A_{C2}$

$A_{C_Conveyance_2} := A_{C2}$ $\quad$ $A_{C_Conveyance_2} = 1.32 \cdot acre$

$A_{C_Detention_2} := A_{C2}$ $\quad$ $A_{C_Detention_2} = 1.32 \cdot acre$

$A_{C_WQ_2} := A_{C2}$ $\quad$ $A_{C_WQ_2} = 1.32 \cdot acre$

Sub-basin C3

Sub-basin C3 also comprises an area immediately north of Badger Court, extending to the southerly ROW of Wolverine Drive above. All runoff from this sub-basin is included in conveyance design, detention design and water quality design.

$A_{C3} := 1.34acre$ $\quad$ $Area_{C_3} := A_{C3}$

$A_{C_Conveyance_3} := A_{C3}$ $\quad$ $A_{C_Conveyance_3} = 1.34 \cdot acre$

$A_{C_Detention_3} := A_{C3}$ $\quad$ $A_{C_Detention_3} = 1.34 \cdot acre$

$A_{C_WQ_3} := A_{C3}$ $\quad$ $A_{C_WQ_3} = 1.34 \cdot acre$

Sub-basin C4

Sub-basin C4 comprises an area immediately north of Buckeye Court, extending to the southerly and easterly ROW of Wolverine Drive above. All runoff from this sub-basin is included in conveyance design, detention design and water quality design.

$A_{C4} := 1.33acre$ $\quad$ $Area_{C_4} := A_{C4}$

$A_{C_Conveyance_4} := A_{C4}$ $\quad$ $A_{C_Conveyance_4} = 1.33 \cdot acre$

$A_{C_Detention_4} := A_{C4}$ $\quad$ $A_{C_Detention_4} = 1.33 \cdot acre$

$A_{C_WQ_4} := A_{C4}$ $\quad$ $A_{C_WQ_4} = 1.33 \cdot acre$

Sub-basin C5

Sub-basin C5 comprises an area at the northwest corner of the proposed subdivision, including a small portion of existing residential land on Country Club Hill. All runoff from this sub-basin is included in conveyance design. A portion of the runoff from this sub-basin is excluded from detention design and water quality design.

$A_{C5} := 1.41acre$ $\quad$ $Area_{C_5} := A_{C5}$

$A_{C_Conveyance_5} := A_{C5}$ $\quad$ $A_{C_Conveyance_5} = 1.41 \cdot acre$

$A_{C_Detention_5} := A_{C5} - \frac{1}{2} \cdot 130ft \cdot 150ft$ $\quad$ $A_{C_Detention_5} = 1.19 \cdot acre$

$A_{C_WQ_5} := A_{C_Detention_5}$ $\quad$ $A_{C_WQ_5} = 1.19 \cdot acre$

Sub-basin C6

Sub-basin C6 comprises an area central to the proposed subdivision, located immediately above Badger Court upstream from the proposed detention pond. All runoff from this sub-basin is included in conveyance design, detention design and water quality design.

$A_{C6} := 4.21acre$ $\quad$ $Area_{C_6} := A_{C6}$

$A_{C_Conveyance_6} := A_{C6}$ $\quad$ $A_{C_Conveyance_6} = 4.21 \cdot acre$

$A_{C_Detention_6} := A_{C6}$ $\quad$ $A_{C_Detention_6} = 4.21 \cdot acre$

$A_{C_WQ_6} := A_{C_Detention_6}$ $\quad$ $A_{C_WQ_6} = 4.21 \cdot acre$

Sub-basin C7

Sub-basin C7 comprises an area draining into Wolverine Drive. All runoff from this sub-basin is included in conveyance design, detention design and water quality design.

$A_{C7} := 1.08acre$ $\quad$ $Area_{C_7} := A_{C7}$

$A_{C_Conveyance_7} := A_{C7}$ $\quad$ $A_{C_Conveyance_7} = 1.08 \cdot acre$

$A_{C_Detention_7} := A_{C7}$ $\quad$ $A_{C_Detention_7} = 1.08 \cdot acre$

$A_{C_WQ_7} := A_{C_Detention_7}$ $\quad$ $A_{C_WQ_7} = 1.08 \cdot acre$

Sub-basin C8

Sub-basin C8 comprises an area draining into Wolverine Drive, upstream from C7. All runoff from this sub-basin is included in conveyance design, detention design and water quality design.

$A_{C8} := 1.47acre$ $\quad$ $Area_{C_8} := A_{C8}$

$A_{C_Conveyance_8} := A_{C8}$ $\quad$ $A_{C_Conveyance_8} = 1.47 \cdot acre$

$A_{C_Detention_8} := A_{C8}$ $\quad$ $A_{C_Detention_8} = 1.47 \cdot acre$

$A_{C_WQ_8} := A_{C_Detention_8}$ $\quad$ $A_{C_WQ_8} = 1.47 \cdot acre$

Total Contributing Area of Central Outfall Basin for Conveyance Design

$A_{Basin_C_Conveyance} := \sum A_{C_Conveyance}$ $\quad$ $A_{Basin_C_Conveyance} = 14.02 \cdot acre$

Total Contributing Area of Central Outfall Basin for Detention Bypass

$A_{Basin_C_Detention_Bypass} := \sum A_{C_Conveyance}$ $\quad$ $A_{Basin_C_Detention_Bypass} = 14.02 \cdot acre$

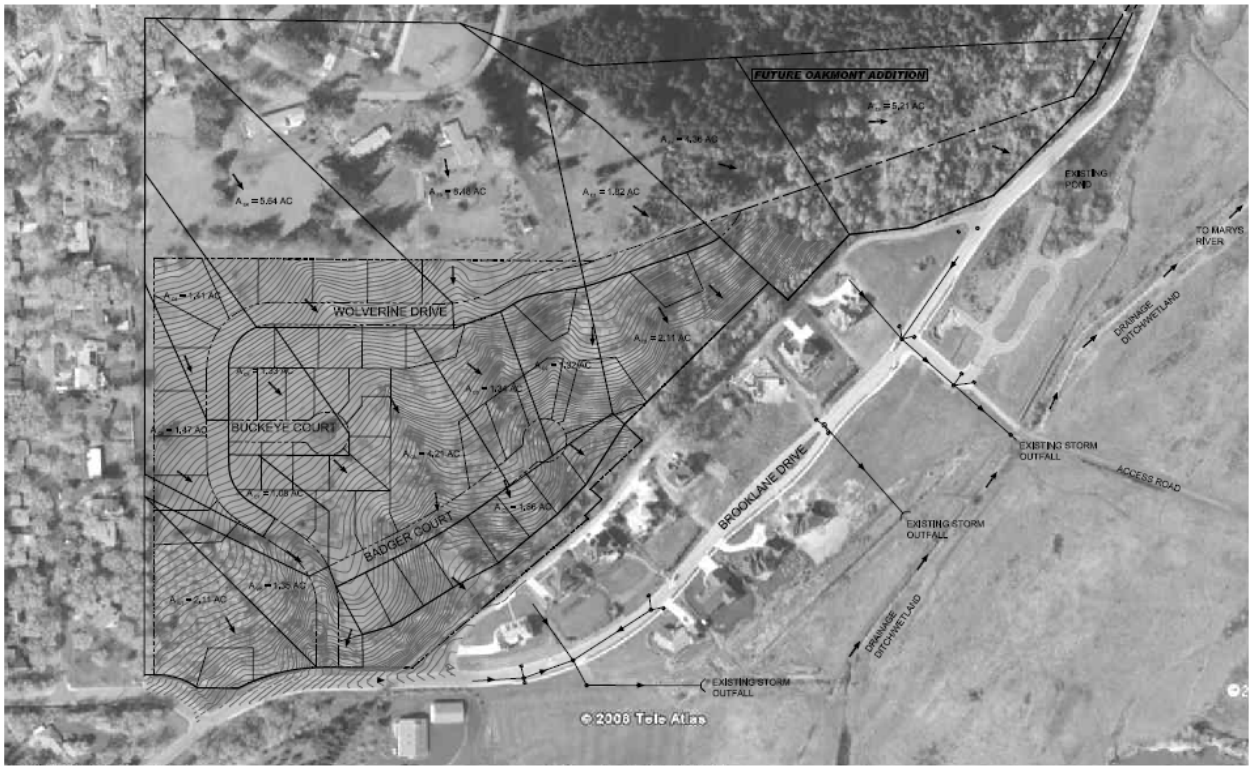
Total Contributing Area of Central Outfall Basin for Detention Design

$A_{Basin_C_Detention} := \sum A_{C_Detention}$ $\quad$ $A_{Basin_C_Detention} = 13.80 \cdot acre$

Total Contributing Area of Central Outfall Basin for Water Quality Design

$A_{Basin_C_WQ} := \sum A_{C_WQ}$ $\quad$ $A_{Basin_C_WQ} = 11.94 \cdot acre$

Drainage Patterns - Basin Map



SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

East Outfall - Contributing Runoff Areas

Quantitative contributing runoff basin sub-areas of subject basin:

Sub-basin E1

Sub-basin E1 comprises the easterly portion of the subject basin which drains into the City storm drain in the private drive located north of and paralleling Brooklane Drive. The portion of this sub-basin within Brooklane Heights is reserved for open space, resulting in no need for additional conveyance, storage or water quality facilities.

$A_{E1} := 4.36acre$ $\qquad$ $Area_{E_1} := A_{E1}$

$A_{E_Conveyance_1} := A_{E1}$ $\qquad$ $A_{E_Conveyance_1} = 4.36 \cdot acre$

$A_{E_Detention_1} := 0$ $\qquad$ $A_{E_Detention_1} = 0.00 \cdot acre$

$A_{E_WQ_1} := 0$ $\qquad$ $A_{E_WQ_1} = 0.00 \cdot acre$

Sub-basin E2

Sub-basin E2 comprises the easterly portion of the subject basin located above Wolverine Drive. All runoff from this sub-basin contributes to conveyance design. Only runoff from the Brooklane Heights portion of the sub-basin is included in detention design and water quality design.

$A_{E2} := 1.82acre$ $\quad$ $Area_{E_2} := A_{E2}$

$A_{E_Conveyance_2} := A_{E2}$ $\quad$ $A_{E_Conveyance_2} = 1.82 \cdot acre$

$A_{E_Detention_2} := 50ft \cdot 335ft$ $\quad$ $A_{E_Detention_2} = 0.38 \cdot acre$

$A_{E_WQ_2} := A_{E_Detention_2}$ $\quad$ $A_{E_WQ_2} = 0.38 \cdot acre$

Sub-basin E3

Sub-basin E3 comprises an area immediately north of Wolverine Drive, consisting primarily of existing residential development on the southerly sloping face of Country Club Hill. All runoff from this sub-basin contributes to conveyance design. Only runoff from Brooklane Heights portion of the sub-basin is included in detention design and water quality design.

$A_{E3} := 8.48acre$ $\quad$ $Area_{C_3} := A_{E3}$

$A_{E_Conveyance_3} := A_{E3}$ $\quad$ $A_{E_Conveyance_3} = 8.48 \cdot acre$

$A_{E_Detention_3} := 21600ft^2 + 500ft \cdot 50ft$ $\quad$ $A_{E_Detention_3} = 1.07 \cdot acre$

$A_{E_WQ_3} := A_{E_Detention_3}$ $\quad$ $A_{E_WQ_3} = 1.07 \cdot acre$

Sub-basin E4

Sub-basin E4 also comprises an area immediately north of Wolverine Drive, consisting primarily of existing residential development on the southerly sloping face of Country Club Hill. All runoff from this sub-basin contributes to conveyance design. Only runoff from Brooklane Heights portion of the sub-basin is included in detention design and water quality design.

$A_{E4} := 5.64acre$ $\quad$ $Area_{C_4} := A_{E4}$

$A_{E_Conveyance_4} := A_{E4}$ $\quad$ $A_{E_Conveyance_4} = 5.64 \cdot acre$

$A_{E_Detention_4} := 150ft \cdot 500ft$ $\quad$ $A_{E_Detention_4} = 1.72 \cdot acre$

$A_{E_WQ_4} := A_{E_Detention_4}$ $\quad$ $A_{E_WQ_4} = 1.72 \cdot acre$

Sub-basin E5

Sub-basin E5 comprises the easterly portion of the subject basin located below Wolverine Drive which drains directly into Brooklane Drive. Runoff from this sub-area, which drains into the City's existing storm drain system, will not be provided with additional conveyance, storage or treatment facilities. This area is dedicated primarily to open space, supporting only one building lot and no streets, thus generates negligible increased stormwater runoff or pollution. Runoff from this sub-area, left primarily in a natural state, will not be serviced by a water quality treatment facility.

$A_{E5} := 2.11acre$ $\quad$ $Area_{E_5} := A_{E5}$

$A_{E_Conveyance_5} := A_{E5}$ $\quad$ $A_{E_Conveyance_5} = 2.11 \cdot acre$

$A_{E_Detention_5} := 0$ $\quad$ $A_{E_Detention_5} = 0.00 \cdot acre$

$A_{E_WQ_5} := A_{E_Detention_5}$ $\quad$ $A_{E_WQ_5} = 0.00 \cdot acre$

Sub-basin E6

Sub-basin E6 comprises extreme easterly end of the parcel which drains directly into Brooklane Drive. With no new development proposed in this area with the Brooklane Heights Subdivision, no additional conveyance, detention or water quality facilities are proposed.

$A_{E6} := 5.21acre$ $\quad$ $Area_{E_6} := A_{E6}$

Total Contributing Area of East Outfall Basin for Conveyance Design

$A_{Basin_E_Conveyance} := \sum A_{E_Conveyance}$ $\quad$ $A_{Basin_E_Conveyance} = 22.41 \cdot acre$

Total Contributing Area of East Outfall Basin for Detention Bypass

$A_{Basin_E_Detention_Bypass} := A_{E2} + A_{E3} + A_{E4}$ $\quad$ $A_{Basin_E_Detention_Bypass} = 15.94 \cdot acre$

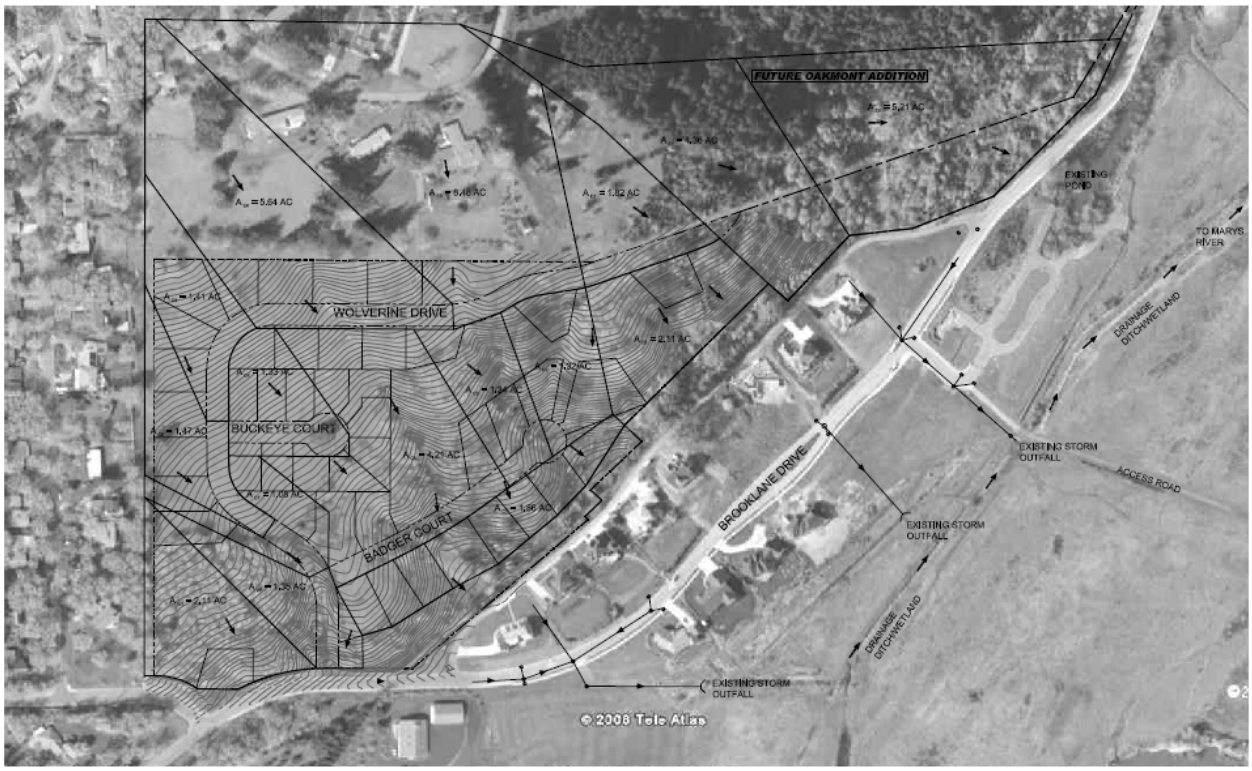
Total Contributing Area of East Outfall Basin for Detention Design

$A_{Basin_E_Detention} := \sum A_{E_Detention}$ $\quad$ $A_{Basin_E_Detention} = 3.18 \cdot acre$

Total Contributing Area of East Outfall Basin for Water Quality Design

$A_{Basin_E_WQ} := \sum A_{E_WQ}$ $\quad$ $A_{Basin_E_WQ} = 3.18 \cdot acre$

Drainage Patterns - Basin Map



SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

Summary of West Outfall Basin Design Area Parameters

Conveyance Design Area $A_{Basin_W_Conveyance} = 3.46 \cdot acre$

Detention Bypass Area $A_{Basin_W_Detention_Bypass} = 3.46 \cdot acre$

Detention Design Area $A_{Basin_W_Detention} = 1.35 \cdot acre$

Water Quality Design Area $A_{Basin_W_WQ} = 1.35 \cdot acre$

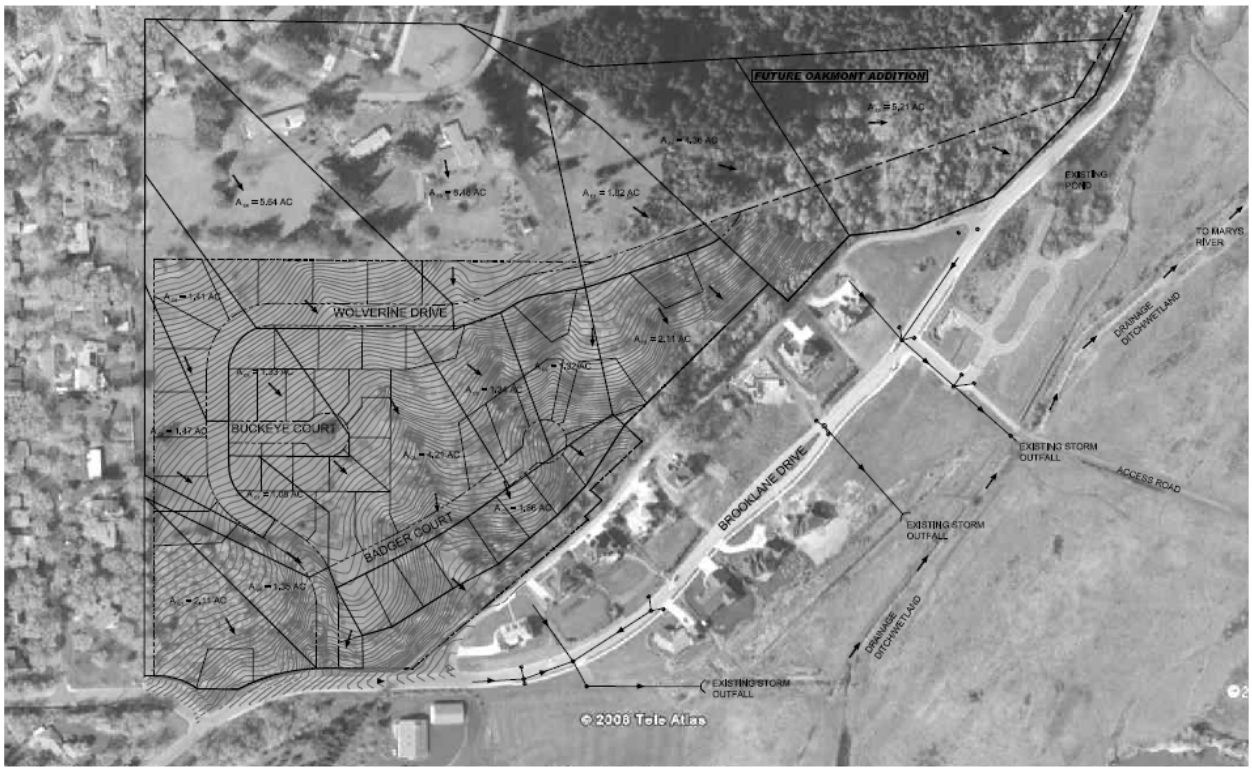
Impervious Lot Area $A_{Basin_W_0} := 3 \cdot 4500ft^2$ $A_{Basin_W_0} = 0.31 \cdot acre$

Impervious Street Area $A_{Basin_W_1} := 38ft \cdot 220ft$ $A_{Basin_W_1} = 0.19 \cdot acre$

Open Space Area $A_{Basin_W_2} := A_{Basin_W_Detention} - A_{Basin_W_0} - A_{Basin_W_1}$

$A_{Basin_W_2} = 0.85 \cdot acre$

Drainage Patterns - Basin Map

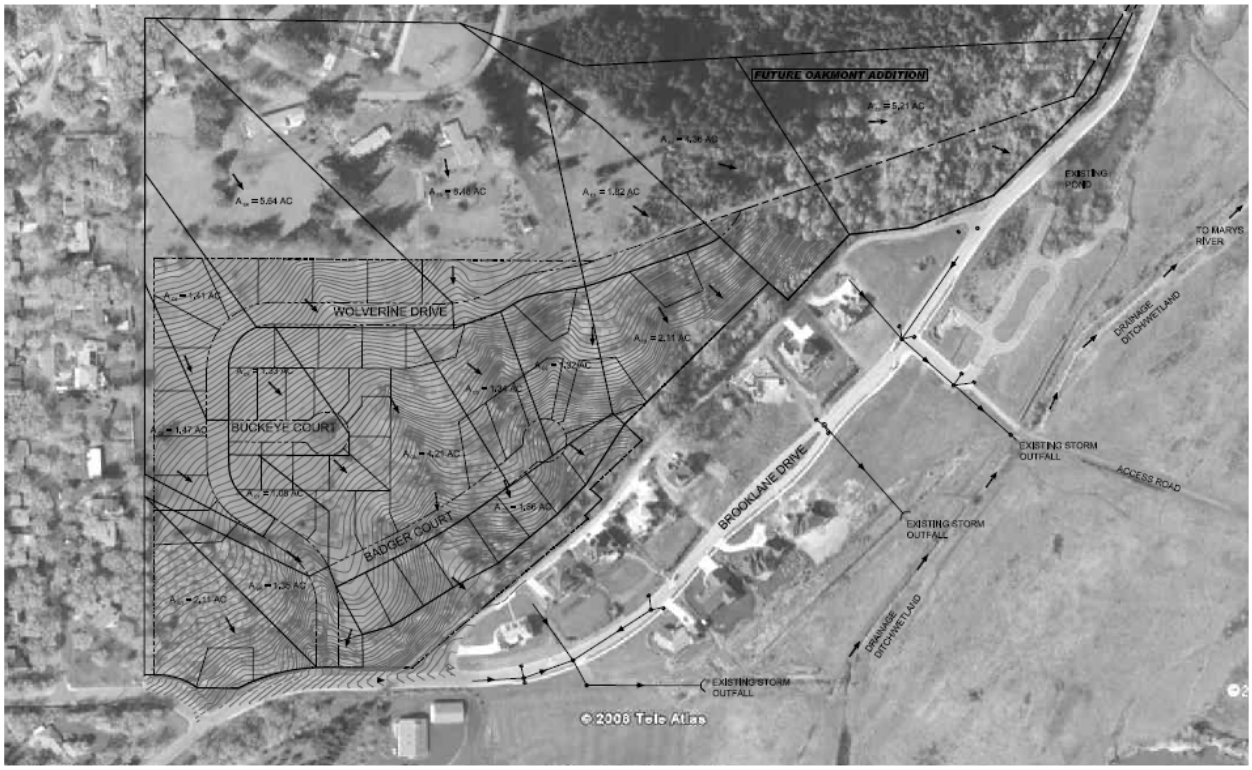


SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

Summary of Central Outfall Basin Design Area Parameters

Conveyance Design	$A_{Basin_C_Conveyance} = 14.02 \cdot acre$	
Detention Bypass Area	$A_{Basin_C_Detention_Bypass} = 14.02 \cdot acre$	
Detention Design	$A_{Basin_C_Detention} = 13.80 \cdot acre$	
Water Quality Design	$A_{Basin_C_WQ} = 11.94 \cdot acre$	
Impervious Lot Area	$A_{Basin_C_0} := 36 \cdot 4500ft^2$	$A_{Basin_C_0} = 3.72 \cdot acre$
Impervious Street Area	$A_{Basin_C_1} := 38ft \cdot 1560ft$	$A_{Basin_C_1} = 1.36 \cdot acre$
Open Space Area	$A_{Basin_C_2} := A_{Basin_C_Detention} - A_{Basin_C_0} - A_{Basin_C_1}$	
	$A_{Basin_C_2} = 8.72 \cdot acre$	
Tract B Runoff Area	$A_{C0} = 0.96 \cdot acre$	

Drainage Patterns - Basin Map



SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

Summary of East Outfall Basin Design Area Parameters

Conveyance Design $A_{Basin_E_Conveyance} = 22.41 \cdot acre$

Detention Bypass Area $A_{Basin_E_Detention_Bypass} = 15.94 \cdot acre$

Detention Design $A_{Basin_E_Detention} = 3.18 \cdot acre$

Water Quality Design $A_{Basin_E_WQ} = 3.18 \cdot acre$

Impervious Lot Area $A_{Basin_E_0} := 4 \cdot 4500ft^2$ $A_{Basin_E_0} = 0.41 \cdot acre$

Impervious Street Area $A_{Basin_E_1} := 38ft \cdot 1000ft$ $A_{Basin_E_1} = 0.87 \cdot acre$

Open Space Area $A_{Basin_E_2} := A_{Basin_E_Detention} - A_{Basin_E_0} - A_{Basin_E_1}$

$A_{Basin_E_2} = 1.89 \cdot acre$

Site Hydrologic Parameters

TABLE 2.1 (Bedient & Huber)
Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Land Use (Antecedent moisture condition II; Ia = 0.2S)

LAND USE DESCRIPTION			HYDROLOGIC SOIL GROUP A	B	C	D	
Cultivated land[1]							
Without conservation treatment			72	81	88	91	
With conservation treatment			62	71	78	81	
Pasture or range land							
Poor condition			68	79	86	89	
Good condition			39	61	74	80	
Meadow, good condition			30	58	71	78	
Wood or forest land							
Thin stand, poor cover, no mulch			45	66	77	83	
Good cover[2]			25	55	70	77	
Open spaces, lawns, parks, golf courses, cemeteries, etc.							
Good condition: grass cover on 75% or more of the area			39	61	74	80	
Fair condition: grass cover on 50-75% of the area			49	69	79	84	
Commercial and business areas (85% impervious)			89	92	94	95	
Industrial areas (72% impervious)				81	88	91	93
Residential[3]	Avg lot size	Avg % impervious[4]					
	≤1/8 ac	65	77	85	90	92	
	≤1/4 ac	38	61	75	83	87	
	≤1/3 ac	30	57	72	81	86	
	≤1/2 ac	25	54	70	80	85	
	≤1 ac	20	51	68	79	84	
Paved parking lots, roofs, driveways, etc.[5]			98	98	98	98	
Streets and roads							
Paved with curbs and storm sewers[5]			98	98	98	98	
Gravel			76	85	89	91	
Dirt			72	82	87	89	

1. For a more detailed description of agricultural land use curve numbers, refer to National Engineering Handbook, Section 4, "Hydrology," chapter 9, Aug. 1972.
2. Good cover is protected from grazing and litter and brush cover soil.
3. Curve numbers are computed assuming that the runoff from the house and driveway is directed toward the street with a minimum of roof water directed to lawns where additional infiltration could occur.
4. The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.
5. In some warmer climates of the country a curve number of 95 may be used.

Site Parameters for SBUH Hydrograph Analsyes

Develop site parameters to be used in SBUH hydrograph analyses.

Pre-Development Site Runoff SCS Curve Numbers (Bedient, Huber Table 2.1):

Hydrologic Soil Group: Assume 100% Group "B"
(NRCS Map Symbol 167-Willakenzie-Wellsdale complex 12 to 20 percent south slopes)

Land Use Description for pre-development conditions: "Meadow, good condition"

Estimated pre-development SCS Curve Number $CN_{pre} := 58$

Post-Development Site Runoff SCS Curve Numbers (Bedient, Huber Table 2.1):

Hydrologic Soil Group: Assume 100% Group "B"
(NRCS Map Symbol 167-Willakenzie-Wellsdale complex 12 to 20 percent south slopes)

Estimated post-development SCS Curve Number for impervious lot development $CN_0 := 98$

Estimated post-development SCS Curve Number for urban streets $CN_1 := 98$

Estimated post-development SCS Curve Number for preserved areas $CN_2 := CN_{pre}$

Basin W Post-Development Site Runoff SCS Curve Number

$$CN_{post_W} := \frac{A_{Basin_W} \cdot CN}{\sum A_{Basin_W}} \qquad CN_{post_W} = 72.87$$

Basin C Post-Development Site Runoff SCS Curve Number

$$CN_{post_C} := \frac{A_{Basin_C} \cdot CN}{\sum A_{Basin_C}} \qquad CN_{post_C} = 72.73$$

Basin E Post-Development Site Runoff SCS Curve Number

$$CN_{post_E} := \frac{A_{Basin_E} \cdot CN}{\sum A_{Basin_E}} \qquad CN_{post_E} = 74.19$$

Select a Uniform Post-Development Site Runoff SCS Curve Number

$$CN_{post_weighted} := \frac{A_{Basin_W} \cdot CN + A_{Basin_C} \cdot CN + A_{Basin_E} \cdot CN}{\sum A_{Basin_W} + \sum A_{Basin_C} + \sum A_{Basin_E}} \qquad CN_{post_weighted} = 72.99$$

$CN_{post} := 73$

Time of Concentration (SCS TR-55) for Basin W Detention Facility

Define unitless basin parameters to determine times of concentration by SCS TR-55 methods:

Basin Hydraulic Length (ft)

$L_{Basin_W} := 550$

Average Basin Slope (%)

$Elev_{Top_W} := 360$ $\quad Elev_{Bottom_W} := 270$

$$s_{Basin_W} := \frac{Elev_{Top_W} - Elev_{Bottom_W}}{L_{Basin_W}} \cdot 100 \qquad s_{Basin_W} = 16.36$$

Pre-development Lag Time (SCS TR-55)

$$S_{CN_pre_W} := \frac{1000}{CN_{pre}} - 10 \qquad S_{CN_pre_W} = 7.24$$

$$t_{lag_pre_W} := \frac{L_{Basin_W}^{0.8} \cdot \left(S_{CN_pre_W} + 1\right)^{0.7}}{1900 \cdot s_{Basin_W}^{0.5}} \cdot hr \qquad t_{lag_pre_W} = 5.3 \cdot min$$

Pre-development Time of Concentration

$$t_{c_pre_W} := 1.67 \cdot t_{lag_pre_W} \qquad t_{c_pre_W} = 8.9 \cdot min$$

Post-development Lag Time (SCS TR-55)

$$S_{CN_post_W} := \frac{1000}{CN_{post}} - 10 \qquad S_{CN_post_W} = 3.70$$

$$t_{lag_post_W} := \frac{L_{Basin_W}^{0.8} \cdot \left(S_{CN_post_W} + 1\right)^{0.7}}{1900 \cdot s_{Basin_W}^{0.5}} \cdot hr \qquad t_{lag_post_W} = 3.6 \cdot min$$

Post-development Time of Concentration

$$t_{c_post_W} := 1.67 \cdot t_{lag_post_W} \qquad t_{c_post_W} = 6.0 \cdot min$$

Total Contributing Area(s) Included in Detention Design for West Outfall Basin

$A_{Basin_W_Detention} = 1.35 \cdot acre$

Time of Concentration (SCS TR-55) for Basin C Detention Facility

Define unitless basin parameters to determine times of concentration by SCS TR-55 methods:

Basin Hydraulic Length (ft)

$L_{Basin_C} := 1120$

Average Basin Slope (%)

$Elev_{Top_C} := 422$ $\quad Elev_{Bottom_C} := 254$

$$s_{Basin_C} := \frac{Elev_{Top_C} - Elev_{Bottom_C}}{L_{Basin_C}} \cdot 100 \qquad s_{Basin_C} = 15.00$$

Pre-development Lag Time (SCS TR-55)

$$S_{CN_pre_C} := \frac{1000}{CN_{pre}} - 10 \qquad S_{CN_pre_C} = 7.24$$

$$t_{lag_pre_C} := \frac{L_{Basin_C}^{0.8} \cdot \left(S_{CN_pre_C} + 1\right)^{0.7}}{1900 \cdot s_{Basin_C}^{0.5}} \cdot hr \qquad t_{lag_pre_C} = 9.8 \cdot min$$

Pre-development Time of Concentration

$$t_{c_pre_C} := 1.67 \cdot t_{lag_pre_C} \qquad t_{c_pre_C} = 16.4 \cdot min$$

Post-development Lag Time (SCS TR-55)

$$S_{CN_post_C} := \frac{1000}{CN_{post}} - 10 \qquad S_{CN_post_C} = 3.70$$

$$t_{lag_post_C} := \frac{L_{Basin_C}^{0.8} \cdot \left(S_{CN_post_C} + 1\right)^{0.7}}{1900 \cdot s_{Basin_C}^{0.5}} \cdot hr \qquad t_{lag_post_C} = 6.6 \cdot min$$

Post-development Time of Concentration

$$t_{c_post_C} := 1.67 \cdot t_{lag_post_C} \qquad t_{c_post_C} = 11.1 \cdot min$$

Total Contributing Area(s) Included in Detention Design for Central Outfall Basin

$A_{Basin_C_Detention} = 13.80 \cdot acre$

Time of Concentration (SCS TR-55) for Basin E Detention Facility

Define unitless basin parameters to determine times of concentration by SCS TR-55 methods:

Basin Hydraulic Length (ft)

$L_{Basin_E} := 1000$

Average Basin Slope (%)

$Elev_{Top_E} := 424$ $\quad Elev_{Bottom_E} := 258$

$$s_{Basin_E} := \frac{Elev_{Top_E} - Elev_{Bottom_E}}{L_{Basin_E}} \cdot 100 \qquad s_{Basin_E} = 16.60$$

Pre-development Lag Time (SCS TR-55)

$$S_{CN_pre_E} := \frac{1000}{CN_{pre}} - 10 \qquad S_{CN_pre_E} = 7.24$$

$$t_{lag_pre_E} := \frac{L_{Basin_E}^{0.8} \cdot \left(S_{CN_pre_E} + 1\right)^{0.7}}{1900 \cdot s_{Basin_E}^{0.5}} \cdot hr \qquad t_{lag_pre_E} = 8.5 \cdot min$$

Pre-development Time of Concentration

$$t_{c_pre_E} := 1.67 \cdot t_{lag_pre_E} \qquad t_{c_pre_E} = 14.2 \cdot min$$

Post-development Lag Time (SCS TR-55)

$$S_{CN_post_E} := \frac{1000}{CN_{post}} - 10 \qquad S_{CN_post_E} = 3.70$$

$$t_{lag_post_E} := \frac{L_{Basin_E}^{0.8} \cdot \left(S_{CN_post_E} + 1\right)^{0.7}}{1900 \cdot s_{Basin_E}^{0.5}} \cdot hr \qquad t_{lag_post_E} = 5.8 \cdot min$$

Post-development Time of Concentration

$$t_{c_post_E} := 1.67 \cdot t_{lag_post_E} \qquad t_{c_post_E} = 9.6 \cdot min$$

Total Contributing Area(s) Included in Detention Design for East Outfall Basin

$A_{Basin_E_Detention} = 3.18 \cdot acre$

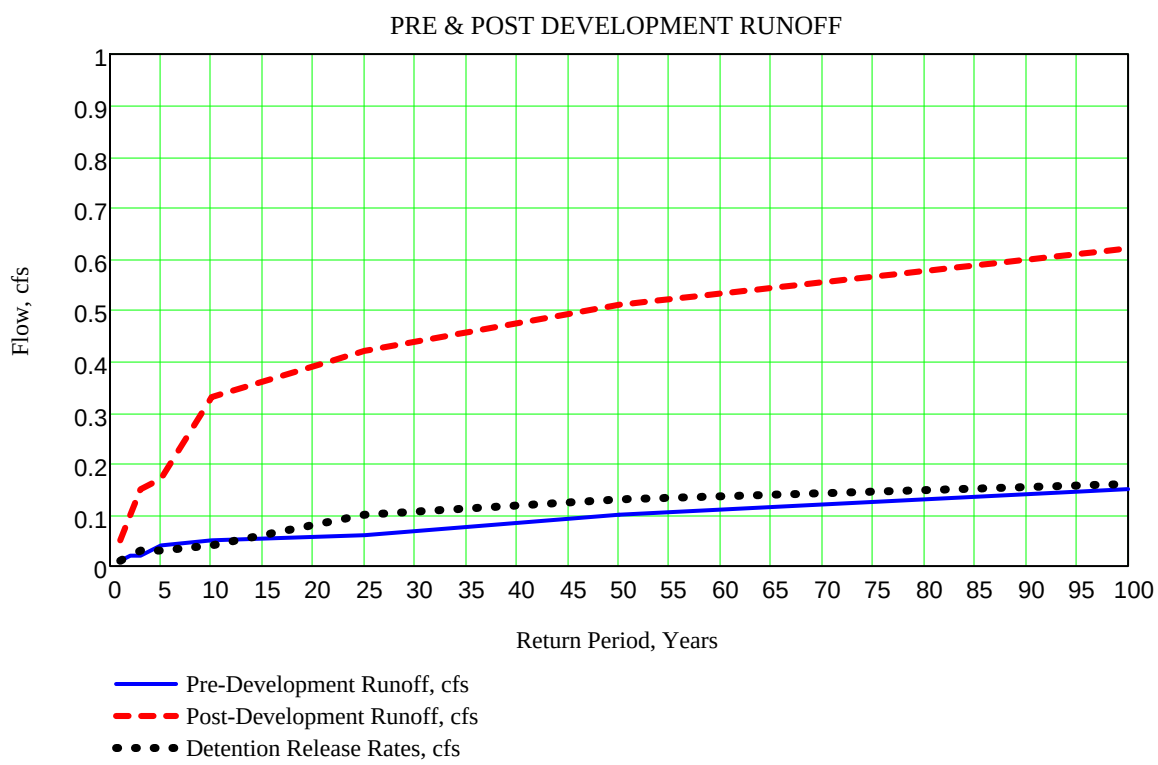
Detention Facility W Design Flows

Using the SBUH method, compute pre-development & post-development peak flows for various return periods:

Return Period (years)	Pre-Dev Runoff (cfs)	Post-Dev Runoff (cfs)	Detention Discharge (cfs)
1	0.01	0.05	0.01
2	0.02	0.10	0.02
3	0.02	0.15	0.03
5	0.04	0.17	0.03
10	0.05	0.33	0.04
25	0.06	0.42	0.10
50	0.10	0.51	0.13
100	0.15	0.62	0.16

$T = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 5 \\ 10 \\ 25 \\ 50 \\ 100 \end{pmatrix}$ $Q_{pre_w} := \begin{pmatrix} 0.01 \\ 0.02 \\ 0.02 \\ 0.04 \\ 0.05 \\ 0.06 \\ 0.10 \\ 0.15 \end{pmatrix} \cdot cfs$ $Q_{post_w} := \begin{pmatrix} 0.05 \\ 0.10 \\ 0.15 \\ 0.17 \\ 0.33 \\ 0.42 \\ 0.51 \\ 0.62 \end{pmatrix} cfs$ $Q_{dischg_w} := \begin{pmatrix} 0.01 \\ 0.02 \\ 0.03 \\ 0.03 \\ 0.04 \\ 0.10 \\ 0.13 \\ 0.16 \end{pmatrix} cfs$

Display the Calculated Runoff and Release Rates Graphically



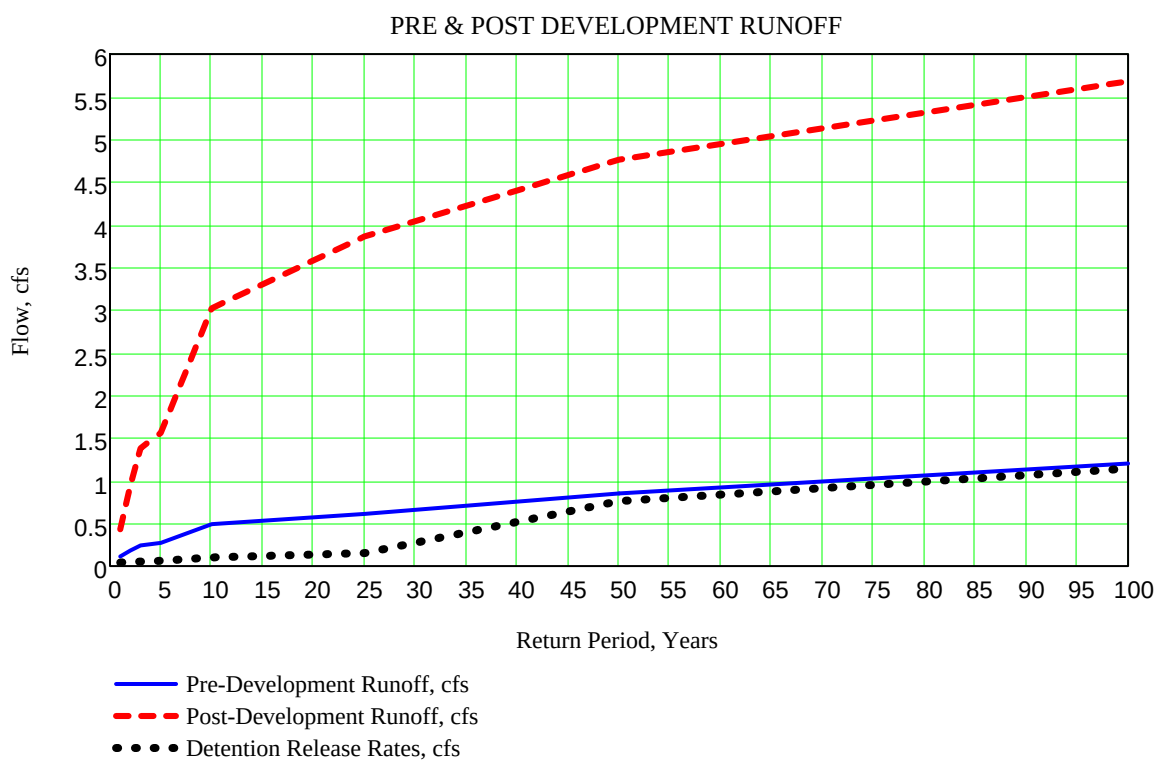
Detention Facility C Design Flows

Using the SBUH method, compute pre-development & post-development peak flows for various return periods:

Return Period (years)	Pre-Dev Runoff (cfs)	Post-Dev Runoff (cfs)	Detention Discharge (cfs)
1	0.11	0.43	0.04
2	0.18	0.94	0.05
3	0.24	1.38	0.05
5	0.27	1.56	0.06
10	0.49	3.02	0.10
25	0.61	3.86	0.15
50	0.85	4.76	0.76
100	1.20	5.68	1.14

$T = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 5 \\ 10 \\ 25 \\ 50 \\ 100 \end{pmatrix}$ $Q_{pre_C} := \begin{pmatrix} 0.11 \\ 0.18 \\ 0.24 \\ 0.27 \\ 0.49 \\ 0.61 \\ 0.85 \\ 1.20 \end{pmatrix} \cdot cfs$ $Q_{post_C} := \begin{pmatrix} 0.43 \\ 0.94 \\ 1.38 \\ 1.56 \\ 3.02 \\ 3.86 \\ 4.76 \\ 5.68 \end{pmatrix} cfs$ $Q_{dischg_C} := \begin{pmatrix} 0.04 \\ 0.05 \\ 0.05 \\ 0.06 \\ 0.10 \\ 0.15 \\ 0.76 \\ 1.14 \end{pmatrix} cfs$

Display the Calculated Runoff and Release Rates Graphically



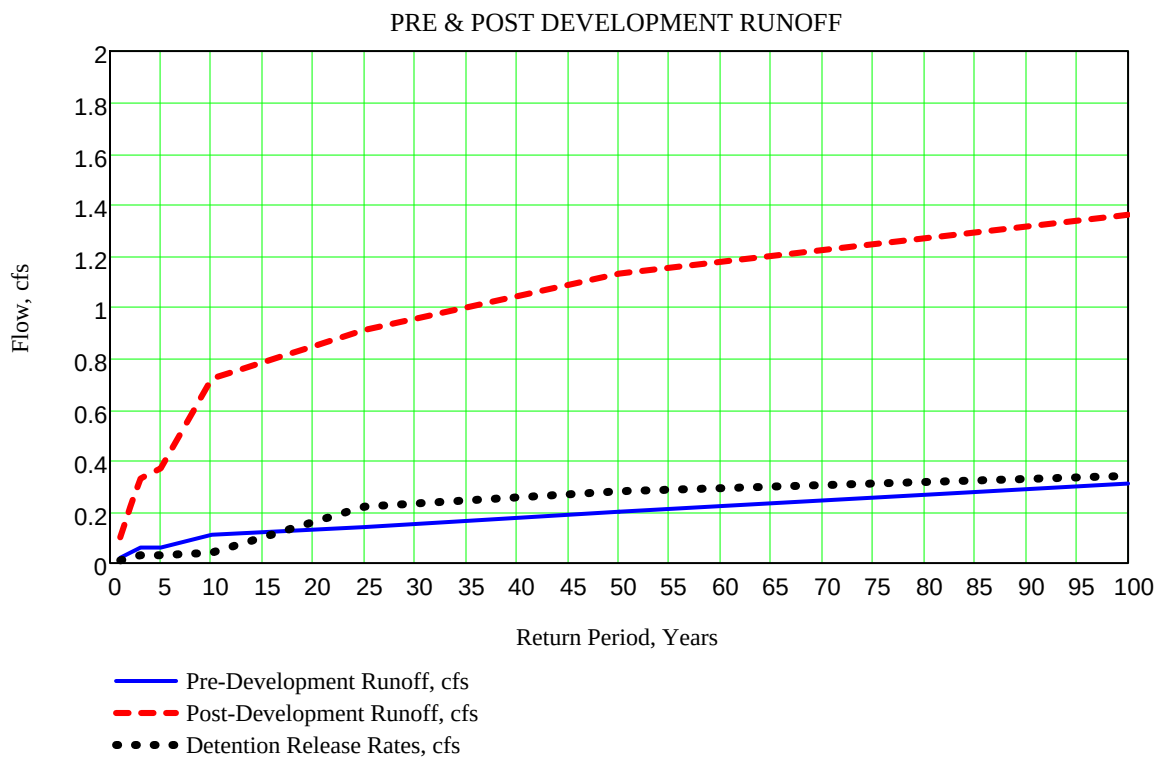
Detention Facility E Design Flows

Using the SBUH method, compute pre-development & post-development peak flows for various return periods:

Return Period (years)	Pre-Dev Runoff (cfs)	Post-Dev Runoff (cfs)	Detention Discharge (cfs)
1	0.02	0.10	0.01
2	0.04	0.22	0.02
3	0.06	0.33	0.03
5	0.06	0.37	0.03
10	0.11	0.72	0.04
25	0.14	0.91	0.22
50	0.20	1.13	0.28
100	0.31	1.36	0.34

$T = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 5 \\ 10 \\ 25 \\ 50 \\ 100 \end{pmatrix}$ $Q_{pre_E} := \begin{pmatrix} 0.02 \\ 0.04 \\ 0.06 \\ 0.06 \\ 0.11 \\ 0.14 \\ 0.20 \\ 0.31 \end{pmatrix} \cdot cfs$ $Q_{post_E} := \begin{pmatrix} 0.10 \\ 0.22 \\ 0.33 \\ 0.37 \\ 0.72 \\ 0.91 \\ 1.13 \\ 1.36 \end{pmatrix} cfs$ $Q_{dischg_E} := \begin{pmatrix} 0.01 \\ 0.02 \\ 0.03 \\ 0.03 \\ 0.04 \\ 0.22 \\ 0.28 \\ 0.34 \end{pmatrix} cfs$

Display the Calculated Runoff and Release Rates Graphically



BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 9
Runoff Conveyance Analyses

STORMWATER RUNOFF CONVEYANCE
10-YEAR 24-HOUR DESIGN RAINFALL EVENT
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

MathCad Reference Document(s)

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Brooklane Heights Runoff.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Corvallis Rainfall Curves.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\12-inch PVC Pipe Hydraulics.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Swale Hydraulics.xmcd

Stormwater System Summary

Catchments: City of Corvallis Public Works Department standard curb inlets with sediment traps.
Piped Conveyance: City of Corvallis Public Works Department standard piped conveyance system.
Channel Conveyance: KCSWDM standard channel conveyance system.
Storage: On site detention system conforming to SWMP Appendix F (Technical Memorandum No. 4).
Treatment: Stormwater Management "StormFilter" flow-through media-filled cartridge filtration system.
Disposal: To existing City of Corvallis public storm drain system.
Overflow: Overflow into Brooklane Drive.
Maintenance: City of Corvallis Public Works Department.

Hydrologic Design Criteria

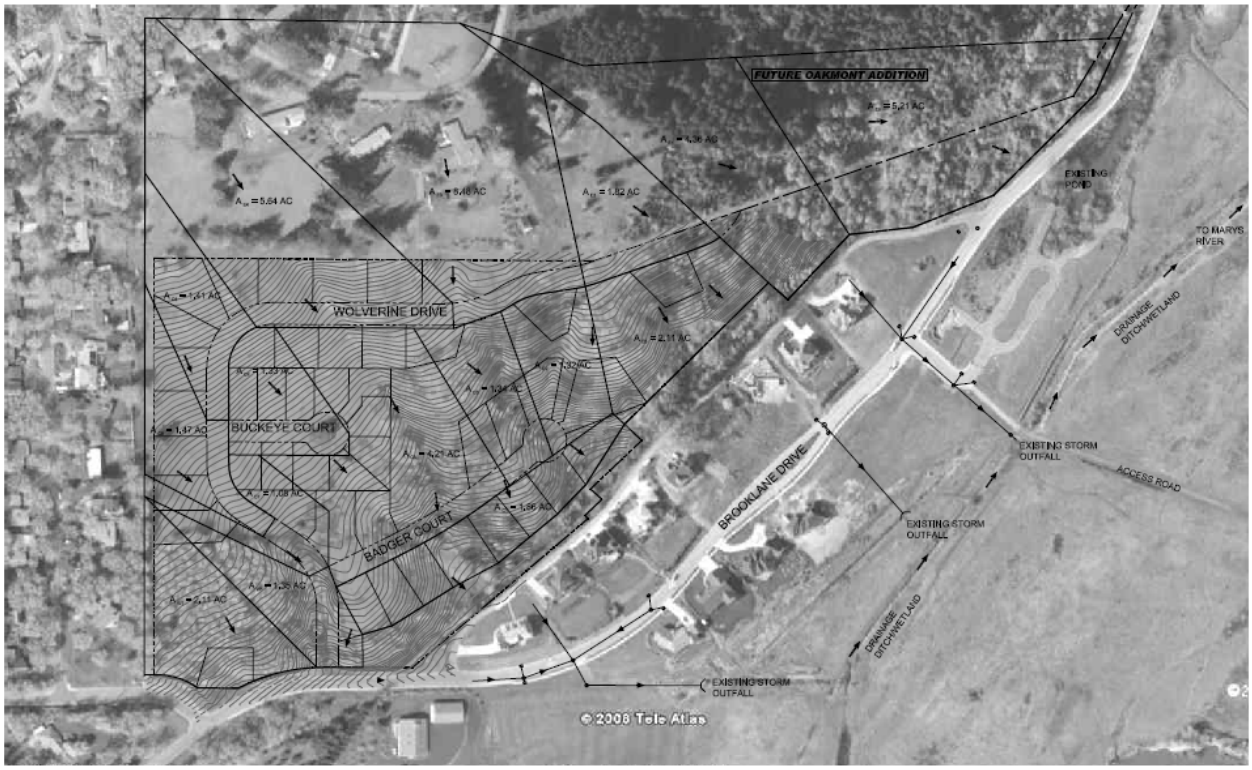
City of Corvallis Corvallis Comprehensive Plan.
City of Corvallis Stormwater Master Plan, September 2002, including Appendix F (Technical Memo No. 4).
King County, Washington Surface Water Design Manual used for guidance (SWMP Technical Memo No. 4).
Time of concentration based on SCS Lag Method (TR-55).
Use Rational Method to design conveyance system for the 10-year, 24-hour design storm event.
Use Rational Method to check conveyance system for the 100-year, 24-hour design storm event.
Use Santa Barbara Urban Hydrographs with SCS Type 1A rainfall distribution for detention system design.
Use SBUH method to design detention system for the 10-year, 24-hour storm event.
Design water quality facilites for the 0.9-inch rainfall, 24-hour storm event.

Basin Area Parameters

The project site has three discrete points of stormwater discharge. The "West" basin outfall pipe connects to the existing City storm drain system at the intersection Wolverine Drive and Brooklane Drive. The "Central" basin outfall pipe connects to the existing system north of Brooklane on a private access drive. Likewise, the "East" basin outfall connects to the City system near the easterly end of the private drive. Additionally, the extreme easterly portion of the site drains into the existing City storm drain system in Brooklane Drive.

Smaller sub-basins are identified for sizing elements of the conveyance system. Aggregate basin areas are used as appropriate for design of the detention and water quality facilities respectively.

Drainage Patterns - Basin Map



SURFACE DRAINAGE PATTERNS
Scale: 1" = 100'

Analysis Procedure

Starting at the upper end of the stormwater system, check each reach for curb and pipeline conveyance capacity for 10-year frequency storm events. Use the Rational Method formula, Q = CiA.

Overland Flow Velocity Factors

TABLE 3.2.1.C k_R VALUES FOR T_t USING THE RATIONAL METHOD

Land Cover Category	k_R
Forest with heavy ground litter and meadow	2.5
Fallow or minimum tillage cultivation	4.7
Short grass pasture and lawns	7.0
Nearly bare ground	10.1
Grassed waterway	15.0
Paved area (sheet flow) and shallow gutter flow	20.0

Select $k_R := 7.0$ "Short grass pasture and lawns" to use throughout.

Runoff Coefficients

TABLE 3.2.1.A RUNOFF COEFFICIENTS - "C" VALUES FOR THE RATIONAL METHOD

General Land Covers		Single Family Residential Areas*	
Land Cover	C	Land Cover Density	C
Dense forest	0.10	0.20 DU/GA (1 unit per 5 ac.)	0.17
Light forest	0.15	0.40 DU/GA (1 unit per 2.5 ac.)	0.20
Pasture	0.20	0.80 DU/GA (1 unit per 1.25 ac.)	0.27
Lawns	0.25	1.00 DU/GA	0.30
Playgrounds	0.30	1.50 DU/GA	0.33
Gravel areas	0.80	2.00 DU/GA	0.36
Pavement and roofs	0.90	2.50 DU/GA	0.39
Open water (pond, lakes, wetlands)	1.00	3.00 DU/GA	0.42
		3.50 DU/GA	0.45
		4.00 DU/GA	0.48
		4.50 DU/GA	0.51
		5.00 DU/GA	0.54
		5.50 DU/GA	0.57
		6.00 DU/GA	0.60

* Based on average 2,500 square feet per lot of impervious coverage.
For combinations of land covers listed above, an area-weighted "C_c x A_t" sum should be computed based on the equation $C_c \times A_t = (C_1 \times A_1) + (C_2 \times A_2) + \ldots + (C_n \times A_n)$, where $A_t = (A_1 + A_2 + \ldots + A_n)$, the total drainage basin area.

For post-development runoff, select appropriate runoff coefficients for each sub-basin:

Central Outfall Basin

$A_{C8} = 1.47 \cdot acre$ $C_{C8} := 0.42$

$A_{C7} = 1.08 \cdot acre$ $C_{C7} := 0.42$

$A_{C6} = 4.21 \cdot acre$ $C_{C6} := 0.39$

$A_{C5} = 1.41 \cdot acre$ $C_{C5} := 0.39$

$A_{C4} = 1.33 \cdot acre$ $C_{C4} := 0.42$

$A_{C3} = 1.34 \cdot acre$ $C_{C3} := 0.36$

$A_{C2} = 1.32 \cdot acre$ $C_{C2} := 0.39$

$A_{C1} = 1.86 \cdot acre$ $C_{C1} := 0.48$

East Outfall Basin

$A_{E6} = 5.21 \cdot acre$ $C_{E6} := 0.10$

$A_{E5} = 2.11 \cdot acre$ $C_{E5} := 0.33$

$A_{E4} = 5.64 \cdot acre$ $C_{E4} := 0.30$

$A_{E3} = 8.48 \cdot acre$ $C_{E3} := 0.33$

$A_{E2} = 1.82 \cdot acre$ $C_{E2} := 0.20$

$A_{E1} = 4.36 \cdot acre$ $C_{E1} := 0.10$

West Outfall Basin

$A_{W2} = 2.11 \cdot acre$ $C_{W2} := 0.20$

$A_{W1} = 1.35 \cdot acre$ $C_{W1} := 0.27$

Central Outfall Basin

Sub-basin C8

Sub-basin C8 comprises an area draining into Wolverine Drive, upstream from C7. This is an uppermost reach of a sub-area.

$A_{C8} = 1.47 \cdot acre$

Runoff coefficient $C_{C8} = 0.42$

Runoff velocity factor $k_{R_C8} := 7.0fps$

Runoff length $L_{C8} := 630ft$

Elevation change $\Delta H_{C8} := 90ft$

Runoff path slope $s_{C8} := \frac{\Delta H_{C8}}{L_{C8}}$ $s_{C8} = 0.143$

Overland flow velocity $V_{C8} := k_{R_C8} \cdot \sqrt{s_{C8}}$ $V_{C8} = 2.65 \cdot fps$

Overland travel time $T_{t_C8} := \frac{L_{C8}}{V_{C8}}$ $T_{t_C8} = 3.97 \cdot min$

Time of concentration $T_{c_C8} := \max(6.3min, T_{t_C8})$ $T_{c_C8} = 6.30 \cdot min$

Rainfall intensity $i_{C8} := P_10\left(\frac{T_{c_C8}}{min}\right) \cdot \frac{in}{hr}$ $i_{C8} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C8} := C_{C8} \cdot i_{C8} \cdot A_{C8}$ $Q_{C8} = 1.51 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C8} := 12in$

Outfall pipe gradient $s_{pipe_C8} := 13\%$

Outfall pipe capacity, flowing full $Q_{pipe_C8} := Q_p\left(\frac{d_{pipe_C8}}{ft}, s_{pipe_C8}\right)$ $Q_{pipe_C8} = 18.6 \cdot cfs$

$Pipe_Capacity_{C8} := if(Q_{pipe_C8} \geq Q_{C8}, "OK!", "No Good!")$ $Pipe_Capacity_{C8} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C8} := V_p\left(\frac{d_{pipe_C8}}{ft}, s_{pipe_C8}\right)$ $V_{pipe_C8} = 23.7 \cdot fps$

$Pipe_Velocity_{C8} := if(V_{pipe_C8} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{C8} = "OK!"$

Sub-basin C7

Sub-basin C7 comprises an area draining into Wolverine Drive. Sub-basin C7 is located immediately downstream and in the flow path of sub-basin C8.

$A_{C7} = 1.08 \cdot acre$

Runoff coefficient $C_{C7} = 0.42$

Runoff velocity factor $k_{R_C7} := 7.0fps$

Runoff length $L_{C7} := 780ft$

Elevation change $\Delta H_{C7} := 110ft$

Runoff path slope $s_{C7} := \frac{\Delta H_{C7}}{L_{C7}}$ $s_{C7} = 0.141$

Overland flow velocity $V_{C7} := k_{R_C7} \cdot \sqrt{s_{C7}}$ $V_{C7} = 2.63 \cdot fps$

Overland travel time $T_{t_C7} := \frac{L_{C7}}{V_{C7}}$ $T_{t_C7} = 4.95 \cdot min$

Time of concentration $T_{c_C7} := \max(6.3min, T_{t_C7})$ $T_{c_C7} = 6.30 \cdot min$

Rainfall intensity $i_{C7} := P_10\left(\frac{T_{c_C7}}{min}\right) \cdot \frac{in}{hr}$ $i_{C7} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C7} := i_{C7} \cdot (C_{C8} \cdot A_{C8} + C_{C7} \cdot A_{C7})$ $Q_{C7} = 2.61 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C7} := 12in$

Outfall pipe gradient $s_{pipe_C7} := 3\%$

Outfall pipe capacity, flowing full $Q_{pipe_C7} := Q_p\left(\frac{d_{pipe_C7}}{ft}, s_{pipe_C7}\right)$ $Q_{pipe_C7} = 8.9 \cdot cfs$

$Pipe_Capacity_{C7} := if(Q_{pipe_C7} \geq Q_{C7}, "OK!", "No Good!")$ $Pipe_Capacity_{C7} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C7} := V_p\left(\frac{d_{pipe_C7}}{ft}, s_{pipe_C7}\right)$ $V_{pipe_C7} = 11.4 \cdot fps$

$Pipe_Velocity_{C7} := if(V_{pipe_C7} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{C7} = "OK!"$

Sub-basin C5

Sub-basin C5 comprises an area at the northwest corner of the proposed subdivision, including a small portion of existing residential land on Country Club Hill. This is an uppermost reach of a sub-area.

$A_{C5} = 1.41 \cdot acre$

Runoff coefficient $C_{C5} = 0.39$

Runoff velocity factor $k_{R_C5} := 7.0fps$

Runoff length $L_{C5} := 600ft$

Elevation change $\Delta H_{C5} := 94ft$

Runoff path slope $s_{C5} := \frac{\Delta H_{C5}}{L_{C5}}$ $s_{C5} = 0.157$

Overland flow velocity $V_{C5} := k_{R_C5} \cdot \sqrt{s_{C5}}$ $V_{C5} = 2.77 \cdot fps$

Overland travel time $T_{t_C5} := \frac{L_{C5}}{V_{C5}}$ $T_{t_C5} = 3.61 \cdot min$

Time of concentration $T_{c_C5} := \max(6.3min, T_{t_C5})$ $T_{c_C5} = 6.30 \cdot min$

Rainfall intensity $i_{C5} := P_10\left(\frac{T_{c_C5}}{min}\right) \cdot \frac{in}{hr}$ $i_{C5} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C5} := C_{C5} \cdot i_{C5} \cdot A_{C5}$ $Q_{C5} = 1.34 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C5} := 12in$

Outfall pipe gradient $s_{pipe_C5} := 11\%$

Outfall pipe capacity, flowing full $Q_{pipe_C5} := Q_p\left(\frac{d_{pipe_C5}}{ft}, s_{pipe_C5}\right)$ $Q_{pipe_C5} = 17.1 \cdot cfs$

$Pipe_Capacity_{C5} := if(Q_{pipe_C5} \geq Q_{C5}, "OK!", "No Good!")$ $Pipe_Capacity_{C5} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C5} := V_p\left(\frac{d_{pipe_C5}}{ft}, s_{pipe_C5}\right)$ $V_{pipe_C5} = 21.8 \cdot fps$

$Pipe_Velocity_{C5} := if(V_{pipe_C5} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{C5} = "OK!"$

Sub-basin C4

Sub-basin C4 comprises an area immediately north of Buckeye Court, extending to the southerly and easterly ROW of Wolverine Drive above. Sub-basin C4 is located immediately downstream and in the flow path of sub-basin C5.

$A_{C4} = 1.33 \cdot acre$

Runoff coefficient $C_{C4} = 0.42$

Runoff velocity factor $k_{R_C4} := 7.0fps$

Runoff length $L_{C4} := 760ft$

Elevation change $\Delta H_{C4} := 122ft$

Runoff path slope $s_{C4} := \frac{\Delta H_{C4}}{L_{C4}}$ $s_{C4} = 0.161$

Overland flow velocity $V_{C4} := k_{R_C4} \cdot \sqrt{s_{C4}}$ $V_{C4} = 2.80 \cdot fps$

Overland travel time $T_{t_C4} := \frac{L_{C4}}{V_{C4}}$ $T_{t_C4} = 4.52 \cdot min$

Time of concentration $T_{c_C4} := \max(6.3min, T_{t_C4})$ $T_{c_C4} = 6.30 \cdot min$

Rainfall intensity $i_{C4} := P_10\left(\frac{T_{c_C4}}{min}\right) \cdot \frac{in}{hr}$ $i_{C4} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C4} := i_{C4} \cdot (C_{C5} \cdot A_{C5} + C_{C4} \cdot A_{C4})$ $Q_{C4} = 2.70 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C4} := 12in$

Outfall pipe gradient $s_{pipe_C4} := 11\%$

Outfall pipe capacity, flowing full $Q_{pipe_C4} := Q_p\left(\frac{d_{pipe_C4}}{ft}, s_{pipe_C4}\right)$ $Q_{pipe_C4} = 17.1 \cdot cfs$

$Pipe_Capacity_{C4} := if(Q_{pipe_C4} \geq Q_{C4}, "OK!", "No Good!")$ $Pipe_Capacity_{C4} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C4} := V_p\left(\frac{d_{pipe_C4}}{ft}, s_{pipe_C4}\right)$ $V_{pipe_C4} = 21.8 \cdot fps$

$Pipe_Velocity_{C4} := if(V_{pipe_C4} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{C4} = "OK!"$

Check Gabion Lined Channel (Swale) Hydraulics

Outfall swale depth $d_{swale_C4} := 12in$

Outfall swale gradient $s_{swale_C4} := 40\%$

Outfall swale capacity, flowing full

$$Q_{swale_C4_gabion} := Q_{c_gabion}\left(\frac{d_{swale_C4}}{ft}, s_{swale_C4}\right)$$

$Q_{swale_C4_gabion} = 49.1 \cdot cfs$

$Swale_Capacity_{C4_gabion} := if\left(Q_{swale_C4_gabion} \geq Q_{C4}, \text{"OK!"}, \text{"No Good!"}\right)$

$Swale_Capacity_{C4_gabion} = \text{"OK!"}$

Solve for Water Depth at Design Flow & Gradient

$Q_{C4} = 2.70 \cdot cfs$

$s_{swale_C4} = 0.4000$

$d_{swale_C4} = 1.00\,ft$

Guess value $y_{gabion_C4} := 1.0$

Given

$Q_{c_gabion}\left(y_{gabion_C4}, s_{swale_C4}\right) = Q_{C4}$

$d_{Q_gabion_C4} := Find\left(y_{gabion_C4}\right)$

$d_{Q_gabion_C4} = 0.337$

Channel Velocity at Design Flow & Gradient

$$V_{swale_C4_gabion}\left(d, s_c\right) := \frac{1.49}{n_{gabion}} \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot fps$$

$V_{swale_C4_gabion}\left(d_{Q_gabion_C4}, s_{swale_C4}\right) = 7.93 \cdot fps$

$V_{c_gabion_max} = 20.00 \cdot fps$

$Check_{velocity_swale_C4_gabion} := if\left(V_{swale_C4_gabion}\left(d_{Q_gabion}, s_{swale_C4}\right) \leq V_{c_gabion_max}, \text{"OK"}, \text{"No Good!"}\right)$

$Check_{velocity_swale_C4_gabion} = \text{"OK"}$

Check Gabion Lined Overgrown (weeds) Channel (Swale) Hydraulics

Outfall swale capacity, flowing full

$$Q_{swale_C4_weeds} := Q_{c_weeds}\left(\frac{d_{swale_C4}}{ft}, s_{swale_C4}\right)$$

$$Q_{swale_C4_weeds} = 21.5 \cdot cfs$$

$$Swale_Capacity_{C4_weeds} := if\left(Q_{swale_C4_weeds} \geq Q_{C4}, \text{"OK!"}, \text{"No Good!"}\right)$$

$$Swale_Capacity_{C4_weeds} = \text{"OK!"}$$

Solve for Water Depth at Design Flow

$Q_{C4} = 2.70 \cdot cfs$

$s_{swale_C4} = 0.4000$

$d_{swale_C4} = 1.00\,ft$

Guess value $y_{weeds_C4} := 3$

Given

$$Q_{c_weeds}\left(y_{weeds_C4}, s_{swale_C4}\right) = Q_{C4}$$

$$d_{Q_weeds_C4} := Find\left(y_{weeds_C4}\right)$$

$$d_{Q_weeds_C4} = 0.460$$

Channel Velocity at Design Flow

$$V_{swale_C4_weeds}\left(d, s_c\right) := \frac{1.49}{n_{weeds}} \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot fps$$

$$V_{swale_C4_weeds}\left(d_{Q_weeds_C4}, s_{swale_C4}\right) = 4.27 \cdot fps$$

Sub-basin C6

Sub-basin C6 comprises an area central to the proposed subdivision, located immediately above Badger Court. Discharge includes sub-basins C5 and C4 above.

$A_{C6} = 4.21 \cdot acre$

Runoff coefficient $C_{C6} = 0.39$

Runoff velocity factor $k_{R_C6} := 7.0fps$

Runoff length $L_{C6} := 780ft$

Elevation change $\Delta H_{C6} := 110ft$

Runoff path slope $s_{C6} := \frac{\Delta H_{C6}}{L_{C6}}$ $s_{C6} = 0.141$

Overland flow velocity $V_{C6} := k_{R_C6} \cdot \sqrt{s_{C6}}$ $V_{C6} = 2.63 \cdot fps$

Overland travel time $T_{t_C6} := \frac{L_{C6}}{V_{C6}}$ $T_{t_C6} = 4.95 \cdot min$

Time of concentration $T_{c_C6} := \max(6.3min, T_{t_C6})$ $T_{c_C6} = 6.30 \cdot min$

Rainfall intensity $i_{C6} := P_10\left(\frac{T_{c_C6}}{min}\right) \cdot \frac{in}{hr}$ $i_{C6} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C6} := i_{C6} \cdot (C_{C6} \cdot A_{C6} + C_{C5} \cdot A_{C5} + C_{C4} \cdot A_{C4})$ $Q_{C6} = 6.71 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C6} := 12in$

Outfall pipe gradient $s_{pipe_C6} := 5\%$

Outfall pipe capacity, flowing full $Q_{pipe_C6} := Q_p\left(\frac{d_{pipe_C6}}{ft}, s_{pipe_C6}\right)$ $Q_{pipe_C6} = 11.5 \cdot cfs$

$Pipe_Capacity_{C6} := if(Q_{pipe_C6} \geq Q_{C6}, "OK!", "No Good!")$ $Pipe_Capacity_{C6} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C6} := V_p\left(\frac{d_{pipe_C6}}{ft}, s_{pipe_C6}\right)$ $V_{pipe_C6} = 14.7 \cdot fps$

$Pipe_Velocity_{C6} := if(V_{pipe_C6} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{C6} = "OK!"$

Sub-basin C6a

Within sub-basin C6 is a private storm drain which may or may not be used for residential roof and site drainage for as many as 5 homes located on the south side of Buckeye Place. A supplemental runoff calculation is provided here for the private storm drain pipeline.

$A_{C6a} := 5 \times 2500ft^2$ $\quad A_{C6a} = 0.29 \cdot acre$

Runoff coefficient $\quad C_{C6a} := 0.90$

Runoff velocity factor $\quad k_{R_C6a} := 20.0fps$

Runoff length $\quad L_{C6a} := 350ft$

Elevation change $\quad \Delta H_{C6a} := 60ft$

Runoff path slope $\quad s_{C6a} := \frac{\Delta H_{C6a}}{L_{C6a}}$ $\quad s_{C6a} = 0.171$

Overland flow velocity $\quad V_{C6a} := k_{R_C6a} \cdot \sqrt{s_{C6a}}$ $\quad V_{C6a} = 8.28 \cdot fps$

Overland travel time $\quad T_{t_C6a} := \frac{L_{C6a}}{V_{C6a}}$ $\quad T_{t_C6a} = 0.70 \cdot min$

Time of concentration $\quad T_{c_C6a} := \max(6.3min, T_{t_C6a})$ $\quad T_{c_C6a} = 6.30 \cdot min$

Rainfall intensity $\quad i_{C6a} := P_10\left(\frac{T_{c_C6a}}{min}\right) \cdot \frac{in}{hr}$ $\quad i_{C6a} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $\quad Q_{C6a} := C_{C6a} \cdot i_{C6a} \cdot A_{C6a}$ $\quad Q_{C6a} = 0.63 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $\quad d_{pipe_C6a} := 12in$

Outfall pipe gradient $\quad s_{pipe_C6a} := 17\%$

Outfall pipe capacity, flowing full $\quad Q_{pipe_C6a} := Q_p\left(\frac{d_{pipe_C6a}}{ft}, s_{pipe_C6a}\right)$ $\quad Q_{pipe_C6a} = 21.3 \cdot cfs$

$Pipe_Capacity_{C6a} := if(Q_{pipe_C6a} \geq Q_{C6a}, "OK!", "No\ Good!")$ $\quad Pipe_Capacity_{C6a} = "OK!"$

Outfall pipe velocity, flowing full $\quad V_{pipe_C6a} := V_p\left(\frac{d_{pipe_C6a}}{ft}, s_{pipe_C6a}\right)$ $\quad V_{pipe_C6a} = 27.1 \cdot fps$

$Pipe_Velocity_{C6a} := if(V_{pipe_C6a} \geq 2fps, "OK!", "No\ Good!")$ $\quad Pipe_Velocity_{C6a} = "OK!"$

Sub-basin C2

Sub-basin C2 comprises the area immediately north of the cul-de-sac on Badger Court, extending to the southerly ROW of Wolverine Drive above. This is the upper reach of a sub-basin.

$A_{C2} = 1.32 \cdot acre$

Runoff coefficient $C_{C2} = 0.39$

Runoff velocity factor $k_{R_C2} := 7.0fps$

Runoff length $L_{C2} := 1650ft$

Elevation change $\Delta H_{C2} := 185ft$

Runoff path slope $s_{C2} := \frac{\Delta H_{C2}}{L_{C2}}$ $s_{C2} = 0.112$

Overland flow velocity $V_{C2} := k_{R_C2} \cdot \sqrt{s_{C2}}$ $V_{C2} = 2.34 \cdot fps$

Overland travel time $T_{t_C2} := \frac{L_{C2}}{V_{C2}}$ $T_{t_C2} = 11.73 \cdot min$

Time of concentration $T_{c_C2} := \max(6.3min, T_{t_C2})$ $T_{c_C2} = 11.73 \cdot min$

Rainfall intensity $i_{C2} := P_10\left(\frac{T_{c_C2}}{min}\right) \cdot \frac{in}{hr}$ $i_{C2} = 2.12 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C2} := C_{C2} \cdot i_{C2} \cdot A_{C2}$ $Q_{C2} = 1.10 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C2} := 12in$

Outfall pipe gradient $s_{pipe_C2} := 2\%$

Outfall pipe capacity, flowing full $Q_{pipe_C2} := Q_p\left(\frac{d_{pipe_C2}}{ft}, s_{pipe_C2}\right)$ $Q_{pipe_C2} = 7.3 \cdot cfs$

$Pipe_Capacity_{C2} := if(Q_{pipe_C2} \geq Q_{C2}, "OK!", "No\ Good!")$ $Pipe_Capacity_{C2} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C2} := V_p\left(\frac{d_{pipe_C2}}{ft}, s_{pipe_C2}\right)$ $V_{pipe_C2} = 9.3 \cdot fps$

$Pipe_Velocity_{C2} := if(V_{pipe_C2} \geq 2fps, "OK!", "No\ Good!")$ $Pipe_Velocity_{C2} = "OK!"$

Sub-basin C3

Sub-basin C3 also comprises an area immediately north of Badger Court, extending to the southerly ROW of Wolverine Drive above. This basin is located downstream from C2.

$A_{C3} = 1.34 \cdot acre$

Runoff coefficient $C_{C3} = 0.36$

Runoff velocity factor $k_{R_C3} := 7.0fps$

Runoff length $L_{C3} := 1180ft$

Elevation change $\Delta H_{C3} := 195ft$

Runoff path slope $s_{C3} := \frac{\Delta H_{C3}}{L_{C3}}$ $s_{C3} = 0.165$

Overland flow velocity $V_{C3} := k_{R_C3} \cdot \sqrt{s_{C3}}$ $V_{C3} = 2.85 \cdot fps$

Overland travel time $T_{t_C3} := \frac{L_{C3}}{V_{C3}}$ $T_{t_C3} = 6.91 \cdot min$

Time of concentration $T_{c_C3} := \max(6.3min, T_{t_C3})$ $T_{c_C3} = 6.91 \cdot min$

Rainfall intensity $i_{C3} := P_10\left(\frac{T_{c_C3}}{min}\right) \cdot \frac{in}{hr}$ $i_{C3} = 2.37 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{C3} := i_{C3} \cdot (C_{C3} \cdot A_{C3} + C_{C2} \cdot A_{C2})$ $Q_{C3} = 2.39 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_C3} := 12in$

Outfall pipe gradient $s_{pipe_C3} := 2\%$

Outfall pipe capacity, flowing full $Q_{pipe_C3} := Q_p\left(\frac{d_{pipe_C3}}{ft}, s_{pipe_C3}\right)$ $Q_{pipe_C3} = 7.3 \cdot cfs$

$Pipe_Capacity_{C3} := if(Q_{pipe_C3} \geq Q_{C3}, "OK!", "No Good!")$ $Pipe_Capacity_{C3} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_C3} := V_p\left(\frac{d_{pipe_C3}}{ft}, s_{pipe_C3}\right)$ $V_{pipe_C3} = 9.3 \cdot fps$

$Pipe_Velocity_{C3} := if(V_{pipe_C3} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{C3} = "OK!"$

Central Basin C Accumulative Conveyance above Detention Facility

$A_C := A_{C2} + A_{C3} + A_{C4} + A_{C5} + A_{C6} + A_{C7} + A_{C8}$ $\quad A_C = 12.16 \cdot acre$

Runoff coefficient $\quad C_C := 0.42$

Runoff velocity factor $\quad k_{R_C} := 7.0fps$

Runoff length $\quad L_C := 1340ft$

Elevation change $\quad \Delta H_C := 150ft$

Runoff path slope $\quad s_C := \frac{\Delta H_C}{L_C}$ $\quad s_C = 0.112$

Overland flow velocity $\quad V_C := k_{R_C} \cdot \sqrt{s_C}$ $\quad V_C = 2.34 \cdot fps$

Overland travel time $\quad T_{t_C} := \frac{L_C}{V_C}$ $\quad T_{t_C} = 9.54 \cdot min$

Time of concentration $\quad T_{c_C} := \max(6.3min, T_{t_C})$ $\quad T_{c_C} = 9.54 \cdot min$

Rainfall intensity $\quad i_C := P_10\left(\frac{T_{c_C}}{min}\right) \cdot \frac{in}{hr}$ $\quad i_C = 2.22 \cdot \frac{in}{hr}$

Sub-area runoff $\quad Q_C := C_C \cdot i_C \cdot A_C$ $\quad Q_C = 11.42 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $\quad d_{pipe_C} := 12in$

Outfall pipe gradient $\quad s_{pipe_C} := 15\%$

Outfall pipe capacity, flowing full $\quad Q_{pipe_C} := Q_p\left(\frac{d_{pipe_C}}{ft}, s_{pipe_C}\right)$ $\quad Q_{pipe_C} = 20.0 \cdot cfs$

$Pipe_Capacity_C := if(Q_{pipe_C} \geq Q_C, "OK!", "No Good!")$ $\quad Pipe_Capacity_C = "OK!"$

Outfall pipe velocity, flowing full $\quad V_{pipe_C} := V_p\left(\frac{d_{pipe_C}}{ft}, s_{pipe_C}\right)$ $\quad V_{pipe_C} = 25.4 \cdot fps$

$Pipe_Velocity_C := if(V_{pipe_C} \geq 2fps, "OK!", "No Good!")$ $\quad Pipe_Velocity_C = "OK!"$

Sub-basin C1 East

Sub-basin C1 comprises the tier of lots immediately downslope from Badger Court. For pipeline analyses, the sub-basin is further divided into two approximately equal areas, "east" of the detention facility and "west" of the detention facility.

$A_{C1} = 1.86 \cdot acre$	$A_{C1e} := \frac{1}{2} \cdot A_{C1}$	$A_{C1e} = 0.93 \cdot acre$
Runoff coefficient	$C_{C1e} := C_{C1}$	$C_{C1e} = 0.48$
Runoff velocity factor	$k_{R_C1e} := 7.0fps$	
Runoff length	$L_{C1e} := 180ft$	
Elevation change	$\Delta H_{C1e} := 52ft$	
Runoff path slope	$s_{C1e} := \frac{\Delta H_{C1e}}{L_{C1e}}$	$s_{C1e} = 0.289$
Overland flow velocity	$V_{C1e} := k_{R_C1e} \cdot \sqrt{s_{C1e}}$	$V_{C1e} = 3.76 \cdot fps$
Overland travel time	$T_{t_C1e} := \frac{L_{C1e}}{V_{C1e}}$	$T_{t_C1e} = 0.80 \cdot min$
Time of concentration	$T_{c_C1e} := \max(6.3min, T_{t_C1e})$	$T_{c_C1e} = 6.30 \cdot min$
Rainfall intensity	$i_{C1e} := P_10\left(\frac{T_{c_C1e}}{min}\right) \cdot \frac{in}{hr}$	$i_{C1e} = 2.42 \cdot \frac{in}{hr}$
Sub-area runoff	$Q_{C1e} := C_{C1e} \cdot i_{C1e} \cdot A_{C1e}$	$Q_{C1e} = 1.09 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size	$d_{pipe_C1e} := 12in$	
Outfall pipe gradient	$s_{pipe_C1e} := 3\%$	
Outfall pipe capacity, flowing full	$Q_{pipe_C1e} := Q_p\left(\frac{d_{pipe_C1e}}{ft}, s_{pipe_C1e}\right)$	$Q_{pipe_C1e} = 8.9 \cdot cfs$
$Pipe_Capacity_{C1e} := if(Q_{pipe_C1e} \geq Q_{C1e}, "OK!", "No\ Good!")$		$Pipe_Capacity_{C1e} = "OK!"$
Outfall pipe velocity, flowing full	$V_{pipe_C1e} := V_p\left(\frac{d_{pipe_C1e}}{ft}, s_{pipe_C1e}\right)$	$V_{pipe_C1e} = 11.4 \cdot fps$
$Pipe_Velocity_{C1e} := if(V_{pipe_C1e} \geq 2fps, "OK!", "No\ Good!")$		$Pipe_Velocity_{C1e} = "OK!"$

Sub-basin C1 West

Sub-basin C1 comprises the tier of lots immediately downslope from Badger Court. For pipeline analyses, the sub-basin is further divided into two approximately equal areas, "east" of the detention facility and "west" of the detention facility.

$A_{C1} = 1.86 \cdot acre$ $\quad A_{C1w} := \frac{1}{2} \cdot A_{C1}$ $\quad A_{C1w} = 0.93 \cdot acre$

Runoff coefficient $\quad C_{C1w} := C_{C1}$ $\quad C_{C1w} = 0.48$

Runoff velocity factor $\quad k_{R_C1w} := 7.0fps$

Runoff length $\quad L_{C1w} := 290ft$

Elevation change $\quad \Delta H_{C1w} := 10ft$

Runoff path slope $\quad s_{C1w} := \frac{\Delta H_{C1w}}{L_{C1w}}$ $\quad s_{C1w} = 0.034$

Overland flow velocity $\quad V_{C1w} := k_{R_C1w} \cdot \sqrt{s_{C1w}}$ $\quad V_{C1w} = 1.30 \cdot fps$

Overland travel time $\quad T_{t_C1w} := \frac{L_{C1w}}{V_{C1w}}$ $\quad T_{t_C1w} = 3.72 \cdot min$

Time of concentration $\quad T_{c_C1w} := \max(6.3min, T_{t_C1w})$ $\quad T_{c_C1w} = 6.30 \cdot min$

Rainfall intensity $\quad i_{C1w} := P_10\left(\frac{T_{c_C1w}}{min}\right) \cdot \frac{in}{hr}$ $\quad i_{C1w} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $\quad Q_{C1w} := C_{C1w} \cdot i_{C1w} \cdot A_{C1w}$ $\quad Q_{C1w} = 1.09 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $\quad d_{pipe_C1w} := 12in$

Outfall pipe gradient $\quad s_{pipe_C1w} := 3\%$

Outfall pipe capacity, flowing full $\quad Q_{pipe_C1w} := Q_p\left(\frac{d_{pipe_C1w}}{ft}, s_{pipe_C1w}\right)$ $\quad Q_{pipe_C1w} = 8.9 \cdot cfs$

$Pipe_Capacity_{C1w} := if(Q_{pipe_C1w} \geq Q_{C1w}, "OK!", "No\ Good!")$ $\quad Pipe_Capacity_{C1w} = "OK!"$

Outfall pipe velocity, flowing full $\quad V_{pipe_C1w} := V_p\left(\frac{d_{pipe_C1w}}{ft}, s_{pipe_C1w}\right)$ $\quad V_{pipe_C1w} = 11.4 \cdot fps$

$Pipe_Velocity_{C1w} := if(V_{pipe_C1w} \geq 2fps, "OK!", "No\ Good!")$ $\quad Pipe_Velocity_{C1w} = "OK!"$

Sub-basin C0 - Tract B

Sub-basin C0 comprises a contributing portion of open space Tract B. A runoff estimate is provided to be incorporated into the hydraulic analysis of the exiting downstream collection system.

$A_{C0} = 0.96 \cdot acre$	$A_{C0} = 0.96 \cdot acre$	
Runoff coefficient	$C_{C0} := 0.10$	
Runoff velocity factor	$k_{R_C0} := 2.5fps$	
Runoff length	$L_{C0} := 300ft$	
Elevation change	$\Delta H_{C0} := 35ft$	
Runoff path slope	$s_{C0} := \frac{\Delta H_{C0}}{L_{C0}}$	$s_{C0} = 0.117$
Overland flow velocity	$V_{C0} := k_{R_C0} \cdot \sqrt{s_{C0}}$	$V_{C0} = 0.85 \cdot fps$
Overland travel time	$T_{t_C0} := \frac{L_{C0}}{V_{C0}}$	$T_{t_C0} = 5.86 \cdot min$
Time of concentration	$T_{c_C0} := \max(6.3min, T_{t_C0})$	$T_{c_C0} = 6.30 \cdot min$
Rainfall intensity	$i_{C0} := P_10\left(\frac{T_{c_C0}}{min}\right) \cdot \frac{in}{hr}$	$i_{C0} = 2.42 \cdot \frac{in}{hr}$
Sub-area runoff	$Q_{C0} := C_{C0} \cdot i_{C0} \cdot A_{C0}$	$Q_{C0} = 0.23 \cdot cfs$

West Outfall Basin

Sub-basin W1

Sub-basin W1 comprises the SW corner of the subject basin which drains directly into Wolverine Drive.

$A_{W1} = 1.35 \cdot acre$

Runoff coefficient $C_{W1} = 0.27$

Runoff velocity factor $k_{R_W1} := 7.0fps$

Runoff length $L_{W1} := 600ft$

Elevation change $\Delta H_{W1} := 85ft$

Runoff path slope $s_{W1} := \frac{\Delta H_{W1}}{L_{W1}}$ $s_{W1} = 0.142$

Overland flow velocity $V_{W1} := k_{R_W1} \cdot \sqrt{s_{W1}}$ $V_{W1} = 2.63 \cdot fps$

Overland travel time $T_{t_W1} := \frac{L_{W1}}{V_{W1}}$ $T_{t_W1} = 3.80 \cdot min$

Time of concentration $T_{c_W1} := \max(6.3min, T_{t_W1})$ $T_{c_W1} = 6.30 \cdot min$

Rainfall intensity $i_{W1} := P_10\left(\frac{T_{c_W1}}{min}\right) \cdot \frac{in}{hr}$ $i_{W1} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{W1} := C_{W1} \cdot i_{W1} \cdot A_{W1}$ $Q_{W1} = 0.89 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_W1} := 12in$

Outfall pipe gradient $s_{pipe_W1} := 2\%$

Outfall pipe capacity, flowing full $Q_{pipe_W1} := Q_p\left(\frac{d_{pipe_W1}}{ft}, s_{pipe_W1}\right)$ $Q_{pipe_W1} = 7.3 \cdot cfs$

$Pipe_Capacity_{W1} := if(Q_{pipe_W1} \geq Q_{W1}, "OK!", "No Good!")$ $Pipe_Capacity_{W1} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_W1} := V_p\left(\frac{d_{pipe_W1}}{ft}, s_{pipe_W1}\right)$ $V_{pipe_W1} = 9.3 \cdot fps$

$Pipe_Velocity_{W1} := if(V_{pipe_W1} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{W1} = "OK!"$

East Outfall Basin

Sub-basin E4

Sub-basin E4 also comprises an area immediately north of Wolverine Drive, consisting primarily of existing residential development on the southerly sloping face of Country Club Hill. This is an uppermost reach of a sub-area.

$A_{E4} = 5.64 \cdot acre$

Runoff coefficient $C_{E4} = 0.30$

Runoff velocity factor $k_{R_E4} := 7.0fps$

Runoff length $L_{E4} := 1000ft$

Elevation change $\Delta H_{E4} := 150ft$

Runoff path slope $s_{E4} := \frac{\Delta H_{E4}}{L_{E4}}$ $s_{E4} = 0.150$

Overland flow velocity $V_{E4} := k_{R_E4} \cdot \sqrt{s_{E4}}$ $V_{E4} = 2.71 \cdot fps$

Overland travel time $T_{t_E4} := \frac{L_{E4}}{V_{E4}}$ $T_{t_E4} = 6.15 \cdot min$

Time of concentration $T_{c_E4} := \max(6.3min, T_{t_E4})$ $T_{c_E4} = 6.30 \cdot min$

Rainfall intensity $i_{E4} := P_10\left(\frac{T_{c_E4}}{min}\right) \cdot \frac{in}{hr}$ $i_{E4} = 2.42 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{E4} := C_{E4} \cdot i_{E4} \cdot A_{E4}$ $Q_{E4} = 4.12 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_E4} := 12in$

Outfall pipe gradient $s_{pipe_E4} := 2.4\%$

Outfall pipe capacity, flowing full $Q_{pipe_E4} := Q_p\left(\frac{d_{pipe_E4}}{ft}, s_{pipe_E4}\right)$ $Q_{pipe_E4} = 8.0 \cdot cfs$

$Pipe_Capacity_{E4} := if(Q_{pipe_E4} \geq Q_{E4}, "OK!", "No Good!")$ $Pipe_Capacity_{E4} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_E4} := V_p\left(\frac{d_{pipe_E4}}{ft}, s_{pipe_E4}\right)$ $V_{pipe_E4} = 10.2 \cdot fps$

$Pipe_Velocity_{E4} := if(V_{pipe_E4} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{E4} = "OK!"$

Sub-basin E3

Sub-basin E3 comprises an area immediately north of Wolverine Drive, consisting primarily of existing residential development on the southerly sloping face of Country Club Hill. Runoff from this basin is included in detention design and water quality design. Sub-basin E3 is located immediately downstream of sub-basin E4.

$A_{E3} = 8.48 \cdot acre$

Runoff coefficient $C_{E3} = 0.33$

Runoff velocity factor $k_{R_E3} := 7.0fps$

Runoff length $L_{E3} := 1250ft$

Elevation change $\Delta H_{E3} := 115ft$

Runoff path slope $s_{E3} := \frac{\Delta H_{E3}}{L_{E3}}$ $s_{E3} = 0.092$

Overland flow velocity $V_{E3} := k_{R_E3} \cdot \sqrt{s_{E3}}$ $V_{E3} = 2.12 \cdot fps$

Overland travel time $T_{t_E3} := \frac{L_{E3}}{V_{E3}}$ $T_{t_E3} = 9.81 \cdot min$

Time of concentration $T_{c_E3} := \max(6.3min, T_{t_E3}, T_{t_E4})$ $T_{c_E3} = 9.81 \cdot min$

Rainfall intensity $i_{E3} := P_10\left(\frac{T_{c_E3}}{min}\right) \cdot \frac{in}{hr}$ $i_{E3} = 2.20 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{E3} := i_{E3} \cdot (C_{C4} \cdot A_{E4} + C_{C3} \cdot A_{E3})$ $Q_{E3} = 12.04 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_E3} := 15in$

Outfall pipe gradient $s_{pipe_E3} := 4\%$

Outfall pipe capacity, flowing full $Q_{pipe_E3} := Q_p\left(\frac{d_{pipe_E3}}{ft}, s_{pipe_E3}\right)$ $Q_{pipe_E3} = 18.7 \cdot cfs$

$Pipe_Capacity_{E3} := if(Q_{pipe_E3} \geq Q_{E3}, "OK!", "No Good!")$ $Pipe_Capacity_{E3} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_E3} := V_p\left(\frac{d_{pipe_E3}}{ft}, s_{pipe_E3}\right)$ $V_{pipe_E3} = 15.2 \cdot fps$

$Pipe_Velocity_{E3} := if(V_{pipe_E3} \geq 2fps, "OK!", "No Good!")$ $Pipe_Velocity_{E3} = "OK!"$

Sub-basin E2

Sub-basin E2 comprises the easterly portion of the subject basin located above Wolverine Drive. This sub-basin is located downstream from sub-basins E3 and E4. The outfall consists of a pipe, followed by a constructed open channel.

$A_{E2} = 1.82 \cdot acre$

Runoff coefficient $C_{E2} = 0.20$

Runoff velocity factor $k_{R_E2} := 7.0fps$

Runoff length $L_{E2} := 530ft$

Elevation change $\Delta H_{E2} := 75ft$

Runoff path slope $s_{E2} := \frac{\Delta H_{E2}}{L_{E2}}$ $s_{E2} = 0.142$

Overland flow velocity $V_{E2} := k_{R_E2} \cdot \sqrt{s_{E2}}$ $V_{E2} = 2.63 \cdot fps$

Overland travel time $T_{t_E2} := \frac{L_{E2}}{V_{E2}}$ $T_{t_E2} = 3.35 \cdot min$

Time of concentration $T_{c_E2} := \max(6.3min, T_{t_E2}, T_{t_E3}, T_{t_E4})$ $T_{c_E2} = 9.81 \cdot min$

Rainfall intensity $i_{E2} := P_10\left(\frac{T_{c_E2}}{min}\right) \cdot \frac{in}{hr}$ $i_{E2} = 2.20 \cdot \frac{in}{hr}$

Sub-area runoff $Q_{E2} := i_{E2} \cdot (C_{C4} \cdot A_{E4} + C_{C3} \cdot A_{E3} + C_{C2} \cdot A_{E2})$ $Q_{E2} = 13.62 \cdot cfs$

Check Pipe Hydraulics

Outfall pipe size $d_{pipe_E2} := 15in$

Outfall pipe gradient $s_{pipe_E2} := 6\%$

Outfall pipe capacity, flowing full $Q_{pipe_E2} := Q_p\left(\frac{d_{pipe_E2}}{ft}, s_{pipe_E2}\right)$ $Q_{pipe_E2} = 22.9 \cdot cfs$

$Pipe_Capacity_{E2} := if(Q_{pipe_E2} \geq Q_{E2}, "OK!", "No\ Good!")$ $Pipe_Capacity_{E2} = "OK!"$

Outfall pipe velocity, flowing full $V_{pipe_E2} := V_p\left(\frac{d_{pipe_E2}}{ft}, s_{pipe_E2}\right)$ $V_{pipe_E2} = 18.7 \cdot fps$

$Pipe_Velocity_{E2} := if(V_{pipe_E2} \geq 2fps, "OK!", "No\ Good!")$ $Pipe_Velocity_{E2} = "OK!"$

Sub-basin E1

Sub-basin E1 comprises the westerly portion of the subject basin located below Wolverine Drive which drains directly into Brooklane Drive. Runoff from this sub-area, which drains into the City's existing storm drain system, will not be provided with additional conveyance, storage or treatment facilities. This area is dedicated primarily to open space, supporting only one building lot and no streets, thus generates negligible increased stormwater runoff or pollution. Runoff from this sub-area, left primarily in a natural state, will not be serviced by a water quality treatment facility.

$A_{E1} = 4.36 \cdot acre$

Runoff coefficient	$C_{E1} = 0.10$	
Runoff velocity factor	$k_{R_E1} := 2.5fps$	
Runoff length	$L_{E1} := 550ft$	
Elevation change	$\Delta H_{E1} := 140ft$	
Runoff path slope	$s_{E1} := \frac{\Delta H_{E1}}{L_{E1}}$	$s_{E1} = 0.255$
Overland flow velocity	$V_{E1} := k_{R_E1} \cdot \sqrt{s_{E1}}$	$V_{E1} = 1.26 \cdot fps$
Overland travel time	$T_{t_E1} := \frac{L_{E1}}{V_{E1}}$	$T_{t_E1} = 7.27 \cdot min$
Time of concentration	$T_{c_E1} := \max(6.3min, T_{t_E1})$	$T_{c_E1} = 7.27 \cdot min$
Rainfall intensity	$i_{E1} := P_10\left(\frac{T_{c_E1}}{min}\right) \cdot \frac{in}{hr}$	$i_{E1} = 2.35 \cdot \frac{in}{hr}$
Sub-area runoff	$Q_{E1} := C_{E1} \cdot i_{E1} \cdot A_{E1}$	$Q_{E1} = 1.03 \cdot cfs$

Sub-basin E5

Sub-basin E5 comprises the easterly portion of the subject basin located below Wolverine Drive which drains directly into Brooklane Drive. Runoff from this sub-area, which drains into the City's existing storm drain system, will not be provided with additional conveyance, storage or treatment facilities. This area is dedicated primarily to open space, supporting only one building lot and no streets, thus generates negligible increased stormwater runoff or pollution. Runoff from this sub-area, left primarily in a natural state, will not be serviced by a water quality treatment facility.

$A_{E5} = 2.11 \cdot acre$

Runoff coefficient	$C_{E5} = 0.33$	
Runoff velocity factor	$k_{R_E5} := 2.5fps$	
Runoff length	$L_{E5} := 300ft$	
Elevation change	$\Delta H_{E5} := 30ft$	
Runoff path slope	$s_{E5} := \frac{\Delta H_{E5}}{L_{E5}}$	$s_{E5} = 0.100$
Overland flow velocity	$V_{E5} := k_{R_E5} \cdot \sqrt{s_{E5}}$	$V_{E5} = 0.79 \cdot fps$
Overland travel time	$T_{t_E5} := \frac{L_{E5}}{V_{E5}}$	$T_{t_E5} = 6.32 \cdot min$
Time of concentration	$T_{c_E5} := \max(6.3min, T_{t_E5})$	$T_{c_E5} = 6.32 \cdot min$
Rainfall intensity	$i_{E5} := P_10\left(\frac{T_{c_E5}}{min}\right) \cdot \frac{in}{hr}$	$i_{E5} = 2.42 \cdot \frac{in}{hr}$
Sub-area runoff	$Q_{E5} := C_{E5} \cdot i_{E5} \cdot A_{E5}$	$Q_{E5} = 1.70 \cdot cfs$

Sub-basin E6

Sub-basin E6 comprises extreme easterly end of the parcel which drains directly into Brooklane Drive. With no new development proposed in this area with the Brooklane Heights Subdivision, no additional conveyance, detention or water quality facilities are proposed.

$A_{E6} = 5.21 \cdot acre$

Runoff coefficient	$C_{E6} = 0.10$	
Runoff velocity factor	$k_{R_E6} := 2.5fps$	
Runoff length	$L_{E6} := 700ft$	
Elevation change	$\Delta H_{E6} := 70ft$	
Runoff path slope	$s_{E6} := \frac{\Delta H_{E6}}{L_{E6}}$	$s_{E6} = 0.100$
Overland flow velocity	$V_{E6} := k_{R_E6} \cdot \sqrt{s_{E6}}$	$V_{E6} = 0.79 \cdot fps$
Overland travel time	$T_{t_E6} := \frac{L_{E6}}{V_{E6}}$	$T_{t_E6} = 14.76 \cdot min$
Time of concentration	$T_{c_E6} := \max(6.3min, T_{t_E6})$	$T_{c_E6} = 14.76 \cdot min$
Rainfall intensity	$i_{E6} := P_10\left(\frac{T_{c_E6}}{min}\right) \cdot \frac{in}{hr}$	$i_{E6} = 2.01 \cdot \frac{in}{hr}$
Sub-area runoff	$Q_{E6} := C_{E6} \cdot i_{E6} \cdot A_{E6}$	$Q_{E6} = 1.05 \cdot cfs$

STORMWATER 12"Φ PVC PIPE HYDRAULICS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

MathCad Reference Document(s)

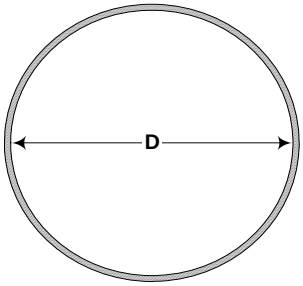
Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Area.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Radius.xmcd

Special Units & Dimensions

$cfs := \frac{ft^3}{sec}$ $\quad fps := \frac{ft}{sec}$

Sketch of Circular Pipe Section



Dimensions

$D_p := 1.000$ Pipe diameter, feet

Evaluate the Pipe Full-Flow Capacity over a Range of Hydraulic Slopes

$d_P := D_p$

Hydraulic Area of Full Pipe

$$A_p(d_P) := \pi\left(\frac{d_P}{2}\right)^2$$

Wetted Perimeter of Full Pipe

$$P_p(d_P) := \pi \cdot d_P$$

Hydraulic Radius

$$R_p(d_P) := \frac{A_p(d_P)}{P_p(d_P)}$$

Hydraulic Gradient Range (substitute pipe slopes for available field conditions)

$s_P := 0.0000, 0.001 .. 0.15$

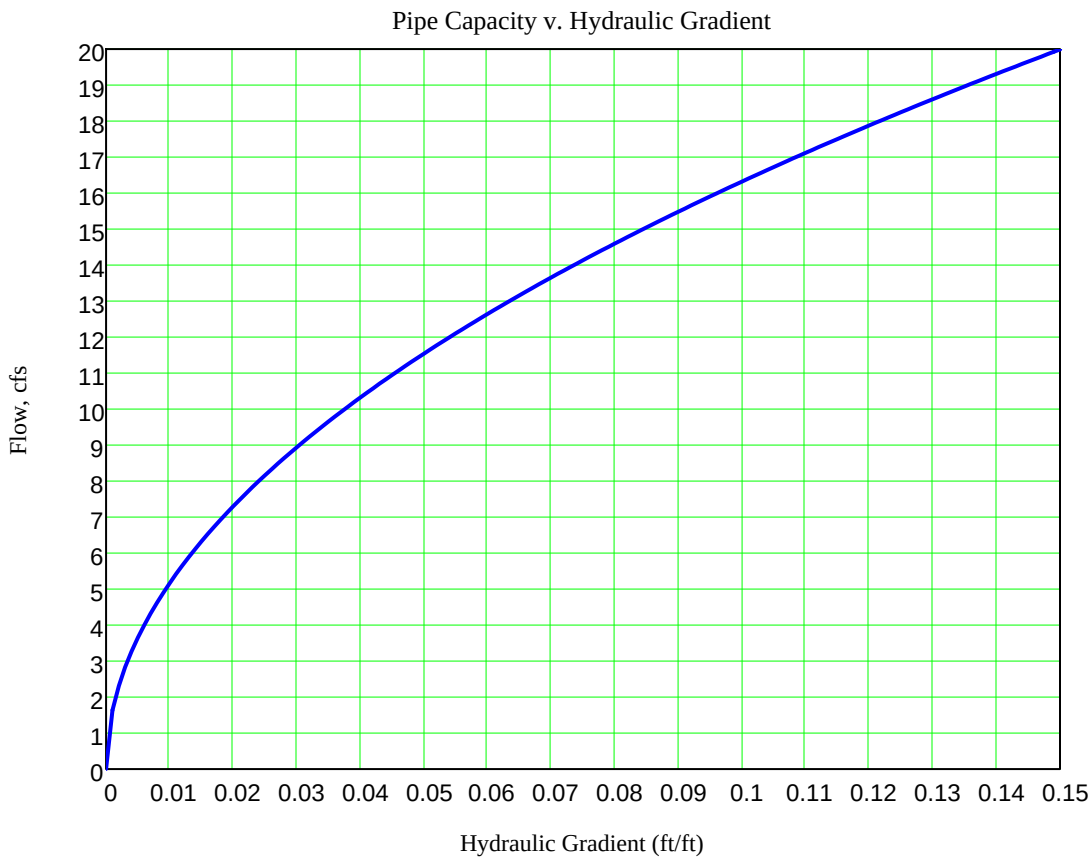
Roughness Coefficient

$n_P := 0.009$ (PVC Pipe)

Manning's Equation for Pipe Hydraulic Capacity, Flowing Full

$$Q_p(d_P, s_P) := \frac{1.49}{n_P} \cdot A_p(d_P) \cdot R_p(d_P)^{\frac{2}{3}} \cdot s_P^{\frac{1}{2}} \cdot cfs$$ (Equation 9.13, UniBell)

Graph the Capacity Function over the specified range of hydraulic gradients



Minimum pipe slope for 12-inch PVC pipe

$s_{min} := 0.0050$

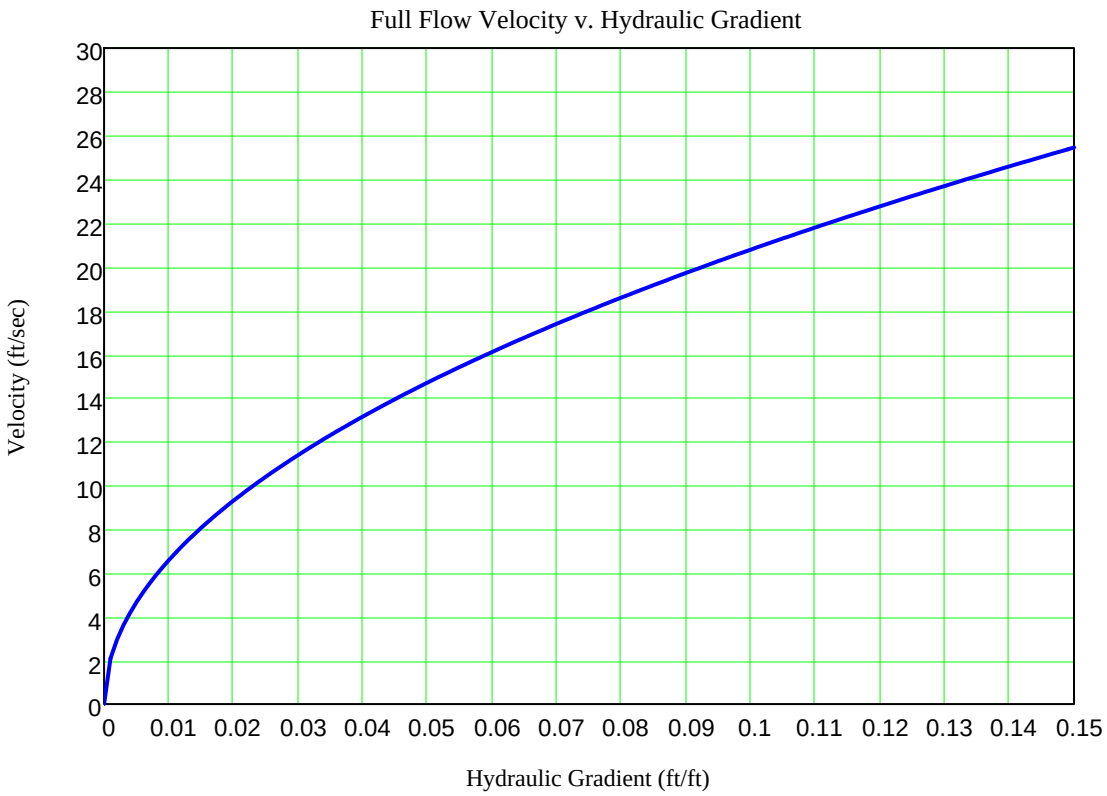
$Q_p(d_P, s_{min}) = 3.65 \cdot cfs$

$Q_p(d_P, s_{min}) = 1638 \cdot gpm$

Pipe Velocity, Flowing Full

$$V_p(d_P, s_P) := \frac{1.49}{n_P} \cdot R_p(d_P)^{\frac{2}{3}} \cdot s_P^{\frac{1}{2}} \cdot cfs$$ (Manning's Equation)

Graph the Velocity Function over the specified range of hydraulic gradients



STORMWATER 15"Φ PVC PIPE HYDRAULICS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

MathCad Reference Document(s)

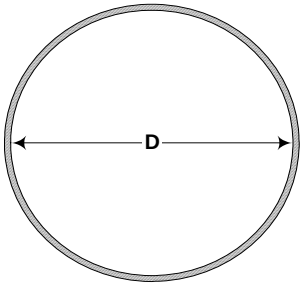
Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Area.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Radius.xmcd

Special Units & Dimensions

$cfs := \frac{ft^3}{sec}$ $\quad fps := \frac{ft}{sec}$

Sketch of Circular Pipe Section



Dimensions

$D_p := 1.250$ Pipe diameter, feet

Evaluate the Pipe Full-Flow Capacity over a Range of Hydraulic Slopes

$d_P := D_p$

Hydraulic Area of Full Pipe

$$A_p(d_P) := \pi\left(\frac{d_P}{2}\right)^2$$

Wetted Perimeter of Full Pipe

$$P_p(d_P) := \pi \cdot d_P$$

Hydraulic Radius

$$R_p(d_P) := \frac{A_p(d_P)}{P_p(d_P)}$$

Hydraulic Gradient Range (substitute pipe slopes for available field conditions)

$s_P := 0.0000, 0.001 .. 0.30$

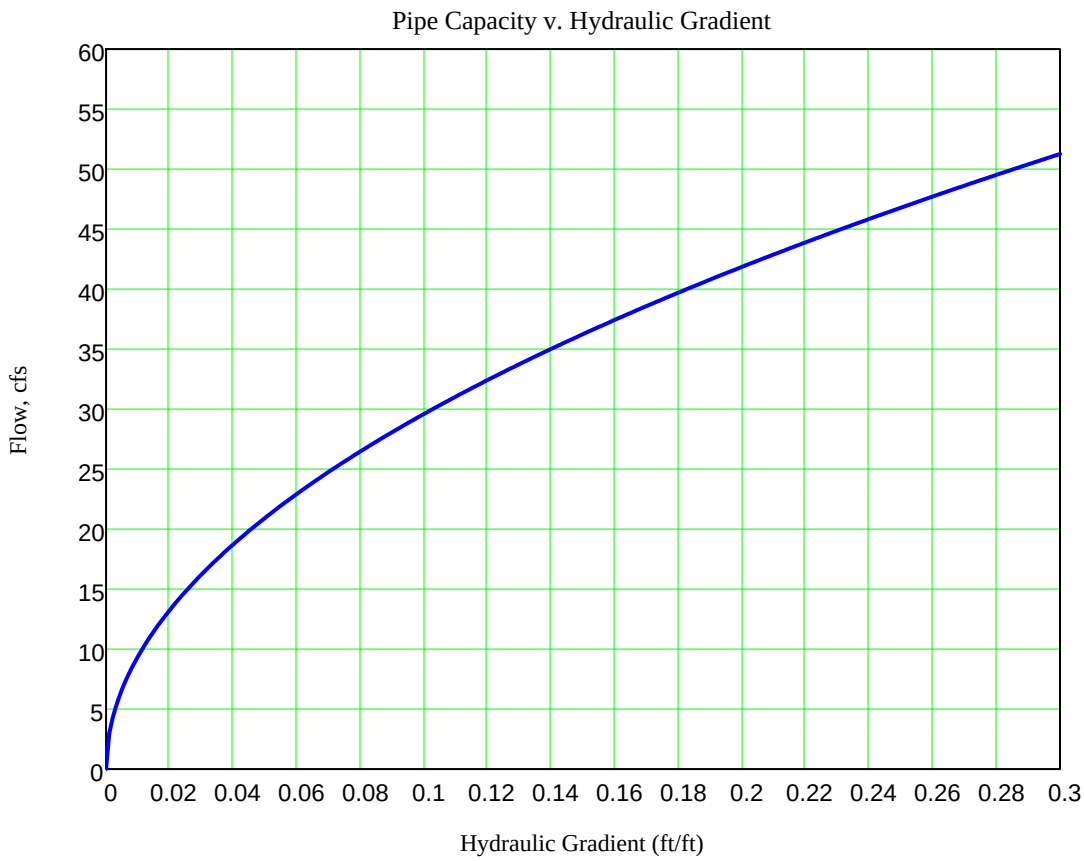
Roughness Coefficient

$n_P := 0.009$ (PVC Pipe)

Manning's Equation for Pipe Hydraulic Capacity, Flowing Full

$$Q_p(d_P, s_P) := \frac{1.49}{n_P} \cdot A_p(d_P) \cdot R_p(d_P)^{\frac{2}{3}} \cdot s_P^{\frac{1}{2}} \cdot cfs$$ (Equation 9.13, UniBell)

Graph the Capacity Function over the specified range of hydraulic gradients



Minimum pipe slope for 15-inch PVC pipe

$s_{min} := 0.0030$

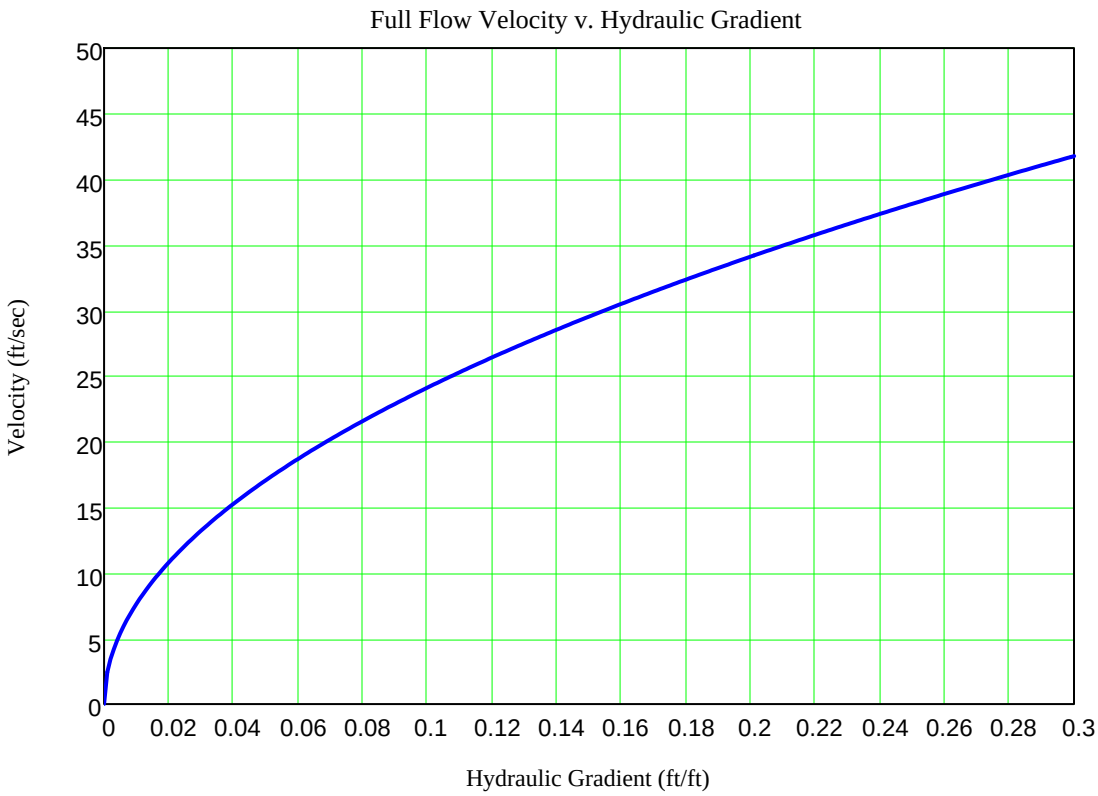
$Q_p(d_P, s_{min}) = 5.12 \cdot cfs$

$Q_p(d_P, s_{min}) = 2300 \cdot gpm$

Pipe Velocity, Flowing Full

$$V_p(d_P, s_P) := \frac{1.49}{n_P} \cdot R_p(d_P)^{\frac{2}{3}} \cdot s_P^{\frac{1}{2}} \cdot fps$$ (Manning's Equation)

Graph the Velocity Function over the specified range of hydraulic gradients



HYDRAULIC AREA FUNCTION
STORMWATER RUNOFF ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Data Set - 2 Arrays

From Table 7-4 King & Brater

d/D values $vx := \begin{pmatrix} 0 \\ .1 \\ .2 \\ .3 \\ .4 \\ .5 \\ .6 \\ .7 \\ .8 \\ .9 \\ 1.0 \end{pmatrix}$

A/D^2 values $vy := \begin{pmatrix} 0 \\ .041 \\ .112 \\ .198 \\ .293 \\ .393 \\ .492 \\ .587 \\ .674 \\ .745 \\ .785 \end{pmatrix}$

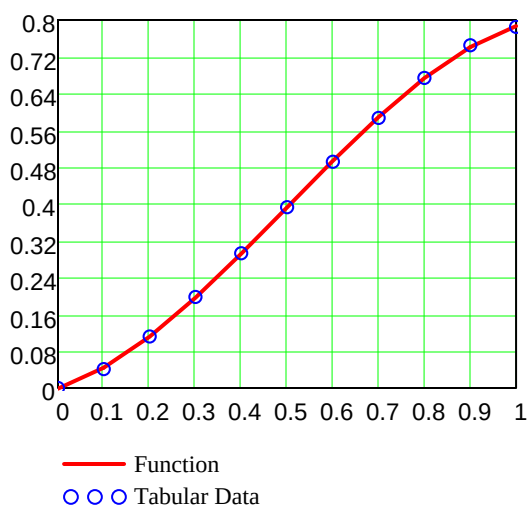
Regression Analysis of Data

Try a 3rd order polynomial:

$n := 3 \qquad coeff := regress(vx, vy, n)$

Regression Function Plot

For $x := 0, 0.1 .. 1.0$



Good comparison, so

$$y := coeff_6 \cdot x^3 + coeff_5 \cdot x^2 + coeff_4 \cdot x + coeff_3$$

where

$$y := \frac{A_d}{D^2} \qquad x := \frac{d}{D}$$

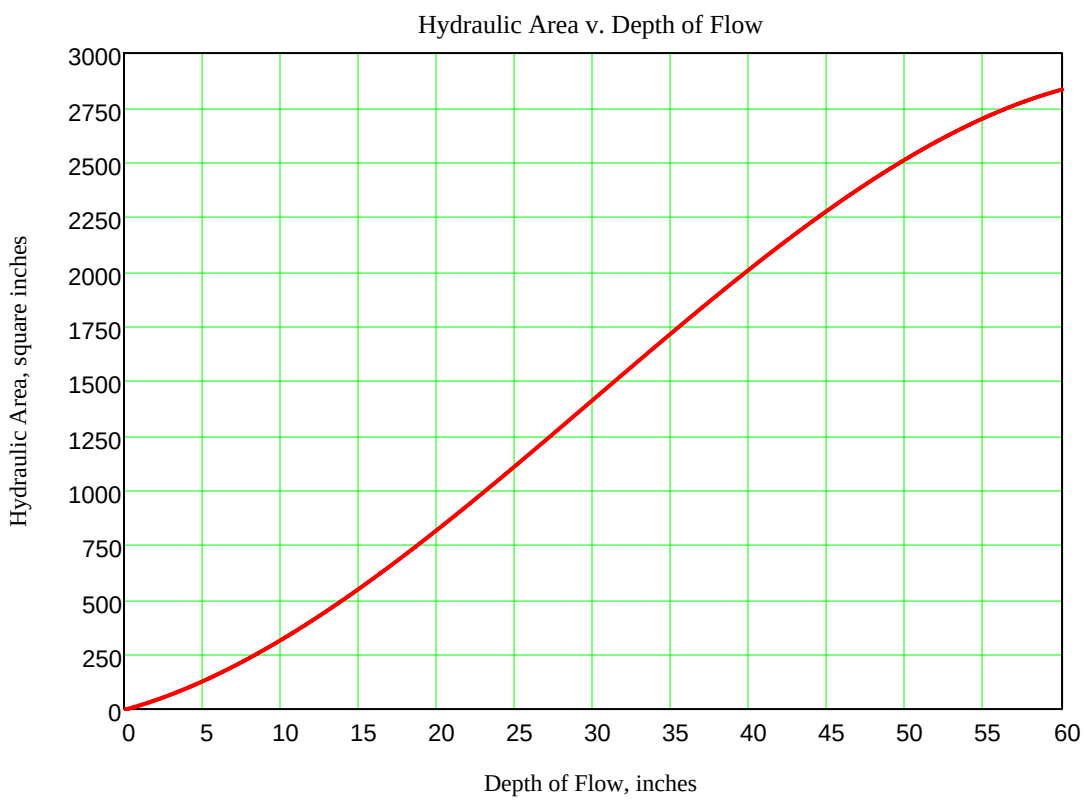
Using the derived polynomial expression, calculate the hydraulic area of a circular pipe

Diameter, $D := 60in$

Depth of flow, $d := 0in, 0.01in .. D$

Hydraulic area, $$Area(D, d) := D^2 \cdot \left[coeff_6 \cdot \left(\frac{d}{D}\right)^3 + coeff_5 \cdot \left(\frac{d}{D}\right)^2 + coeff_4 \cdot \left(\frac{d}{D}\right) + coeff_3 \right]$$

Plot the function



HYRAULIC RADIUS FUNCTION
STORMWATER RUNOFF ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Data Set - 2 Arrays

From Table 7-5 King & Brater

d/D values $vx := \begin{pmatrix} 0 \\ .1 \\ .2 \\ .3 \\ .4 \\ .5 \\ .6 \\ .7 \\ .8 \\ .9 \\ 1.0 \end{pmatrix}$

R/D values $vy := \begin{pmatrix} 0 \\ .063 \\ .121 \\ .171 \\ .214 \\ .250 \\ .278 \\ .296 \\ .304 \\ .298 \\ .250 \end{pmatrix}$

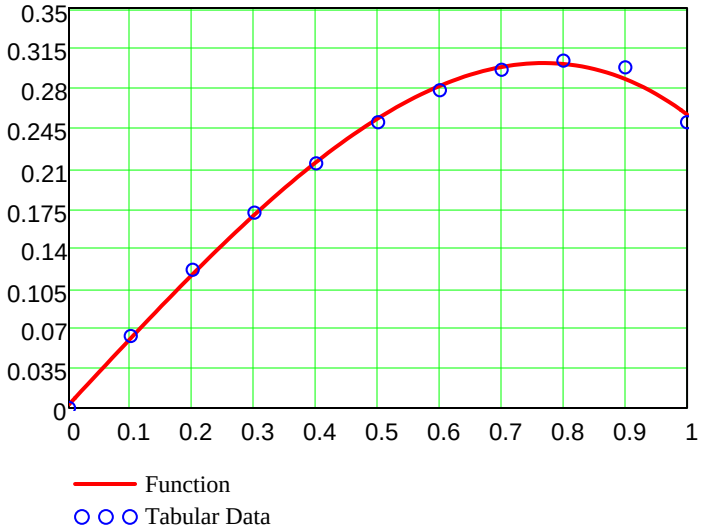
Regression Analysis of Data

Try a 3rd order polynomial:

$n := 3 \qquad coeff := regress(vx, vy, n)$

Regression Function Plot

For $x := 0, 0.01 .. 1.0$



Good comparison, so

$$y := coeff_6 \cdot x^3 + coeff_5 \cdot x^2 + coeff_4 \cdot x + coeff_3$$

where

$$y := \frac{R_d}{D} \qquad x := \frac{d}{D}$$

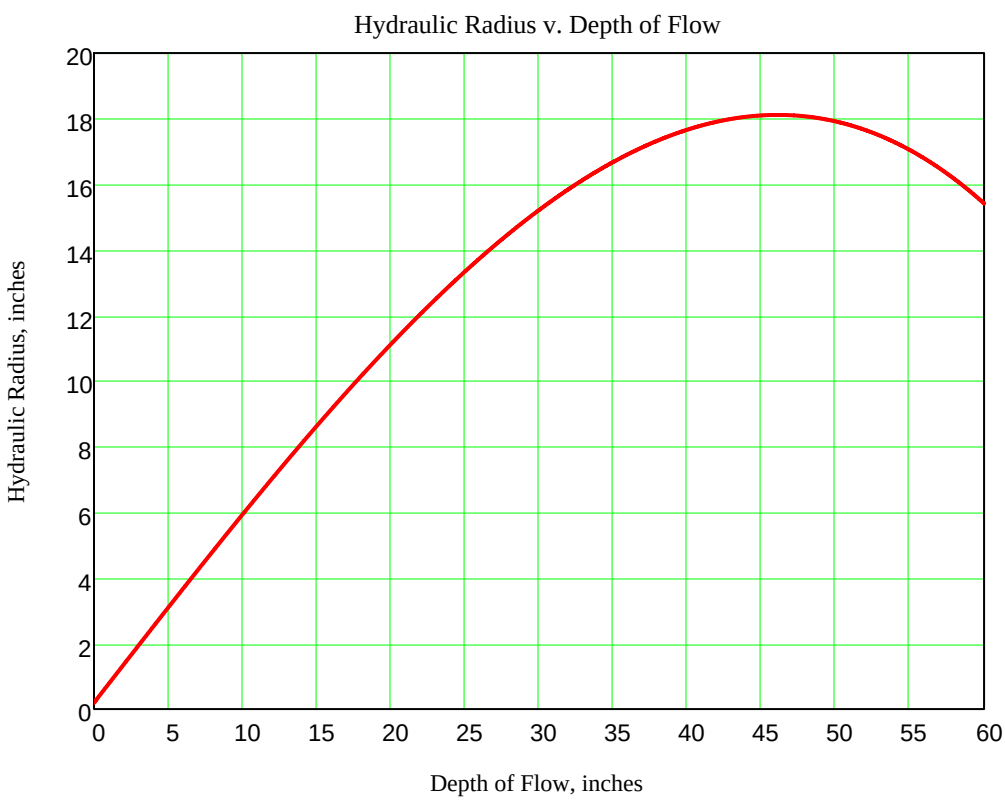
Using the derived polynomial expression, calculate the hydraulic radius of a circular pipe

Diameter, $D := 60in$

Depth of flow, $d := 0in, .01in .. D$

Hydraulic radius, $Radius(D, d) := D \cdot \left[coeff_6 \cdot \left(\frac{d}{D}\right)^3 + coeff_5 \cdot \left(\frac{d}{D}\right)^2 + coeff_4 \cdot \left(\frac{d}{D}\right) + coeff_3 \right]$

Plot the function

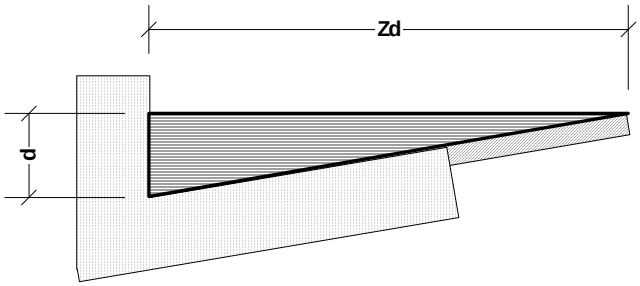


GUTTER FLOW HYDRAULICS
STORMWATER RUNOFF CONVEYANCE ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Special Units & Dimensions

$cfs := \frac{ft^3}{sec}$ $\quad fps := \frac{ft}{sec}$

Sketch of Gutter Section



Street width, curb-to-curb

$W_{street} := 28ft$

Street cross slope

$z := 2\%$ (City of Corvallis Standard Detail 101)

$Z := \frac{1}{z}$ $\quad Z = 50.00$

Maximum water depth at curb

$d_{g_max} := \frac{1}{2} \cdot W_{street} \cdot z$ $\quad d_{g_max} = 3.36 \cdot in$

Surface width of flow in gutter

$Z \cdot d_{g_max} = 14.00 \cdot ft$

Manning's roughness coefficient,

$n_g := 0.011$ (Table 4.2, Bedient & Huber)

Maximum hydraulic gradient (in direction of gutter flow) $s_{g_max} := 15.0\%$

Calculate maximum gutter capacity, flowing full against peak flow (Mannings Equation, AISI 1985 Modern Sewer Design)

$$Q_{g_max} := 0.56 \cdot \left(\frac{Z}{n_g}\right) \cdot \left(\frac{d_{g_max}}{ft}\right)^{2.7} \cdot s_{g_max}^{\frac{1}{2}} \cdot cfs$$

$$Q_{g_max} = 31.71 \cdot cfs$$

Minimum hydraulic gradient (in direction of gutter flow) $s_{g_min} := 0.5\%$

Calculate minimum gutter capacity, flowing full against peak flow (Mannings Equation, AISI 1985 Modern Sewer Design)

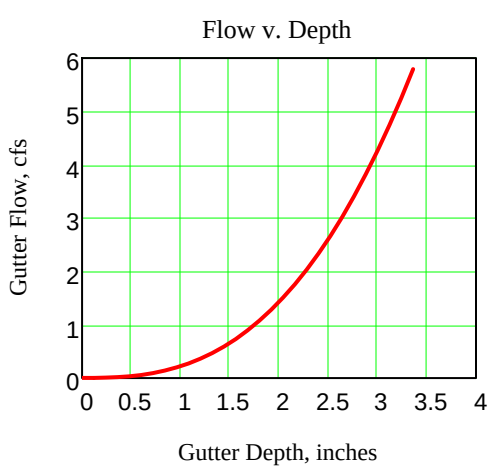
$$Q_{g_min} := 0.56 \cdot \left(\frac{Z}{n_g}\right) \cdot \left(\frac{d_{g_max}}{ft}\right)^{2.7} \cdot s_{g_min}^{\frac{1}{2}} \cdot cfs$$

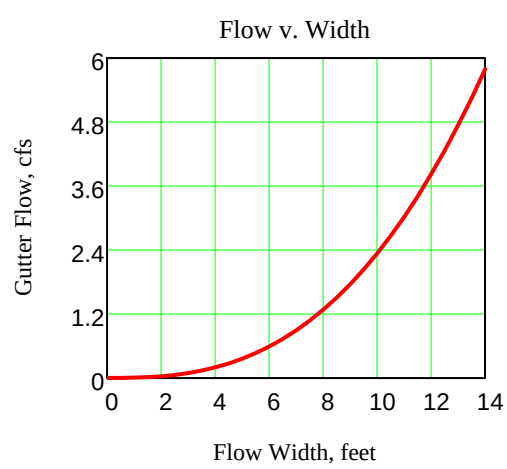
$$Q_{g_min} = 5.79 \cdot cfs$$

Evaluate gutter hydraulic capacity at various depths of flow at minimum slope

$$d_g := 0ft, 0.01ft .. d_{g_max}$$

$$Q_g(d_g) := 0.56 \cdot \left(\frac{Z}{n_g}\right) \cdot \left(\frac{d_g}{ft}\right)^{2.7} \cdot s_{g_min}^{\frac{1}{2}} \cdot cfs$$



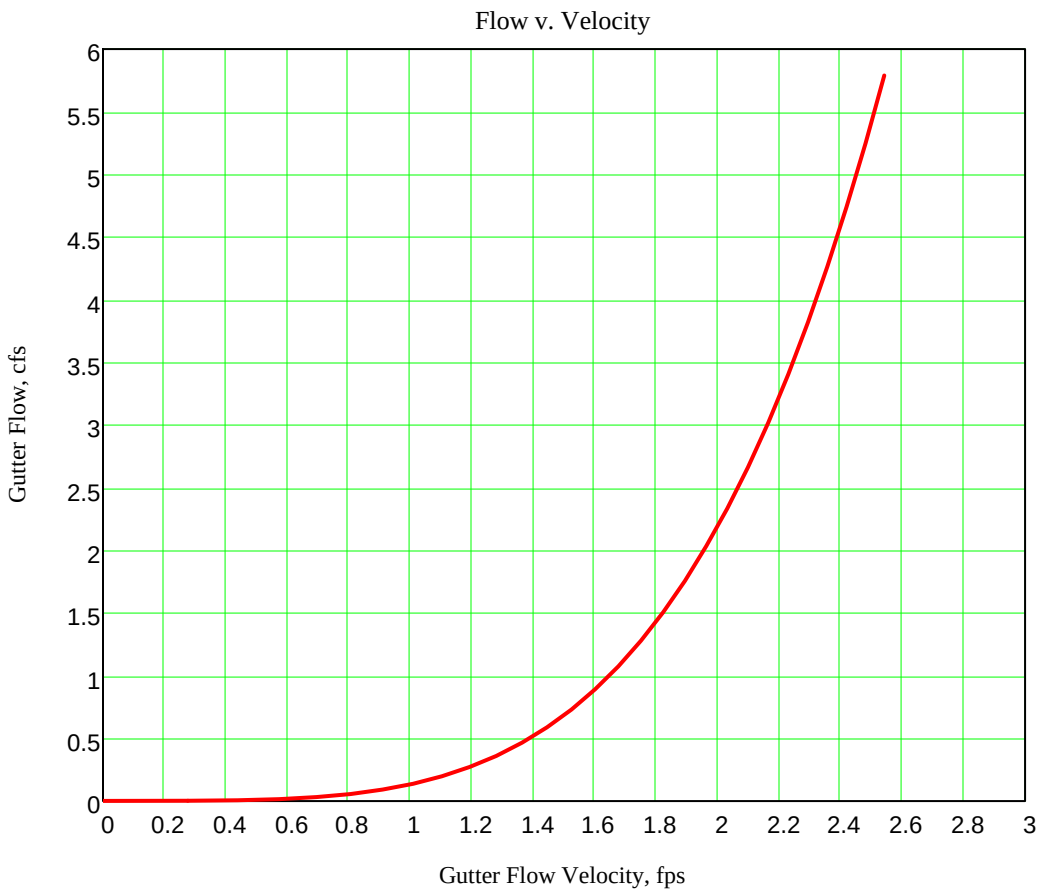


Hydraulic Parameters

$A_g(d_g) := \frac{1}{2} \cdot Z \cdot d_g^{\,2}$ $\qquad P_g(d_g) := d_g \cdot (Z + 1)$ $\qquad R_g(d_g) := \frac{A_g(d_g)}{P_g(d_g)}$

Calculate Gutter Velocity over a Range of Flows

$$V_g(d_g) := \frac{1.486}{n_g} \cdot \left(\frac{R_g(d_g)}{ft}\right)^{\frac{2}{3}} \cdot s_{g_min}^{\frac{1}{2}} \cdot fps$$



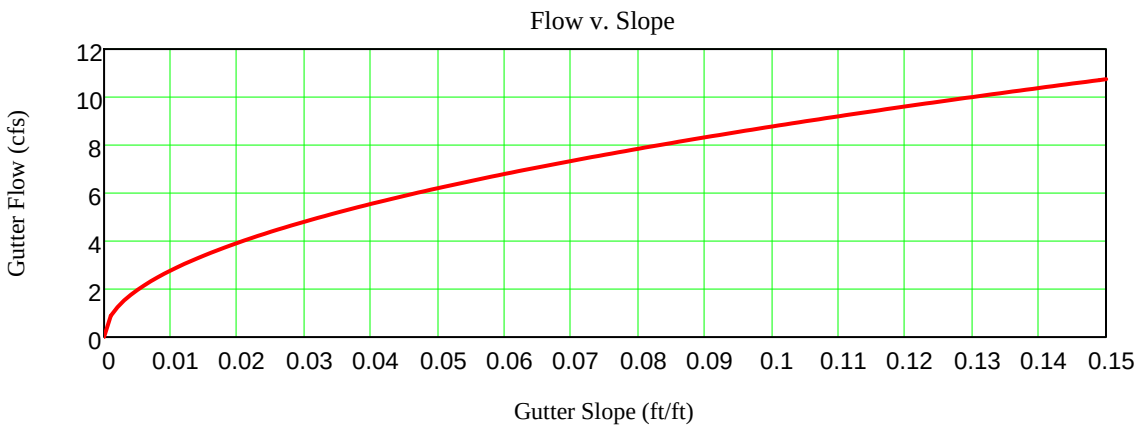
Based on above analyses, select a design flow depth of $\qquad d_{g_des} := 2.25in$

(To maintain a minimum 2 fps flow)

Calculate gutter hydraulic capacity

$s_g := 0, 0.001 .. 0.15$ (Slopes from 0 to 15%)

$Q_g(s_g) := 0.56 \cdot \left(\frac{Z}{n_g}\right) \cdot \left(\frac{d_{g_des}}{ft}\right)^{2.7} \cdot s_g^{\frac{1}{2}} \cdot cfs$ $\quad Q_g(0.005) = 1.96 \cdot cfs$ $\quad Q_g(0.15) = 10.74 \cdot cfs$

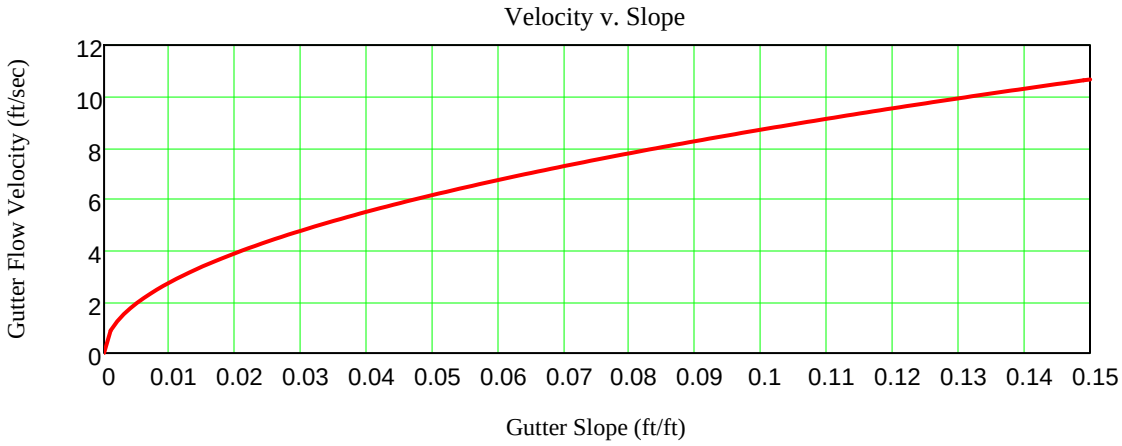


Hydraulic Parameters

$A_g(d_{g_des}) := \frac{1}{2} \cdot Z \cdot d_{g_des}^{2}$ $\quad P_g(d_{g_des}) := d_{g_des} \cdot (Z + 1)$ $\quad R_g(d_{g_des}) := \frac{A_g(d_{g_des})}{P_g(d_{g_des})}$

Calculate Velocity over a Range of Gutter Slopes

$V_g(s_g) := \frac{1.486}{n_g} \cdot \left(\frac{R_g(d_{g_des})}{ft}\right)^{\frac{2}{3}} \cdot s_g^{\frac{1}{2}} \cdot fps$ $\quad V_g(0.005) = 1.95 \cdot fps$ $\quad V_g(0.15) = 10.66 \cdot fps$



CURB INLET HYDRAULICS
STORMWATER RUNOFF CONVEYANCE ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

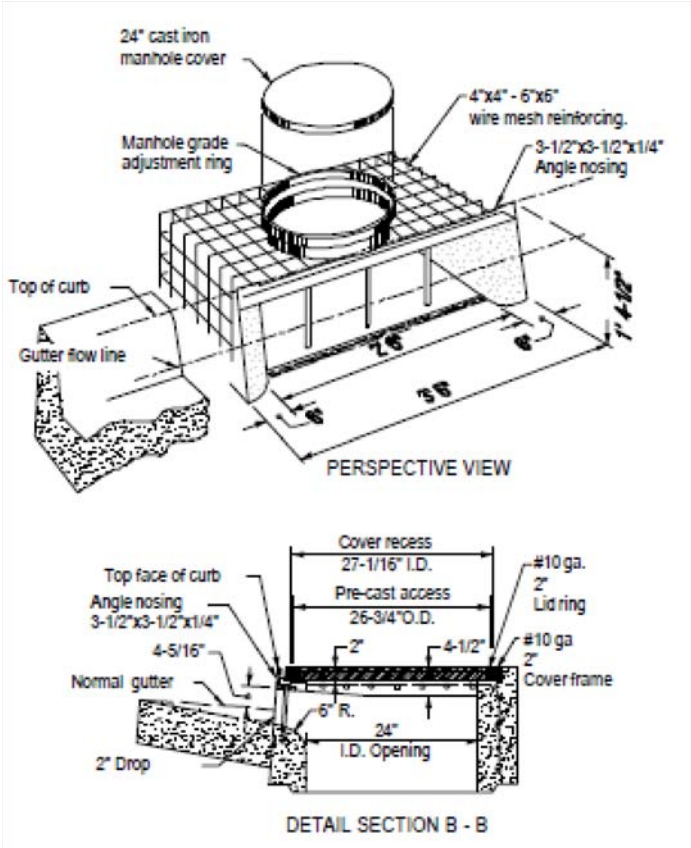
Special Units & Dimensions Used in this MathCad Worksheet

$$cfs := \frac{ft^3}{sec}$$

Approach

For a City of Corvallis standard curb inlet, determine the maximum inlet capacity with the water surface elevation at top of curb.

City of Corvallis Curb Inlet Drawings



Inlet Orifice Dimensions

$h_{open} := 4.3125in + 2.0in$

$h_{open} = 6.31\,in$

$L_{open} := 2.50ft$

Curb Height Elevation

(Measured from bottom of orifice)

$h_{curb} := h_{open} + 3.5in$

$h_{curb} = 9.81\,in$

Brater & King Fig. 4-4 (Low Head Orifice)

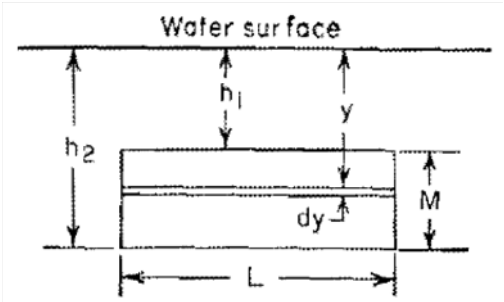


FIG. 4-4. Rectangular orifice.

Orifice Parameters

For water surface at top of curb:

$h_2 := h_{curb}$ $\quad h_2 = 9.81\,in$

$M_o := h_{open}$ $\quad M_o = 6.31\,in$

$h_1 := h_2 - M_o$ $\quad h_1 = 3.50\,in$

$L_o := L_{open}$ $\quad L_o = 2.50\,ft$

Brater & King Equation 4-16 (Low Head Orifices)

$$Q_{curb_inlet} := \frac{2}{3} \cdot L_o \cdot \sqrt{2g} \cdot \left(h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}} \right)$$

$Q_{curb_inlet} = 7.78\,cfs$

STORMWATER 12"Φ PVC PIPE HYDRAULICS
EXISTING STORM DRAIN LATERAL "V"
BROOKLANE PARK ESTATES
CORVALLIS, OREGON

MathCad Reference Document(s)

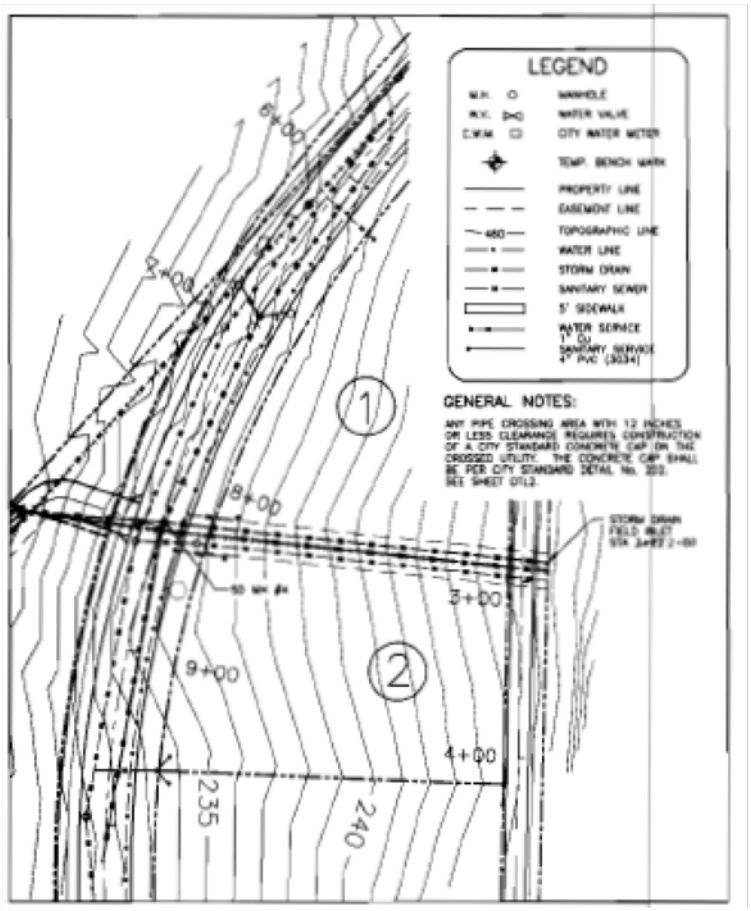
Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Area.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Radius.xmcd

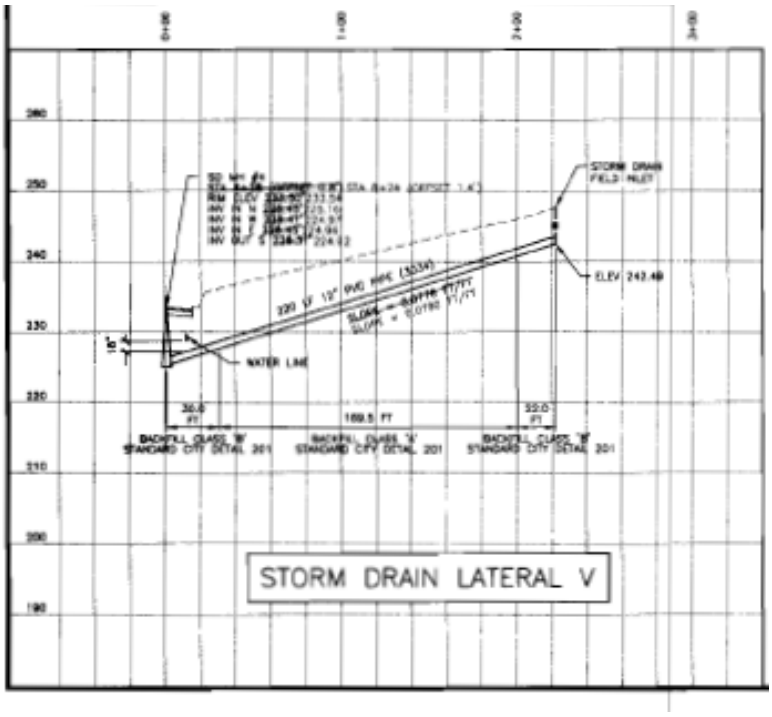
Special Units & Dimensions

$$cfs := \frac{ft^3}{sec} \qquad fps := \frac{ft}{sec}$$

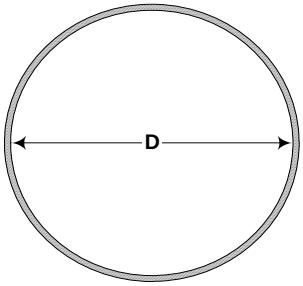
Drawing Excerpt from Brooklane Park Estates Storm Drain As-builts



Drawing Excerpt from Brooklane Park Estates Storm Drain As-builts



Sketch of Circular Pipe Section



Dimensions

$D_p := 1.000$ Pipe diameter, feet

$d_P := D_p$ $d_P = 1.00$

Hydraulic Area of Full Pipe

$$A_p(d_P) := \pi\left(\frac{d_P}{2}\right)^2$$

Wetted Perimeter of Full Pipe

$$P_p(d_P) := \pi \cdot d_P$$

Hydraulic Radius

$$R_p(d_P) := \frac{A_p(d_P)}{P_p(d_P)}$$

As-built record pipe slope for 12-inch PVC pipe

$$s_{as_built} := 0.079$$

$$s_P := s_{as_built}$$

Roughness Coefficient

$n_P := 0.009$ (PVC Pipe)

Manning's Equation for Pipe Hydraulic Capacity, Flowing Full

$$Q_p(d_P, s_P) := \frac{1.49}{n_P} \cdot A_p(d_P) \cdot R_p(d_P)^{\frac{2}{3}} \cdot s_P^{\frac{1}{2}} \cdot cfs$$ (Equation 9.13, UniBell)

Pipe Capacity, flowing full

$$Q_p(d_P, s_P) = 14.50 \cdot cfs$$

Pipe Velocity, Flowing Full

$$V_p(d_P, s_P) := \frac{1.49}{n_P} \cdot R_p(d_P)^{\frac{2}{3}} \cdot s_P^{\frac{1}{2}} \cdot fps$$ (Manning's Equation)

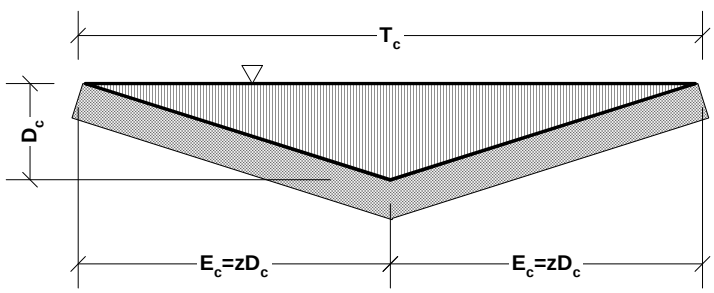
$$V_p(d_P, s_P) = 18.47 \cdot fps$$

GABION-LINED SWALE HYDRAULICS
STORMWATER RUNOFF CONVEYANCE ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Special Units & Dimensions Used in this Analysis

$cfs := \frac{ft^3}{sec}$ $\quad fps := \frac{ft}{sec}$

Sketch of Proposed Triangular Channel Conveyance Section



Conveyance Geometry (feet)

$D_c := 1.0$ Channel depth

$z := 3.0$ H:V side slopes

$E_c := z \cdot D_c$ $\quad E_c = 3.00$

Channel Depth (ft), Flowing Full

$d := D_c$ $\quad d = 1.00$

Channel Top Width (ft)

$T_c := 2 \cdot E_c$ $\quad T_c = 6.00$

Hydraulic Area (sq ft)

$A_c(d) := z \cdot d^2$ $\quad A_c(d) = 3.00$

Wetted Perimeter (ft)

$P_c(d) := 2 \cdot d \cdot \sqrt{1 + z^2}$ $\quad P_c(d) = 6.32$

Hydraulic Radius (ft)

$R_c(d) := \frac{z \cdot d}{2 \cdot \sqrt{1 + z^2}}$ $\quad R_c(d) = 0.474$

Channel Roughness Parameters

TABLE 4.4.1.B VALUES OF ROUGHNESS COEFFICIENT "*n*" FOR OPEN CHANNELS

Type of Channel and Description	Manning's "*n*"* (Normal)
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as #2, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	0.030
2. Same as #1, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.040
4. Same as #3, but some weeds	0.040
5. Same as #4, but more stones	0.050
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Floodplains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as #2, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as #4, but with flood stage reaching branches	0.120

* *Note: These "n" values are "normal" values for use in analysis of channels. For conservative design of channel capacity, the maximum values listed in other references should be considered. For channel bank stability, the minimum values should be considered.*

Channel Lining

For initial construction, use a rock filled gabion mattress. Future condition will be unmaintained vegetation infill.

Manning's Roughness Coefficients

$n_{gabion} := 0.035$ (Constructed Channel A.c.1 "Rock lined, smooth and uniform")

$n_{weeds} := 0.080$ (Unmaintained Channel A.d.1 "Dense weeds")

Channel Hydraulic Capacity

$$Q_{c_gabion}(d, s_c) := \frac{1.49}{n_{gabion}} \cdot A_c(d) \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot cfs$$ (Initial construction condtion, gabion lined.)

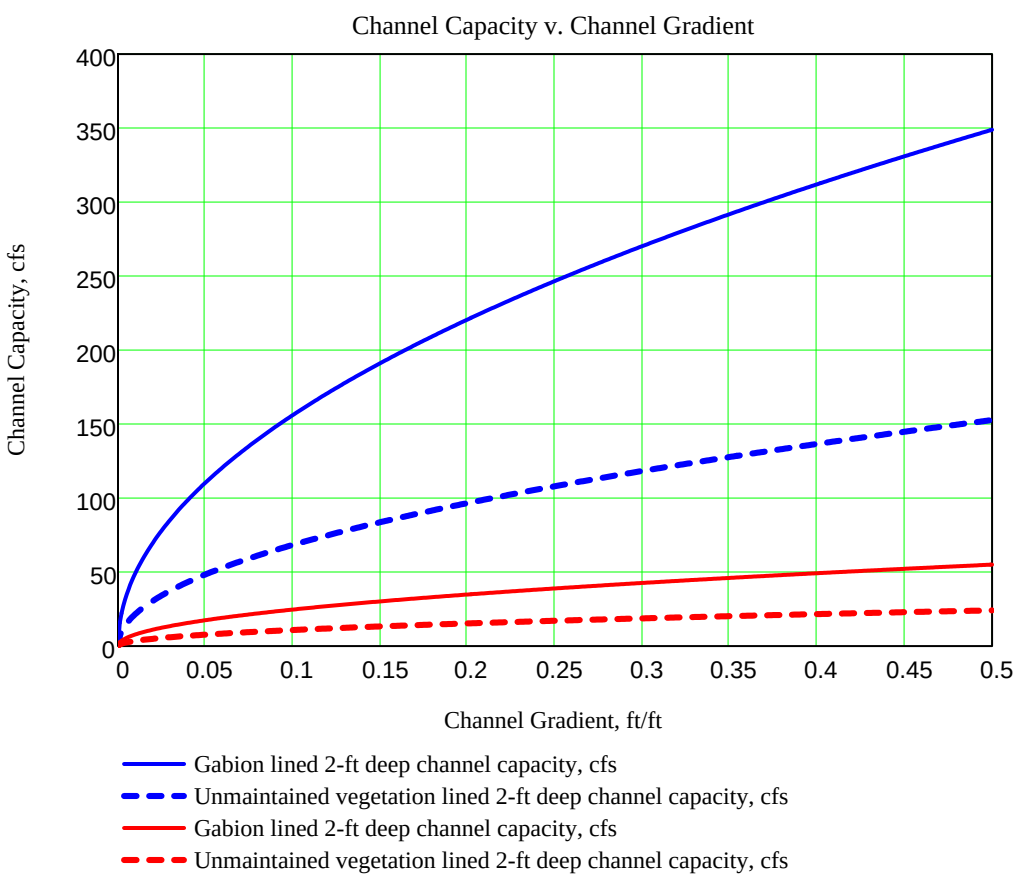
$$Q_{c_weeds}(d, s_c) := \frac{1.49}{n_{weeds}} \cdot A_c(d) \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot cfs$$ (Permanent condition, with unmaintained vegetation.)

Evaluate Channel Capacity over a Range of Gradients

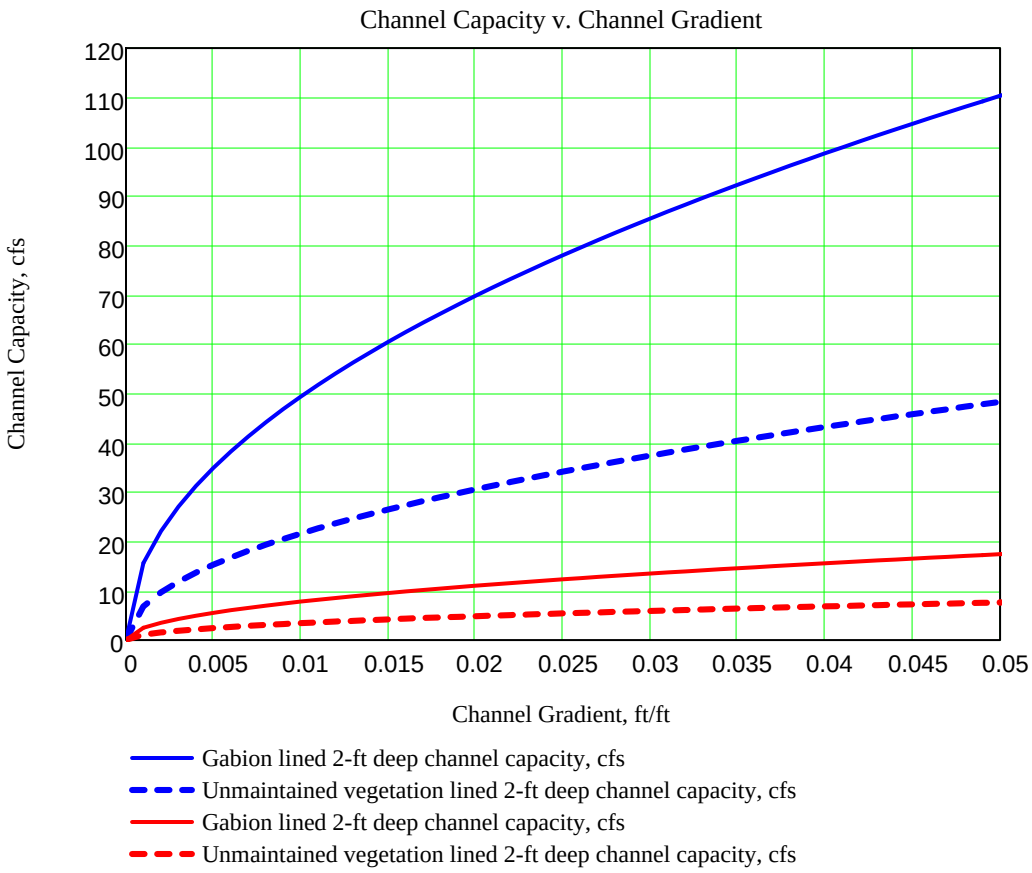
$s_{c_max} := 50\%$

$s_c := 0.00, 0.001 .. s_{c_max}$

Graph the Results for 1-ft Deep and 2-ft Deep Channel Sections



For Mild Channel Slopes



Points of Interest

$Q_{c_weeds}(1.0, 2\%) = 4.81 \cdot cfs$ $\quad$ $Q_{c_weeds}(2.0, 2\%) = 30.52 \cdot cfs$

$Q_{c_weeds}(1.0, 4\%) = 6.80 \cdot cfs$ $\quad$ $Q_{c_weeds}(2.0, 4\%) = 43.16 \cdot cfs$

$Q_{c_weeds}(1.0, 10\%) = 10.75 \cdot cfs$ $\quad$ $Q_{c_weeds}(2.0, 10\%) = 68.24 \cdot cfs$

$Q_{c_weeds}(1.0, 20\%) = 15.20 \cdot cfs$ $\quad$ $Q_{c_weeds}(2.0, 20\%) = 96.50 \cdot cfs$

$Q_{c_weeds}(1.0, 40\%) = 21.49 \cdot cfs$ $\quad$ $Q_{c_weeds}(2.0, 40\%) = 136.48 \cdot cfs$

KCSWDM Channel Protection

TABLE 4.4.1.A CHANNEL PROTECTION

Velocity at Design Flow (fps)		REQUIRED PROTECTION		
Greater than	Less than or equal to	Type of Protection	Thickness	Minimum Height Above Design Water Surface
0	5	Grass lining Or Bioengineered lining	N/A	
5	8	Rock lining[1] Or Bioengineered lining	1 foot	1 foot
8	12	Riprap[2]	2 feet	2 feet
12	20	Slope mattress gabion, etc.	Varies	2 feet

[1] Rock Lining shall be reasonably well graded as follows:
Maximum stone size: 12 inches
Median stone size: 8 inches
Minimum stone size: 2 inches

[2] Riprap shall be reasonably well graded as follows:
Maximum stone size: 24 inches
Median stone size: 16 inches
Minimum stone size: 4 inches

Note: Riprap sizing is governed by side slopes on channel, assumed to be approximately 3:1.

Maximum velocity for gabion lined channel protection

$V_{c_gabion_max} := 20fps$

Channel Velocity, Flowing Full

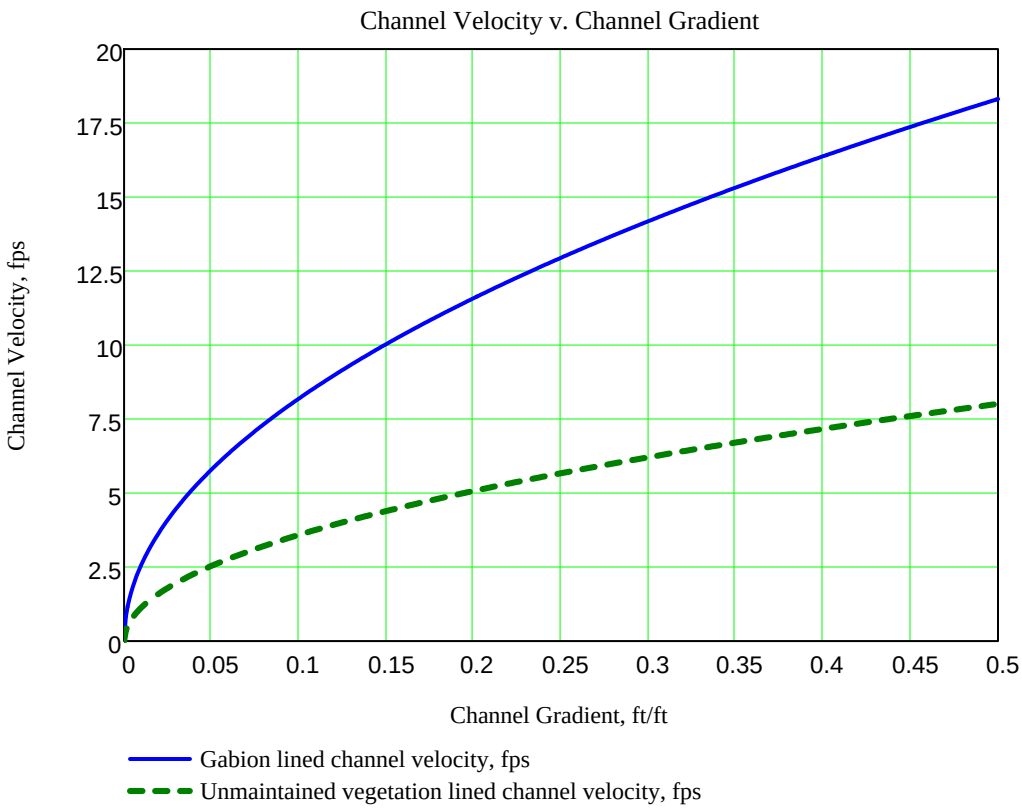
$$V_{c_gabion}(d, s_c) := \frac{1.49}{n_{gabion}} \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot fps$$ (Initial construction condtion, gabion lined.)

$$V_{c_weeds}(d, s_c) := \frac{1.49}{n_{weeds}} \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot fps$$ (Permanent condition, with unmaintained vegetaion.)

Evaluate Channel Velocity Flowing Full over a Range of Gradients

$s_c := 0.00, 0.001 .. s_{c_max}$

Graph the Results for 1-ft Deep Channel



Check Gabion Lined Channel (Swale) Hydraulics

Outfall swale depth $d_{swale} := 12in$

Outfall swale gradient $s_{swale} := 50\%$

Outfall swale capacity, flowing full

$$Q_{swale_gabion} := Q_{c_gabion}\left(\frac{d_{swale}}{ft}, s_{swale}\right)$$

$Q_{swale_gabion} = 54.9 \cdot cfs$

Solve for Water Depth at Design Flow & Gradient

$Q_{des} := 22.2cfs$ (maximum 100-yr conveyance)

$s_{swale} = 0.5000$

$d_{swale} = 1.00\,ft$

Guess value $y_{gabion} := 1.0$

Given

$$Q_{c_gabion}(y_{gabion}, s_{swale}) = Q_{des}$$

$$d_{Q_gabion} := Find(y_{gabion})$$

$d_{Q_gabion} = 0.712$

Channel Velocity at Design Flow & Gradient

$$V_{swale_gabion}(d, s_c) := \frac{1.49}{n_{gabion}} \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot fps$$

$V_{swale_gabion}(d_{Q_gabion}, s_{swale}) = 14.60 \cdot fps$

$V_{c_gabion_max} = 20.00 \cdot fps$

$Check_{velocity_swale_gabion} := if(V_{swale_gabion}(d_{Q_gabion}, s_{swale}) \le V_{c_gabion_max}, "OK", "No\ Good!")$

$Check_{velocity_swale_gabion} = "OK"$

Check Gabion Lined Overgrown (weeds) Channel (Swale) Hydraulics

Outfall swale capacity, flowing full

$$Q_{swale_weeds} := Q_{c_weeds}\left(\frac{d_{swale}}{ft}, s_{swale}\right)$$

$$Q_{swale_weeds} = 24.0 \cdot cfs$$

Solve for Water Depth at Design Flow

$s_{swale} = 0.5000$

$d_{swale} = 1.00\,ft$

Guess value $y_{weeds} := 1.00$

Given

$$Q_{c_weeds}(y_{weeds}, s_{swale}) = Q_{des}$$

$$d_{Q_weeds} := \mathrm{Find}(y_{weeds})$$

$$d_{Q_weeds} = 0.971$$

Channel Velocity at Design Flow

$$V_{swale_weeds}(d, s_c) := \frac{1.49}{n_{weeds}} \cdot R_c(d)^{\frac{2}{3}} \cdot s_c^{\frac{1}{2}} \cdot fps$$

$$V_{swale_weeds}(d_{Q_weeds}, s_{swale}) = 7.85 \cdot fps$$

Check Gabion Lined Channel (Swale) Hydraulics - Mild Slope

Outfall swale depth $d_{swale} = 1.00\,ft$

Outfall swale gradient $s_{swale} := 4\%$

Outfall swale capacity, flowing full

$$Q_{c_gabion}\left(\frac{d_{swale}}{ft}, s_{swale}\right) = 15.54 \cdot cfs$$

Solve for Water Depth at Design Flow & Gradient

$Q_{des} = 22.20 \cdot cfs$ (maximum 100-yr conveyance)

$s_{swale} = 0.0400$

$d_{swale} = 1.00\,ft$

Guess value $y_{gabion} = 1.00$

Given

$$Q_{c_gabion}(y_{gabion}, s_{swale}) = Q_{des}$$

$d_{Q_gabion} := \text{Find}(y_{gabion})$ $d_{Q_gabion} = 1.143$

Channel Velocity at Design Flow & Gradient

$V_{swale_gabion}(d_{Q_gabion}, s_{swale}) = 5.66 \cdot fps$

$V_{c_gabion_max} = 20.00 \cdot fps$

$Check_{velocity_swale_gabion} = \text{"OK"}$

Check Gabion Lined Overgrown (weeds) Channel (Swale) Hydraulics

Outfall swale capacity, flowing full

$$Q_{c_weeds}\left(\frac{d_{swale}}{ft}, s_{swale}\right) = 6.80 \cdot cfs$$

Solve for Water Depth at Design Flow

$s_{swale} = 0.0400$

$d_{swale} = 1.00\,ft$

Guess value $y_{weeds} = 1.00$

Given

$$Q_{c_weeds}(y_{weeds}, s_{swale}) = Q_{des}$$

$d_{Q_weeds} := \text{Find}(y_{weeds})$ $d_{Q_weeds} = 1.559$

Channel Velocity at Design Flow

$$V_{swale_weeds}(d_{Q_weeds}, s_{swale}) = 3.05 \cdot fps$$

Check Gabion Lined Channel (Swale) Hydraulics - Mild Slope

Outfall swale depth $d_{swale} := 2.00ft$

Outfall swale gradient $s_{swale} := 4\%$

Outfall swale capacity, flowing full

$$Q_{c_gabion}\left(\frac{d_{swale}}{ft}, s_{swale}\right) = 98.65 \cdot cfs$$

Solve for Water Depth at Design Flow & Gradient

$Q_{des} = 22.20 \cdot cfs$ (maximum 100-yr conveyance)

$s_{swale} = 0.0400$

$d_{swale} = 2.00\,ft$

Guess value $y_{gabion} = 1.00$

Given

$$Q_{c_gabion}(y_{gabion}, s_{swale}) = Q_{des}$$

$d_{Q_gabion} := \text{Find}(y_{gabion})$ $d_{Q_gabion} = 1.143$

Channel Velocity at Design Flow & Gradient

$V_{swale_gabion}(d_{Q_gabion}, s_{swale}) = 5.66 \cdot fps$

$V_{c_gabion_max} = 20.00 \cdot fps$

$Check_{velocity_swale_gabion} = \text{"OK"}$

Check Gabion Lined Overgrown (weeds) Channel (Swale) Hydraulics

Outfall swale capacity, flowing full

$$Q_{c_weeds}\left(\frac{d_{swale}}{ft}, s_{swale}\right) = 43.16 \cdot cfs$$

Solve for Water Depth at Design Flow

$s_{swale} = 0.0400$

$d_{swale} = 2.00\,ft$

Guess value $y_{weeds} = 1.00$

Given

$$Q_{c_weeds}(y_{weeds}, s_{swale}) = Q_{des}$$

$d_{Q_weeds} := \text{Find}(y_{weeds})$ $d_{Q_weeds} = 1.559$

Channel Velocity at Design Flow

$$V_{swale_weeds}(d_{Q_weeds}, s_{swale}) = 3.05 \cdot fps$$

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 10
SBUH Hydrograph Analyses

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.01	6	1308	341	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.02	6	1212	704	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.02	6	1152	1,045	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.04	6	1104	2,018	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.05	6	1026	2,475	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.06	6	984	3,211	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.10	6	486	4,087	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	0.15	6	486	5,058	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.05	6	486	2,016	1	----	------	------	1-yr post-dev
10	SBUH Runoff	0.10	6	486	2,902	2	----	------	------	2-yr post-dev
11	SBUH Runoff	0.15	6	480	3,626	3	----	------	------	3-yr post-dev
12	SBUH Runoff	0.17	6	480	3,917	5	----	------	------	5-yr post-dev
13	SBUH Runoff	0.33	6	480	6,224	10	----	------	------	10-yr post-dev
14	SBUH Runoff	0.42	6	480	7,424	25	----	------	------	25-yr post-dev
15	SBUH Runoff	0.51	6	480	8,782	50	----	------	------	50-yr post-dev
16	SBUH Runoff	0.62	6	480	10,228	100	----	------	------	100-yr post-dev
17	Reservoir	0.01	6	1446	1,965	1	9	254.57	1,502	1-yr design
18	Reservoir	0.02	6	1440	2,852	2	10	256.12	2,151	2-yr design
19	Reservoir	0.03	6	1440	3,575	3	11	257.31	2,652	3-yr design
20	Reservoir	0.03	6	1440	3,866	5	12	257.80	2,858	5-yr design
21	Reservoir	0.04	6	1440	6,173	10	13	261.87	4,564	10-yr design
22	Reservoir	0.10	6	1146	7,374	25	14	262.05	4,640	25-yr design
23	Reservoir	0.13	6	936	8,732	50	15	262.06	4,645	50-yr design
24	Reservoir	0.16	6	798	10,177	100	16	262.07	4,650	100-yr design

Proj. file: West Tank.GPW | IDF file: Corvallis.IDF | Run date: 11-08-2010

Reservoir Report

English

Reservoir No. 1 - West Concrete Tank

Pond Data

Bottom area = 420.0 sqft Side slope = 0.0:1 Bottom elev. = 251.00 ft Depth = 12.00 ft

Stage / Storage Table

Stage ft	Elevation ft	Contour area sqft	Incr. Storage cuft	Total storage cuft
0.00	251.00	420	0	0
1.20	252.20	420	504	504
2.40	253.40	420	504	1,008
3.60	254.60	420	504	1,512
4.80	255.80	420	504	2,016
6.00	257.00	420	504	2,520
7.20	258.20	420	504	3,024
8.40	259.40	420	504	3,528
9.60	260.60	420	504	4,032
10.80	261.80	420	504	4,536
12.00	263.00	420	504	5,040

Culvert / Orifice Structures

		[A]	[B]	[C]	[D]
Rise in	=	12.0	0.5	0.0	0.5
Span in	=	12.0	0.5	0.0	0.5
No. Barrels	=	1	1	1	1
Invert El. ft	=	251.00	249.00	253.00	255.00
Length ft	=	10.0	0.0	0.0	0.0
Slope %	=	0.50	0.00	0.00	0.00
N-Value	=	.009	.013	.013	.013
Orif. Coeff.	=	0.60	0.60	0.60	0.60
Multi-Stage	=	-----	Yes	Yes	Yes

Weir Structures

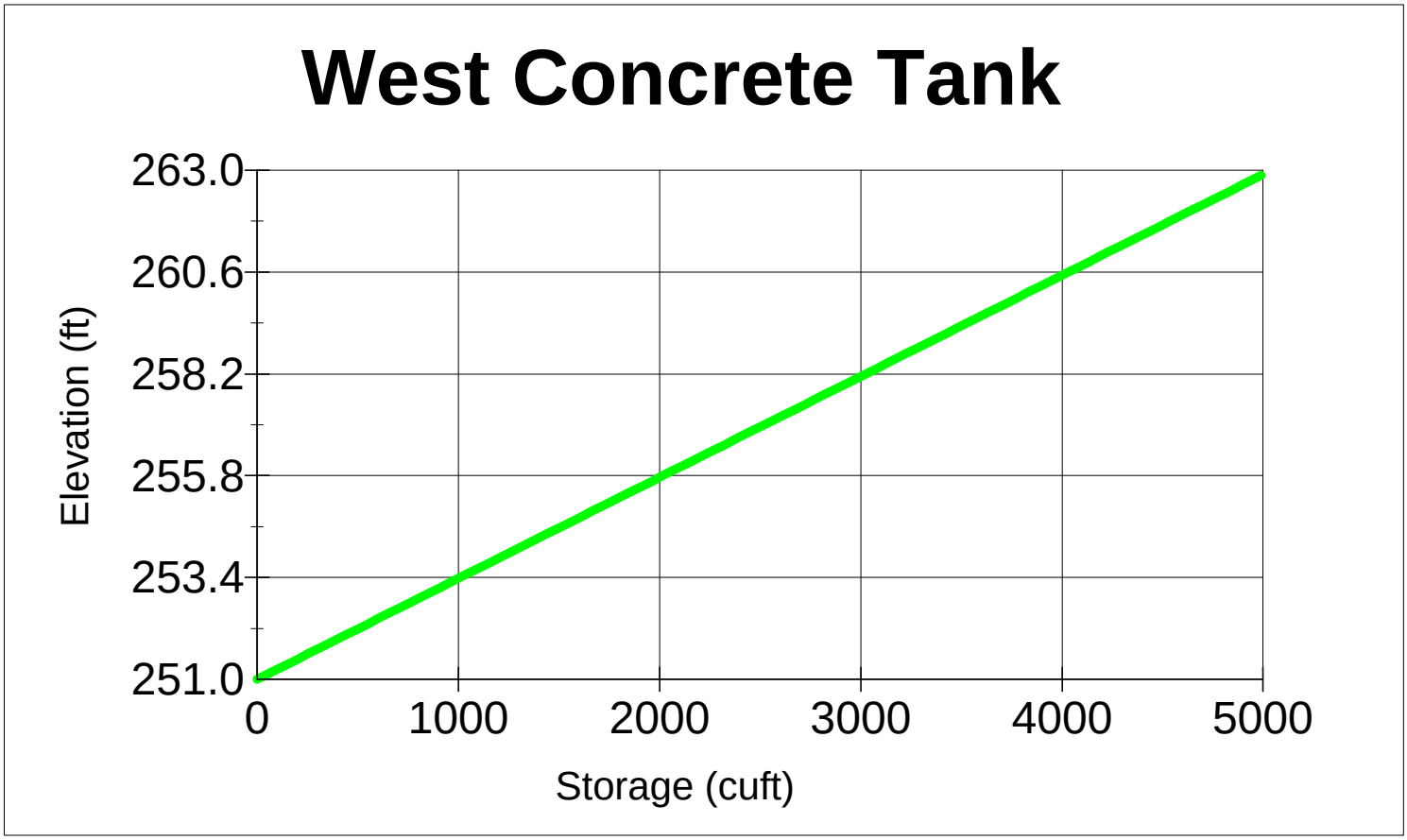
		[A]	[B]	[C]	[D]
Crest Len ft	=	1.57	1.57	0.00	0.00
Crest El. ft	=	262.00	262.50	0.00	0.00
Weir Coeff.	=	3.30	3.30	0.00	0.00
Eqn. Exp.	=	1.50	1.50	0.00	0.00
Multi-Stage	=	Yes	Yes	No	No

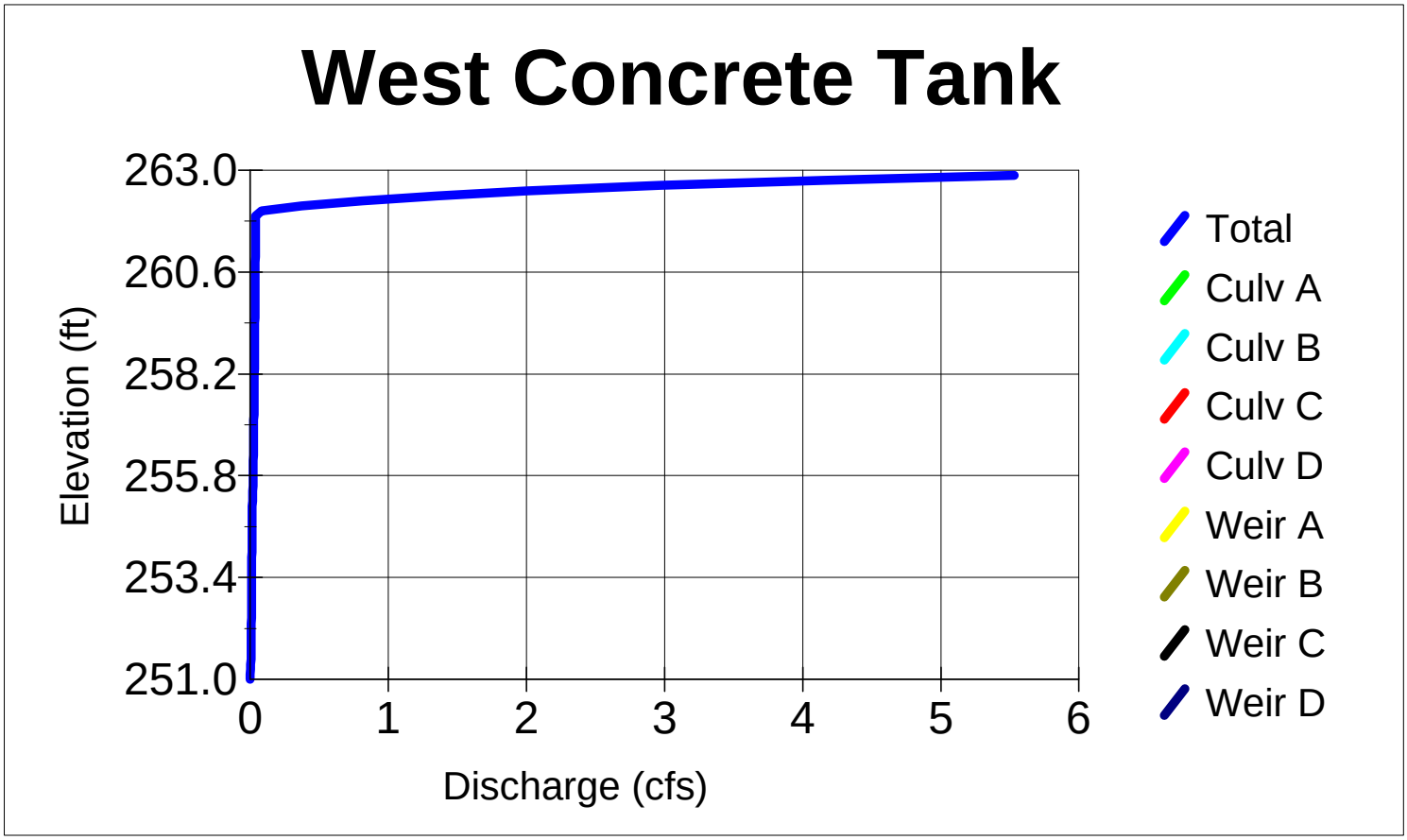
Tailwater Elevation = 0.00 ft

Note: All outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Discharge cfs
0.00	0	251.00	0.00	0.01	---	0.00	0.00	0.00	---	---	0.00
1.20	504	252.20	2.45	0.01	---	0.00	0.00	0.00	---	---	0.01
2.40	1,008	253.40	5.21	0.01	---	0.00	0.00	0.00	---	---	0.01
3.60	1,512	254.60	6.66	0.01	---	0.00	0.00	0.00	---	---	0.01
4.80	2,016	255.80	7.84	0.01	---	0.01	0.00	0.00	---	---	0.02
6.00	2,520	257.00	8.87	0.02	---	0.01	0.00	0.00	---	---	0.03
7.20	3,024	258.20	9.79	0.02	---	0.01	0.00	0.00	---	---	0.03
8.40	3,528	259.40	10.63	0.02	---	0.01	0.00	0.00	---	---	0.03
9.60	4,032	260.60	11.41	0.02	---	0.02	0.00	0.00	---	---	0.04
10.80	4,536	261.80	12.14	0.02	---	0.02	0.00	0.00	---	---	0.04
12.00	5,040	263.00	12.82	0.02	---	0.02	5.18	1.83	---	---	7.05


West Concrete Tank
263.0
260.6
258.2
255.8
253.4
251.0
Elevation (ft)
0
1000
2000
3000
4000
5000
Storage (cuft)


West Concrete Tank
263.0
260.6
258.2
255.8
253.4
251.0
Elevation (ft)
0
1
2
3
4
5
6
Discharge (cfs)
Total
Culv A
Culv B
Culv C
Culv D
Weir A
Weir B
Weir C
Weir D

Hydrograph Plot

English

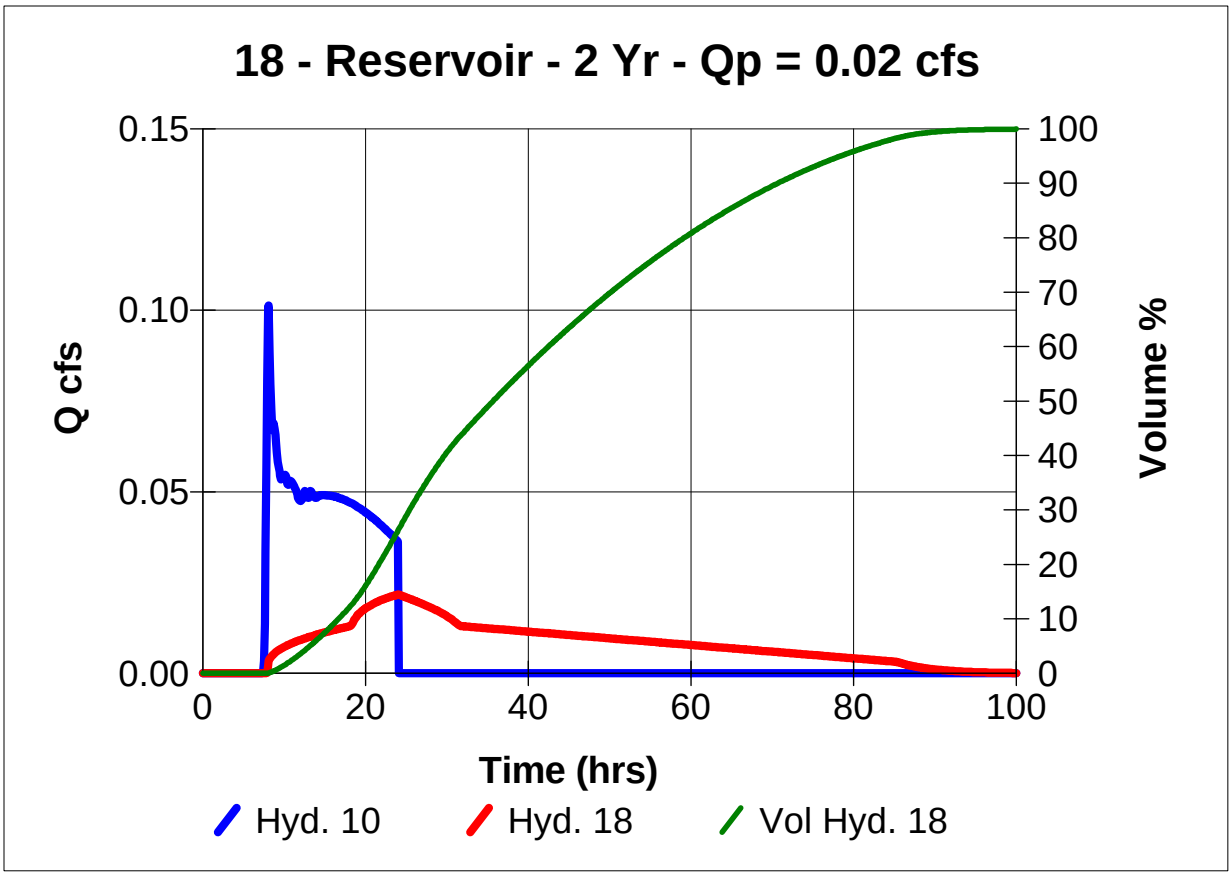
Hyd. No. 18

2-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.02 cfs
Storm frequency	=	2 yrs	Time interval	=	6 min
Inflow hyd. No.	=	10	Reservoir name	=	West Concrete T
Max. Elevation	=	256.12 ft	Max. Storage	=	2,151 cuft

Storage Indication method used.

Total Volume = 2,852 cuft



Hydrograph Plot

English

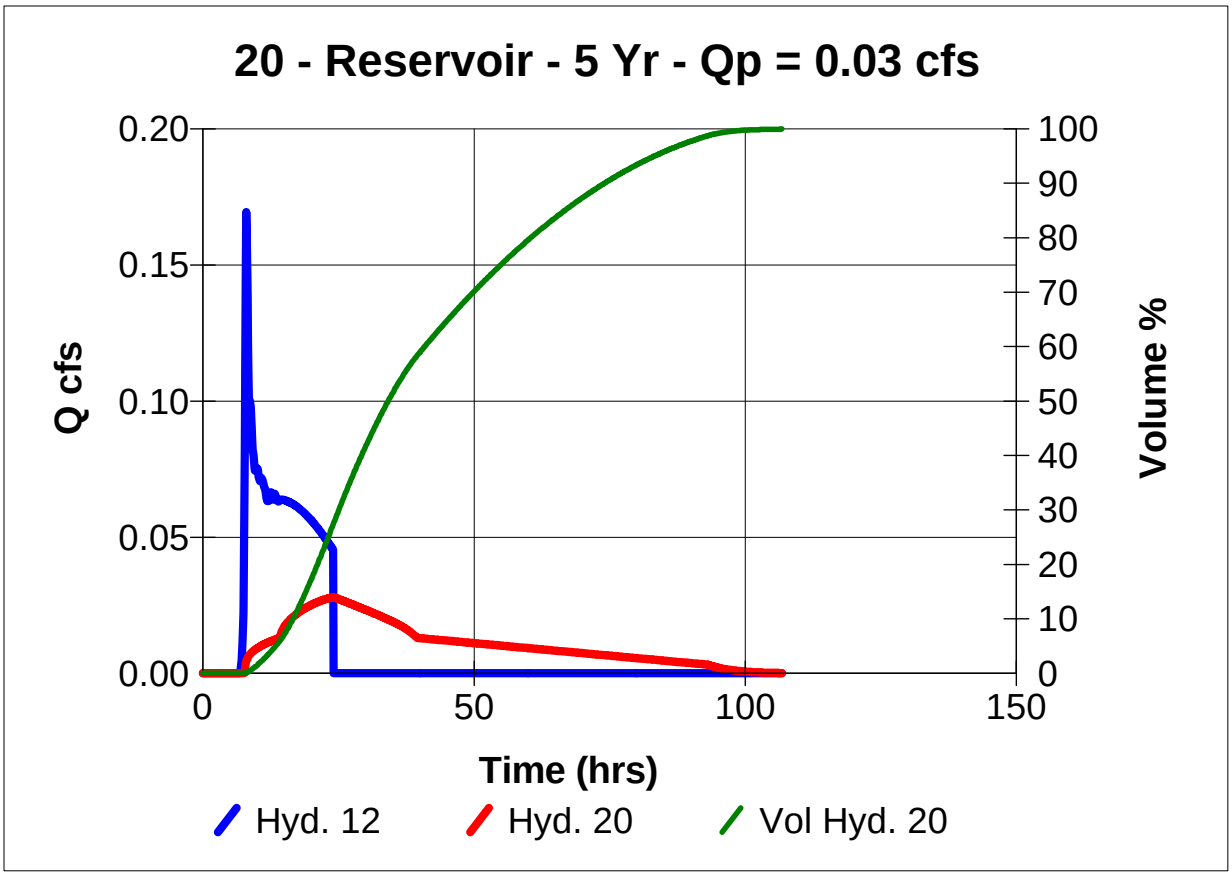
Hyd. No. 20

5-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.03 cfs
Storm frequency	=	5 yrs	Time interval	=	6 min
Inflow hyd. No.	=	12	Reservoir name	=	West Concrete T
Max. Elevation	=	257.80 ft	Max. Storage	=	2,858 cuft

Storage Indication method used.

Total Volume = 3,866 cuft



Hydrograph Plot

English

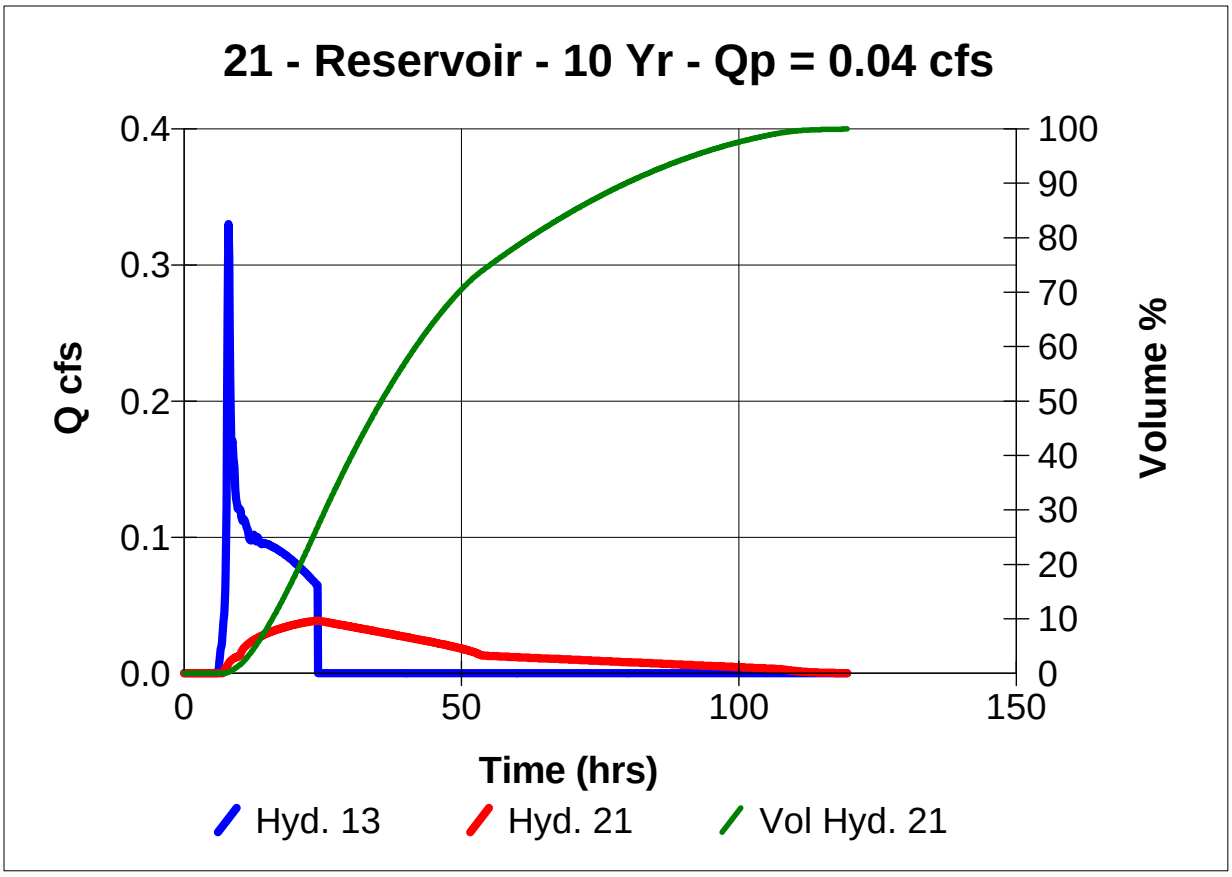
Hyd. No. 21

10-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.04 cfs
Storm frequency	=	10 yrs	Time interval	=	6 min
Inflow hyd. No.	=	13	Reservoir name	=	West Concrete T
Max. Elevation	=	261.87 ft	Max. Storage	=	4,564 cuft

Storage Indication method used.

Total Volume = 6,173 cuft



Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.03	6	1308	874	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.05	6	1212	1,805	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.06	6	1152	2,679	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.08	6	1104	3,775	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.12	6	1026	6,344	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.15	6	984	8,231	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.24	6	486	10,474	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	0.39	6	486	12,963	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.13	6	486	5,167	1	----	------	------	1-yr post-dev
10	SBUH Runoff	0.26	6	486	7,439	2	----	------	------	2-yr post-dev
11	SBUH Runoff	0.38	6	480	9,293	3	----	------	------	3-yr post-dev
12	SBUH Runoff	0.43	6	480	10,039	5	----	------	------	5-yr post-dev
13	SBUH Runoff	0.85	6	480	15,952	10	----	------	------	10-yr post-dev
14	SBUH Runoff	1.06	6	480	19,028	25	----	------	------	25-yr post-dev
15	SBUH Runoff	1.31	6	480	22,509	50	----	------	------	50-yr post-dev
16	SBUH Runoff	1.58	6	480	26,213	100	----	------	------	100-yr post-dev

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.11	6	1314	3,440	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.18	6	1218	7,125	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.24	6	1158	10,585	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.27	6	1140	12,066	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.49	6	1032	25,121	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.61	6	990	32,835	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.85	6	534	41,404	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	1.20	6	498	50,490	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.43	6	498	20,519	1	----	------	------	1-yr post-dev
10	SBUH Runoff	0.94	6	486	29,555	2	----	------	------	2-yr post-dev
11	SBUH Runoff	1.38	6	486	36,928	3	----	------	------	3-yr post-dev
12	SBUH Runoff	1.56	6	486	39,896	5	----	------	------	5-yr post-dev
13	SBUH Runoff	3.02	6	480	63,418	10	----	------	------	10-yr post-dev
14	SBUH Runoff	3.86	6	480	76,014	25	----	------	------	25-yr post-dev
15	SBUH Runoff	4.76	6	480	89,510	50	----	------	------	50-yr post-dev
16	SBUH Runoff	5.68	6	480	103,099	100	----	------	------	100-yr post-dev
17	Reservoir	0.04	6	1446	14,819	1	9	258.37	18,943	1-yr design
18	Reservoir	0.05	6	1446	18,819	2	10	259.44	27,557	2-yr design
19	Reservoir	0.05	6	1446	21,655	3	11	260.33	34,634	3-yr design
20	Reservoir	0.06	6	1446	22,717	5	12	260.69	37,490	5-yr design
21	Reservoir	0.10	6	1446	32,357	10	13	263.48	59,857	10-yr design
22	Reservoir	0.15	6	1446	39,952	25	14	264.93	71,410	25-yr design
23	Reservoir	0.86	6	1440	50,227	50	15	266.16	81,271	50-yr design
24	Reservoir	1.18	6	1248	63,806	100	16	266.21	81,670	100-yr design

Proj. file: Central Tank.GPW | IDF file: Corvallis.IDF | Run date: 02-24-2011

Reservoir Report

English

Reservoir No. 1 - Central Concrete Tank

Pond Data

Bottom area = 8000.0 sqft Side slope = 0.0:1 Bottom elev. = 256.00 ft Depth = 11.00 ft

Stage / Storage Table

Stage ft	Elevation ft	Contour area sqft	Incr. Storage cuft	Total storage cuft
0.00	256.00	8,000	0	0
1.10	257.10	8,000	8,800	8,800
2.20	258.20	8,000	8,800	17,600
3.30	259.30	8,000	8,800	26,400
4.40	260.40	8,000	8,800	35,200
5.50	261.50	8,000	8,800	44,000
6.60	262.60	8,000	8,800	52,800
7.70	263.70	8,000	8,800	61,600
8.80	264.80	8,000	8,800	70,400
9.90	265.90	8,000	8,800	79,200
11.00	267.00	8,000	8,800	88,000

Culvert / Orifice Structures

		[A]	[B]	[C]	[D]
Rise in	=	24.0	1.0	1.0	1.0
Span in	=	24.0	1.0	1.0	1.0
No. Barrels	=	1	1	1	1
Invert El. ft	=	256.00	254.00	262.00	264.00
Length ft	=	20.0	0.0	0.0	0.0
Slope %	=	0.50	0.00	0.00	0.00
N-Value	=	.009	.013	.013	.013
Orif. Coeff.	=	0.60	0.60	0.60	0.60
Multi-Stage	=	-----	Yes	Yes	Yes

Weir Structures

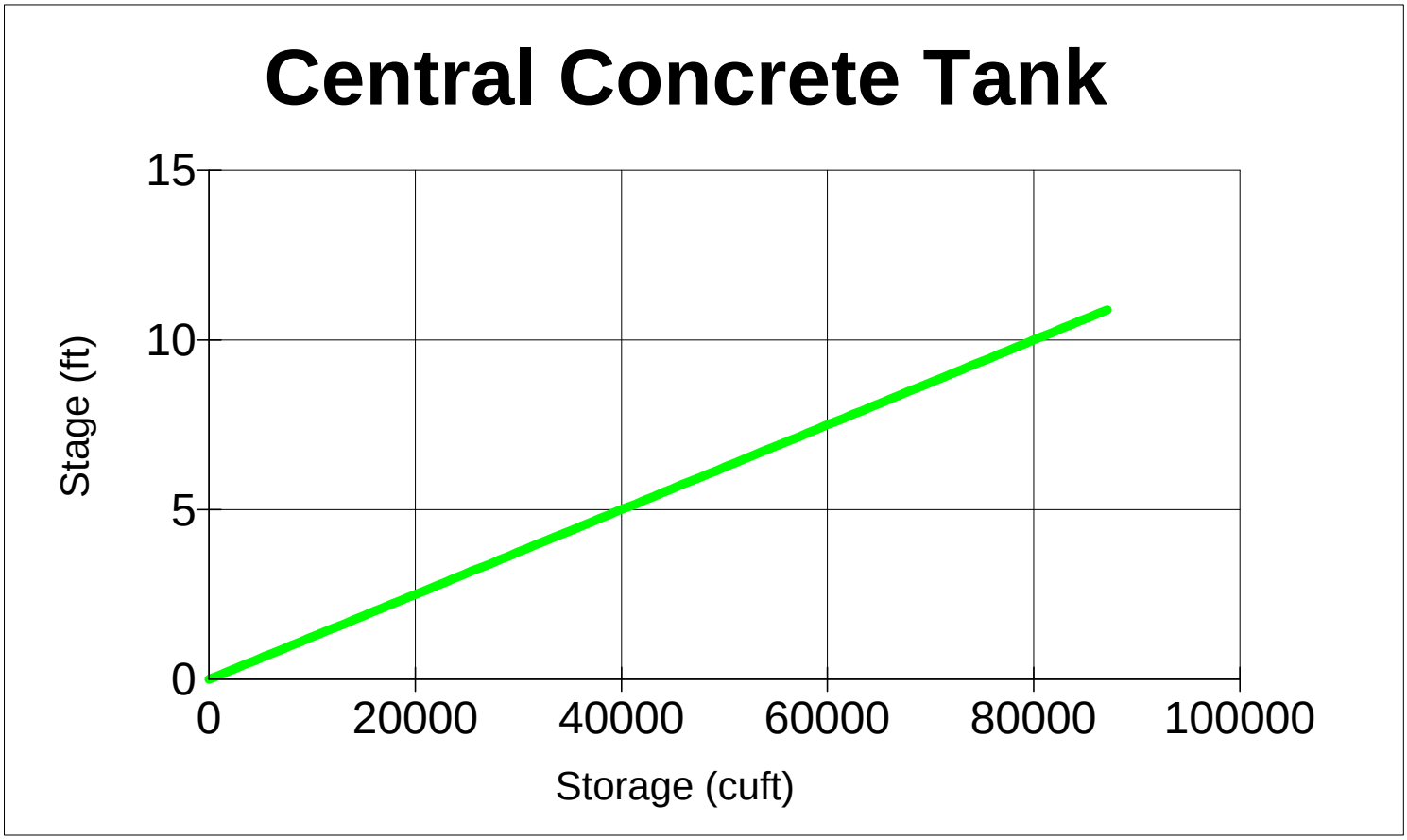
		[A]	[B]	[C]	[D]
Crest Len ft	=	3.14	3.14	0.00	0.00
Crest El. ft	=	266.00	266.50	0.00	0.00
Weir Coeff.	=	3.30	3.30	0.00	0.00
Eqn. Exp.	=	1.50	1.50	0.00	0.00
Multi-Stage	=	Yes	Yes	No	No

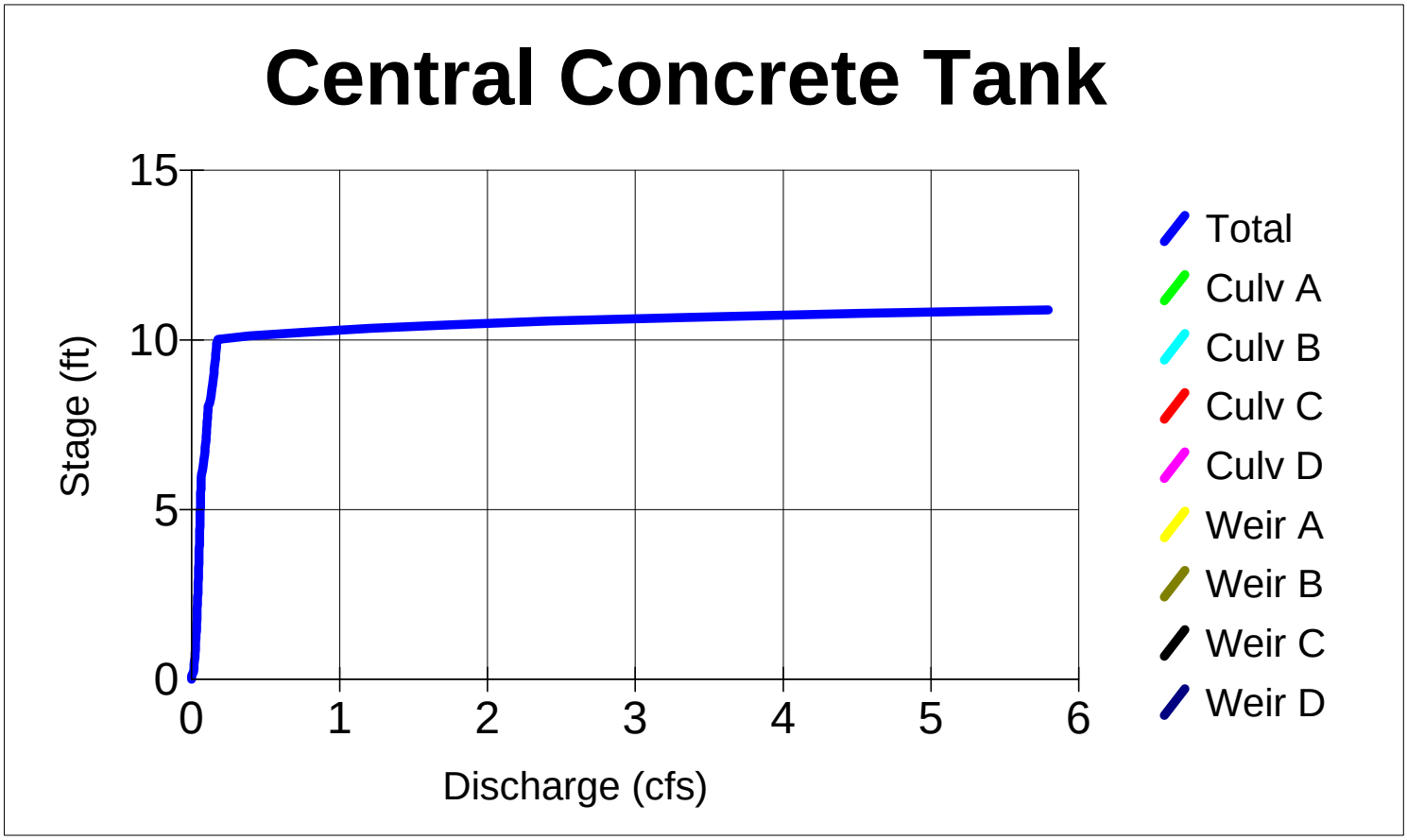
Tailwater Elevation = 0.00 ft

Note: All outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Discharge cfs
0.00	0	256.00	0.00	0.04	0.00	0.00	0.00	0.00	---	---	0.00
1.10	8,800	257.10	3.61	0.03	0.00	0.00	0.00	0.00	---	---	0.03
2.20	17,600	258.20	10.85	0.04	0.00	0.00	0.00	0.00	---	---	0.04
3.30	26,400	259.30	22.94	0.05	0.00	0.00	0.00	0.00	---	---	0.05
4.40	35,200	260.40	27.89	0.05	0.00	0.00	0.00	0.00	---	---	0.05
5.50	44,000	261.50	32.08	0.06	0.00	0.00	0.00	0.00	---	---	0.06
6.60	52,800	262.60	35.79	0.07	0.02	0.00	0.00	0.00	---	---	0.09
7.70	61,600	263.70	39.15	0.07	0.03	0.00	0.00	0.00	---	---	0.11
8.80	70,400	264.80	42.24	0.08	0.04	0.02	0.00	0.00	---	---	0.14
9.90	79,200	265.90	45.12	0.08	0.05	0.04	0.00	0.00	---	---	0.17
11.00	88,000	267.00	47.83	0.08	0.06	0.05	10.36	3.66	---	---	14.21


Central Concrete Tank
15
10
5
0
Stage (ft)
0
20000
40000
60000
80000
100000
Storage (cuft)


Central Concrete Tank
15
10
5
0
Stage (ft)
0
1
2
3
4
5
6
Discharge (cfs)
Total
Culv A
Culv B
Culv C
Culv D
Weir A
Weir B
Weir C
Weir D

Hydrograph Plot

English

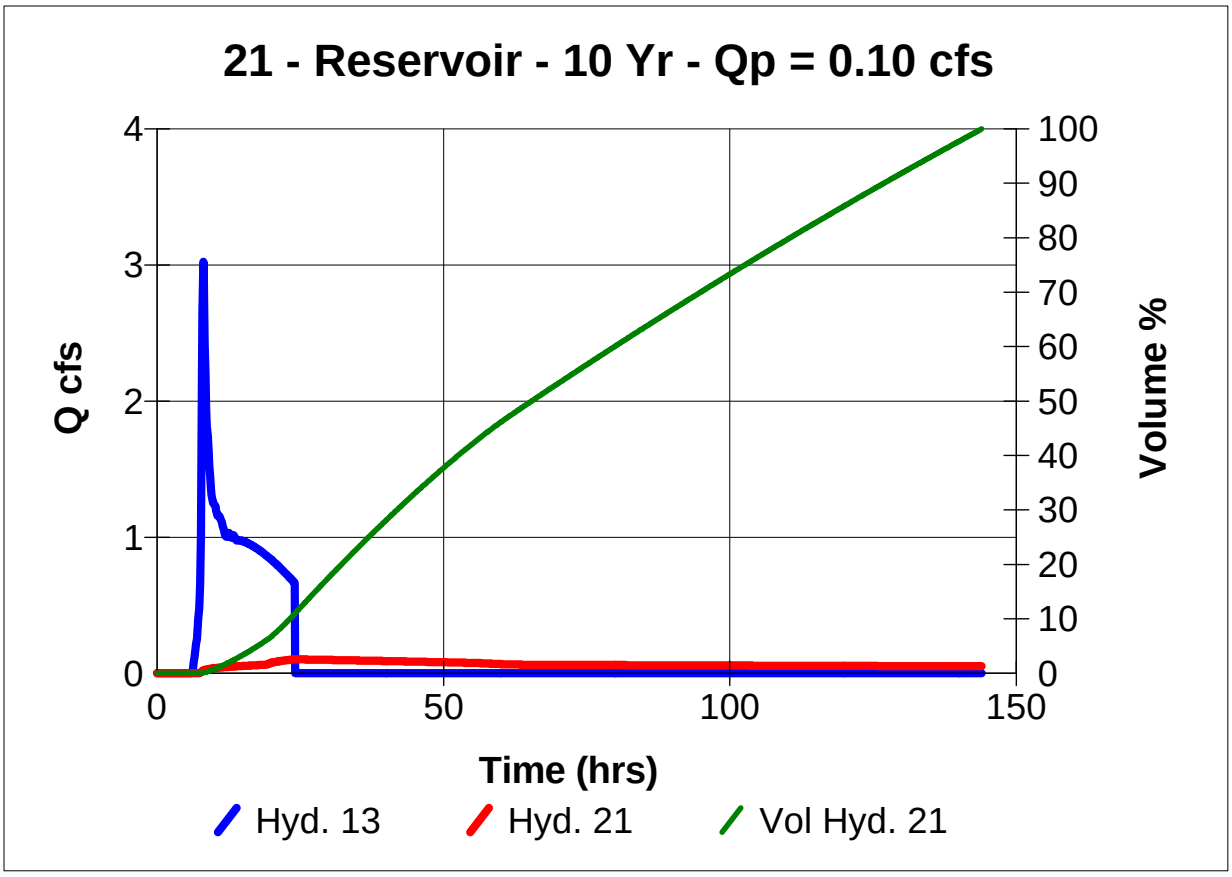
Hyd. No. 21

10-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.10 cfs
Storm frequency	=	10 yrs	Time interval	=	6 min
Inflow hyd. No.	=	13	Reservoir name	=	Central Concret
Max. Elevation	=	263.48 ft	Max. Storage	=	59,857 cuft

Storage Indication method used.

Total Volume = 32,357 cuft



Hydrograph Plot

English

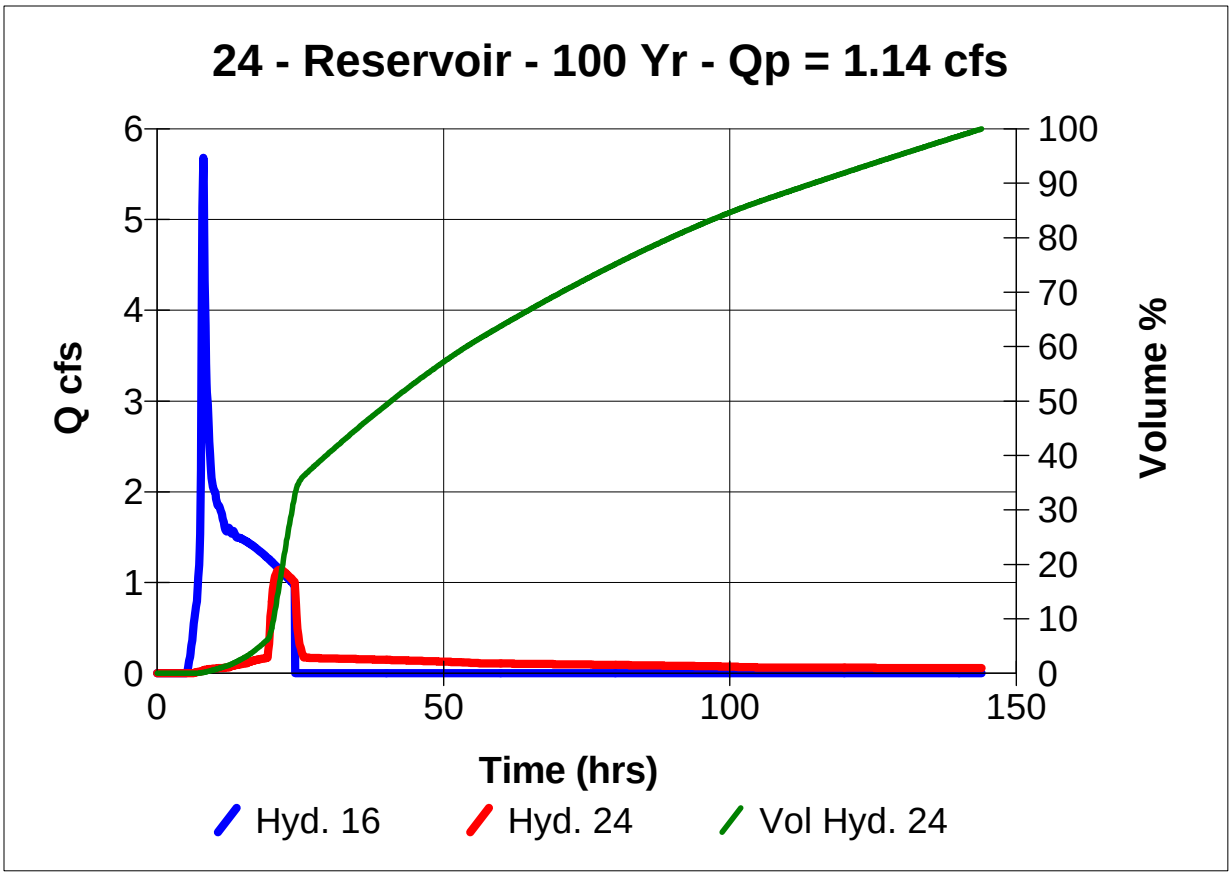
Hyd. No. 24

100-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	1.14 cfs
Storm frequency	=	100 yrs	Time interval	=	6 min
Inflow hyd. No.	=	16	Reservoir name	=	Central Concret
Max. Elevation	=	266.32 ft	Max. Storage	=	82,600 cuft

Storage Indication method used.

Total Volume = 63,612 cuft



Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.11	6	1314	3,495	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.18	6	1218	7,239	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.25	6	1158	10,754	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.27	6	1140	12,258	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.49	6	1032	25,521	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.62	6	990	33,359	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.86	6	534	42,064	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	1.21	6	498	51,295	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.44	6	498	20,846	1	----	------	------	1-yr post-dev
10	SBUH Runoff	0.95	6	486	30,026	2	----	------	------	2-yr post-dev
11	SBUH Runoff	1.40	6	486	37,517	3	----	------	------	3-yr post-dev
12	SBUH Runoff	1.58	6	486	40,532	5	----	------	------	5-yr post-dev
13	SBUH Runoff	3.07	6	480	64,429	10	----	------	------	10-yr post-dev
14	SBUH Runoff	3.92	6	480	77,226	25	----	------	------	25-yr post-dev
15	SBUH Runoff	4.84	6	480	90,937	50	----	------	------	50-yr post-dev
16	SBUH Runoff	5.77	6	480	104,743	100	----	------	------	100-yr post-dev
17	Reservoir	0.04	6	1446	14,975	1	9	258.41	19,256	1-yr design
18	Reservoir	0.05	6	1446	19,008	2	10	259.50	28,012	2-yr design
19	Reservoir	0.05	6	1446	21,866	3	11	260.40	35,204	3-yr design
20	Reservoir	0.06	6	1446	22,938	5	12	260.76	38,106	5-yr design
21	Reservoir	0.10	6	1446	32,899	10	13	263.60	60,804	10-yr design
22	Reservoir	0.15	6	1446	40,687	25	14	265.07	72,522	25-yr design
23	Reservoir	0.85	6	1440	51,466	50	15	266.26	82,045	50-yr design
24	Reservoir	1.18	6	1266	65,254	100	16	266.33	82,672	100-yr design

Proj. file: Central Bypass.GPW | IDF file: Corvallis.IDF | Run date: 02-20-2011

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.12	6	1314	3,732	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.20	6	1218	7,734	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.26	6	1164	11,491	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.29	6	1146	13,100	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.53	6	1032	27,279	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.66	6	990	35,659	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.93	6	528	45,089	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	1.34	6	498	54,977	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.47	6	498	22,292	1	----	------	------	1-yr post-dev
10	SBUH Runoff	1.00	6	486	32,110	2	----	------	------	2-yr post-dev
11	SBUH Runoff	1.48	6	486	40,122	3	----	------	------	3-yr post-dev
12	SBUH Runoff	1.67	6	486	43,347	5	----	------	------	5-yr post-dev
13	SBUH Runoff	3.25	6	486	68,906	10	----	------	------	10-yr post-dev
14	SBUH Runoff	4.14	6	480	82,594	25	----	------	------	25-yr post-dev
15	SBUH Runoff	5.11	6	480	97,259	50	----	------	------	50-yr post-dev
16	SBUH Runoff	6.10	6	480	112,026	100	----	------	------	100-yr post-dev

Proj. file: Central Connection.GPW | IDF file: Corvallis.IDF | Run date: 02-24-2011

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.02	6	1314	796	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.04	6	1212	1,647	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.06	6	1158	2,445	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.06	6	1140	2,787	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.11	6	1032	5,800	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.14	6	990	7,529	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.20	6	498	9,584	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	0.31	6	492	11,865	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.10	6	492	4,734	1	----	------	------	1-yr post-dev
10	SBUH Runoff	0.22	6	486	6,818	2	----	------	------	2-yr post-dev
11	SBUH Runoff	0.33	6	486	8,518	3	----	------	------	3-yr post-dev
12	SBUH Runoff	0.37	6	486	9,203	5	----	------	------	5-yr post-dev
13	SBUH Runoff	0.72	6	480	14,627	10	----	------	------	10-yr post-dev
14	SBUH Runoff	0.91	6	480	17,449	25	----	------	------	25-yr post-dev
15	SBUH Runoff	1.13	6	480	20,643	50	----	------	------	50-yr post-dev
16	SBUH Runoff	1.36	6	480	24,042	100	----	------	------	100-yr post-dev
17	Reservoir	0.01	6	1446	4,140	1	9	327.53	4,239	1-yr design
18	Reservoir	0.02	6	1446	5,569	2	10	329.10	6,115	2-yr design
19	Reservoir	0.03	6	1446	6,821	3	11	330.34	7,609	3-yr design
20	Reservoir	0.03	6	1446	7,329	5	12	330.84	8,213	5-yr design
21	Reservoir	0.04	6	1446	11,384	10	13	334.89	13,067	10-yr design
22	Reservoir	0.22	6	1212	14,175	25	14	335.06	13,272	25-yr design
23	Reservoir	0.28	6	1026	17,369	50	15	335.07	13,288	50-yr design
24	Reservoir	0.34	6	888	20,767	100	16	335.09	13,303	100-yr design

Proj. file: East Tank.GPW	IDF file: Corvallis.IDF	Run date: 02-24-2011

Reservoir Report

English

Reservoir No. 1 - East Concrete Tank

Pond Data

Bottom area = 1200.0 sqft Side slope = 0.0:1 Bottom elev. = 324.00 ft Depth = 12.00 ft

Stage / Storage Table

Stage ft	Elevation ft	Contour area sqft	Incr. Storage cuft	Total storage cuft
0.00	324.00	1,200	0	0
1.20	325.20	1,200	1,440	1,440
2.40	326.40	1,200	1,440	2,880
3.60	327.60	1,200	1,440	4,320
4.80	328.80	1,200	1,440	5,760
6.00	330.00	1,200	1,440	7,200
7.20	331.20	1,200	1,440	8,640
8.40	332.40	1,200	1,440	10,080
9.60	333.60	1,200	1,440	11,520
10.80	334.80	1,200	1,440	12,960
12.00	336.00	1,200	1,440	14,400

Culvert / Orifice Structures

		[A]	[B]	[C]	[D]
Rise in	=	24.0	0.5	0.0	0.5
Span in	=	24.0	0.5	0.0	0.5
No. Barrels	=	1	1	1	1
Invert El. ft	=	324.00	322.00	326.00	328.00
Length ft	=	20.0	0.0	0.0	0.0
Slope %	=	0.50	0.00	0.00	0.00
N-Value	=	.009	.013	.013	.013
Orif. Coeff.	=	0.60	0.60	0.60	0.60
Multi-Stage	=	-----	Yes	Yes	Yes

Weir Structures

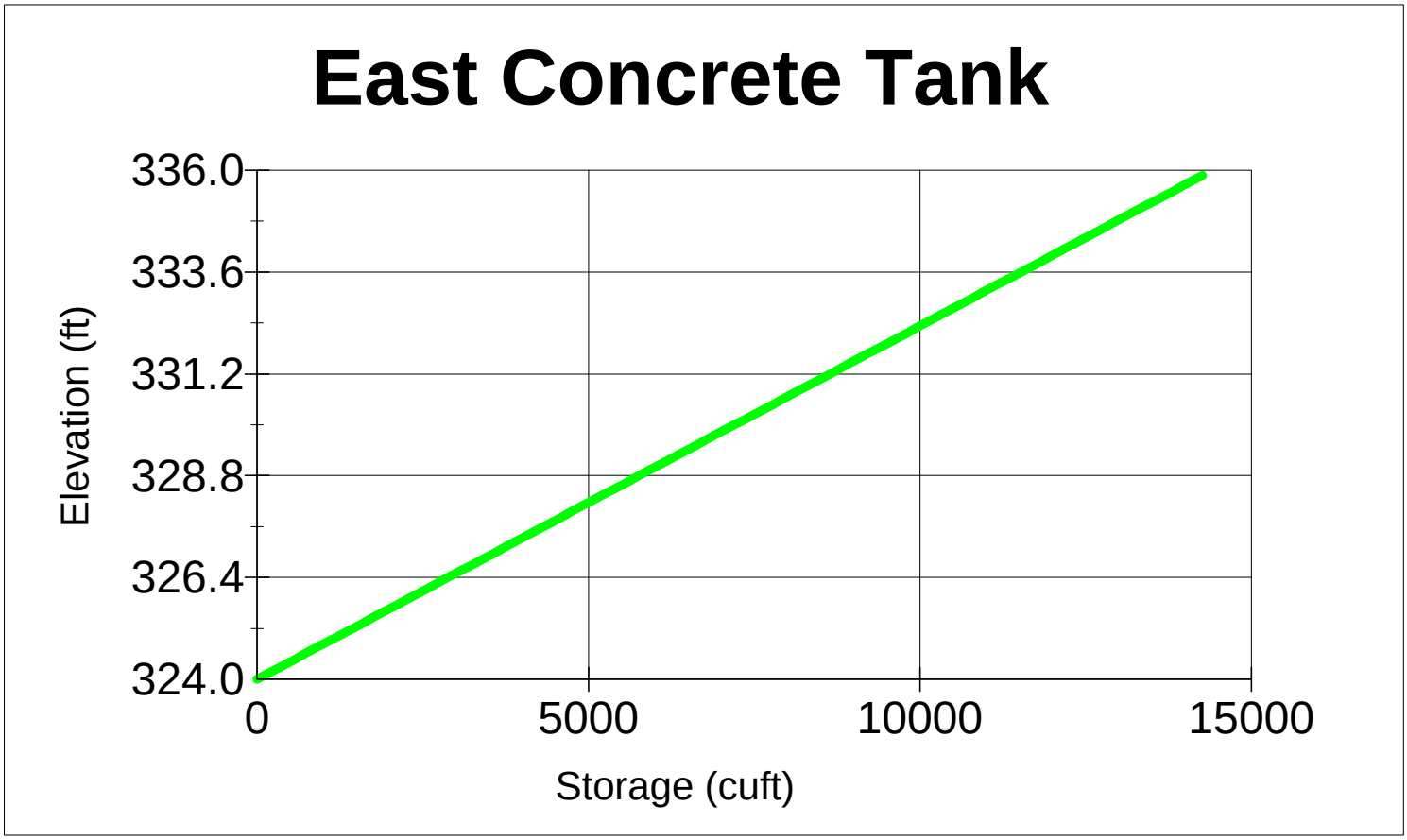
		[A]	[B]	[C]	[D]
Crest Len ft	=	3.14	3.14	0.00	0.00
Crest El. ft	=	335.00	335.50	0.00	0.00
Weir Coeff.	=	3.30	3.30	0.00	0.00
Eqn. Exp.	=	1.50	1.50	0.00	0.00
Multi-Stage	=	Yes	Yes	No	No

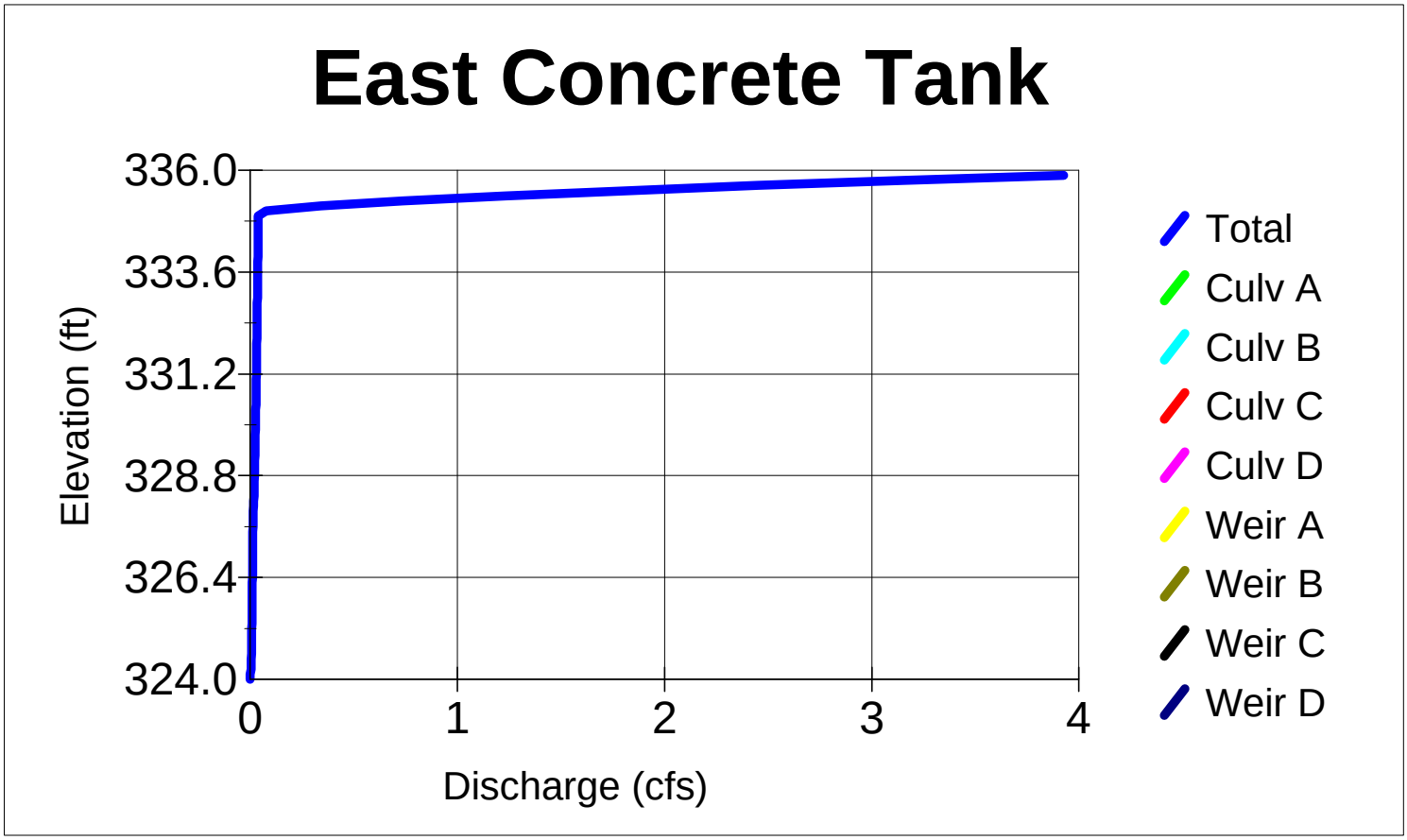
Tailwater Elevation = 0.00 ft

Note: All outflows have been analyzed under inlet and outlet control.

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	Clv D cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Discharge cfs
0.00	0	324.00	0.00	0.01	---	0.00	0.00	0.00	---	---	0.00
1.20	1,440	325.20	4.08	0.01	---	0.00	0.00	0.00	---	---	0.01
2.40	2,880	326.40	14.01	0.01	---	0.00	0.00	0.00	---	---	0.01
3.60	4,320	327.60	24.39	0.01	---	0.00	0.00	0.00	---	---	0.01
4.80	5,760	328.80	29.48	0.01	---	0.01	0.00	0.00	---	---	0.02
6.00	7,200	330.00	33.82	0.02	---	0.01	0.00	0.00	---	---	0.03
7.20	8,640	331.20	37.66	0.02	---	0.01	0.00	0.00	---	---	0.03
8.40	10,080	332.40	41.14	0.02	---	0.01	0.00	0.00	---	---	0.03
9.60	11,520	333.60	44.35	0.02	---	0.02	0.00	0.00	---	---	0.04
10.80	12,960	334.80	47.35	0.02	---	0.02	0.00	0.00	---	---	0.04
12.00	14,400	336.00	50.16	0.02	---	0.02	10.36	3.66	---	---	14.06


East Concrete Tank
336.0
333.6
331.2
328.8
326.4
324.0
Elevation (ft)
0
5000
10000
15000
Storage (cuft)


East Concrete Tank
336.0
333.6
331.2
328.8
326.4
324.0
Elevation (ft)
0
1
2
3
4
Discharge (cfs)
Total
Culv A
Culv B
Culv C
Culv D
Weir A
Weir B
Weir C
Weir D

Hydrograph Plot

English

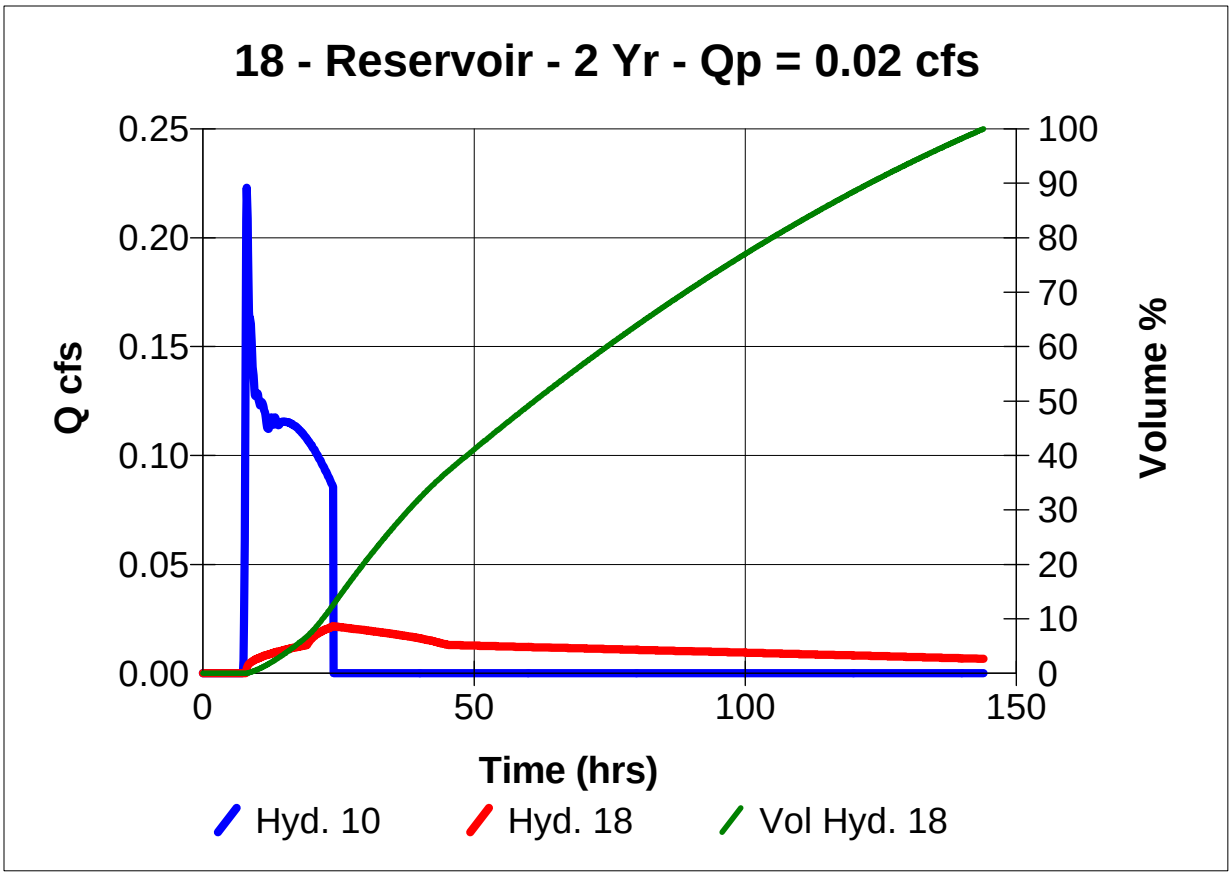
Hyd. No. 18

2-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.02 cfs
Storm frequency	=	2 yrs	Time interval	=	6 min
Inflow hyd. No.	=	10	Reservoir name	=	East Concrete T
Max. Elevation	=	329.10 ft	Max. Storage	=	6,115 cuft

Storage Indication method used.

Total Volume = 5,568 cuft



Hydrograph Plot

English

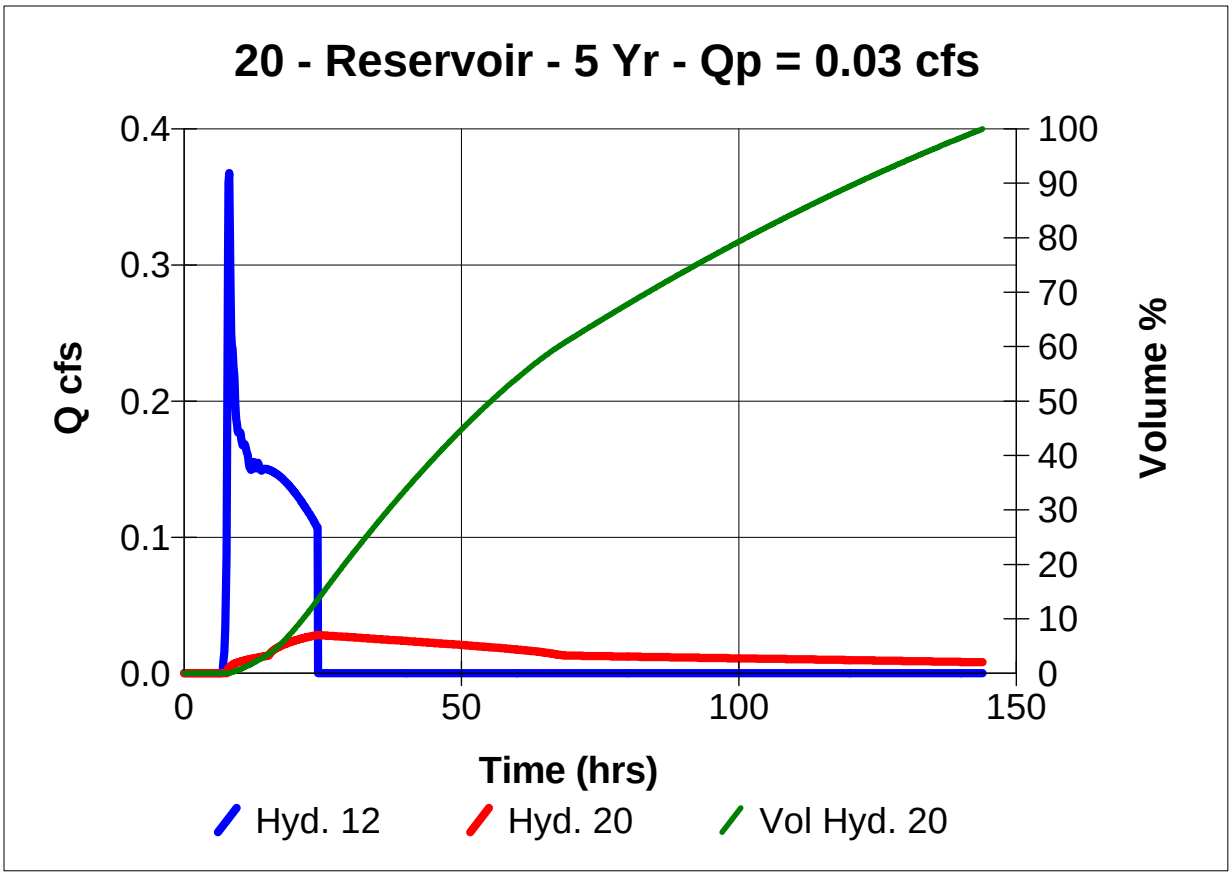
Hyd. No. 20

5-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.03 cfs
Storm frequency	=	5 yrs	Time interval	=	6 min
Inflow hyd. No.	=	12	Reservoir name	=	East Concrete T
Max. Elevation	=	330.84 ft	Max. Storage	=	8,213 cuft

Storage Indication method used.

Total Volume = 7,328 cuft



Hydrograph Plot

English

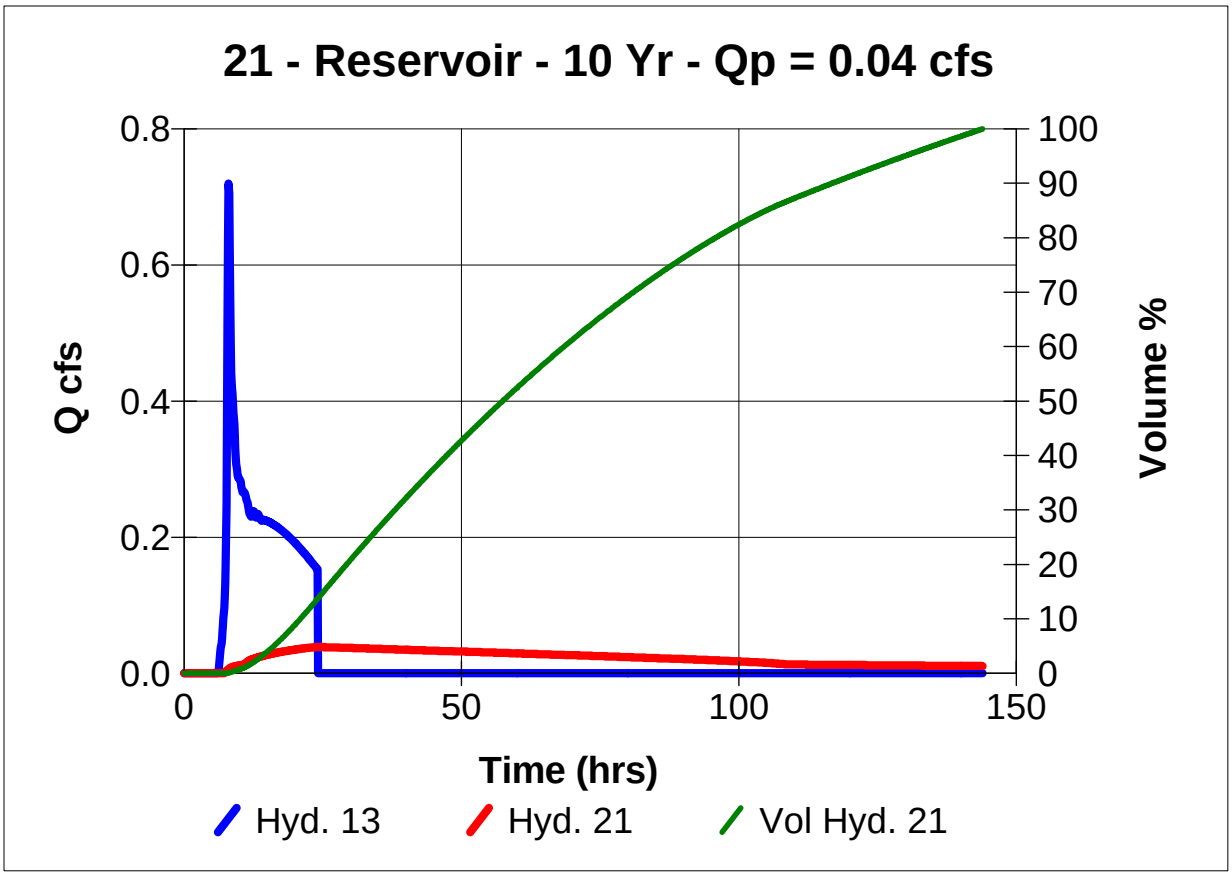
Hyd. No. 21

10-yr design

Hydrograph type	=	Reservoir	Peak discharge	=	0.04 cfs
Storm frequency	=	10 yrs	Time interval	=	6 min
Inflow hyd. No.	=	13	Reservoir name	=	East Concrete T
Max. Elevation	=	334.89 ft	Max. Storage	=	13,068 cuft

Storage Indication method used.

Total Volume = 11,381 cuft



Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.12	6	1320	3,956	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.21	6	1218	8,203	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.28	6	1164	12,191	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.31	6	1146	13,899	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.56	6	1032	28,952	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.70	6	990	37,590	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	0.98	6	528	47,862	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	1.44	6	498	59,268	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.49	6	498	23,671	1	----	------	------	1-yr post-dev
10	SBUH Runoff	1.04	6	486	34,099	2	----	------	------	2-yr post-dev
11	SBUH Runoff	1.54	6	486	42,609	3	----	------	------	3-yr post-dev
12	SBUH Runoff	1.75	6	486	46,034	5	----	------	------	5-yr post-dev
13	SBUH Runoff	3.41	6	486	73,183	10	----	------	------	10-yr post-dev
14	SBUH Runoff	4.29	6	486	87,309	25	----	------	------	25-yr post-dev
15	SBUH Runoff	5.33	6	480	103,299	50	----	------	------	50-yr post-dev
16	SBUH Runoff	6.45	6	480	120,314	100	----	------	------	100-yr post-dev
17	Reservoir	0.42	6	1062	20,383	1	9	335.17	13,407	1-yr design
18	Reservoir	0.58	6	906	30,809	2	10	335.22	13,461	2-yr design
19	Reservoir	0.72	6	756	39,318	3	11	335.26	13,507	3-yr design
20	Reservoir	0.80	6	690	42,743	5	12	335.28	13,534	5-yr design
21	Reservoir	1.79	6	546	69,891	10	13	335.48	13,779	10-yr design
22	Reservoir	2.65	6	516	84,017	25	14	335.60	13,922	25-yr design
23	Reservoir	4.56	6	498	100,007	50	15	335.80	14,154	50-yr design
24	Reservoir	6.34	6	492	117,021	100	16	335.94	14,333	100-yr design

Proj. file: East Bypass.GPW | IDF file: Corvallis.IDF | Run date: 02-20-2011

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	SBUH Runoff	0.17	6	1320	5,541	1	----	------	------	1-yr pre-dev
2	SBUH Runoff	0.29	6	1224	11,498	2	----	------	------	2-yr pre-dev
3	SBUH Runoff	0.40	6	1164	17,094	3	----	------	------	3-yr pre-dev
4	SBUH Runoff	0.44	6	1146	19,491	5	----	------	------	5-yr pre-dev
5	SBUH Runoff	0.79	6	1038	40,621	10	----	------	------	10-yr pre-dev
6	SBUH Runoff	0.98	6	996	52,747	25	----	------	------	25-yr pre-dev
7	SBUH Runoff	1.37	6	534	67,169	50	----	------	------	50-yr pre-dev
8	SBUH Runoff	1.96	6	498	83,184	100	----	------	------	100-yr pre-dev
9	SBUH Runoff	0.68	6	528	33,240	1	----	------	------	1-yr post-dev
10	SBUH Runoff	1.41	6	486	47,888	2	----	------	------	2-yr post-dev
11	SBUH Runoff	2.11	6	486	59,843	3	----	------	------	3-yr post-dev
12	SBUH Runoff	2.39	6	486	64,655	5	----	------	------	5-yr post-dev
13	SBUH Runoff	4.69	6	486	102,795	10	----	------	------	10-yr post-dev
14	SBUH Runoff	5.91	6	486	122,642	25	----	------	------	25-yr post-dev
15	SBUH Runoff	7.31	6	486	145,108	50	----	------	------	50-yr post-dev
16	SBUH Runoff	8.81	6	480	169,014	100	----	------	------	100-yr post-dev

Proj. file: East Connection.GPW | IDF file: Corvallis.IDF | Run date: 02-24-2011

BROOKLANE HEIGHTS

Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 11
Water Quality Analyses

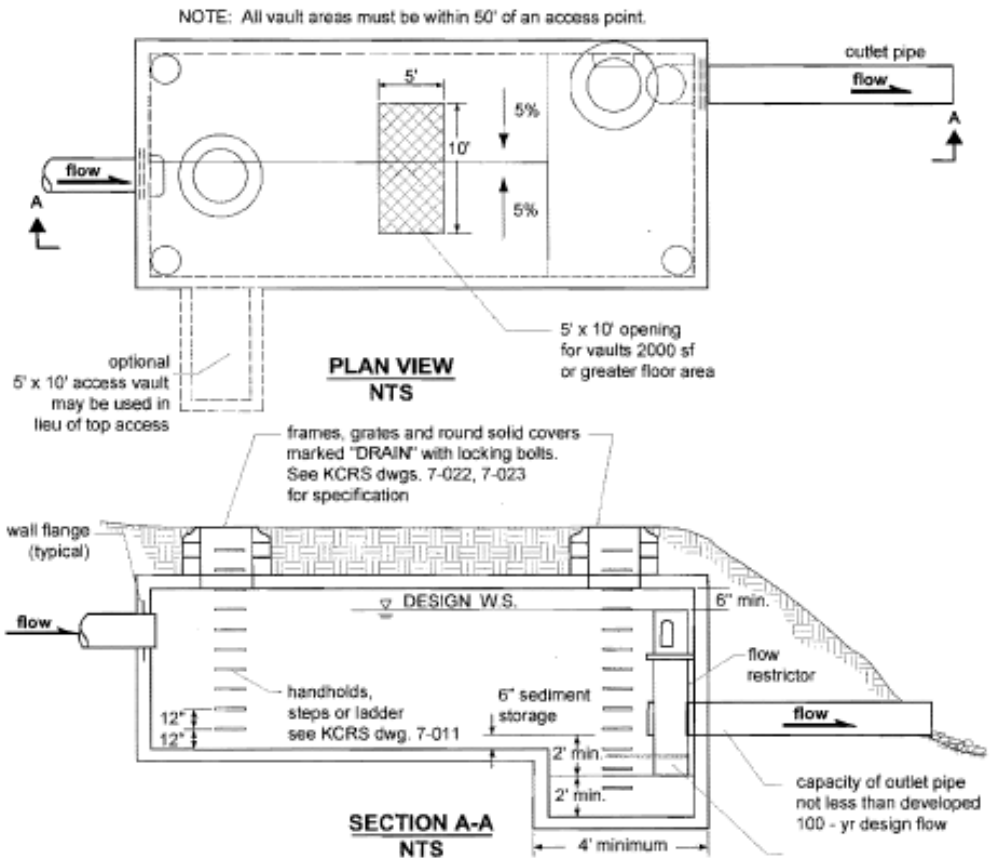
WATER QUALITY FACILITY "W" DESIGN
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Mathcad Reference Document(s)

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Brooklane Heights Runoff.xmcd

Typical Detention Vault - King County Surface Water Design Manual

FIGURE 5.3.3.A TYPICAL DETENTION VAULT



NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment 1 or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults <10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

Presettling Design Parameters for Media Filtration Facilities (KCSWDM 6.5.1)

Rainfall for Water Quality Design

$R_{wq} := 0.9in$ (Stormwater Quality Facility Design Storm, Moser, City of Corvallis, Dec. 15, 2003)

Water Quality Flow Rate (KCSWDM 6.5.5.1.2)

With no detention, use 35% of the developed two-year peak rate

$P_24(2) = 2.54$ inches $35\% \cdot P_24(2) = 0.9$ inch

This value is the same rainfall amount recommended by the Bruce Moser memorandum.

With detention, use the developed two-year pond discharge rate.

From SBUH hydrograph analysis, the two-year developed detention discharge rate is

$Q_{2_peak} := 0.02cfs$ $Q_{2_peak} = 9.0\,gpm$

$Q_{W_wq} := Q_{2_peak}$ $Q_{W_wq} = 9.0\,gpm$

Presettling Volume Required (KCSWDM 6.5.1.2)

From SBUH hydrograph analysis, the two-year developed discharge volume is

$V_{2_W} := 2902ft^3$

Use 35% of this value to estimate the volume for the 0.9-inch design storm

$V_{des_W} := 35\% \cdot V_{2_W}$ $V_{des_W} = 1016 \cdot ft^3$

Use 75% of the required design volume for presettling <u>upstream</u> from media filtration

$V_{reqd_W} := 0.75 \cdot V_{des_W}$ $V_{reqd_W} = 762\,ft^3$

Presettling Volume Provided

Tank Floor Area $A_{tank} := 420ft^2$

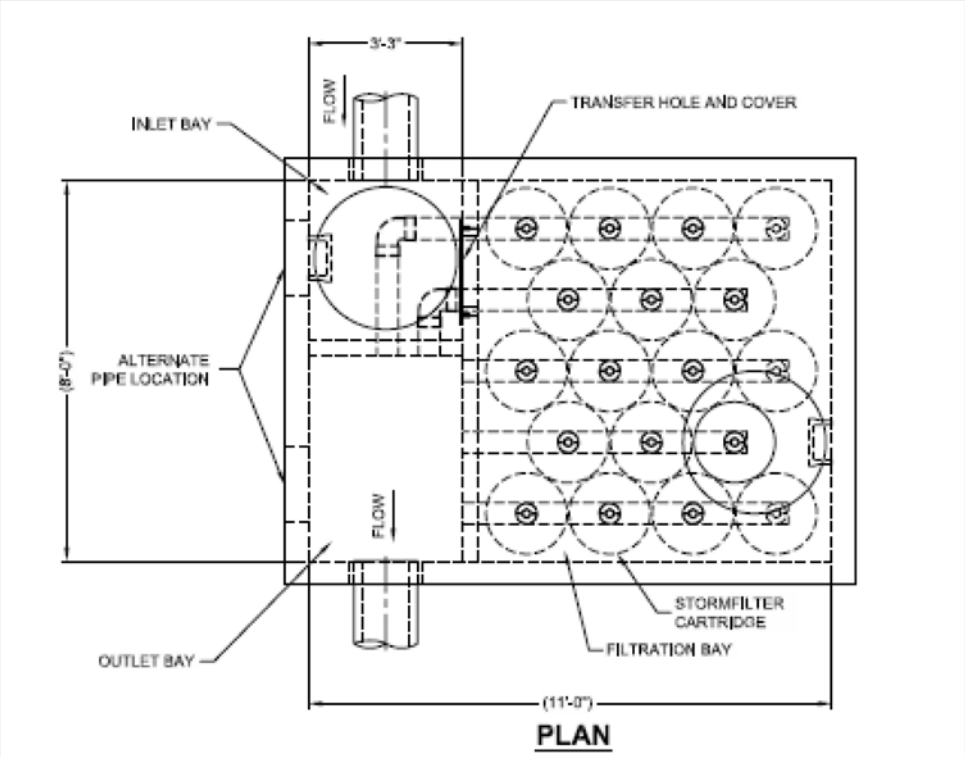
Average Settling Depth $h_{WQ} := 2ft$ (average depth <u>below</u> detention volume)

Settling Volume $V_{WQ_W} := A_{tank} \cdot h_{WQ}$ $V_{WQ_W} = 840\,ft^3$

$Check_{settling_volume} := if(V_{WQ_W} \geq V_{reqd_W}, "OK", "No Good!")$

$Check_{settling_volume} = "OK"$

StormFilter Configuration



StormFilter Flow Rates

TABLE 6.5.5.A MAXIMUM STORMFILTER DESIGN FLOW RATES PER CARTRIDGE FOR BASIC TREATMENT WITH ZPG MEDIA

Effective Cartridge Height (inches)	12	18	27
Cartridge Flow Rate (gpm/cartridge)	5	7.5	11.3

Select Cartridge Height & Number

$H_{cartridge} := 12in$ $\quad N_{cartridge} := 2$

$$Q_{cartridge} := \begin{cases} 5gpm & \text{if } H_{cartridge} = 12in \\ 7.5gpm & \text{if } H_{cartridge} = 18in \\ 11.3gpm & \text{if } H_{cartridge} = 27in \end{cases}$$

StormFilter Capacity

$Q_{stormfilter} := N_{cartridge} \cdot Q_{cartridge}$ $\quad Q_{stormfilter} = 10.0\,gpm$

$Check_{wq} := \text{if}\left(Q_{stormfilter} \geq Q_{W_wq}, \text{"OK"}, \text{"No Good!"}\right)$ $\quad Check_{wq} = \text{"OK"}$

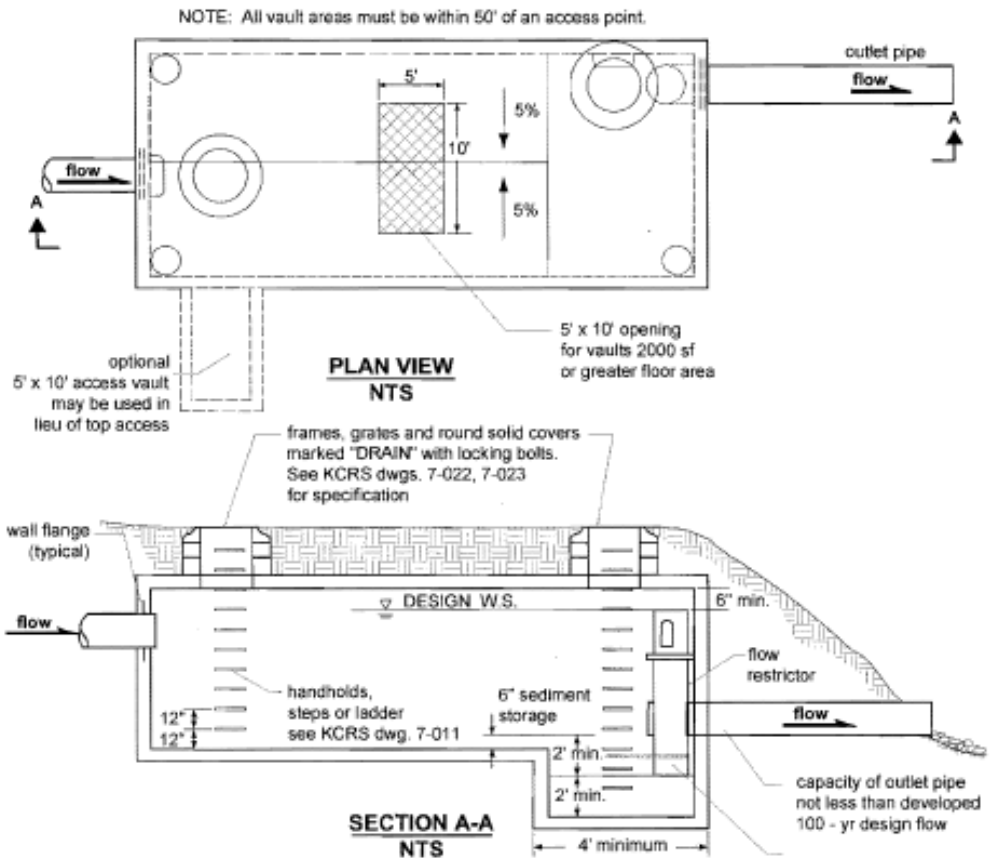
WATER QUALITY FACILITY "C" DESIGN
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Mathcad Reference Document(s)

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Brooklane Heights Runoff.xmcd

Typical Detention Vault - King County Surface Water Design Manual

FIGURE 5.3.3.A TYPICAL DETENTION VAULT



NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment 1 or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults <10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

Presettling Design Parameters for Media Filtration Facilities (KCSWDM 6.5.1)

Rainfall for Water Quality Design

$R_{wq} := 0.9in$ (Stormwater Quality Facility Design Storm, Moser, City of Corvallis, Dec. 15, 2003)

Water Quality Flow Rate (KCSWDM 6.5.5.1.2)

With no detention, use 35% of the developed two-year peak rate

$P_24(2) = 2.54$ inches $35\% \cdot P_24(2) = 0.9$ inch

This value is the same rainfall amount recommended by the Bruce Moser memorandum.

With detention, use the developed two-year pond discharge rate.

From SBUH hydrograph analysis, the two-year developed detention discharge rate is

$Q_{2_peak} := 0.06cfs$ $Q_{2_peak} = 26.9\,gpm$

$Q_{C_wq} := Q_{2_peak}$ $Q_{C_wq} = 26.9\,gpm$

Presettling Volume Required (KCSWDM 6.5.1.2)

From SBUH hydrograph analysis, the two-year developed discharge volume is

$V_{2_C} := 25528ft^3$

Use 35% of this value to estimate the volume for the 0.9-inch design storm

$V_{des_C} := 35\% \cdot V_{2_C}$ $V_{des_C} = 8935 \cdot ft^3$

Use 75% of the required design volume for presettling <u>upstream</u> from media filtration

$V_{reqd_C} := 0.75 \cdot V_{des_C}$ $V_{reqd_C} = 6701\,ft^3$

Presettling Volume Provided

Tank Floor Area $A_{tank} := 6200ft^2$

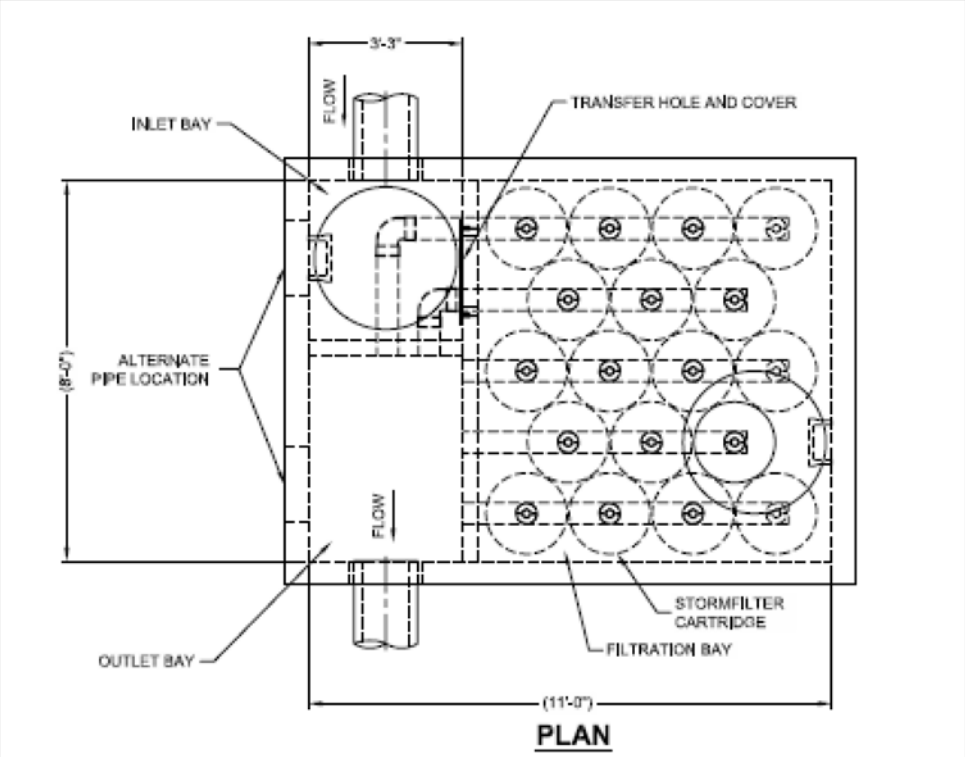
Average Settling Depth $h_{CQ} := 2ft$ (average depth <u>below</u> detention volume)

Settling Volume $V_{CQ_W} := A_{tank} \cdot h_{CQ}$ $V_{CQ_W} = 12400\,ft^3$

$Check_{settling_volume} := if(V_{CQ_W} \geq V_{reqd_C}, "OK", "No\ Good!")$

$Check_{settling_volume} = "OK"$

StormFilter Configuration



StormFilter Flow Rates

TABLE 6.5.5.A MAXIMUM STORMFILTER DESIGN FLOW RATES PER CARTRIDGE FOR BASIC TREATMENT WITH ZPG MEDIA

Effective Cartridge Height (inches)	12	18	27
Cartridge Flow Rate (gpm/cartridge)	5	7.5	11.3

Select Cartridge Height & Number

$H_{cartridge} := 12in$ $\quad N_{cartridge} := 6$

$$Q_{cartridge} := \begin{cases} 5gpm & \text{if } H_{cartridge} = 12in \\ 7.5gpm & \text{if } H_{cartridge} = 18in \\ 11.3gpm & \text{if } H_{cartridge} = 27in \end{cases}$$

StormFilter Capacity

$Q_{stormfilter} := N_{cartridge} \cdot Q_{cartridge}$ $\quad Q_{stormfilter} = 30.0\,gpm$

$Check_{wq} := \text{if}\left(Q_{stormfilter} \geq Q_{C_wq}, \text{"OK"}, \text{"No Good!"}\right)$ $\quad Check_{wq} = \text{"OK"}$

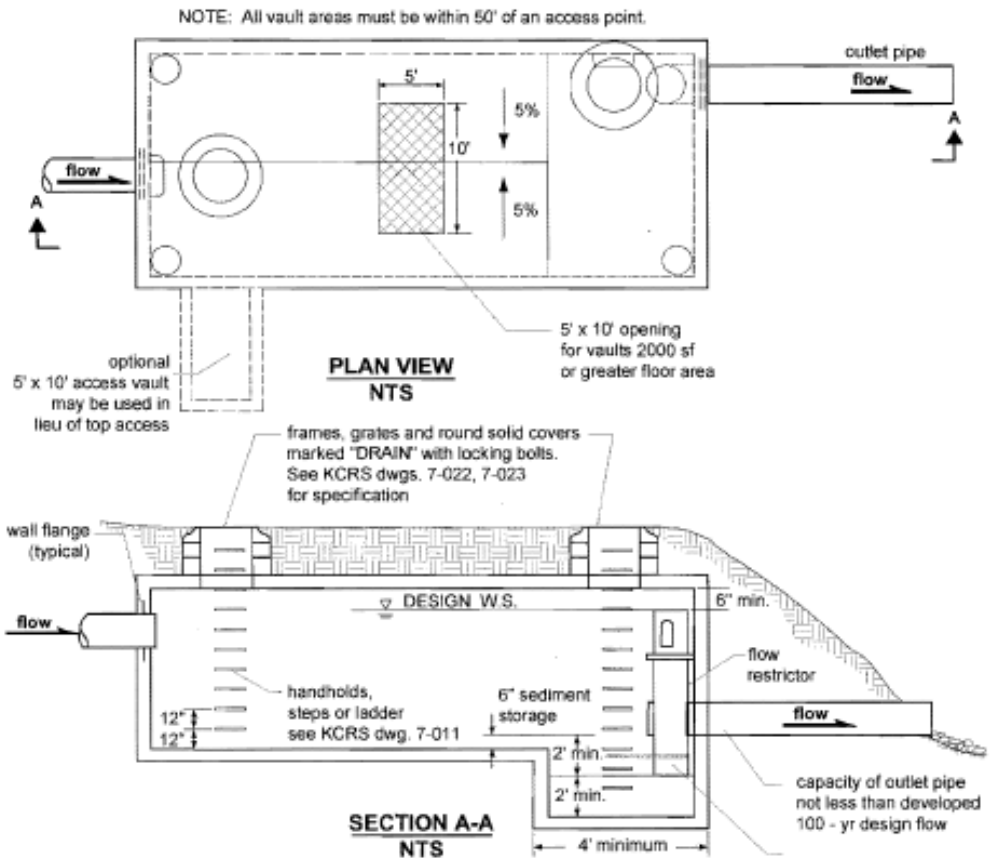
WATER QUALITY FACILITY "E" DESIGN
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Mathcad Reference Document(s)

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Brooklane Heights Runoff.xmcd

Typical Detention Vault - King County Surface Water Design Manual

FIGURE 5.3.3.A TYPICAL DETENTION VAULT



NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment 1 or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults <10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

Presettling Design Parameters for Media Filtration Facilities (KCSWDM 6.5.1)

Rainfall for Water Quality Design

$R_{wq} := 0.9in$ (Stormwater Quality Facility Design Storm, Moser, City of Corvallis, Dec. 15, 2003)

Water Quality Flow Rate (KCSWDM 6.5.5.1.2)

With no detention, use 35% of the developed two-year peak rate

$P_24(2) = 2.54$ inches $35\% \cdot P_24(2) = 0.9$ inch

This value is the same rainfall amount recommended by the Bruce Moser memorandum.

With detention, use the developed two-year pond discharge rate.

From SBUH hydrograph analysis, the two-year developed detention discharge rate is

$Q_{2_peak} := 0.02cfs$ $Q_{2_peak} = 9.0\,gpm$

$Q_{C_wq} := Q_{2_peak}$ $Q_{C_wq} = 9.0\,gpm$

Presettling Volume Required (KCSWDM 6.5.1.2)

From SBUH hydrograph analysis, the two-year developed discharge volume is

$V_{2_C} := 6816ft^3$

Use 35% of this value to estimate the volume for the 0.9-inch design storm

$V_{des_C} := 35\% \cdot V_{2_C}$ $V_{des_C} = 2386 \cdot ft^3$

Use 75% of the required design volume for presettling <u>upstream</u> from media filtration

$V_{reqd_C} := 0.75 \cdot V_{des_C}$ $V_{reqd_C} = 1789\,ft^3$

Presettling Volume Provided

Tank Floor Area $A_{tank} := 1200ft^2$

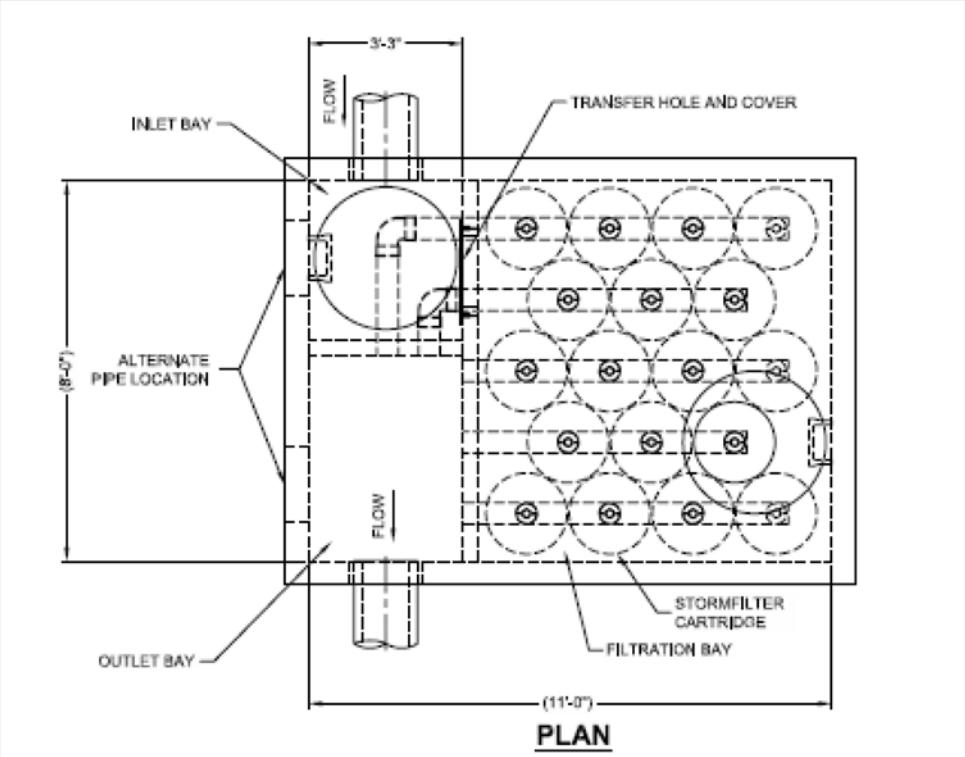
Average Settling Depth $h_{CQ} := 2ft$ (average depth <u>below</u> detention volume)

Settling Volume $V_{CQ_W} := A_{tank} \cdot h_{CQ}$ $V_{CQ_W} = 2400\,ft^3$

$Check_{settling_volume} := if(V_{CQ_W} \geq V_{reqd_C}, "OK", "No Good!")$

$Check_{settling_volume} = "OK"$

StormFilter Configuration



StormFilter Flow Rates

TABLE 6.5.5.A MAXIMUM STORMFILTER DESIGN FLOW RATES PER CARTRIDGE FOR BASIC TREATMENT WITH ZPG MEDIA

Effective Cartridge Height (inches)	12	18	27
Cartridge Flow Rate (gpm/cartridge)	5	7.5	11.3

Select Cartridge Height & Number

$H_{cartridge} := 12in$ $\quad N_{cartridge} := 2$

$$Q_{cartridge} := \begin{cases} 5gpm & \text{if } H_{cartridge} = 12in \\ 7.5gpm & \text{if } H_{cartridge} = 18in \\ 11.3gpm & \text{if } H_{cartridge} = 27in \end{cases}$$

StormFilter Capacity

$Q_{stormfilter} := N_{cartridge} \cdot Q_{cartridge}$ $\quad Q_{stormfilter} = 10.0\,gpm$

$Check_{wq} := \text{if}\left(Q_{stormfilter} \geq Q_{C_wq}, \text{"OK"}, \text{"No Good!"}\right)$ $\quad Check_{wq} = \text{"OK"}$

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Section 12
Flow Control Hydraulics

FLOW CONTROL HYDRAULICS
STORMWATER RUNOFF DETENTION ANALYSIS
CENTRAL BASIN DETENTION FACILITY
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

Reference Document(s)

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Brooklane Heights Runoff.xmcd

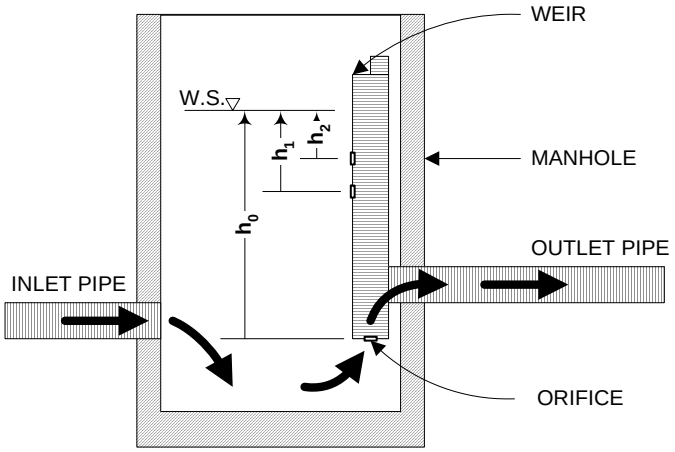
Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Area.xmcd

Reference:C:\Projects\Metolius\Brooklane Heights\Stormwater\Hydraulic Radius.xmcd

Approach

For purposes of confirmation of Hydraflow Hydrographs software reports, a manual calculation of the controlled flow from Basin C for both the 10-year and 100-year detained runoff is provided. The following calculations rely on algrorithms provided in the King County Surface Water Design Manual (KCSWDM).

Sketch of Flow Control Manhole with Orifices and Weir



10-Year Storm Water Depth Parameters

For a 10-year storm, from SBUH Hydrograph Analyses

$Elev_{WS_10} := 263.48ft$

$Elev_{out} := 256.00ft$

Plate Orifice

5.3.4.2 METHODS OF ANALYSIS

This section presents the methods and equations for design of **control structure restrictor devices**. Included are details for the design of orifices, rectangular sharp-crested weirs, v-notch weirs, sutro weirs, and overflow risers.

Orifices

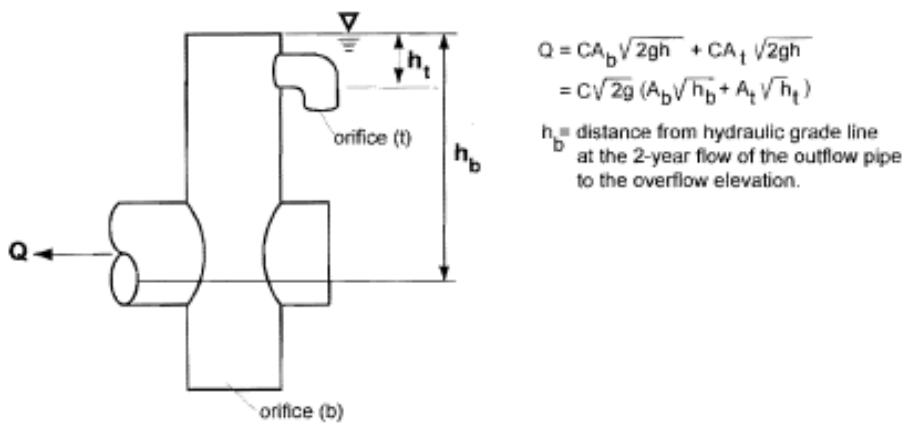
Flow through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = CA\sqrt{2gh} \qquad (5\text{-}4)$$

where
Q = flow (cfs)
C = coefficient of discharge (0.62 for plate orifice)
A = area of orifice (sf)
h = hydraulic head (ft)
g = gravity (32.2 ft/sec^2)

Figure 5.3.4.D illustrates a simplified application of the orifice equation, assuming a water surface at the top of the riser and that the 2-year water surface represents the head in the outlet pipe.

FIGURE 5.3.4.D SIMPLE ORIFICE



The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad (5\text{-}5)$$

where
d = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

Orifice Elevations

$Elev_{o_0} := 254.00ft$ $\quad h_{o_0} := \max(Elev_{WS_10} - Elev_{o_0}, 0)$ $\quad h_{o_0} = 9.48\,ft$

$Elev_{o_1} := 262.00ft$ $\quad h_{o_1} := \max(Elev_{WS_10} - Elev_{o_1}, 0)$ $\quad h_{o_1} = 1.48\,ft$

$Elev_{o_2} := 264.00ft$ $\quad h_{o_2} := \max(Elev_{WS_10} - Elev_{o_2}, 0)$ $\quad h_{o_2} = 0.00\,ft$

Orifice Diameters

$d_{o_0} := 1.00in$ $\quad d_{o_1} := 1.00in$ $\quad d_{o_2} := 1.00in$

Hydraulic Areas of Orifices

$A_{o_0} := \pi\left(\frac{d_{o_0}}{2}\right)^2$ $\quad A_{o_0} = 0.7854 \cdot in^2$

$A_{o_1} := \pi\left(\frac{d_{o_1}}{2}\right)^2$ $\quad A_{o_1} = 0.7854 \cdot in^2$

$A_{o_2} := \pi\left(\frac{d_{o_2}}{2}\right)^2$ $\quad A_{o_2} = 0.7854 \cdot in^2$

Orifice Coefficient

$C_o := 0.62$ (KCSWDM)

Bernoulli's Equation

$Q_{o_0} := C_o \cdot A_{o_0} \cdot \sqrt{2g \cdot h_{o_0}}$ $\quad Q_{o_0} = 37\,gpm$ $\quad Q_{o_0} = 0.08 \cdot cfs$

$Q_{o_1} := C_o \cdot A_{o_1} \cdot \sqrt{2g \cdot h_{o_1}}$ $\quad Q_{o_1} = 15\,gpm$ $\quad Q_{o_1} = 0.03 \cdot cfs$

$Q_{o_2} := C_o \cdot A_{o_2} \cdot \sqrt{2g \cdot h_{o_2}}$ $\quad Q_{o_2} = 0\,gpm$ $\quad Q_{o_2} = 0.00 \cdot cfs$

Total Orifice Discharge $\quad \sum Q_o = 52\,gpm$ $\quad \sum Q_o = 0.12 \cdot cfs$

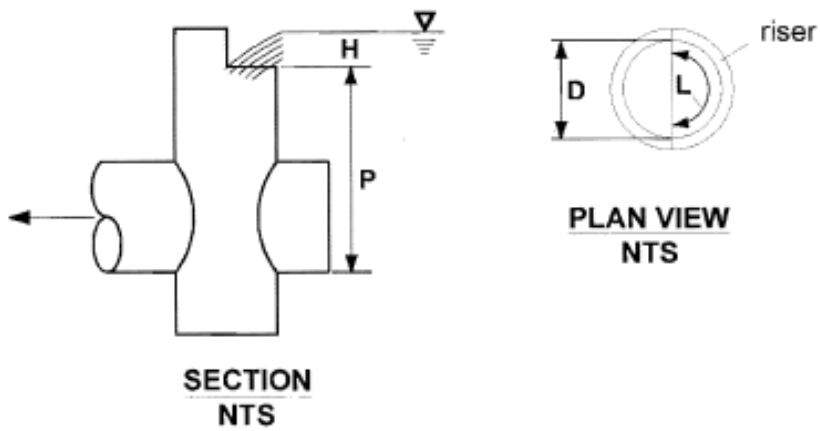
Sharp-Crested Weir

5.3.4 CONTROL STRUCTURES — *METHODS OF ANALYSIS*

Rectangular, Sharp-Crested Weir

The rectangular, sharp-crested weir design shown in Figure 5.3.4.E may be analyzed using standard weir equations for the fully contracted condition.

FIGURE 5.3.4.E RECTANGULAR, SHARP-CRESTED WEIR



$$Q = C(L - 0.2H)H^{3/2} \qquad (5\text{-}6)$$

where Q = flow (cfs)
C = $3.27 + 0.40\,H/P$ (ft)
H, P are as shown above
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50% of the circumference
D = inside riser diameter (ft)

Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

Weir Elevations

$Elev_{weir_0} := 266.00\,ft$ $\quad h_{weir_0} := \max\left(Elev_{WS_10} - Elev_{weir_0}, 0\right)$ $\quad h_{weir_0} = 0.00\,ft$

$Elev_{out} = 256.00\,ft$ $\quad p_{weir_0} := Elev_{weir_0} - Elev_{out}$ $\quad p_{weir_0} = 10.00\,ft$

$Elev_{weir_1} := 266.50\,ft$ $\quad h_{weir_1} := \max\left(Elev_{WS_10} - Elev_{weir_1}, 0\right)$ $\quad h_{weir_1} = 0.00\,ft$

$Elev_{out} = 256.00\,ft$ $\quad p_{weir_1} := Elev_{weir_1} - Elev_{out}$ $\quad p_{weir_1} = 10.50\,ft$

Lengths of Weirs

$L_{weir_0} := 1.57ft$

$L_{weir_1} := 1.57ft$

Weir Coefficient

$C_{weir_10} := 3.27 + 0.40 \cdot \frac{h_{weir}}{p_{weir}}$ (KCSWDM)

$C_{weir_10} = \begin{pmatrix} 3.27 \\ 3.27 \end{pmatrix}$

Weir Discharge

$Q_{weir_10} := C_{weir_10} \cdot \left(\frac{L_{weir} - 0.2 \cdot h_{weir}}{ft} \right) \cdot \left(\frac{h_{weir}}{ft} \right)^{\frac{3}{2}} \cdot cfs$

$Q_{weir_10} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} gpm$ $Q_{weir_10} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix} \cdot cfs$

Total Discharge

$Q_{total_10} := \sum Q_o + \sum Q_{weir_10}$ $Q_{total_10} = 52\,gpm$ $Q_{total_10} = 0.12 \cdot cfs$

Hydrograph Summary Report

$Q_{tank_10} := 0.10cfs$ (Tank detention discharge for a 10-year storm)

Conclusion

Given that the Hydraflow Hydragraphs uses slightly different algorithms for calculating discharge from weirs and orifices, these results are satisfactory.

100-Year Storm Water Depth Parameters

For a 100-year storm, from SBUH Hydrograph Analyses

$Elev_{WS_100} := 266.32ft$

$Elev_{out} = 256.00\,ft$

Orifice Elevations

$Elev_{o_0} = 254.00\,ft$ $\quad h_{o_0} := Elev_{WS_100} - Elev_{o_0}$ $\quad h_{o_0} = 12.32\,ft$

$Elev_{o_1} = 262.00\,ft$ $\quad h_{o_1} := Elev_{WS_100} - Elev_{o_1}$ $\quad h_{o_1} = 4.32\,ft$

$Elev_{o_2} = 264.00\,ft$ $\quad h_{o_2} := Elev_{WS_100} - Elev_{o_2}$ $\quad h_{o_2} = 2.32\,ft$

Orifice Diameters

$$d_o = \begin{pmatrix} 1.00 \\ 1.00 \\ 1.00 \end{pmatrix} \cdot in$$

Hydraulic Areas of Orifices

$$A_o = \begin{pmatrix} 0.7854 \\ 0.7854 \\ 0.7854 \end{pmatrix} \cdot in^2$$

Orifice Coefficient

$C_o = 0.62$ (KCSWDM)

Bernoulli's Equation

$Q_{o_0} := C_o \cdot A_{o_0} \cdot \sqrt{2g \cdot h_{o_0}}$ $\quad Q_{o_0} = 43\,gpm$ $\quad Q_{o_0} = 0.10 \cdot cfs$

$Q_{o_1} := C_o \cdot A_{o_1} \cdot \sqrt{2g \cdot h_{o_1}}$ $\quad Q_{o_1} = 25\,gpm$ $\quad Q_{o_1} = 0.06 \cdot cfs$

$Q_{o_2} := C_o \cdot A_{o_2} \cdot \sqrt{2g \cdot h_{o_2}}$ $\quad Q_{o_2} = 19\,gpm$ $\quad Q_{o_2} = 0.04 \cdot cfs$

Total Orifice Discharge $\quad \sum Q_o = 87\,gpm$ $\quad \sum Q_o = 0.19 \cdot cfs$

$$Q_o = \begin{pmatrix} 43 \\ 25 \\ 19 \end{pmatrix} gpm \qquad Q_o = \begin{pmatrix} 0.10 \\ 0.06 \\ 0.04 \end{pmatrix} \cdot cfs$$

RISER INFLOW HYDRAULICS
STORMWATER RUNOFF DETENTION ANALYSIS
BROOKLANE HEIGHTS SUBDIVISION
CORVALLIS, OREGON

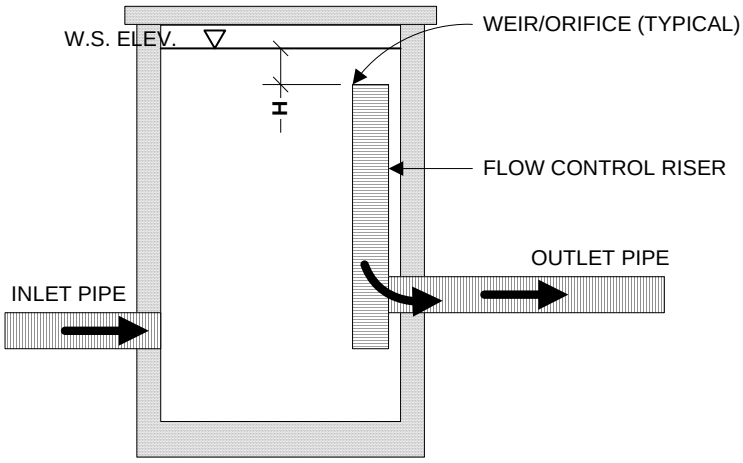
Special Units & Dimensions

$$cfs := \frac{ft^3}{sec}$$

Approach

For purposes of verifying the flow-through capacity of the standpipe weir in flow control structures, the inflow at the top of the riser is evaluated under inundated (surcharge) hydrostatic conditions, when the flow transitions from shallow head weir behavior to deeper head orifice behavior. The following calculations rely on algrorithms provided in the King County Surface Water Design Manual (KCSWDM). The smaller flow control orifices on the standpipe are ignored.

Sketch of Flow Control Riser



Water Depth Parameters

Evaluate surcharge to a maximum of

$H_{surcharge} := 2.0$ feet

Diameter of Circular Weir

$D_{weir} := 2.0$ feet

Riser Inflow Capacity (KCSWDM Figure 5.3.4.H)

$H_{weir} := 0, .01 .. H_{surcharge}$

$$Q_{weir}(H_{weir}, D_{weir}) := \min\left[9.739 \cdot cfs \cdot D_{weir} \cdot (H_{weir})^{\frac{3}{2}}, 3.782 \cdot cfs \cdot (D_{weir})^2 \cdot (H_{weir})^{\frac{1}{2}}\right]$$

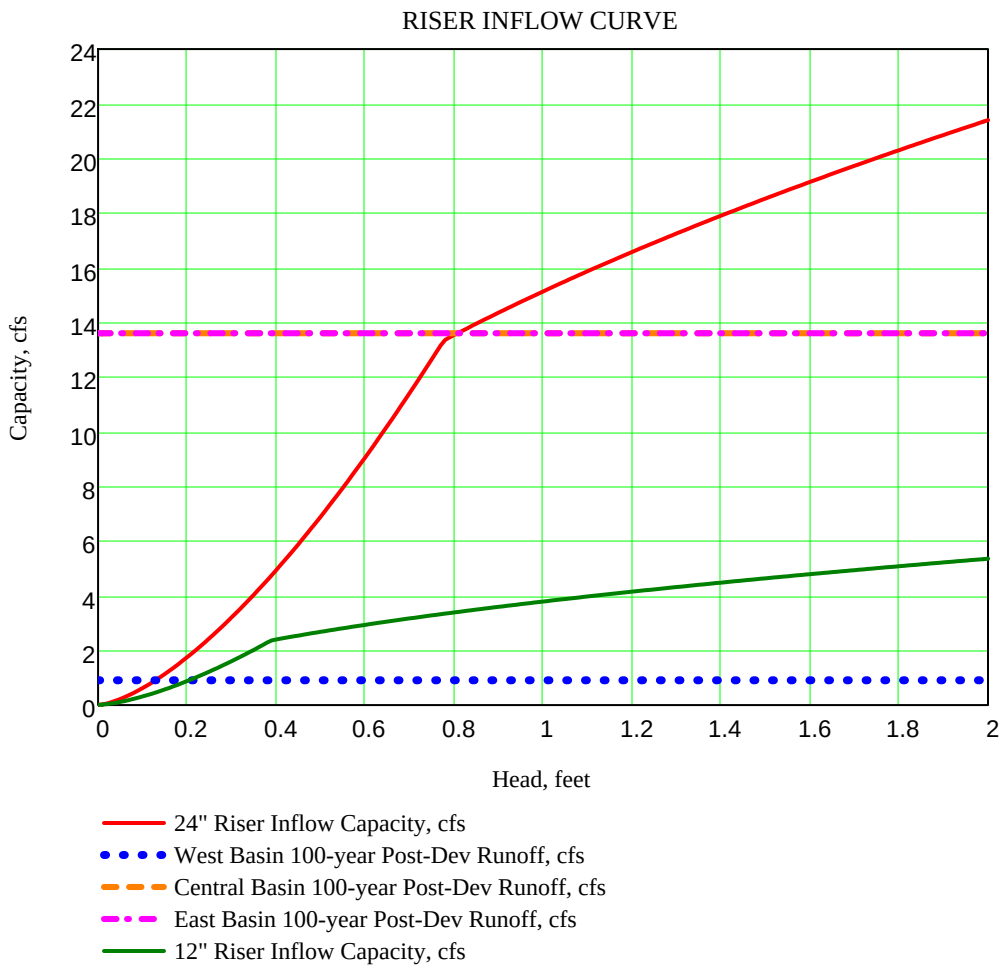
10-year Post Development Peak Rational Method Bypass Flows

West Basin Tank $Q_{Post_W_Bypass} := 0.9cfs$

Central Basin Tank $Q_{Post_C_Bypass} := 13.6cfs$

East Basin Tank $Q_{Post_E_Bypass} := 13.6cfs$

Graph the Riser Inflow Curve against Post-Development Bypass Flows



Standpipe Capacity under Maximum Surcharge

For a 24-inch standpipe $Q_{cap_24} := Q_{weir}(H_{surcharge}, 2.0)$ $Q_{cap_24} = 21.39 \cdot cfs$

For a 12-inch standpipe $Q_{cap_12} := Q_{weir}(H_{surcharge}, 1.0)$ $Q_{cap_12} = 5.35 \cdot cfs$

Weir Elevations

$Elev_{weir_0} := 266.00ft$ $\quad h_{weir_0} := \max\left(Elev_{WS_100} - Elev_{weir_0}, 0\right)$ $\quad h_{weir_0} = 0.32\,ft$

$Elev_{out} = 256.00\,ft$ $\quad p_{weir_0} := Elev_{weir_0} - Elev_{out}$ $\quad p_{weir_0} = 10.00\,ft$

$Elev_{weir_1} := 266.50ft$ $\quad h_{weir_1} := \max\left(Elev_{WS_100} - Elev_{weir_1}, 0\right)$ $\quad h_{weir_1} = 0.00\,ft$

$Elev_{out} = 256.00\,ft$ $\quad p_{weir_1} := Elev_{weir_1} - Elev_{out}$ $\quad p_{weir_1} = 10.50\,ft$

Lengths of Weirs

$L_{weir_0} := 1.57ft$

$L_{weir_1} := 1.57ft$

Weir Coefficients

$$C_{weir_100_0} := 3.27 + 0.40 \cdot \frac{h_{weir_0}}{p_{weir_0}} \qquad C_{weir_100_0} = 3.28$$

$$C_{weir_100_1} := 3.27 + 0.40 \cdot \frac{h_{weir_1}}{p_{weir_1}} \qquad C_{weir_100_1} = 3.27$$

Weir Discharge

$$Q_{weir_100_0} := C_{weir_100_0} \cdot \left(\frac{L_{weir_0} - 0.2 \cdot h_{weir_0}}{ft}\right) \cdot \left(\frac{h_{weir_0}}{ft}\right)^{\frac{3}{2}} \cdot cfs \qquad Q_{weir_100_0} = 0.89 \cdot cfs$$

$$Q_{weir_100_1} := C_{weir_100_1} \cdot \left(\frac{L_{weir_1} - 0.2 \cdot h_{weir_1}}{ft}\right) \cdot \left(\frac{h_{weir_1}}{ft}\right)^{\frac{3}{2}} \cdot cfs \qquad Q_{weir_100_1} = 0.00 \cdot cfs$$

Total Discharge

$Q_{total_100} := \sum Q_o + \sum Q_{weir_100}$ $\quad Q_{total_100} = 488\,gpm$ $\quad Q_{total_100} = 1.09 \cdot cfs$

Hydrograph Summary Report

$Q_{tank_100} := 1.14cfs$ (Tank detention discharge for a 100-year storm)

Conclusion

Given that the Hydraflow Hydragraphs uses slightly different algorithms for calculating discharge from weirs and orifices, these results are satisfactory.

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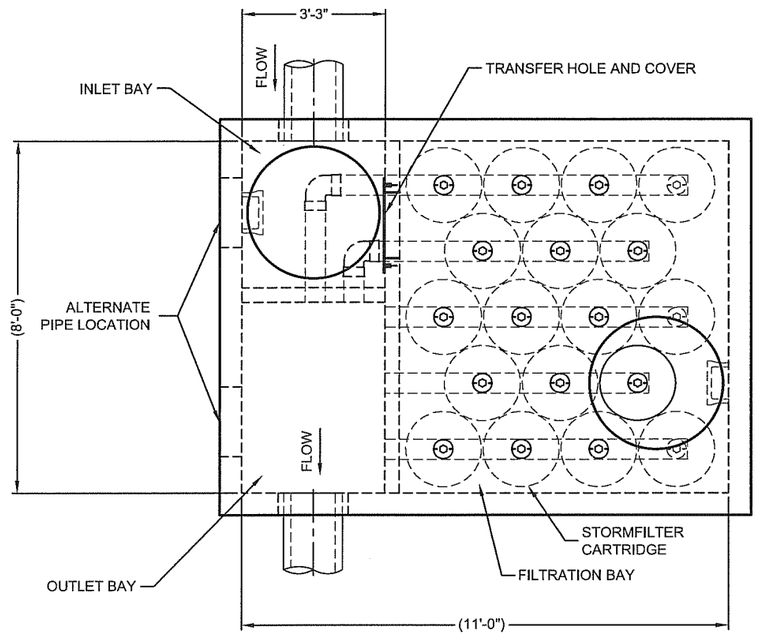
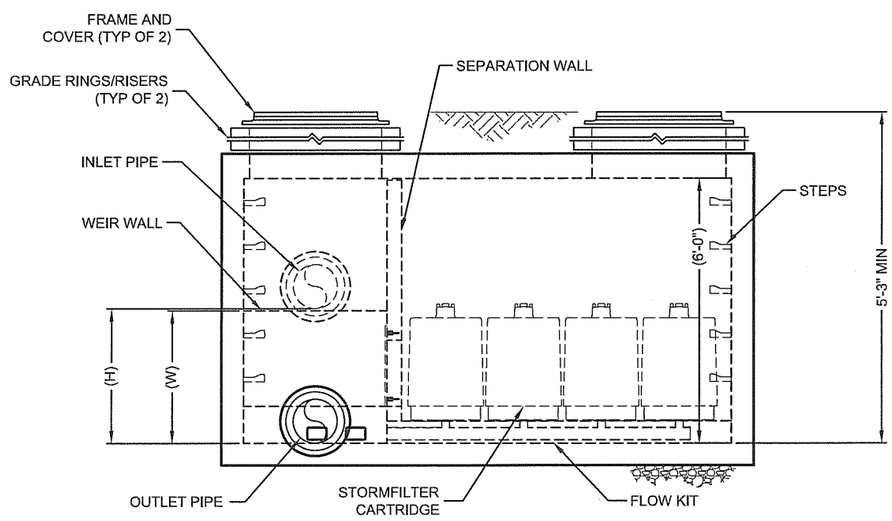
Contech StormFilter



PLAN



ELEVATION

STORMFILTER DESIGN TABLE

- THE 8' x 11' PEAK DIVERSION STORMFILTER TREATMENT CAPACITY VARIES BY CARTRIDGE COUNT AND LOCALLY APPROVED SURFACE AREA SPECIFIC FLOW RATE. PEAK CONVEYANCE CAPACITY TO BE DETERMINED BY ENGINEER OF RECORD.
- THE PEAK DIVERSION STORMFILTER IS AVAILABLE IN A LEFT INLET (AS SHOWN) OR RIGHT INLET CONFIGURATION.
- ALL PARTS PROVIDED AND INTERNAL ASSEMBLY BY CONTECH UNLESS OTHERWISE NOTED.

CARTRIDGE HEIGHT	27"		18"		LOW DROP	
SYSTEM HYDRAULIC DROP (H - REQ'D. MIN.)	3.05'		2.3'		1.8'	
HEIGHT OF WEIR (W)	3.00'		2.25'		1.75'	
TREATMENT BY MEDIA SURFACE AREA	2 gpm/ft²	1 gpm/ft²	2 gpm/ft²	1 gpm/ft²	2 gpm/ft²	1 gpm/ft²
CARTRIDGE FLOW RATE (gpm)	22.5	11.25	15	7.5	10	5

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	*
WATER QUALITY FLOW RATE (cfs)	*
PEAK FLOW RATE (cfs)	*
RETURN PERIOD OF PEAK FLOW (yrs)	*
# OF CARTRIDGES REQUIRED	*
CARTRIDGE FLOW RATE	*
MEDIA TYPE (CSF, PERLITE, ZPG)	*

PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE	*	*	*
OUTLET PIPE	*	*	*

INLET BAY RIM ELEVATION	*
FILTER BAY RIM ELEVATION	*

ANTI-FLOTATION BALLAST	WIDTH	HEIGHT
	*	*

NOTES/SPECIAL REQUIREMENTS:

FRAME AND COVER
(DIAMETER VARIES)
N.T.S.

PERFORMANCE SPECIFICATION
FILTER CARTRIDGES SHALL BE MEDIA-FILLED, PASSIVE, SIPHON ACTUATED, RADIAL FLOW, AND SELF CLEANING. **RADIAL MEDIA DEPTH SHALL BE 7-INCHES**. FILTER MEDIA CONTACT TIME SHALL BE AT LEAST **37 SECONDS.** SPECIFIC FLOW RATE SHALL BE **2 GPM/SF (MAXIMUM)**. SPECIFIC FLOW RATE IS THE MEASURE OF THE FLOW (GPM) DIVIDED BY THE MEDIA SURFACE CONTACT AREA (SF). MEDIA VOLUMETRIC FLOW RATE SHALL BE **6 GPM/CF OF MEDIA (MAXIMUM).**

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH REPRESENTATIVE. www.contech-cpi.com
4. STORMFILTER WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING. CONTRACTOR TO CONFIRM STRUCTURE MEETS REQUIREMENTS OF PROJECT.
5. STRUCTURE SHALL MEET AASHTO HS20 AND CASTINGS SHALL MEET AASHTO M306 LOAD RATING, ASSUMING EARTH COVER OF 0' - 5', AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.

INSTALLATION NOTES
1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STORMFILTER STRUCTURE (LIFTING CLUTCHES PROVIDED).
3. CONTRACTOR TO INSTALL JOINT SEALANT BETWEEN ALL SECTIONS AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH OUTLET PIPE INVERT WITH OUTLET BAY FLOOR.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO PROTECT CARTRIDGES FROM CONSTRUCTION-RELATED EROSION RUNOFF.
6. CONTRACTOR TO REMOVE THE TRANSFER HOLE COVER WHEN THE SYSTEM IS BROUGHT ONLINE.

The Stormwater Management StormFilter®
THIS PRODUCT MAY BE PROTECTED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS: 6,322,689; 6,524,045; 6,706,157; AND OTHER PATENTS PENDING. RELATED FOREIGN PATENTS OR OTHER PATENTS PENDING.

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800-338-1122 513-645-7000 513-645-7993 FAX

THE STORMWATER MANAGEMENT STORMFILTER
8' x 11' PEAK DIVERSION STORMFILTER
STANDARD DETAIL

CONTECH®

StormFilter

Configuration Guide

The Stormwater Management StormFilter®

The Stormwater Management StormFilter®

The Stormwater Management StormFilter® (StormFilter) is a passive, flow-through, stormwater filtration system. The system is comprised of one or more structures that house rechargeable, media-filled cartridges which trap particulates and adsorb materials such as dissolved metals, hydrocarbons, and nutrients in polluted runoff.

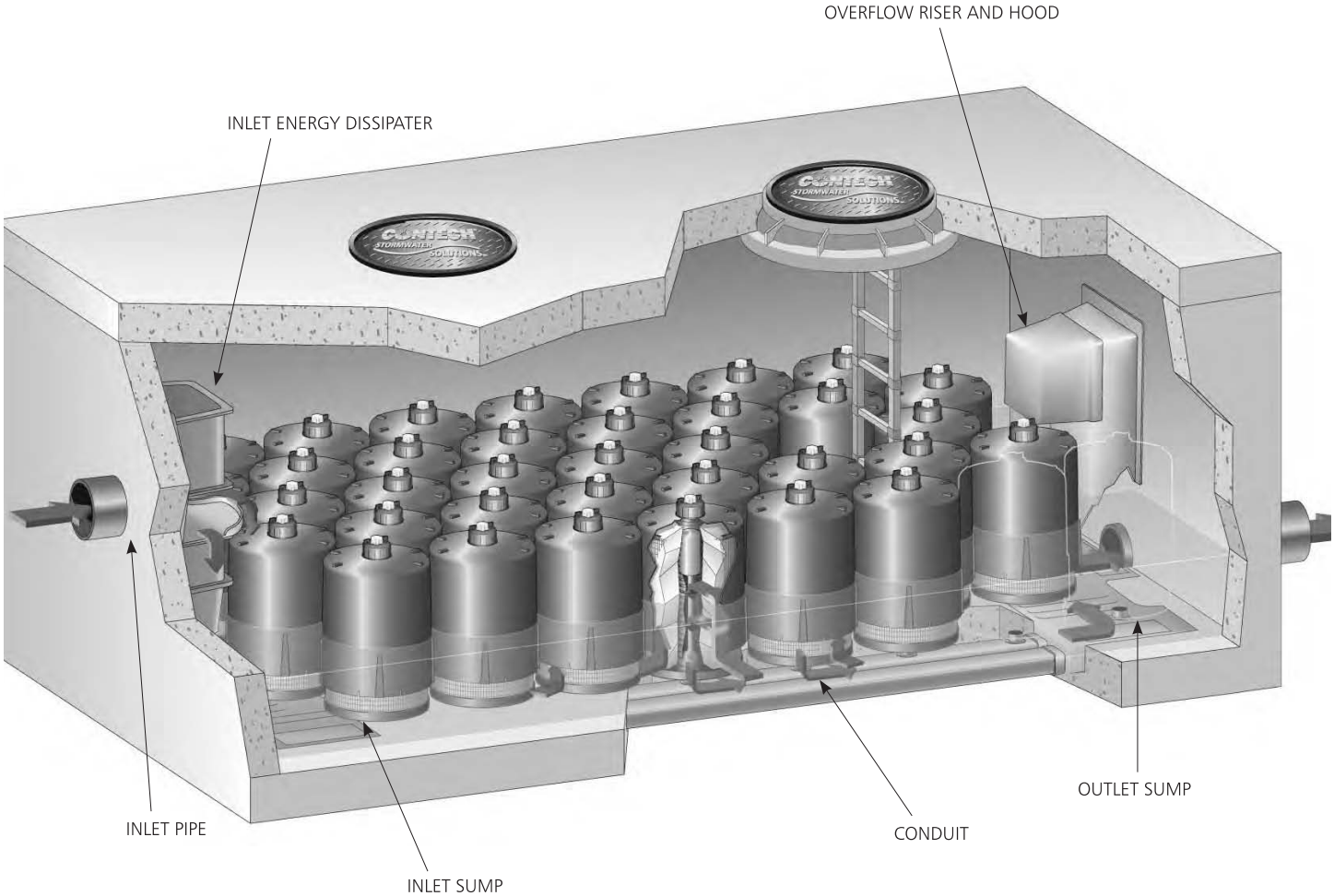
The StormFilter system comes in a variety of configurations and sizes to meet any site need. A variety of filter media is available and can be customized for each site to remove the desired pollutants.

Basic Design

The StormFilter is sized to treat the peak flow of a water quality design storm. The peak flow or WQv is determined from calculations based on the contributing watershed hydrology and from a design storm magnitude set by the local stormwater management agency. The StormFilter system is modular and each unit is designed with the number of cartridges required to meet the peak design flow rate, WQv or cap.

The flow rate through each filter cartridge is set to meet the jurisdictional performance requirements, allowing control over the amount of contact time between the influent and the filter media. The maximum flow rate through each cartridge can be adjusted, between 0.26 gpm/ft^2 and 2 gpm/ft^2 of surface area, using a calibrated restrictor disc at the base of each filter cartridge. Adjustments to the cartridge flow rate will affect the number of cartridges required to treat the peak flow or WQv.

Please contact your local CONTECH representative for site-specific design assistance.



Basic Operation

Priming System Function

The system is designed to siphon stormwater runoff through the StormFilter cartridge. Stormwater enters a StormFilter cartridge, percolates horizontally through the cartridge's filter media and collects in the center tube where the float valve is in a closed (downward) position.

As water passes through the filter media and into the cartridge's center tube, the air in the cartridge is displaced by the water and purged from beneath the filter hood through the one-way check valve located in the cap. Once the center tube is filled with water, there is enough buoyant force to open the float valve and allow the treated water in the center tube to flow into the under-drain manifold. This causes the check valve to close, initiating a siphon that draws polluted water throughout the full surface area and volume of the filter. Thus, the entire filter cartridge is used to filter water throughout the duration of the storm, regardless of the water surface elevation in the unit. This siphon continues until the water surface elevation drops to the elevation of the hood's scrubbing regulators, and the float returns to a closed position. Utilizing the hydraulic potential in the cartridge, the scrubbing regulators cause the filter surface to be clean of attached sediments thus extending the filter's operational life.

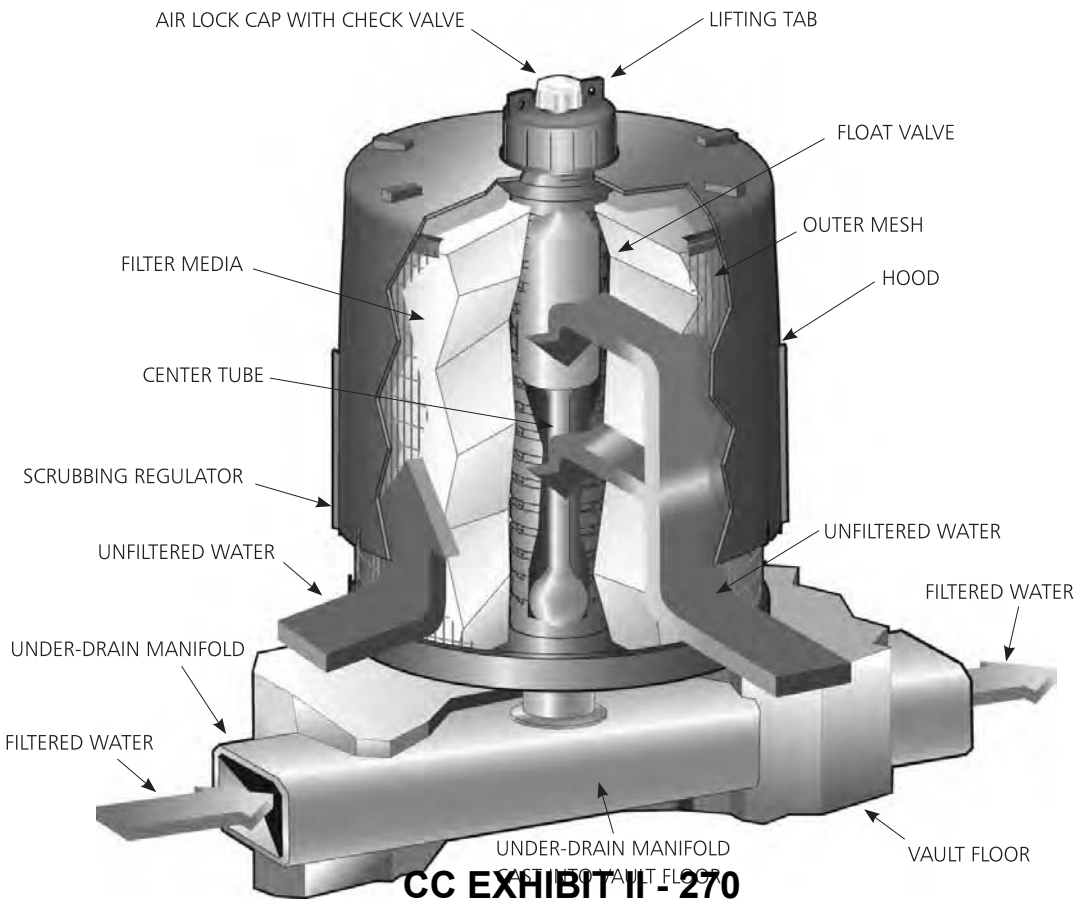
Flow and Valve Control

The filtration rate through a typical StormFilter cartridge can be adjusted so that it has a maximum flow rate of 2 gpm/ft^2 at the design driving head. The flow rate is individually controlled for each cartridge by a restrictor disc located at the connection point between the cartridge and the under-drain manifold. Consisting of a simple orifice disc of a specific diameter, the flow rate through the cartridges can be adjusted to a level that coincides with your treatment requirements by using a disc with the appropriate orifice diameter.

A reduction in flow rate affects the performance of the StormFilter system with regards to both sediment and soluble pollutants. For solids, Stokes' Law predicts the movement of sediment in a fluid and it has been proven that a reduction in the flow velocity through the system will facilitate increased settling and capture of sediments. In addition, some media types have the ability to remove soluble pollutants through chemical processes, like ion exchange. A reduction in the flow velocity through the StormFilter cartridge will increase the contact time between the stormwater and the media, thereby increasing the removal efficiency by increasing the time for a chemical process to take place.

Media type can be changed, but flow rate adjustment requires engineering consultation to ensure hydraulic demands are satisfied.

Through routine maintenance, a media filtration system can adjust the media type to target or update the system to treating specific pollutants, new TMDLs, or changing pollutants of concern. The media change out can provide a long-term solution to changing regulatory requirements.



StormFilter Configurations

The StormFilter technology can be configured to meet your unique site requirements.

Downstream Treatment Configurations

Conventional stormwater treatment involves collecting, conveying and treating stormwater runoff with an end of pipe treatment system before discharging off-site. StormFilter configurations suitable for these applications are listed below and can be engineered to treat a wide range of flows.

Vault/Manhole

The Vault/Manhole consists of one or more precast concrete structures ranging from 48" manholes to 8' x 24' vaults. The largest unit treats water quality design flows up to 3.75 cfs, and can be placed in series or in parallel to treat higher flows if needed.

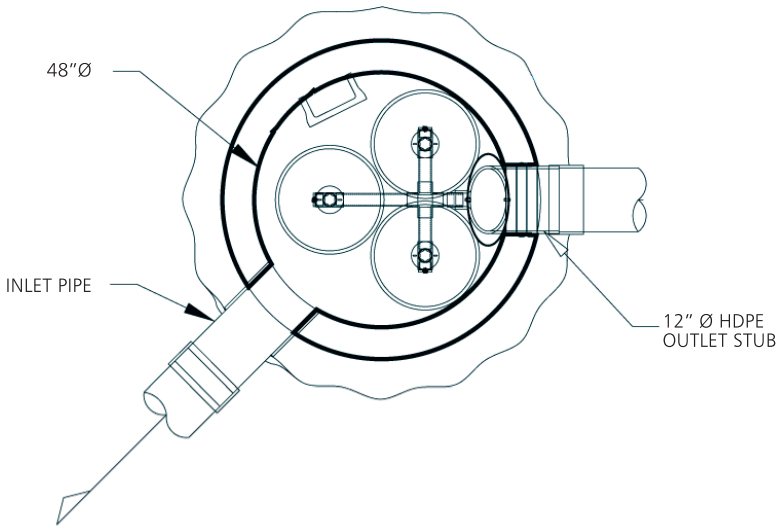
A Vault/Manhole configuration can be installed online or offline from storm system, where the unit has internal overflow bypass. These systems can also be installed offline, where high flows are bypassed around the treatment system and there is no internal overflow. However, if detention, pretreatment, or bypassing is required, it can be installed offline of the storm system.

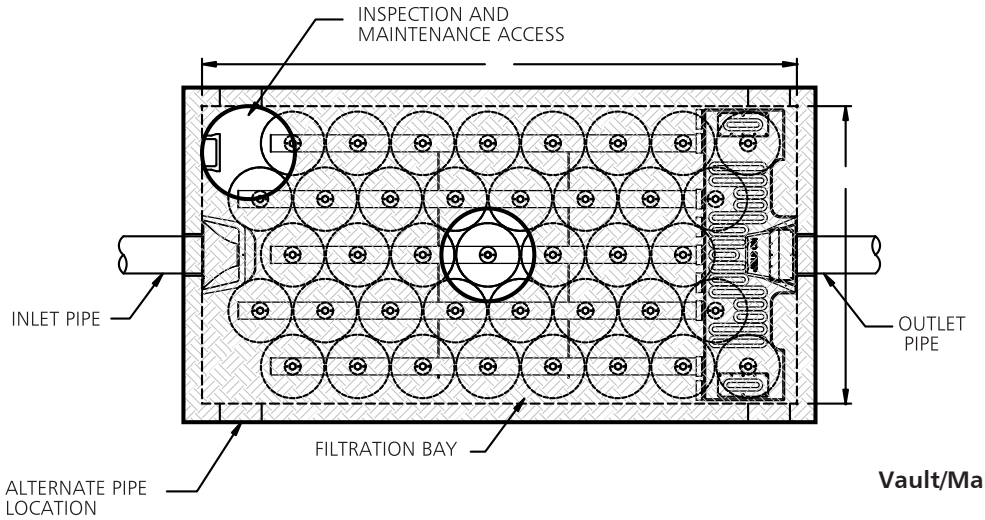
Basic Operation

Vault/Manhole systems are housed in either a vault or manhole. Stormwater first enters the structure through the inlet pipe where it is directed through the energy dissipator. This gently spreads the flow to minimize re-suspension of previously captured pollutants.

Once in the filtration area, the stormwater begins to pond and percolate horizontally through the media contained in the filter cartridges. After passing through the media, treated water that has collected in the cartridge center tube is directed into the outlet sump by an under-drain manifold. The treated water in the outlet sump is then discharged through the outlet pipe.

Precast StormFilter systems have an internal bypass capability from 1.0 cfs to 2.0 cfs, depending upon the size of the system. If peak flows to the system exceed 2.0 cfs, an offline high flow bypass is needed.





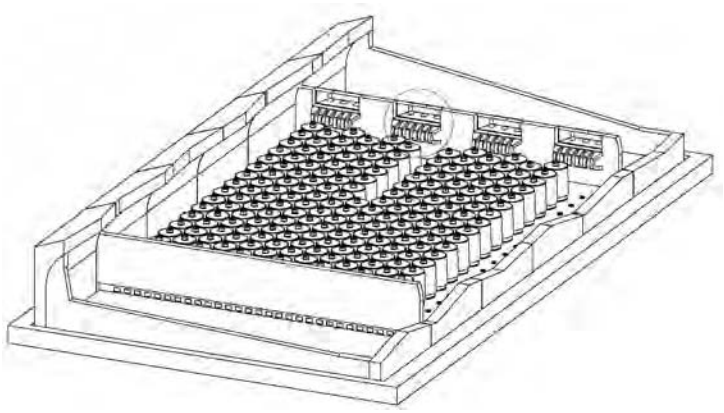
Vault/Manhole StormFilter

High Flow StormFilter

High Flow StormFilter systems can be designed within a variety of structures to meet local requirements and streamline installation. These systems are designed for large sites and large flows. Too big for standard precast structures, they are usually built from precast components that are assembled on site. The High Flow StormFilter is available in several configurations: CON/SPAN®, Panel Vaults, Box Culverts, or Cast-In-Place.

Basic Operation

The High Flow StormFilter design has the same basic configuration and components as the Precast StormFilter but operates on a larger scale.



High Flow StormFilter

Peak Diversion StormFilter

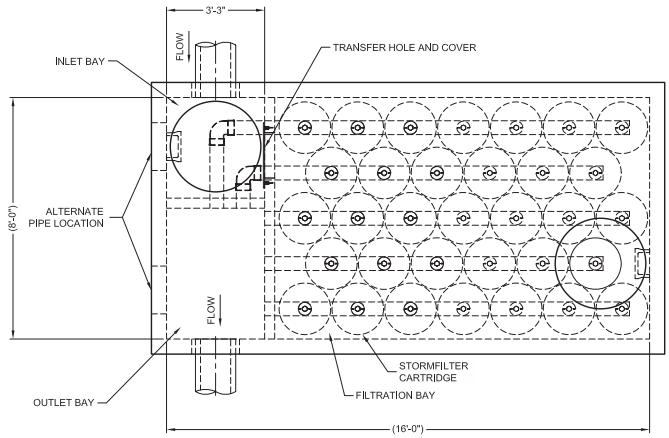
The Peak Diversion StormFilter includes a treatment chamber and offline by-pass capability in one precast vault. Sizes range from 8'x11" to 8'x24 in most areas. Larger units can treat up to 2.5cfs depending on cartridge height and the approved flow rate of regulatory jurisdiction. The integrated off-line bypass eliminates upstream flow splitters, downstream junction structures, and additional piping to save space and reduce the overall foot print. This lowers material and installation cost while reducing potential conflicts with right of way (ROW) boundaries and utilities.

Basic Operation

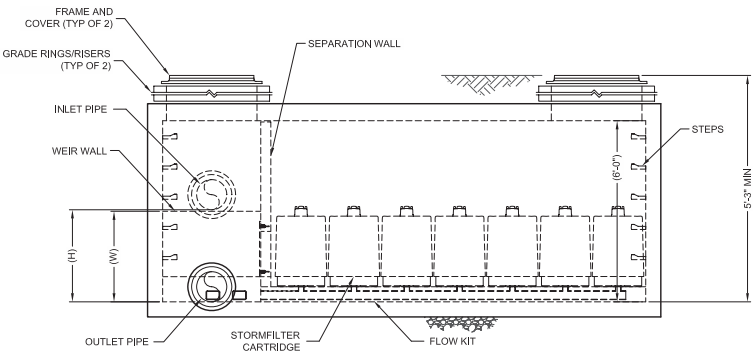
Stormwater enters the structure through one or two inlets pipes into the inlet bay and low flows are directed to the filtration bay through a transfer opening. Once in the filtration area, the stormwater begins to pond and percolate horizontally through the media contained in the filter cartridges. After passing through the media, treated water that has collected in the cartridge center tube is directed into the outlet bay by an under-drain manifold. The treated water in the outlet sump is then discharged through the outlet pipe.

During large storm events greater than the treatment capacity, peak flows are diverted across the overflow weir directly to the outlet. Even during high flows the cartridges are still operating and water is entering the filtration bay from the inlet bay. This continuous flow into the filter bay helps ensure pollutants can not be washed out during high flow events.

As a general rule, the peak bypass capacity is 15 times the design flow rate, depending on the hydraulic grade line and available head loss.



PLAN



ELEVATION

Peak Diversion StormFilter

Volume StormFilter

The Volume StormFilter is designed to meet volume-based regulations where a specific water quality volume (WQv) must be captured and treated. In addition to treatment, the structure can be sized to capture all or a portion of the WQv.

Restrictor discs inside each cartridge can be used to control the discharge rate from the system. The size of the disc is calibrated to provide the design filtration rate at a live storage depth. Because of these discs (and the airlock cap with a one way vent) water can be impounded above the cartridges in the treatment bay.

Structures range in size from a 48" manhole to CON/SPAN sections with a 24' x 10' cross section built to length. In many cases smaller structures are combined with outboard storage, such as pipe, to provide the WQv storage.

The Volume StormFilter can be designed with or without an internal bypass. If peak flows to the system exceed the internal bypass, or external bypass is required, a high flow bypass is needed. The system can also be installed online or offline and uses a traffic-bearing lid.

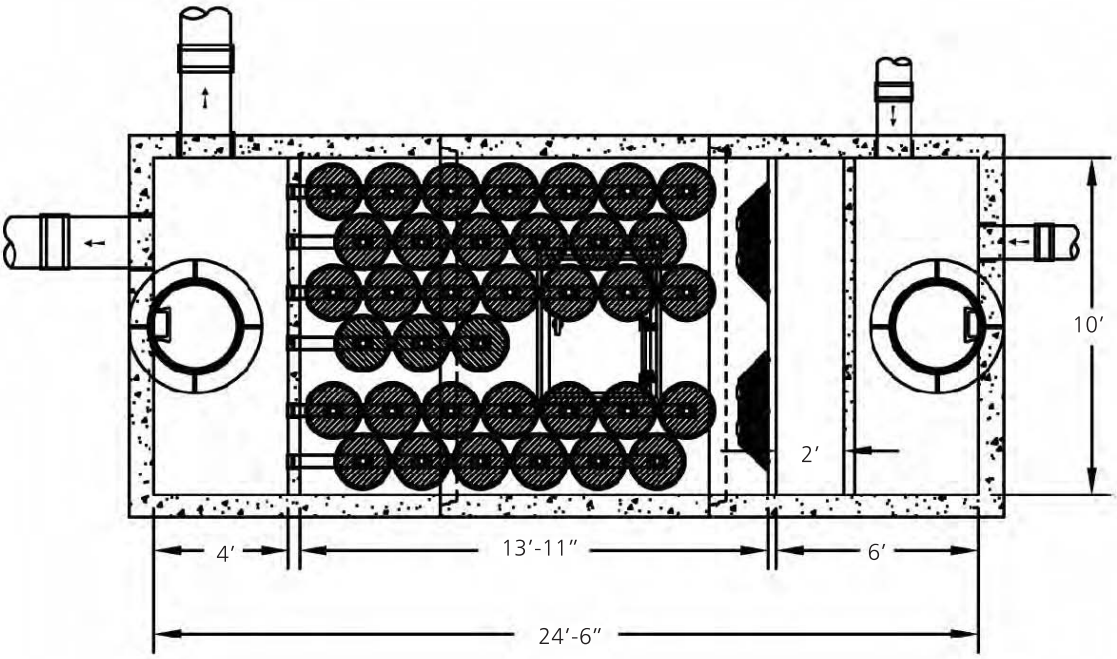
Basic Operation

The Volume StormFilter is typically configured in one of two ways.

A three bay system that incorporates internal storage for the WQv and includes: the storage bay, the filtration bay, and the outlet bay. Water first enters the storage bay (a portion of which includes dead storage) which facilitates pretreatment (gravity separation) and storage of the WQv. The stormwater is then directed into the filtration bay for full treatment and additional storage. The storage bay can be designed with a baffle to trap floatables, oils, and surface scum. Cartridges in the filtration bay treat the stormwater and control the discharge rate. Once in the filtration bay, the stormwater percolates horizontally through the media contained in the filter cartridges. After passing through the cartridge, treated water is directed to the outlet bay by an under-drain manifold where it is discharged through an outlet pipe.

A two bay, precast vault based system similar to the Vault StormFilter where pretreatment and live storage are provided upstream.

Providing WQv storage in an outboard storage facility such as storage pipe provides the versatility to meet most footprint and elevation requirements.



Volume StormFilter

Upstream Treatment Configurations

Low Impact Design (LID) design involves managing runoff close to the source using small, decentralized system. The following suite of StormFilter configurations are easily incorporated on sites where LID site design is recommended. These low-cost, lowdrop, point-of-entry systems also work well when you have a compact drainage area.

CatchBasin StormFilter

The CatchBasin StormFilter (CBSF) consists of a multi-chamber steel, concrete, or plastic catch basin unit that contains up to four StormFilter cartridges. The steel CBSF is offered both as a standard and as a deep unit.

The CBSF is installed flush with the finished grade and is applicable for small drainage areas from roadways and parking lots, and retrofit applications. It can also be fitted with an inlet pipe for roof leaders or similar applications.

The CBSF unit treats water quality design flows up to 0.20 cfs, coupled with an internal weir overflow capacity of 1.0 cfs for the standard steel and concrete units and 1.8 cfs for the deep steel units. Non-traffic rated plastic CBSF units have an internal weir overflow capacity of 0.5 cfs.

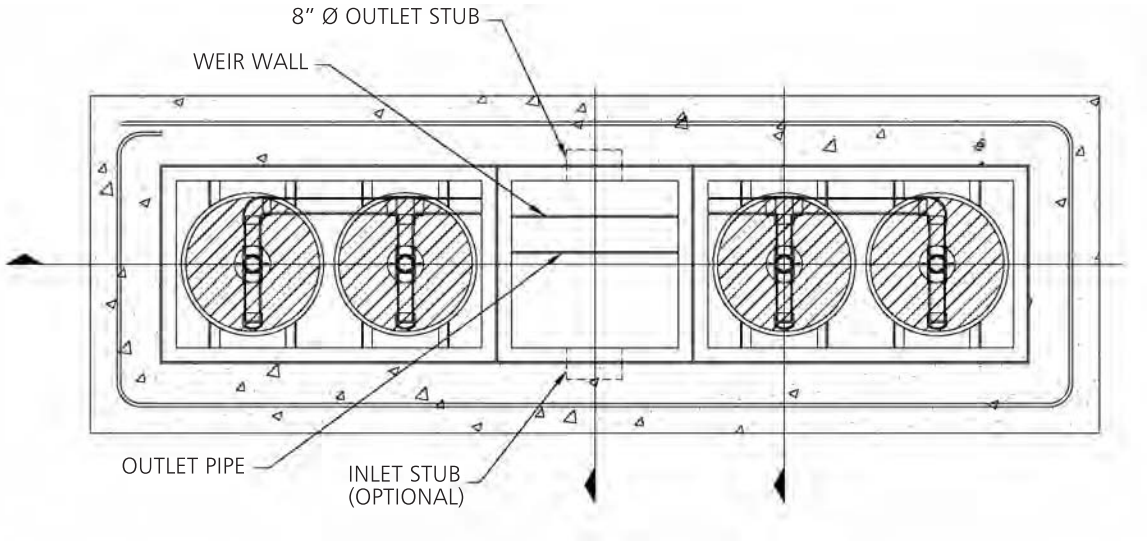
Basic Operation

The CBSF acts as the primary receiver of runoff, similar to a standard, grated catch basin. The steel and concrete CBSF units each have an H-20 rated, traffic-bearing lid that allows the filter to be installed in parking lots and take up no land area. Plastic CBSF units can be used in landscaped areas and for other non-traffic bearing applications.

The CBSF consists of a sumped inlet chamber and cartridge chamber(s). Runoff enters the sumped inlet chamber either by sheet flow from a paved surface or from an inlet pipe discharging directly to the unit. The inlet chamber's internal baffle traps debris and floating oil, and houses an overflow weir. Heavier solids settle into the deep sump, while lighter solids and soluble pollutants are directed under the baffle and into the cartridge chamber through a port between the baffle and the overflow weir. Once in the cartridge chamber, polluted water ponds and percolates horizontally through the media in the filter cartridges. Treated water collects in the cartridge's center tube from where it is directed by an under-drain manifold to the outlet pipe on the downstream side of the overflow weir and discharged.

When flows into the CBSF exceed the water quality design value, excess water spills over the overflow weir, bypassing the cartridge bay, and discharges to the outlet pipe.

The CBSF is particularly useful where small flows are being treated or for sites that are flat and have little available hydraulic head to spare. The unit is ideal for applications in which standard catch basins are to be used. Both water quality and catchment issues can be resolved with the use of the CBSF.



CathBasin StormFilter

Curb Inlet StormFilter

The Curb Inlet StormFilter consists of a precast concrete vault ranging from 6'x8' to 8'x16' in size. These units treat peak water quality design flows up to 1.05 cfs. The system is installed online and includes an internal offline overflow bypass around the filtration chamber. The internal bypass capability is based on depth of the structure. The standard bypass capacity is 15 cfs but is larger for deeper units. A traffic-bearing lid is placed underneath the median or sidewalk adjacent to the roadway.

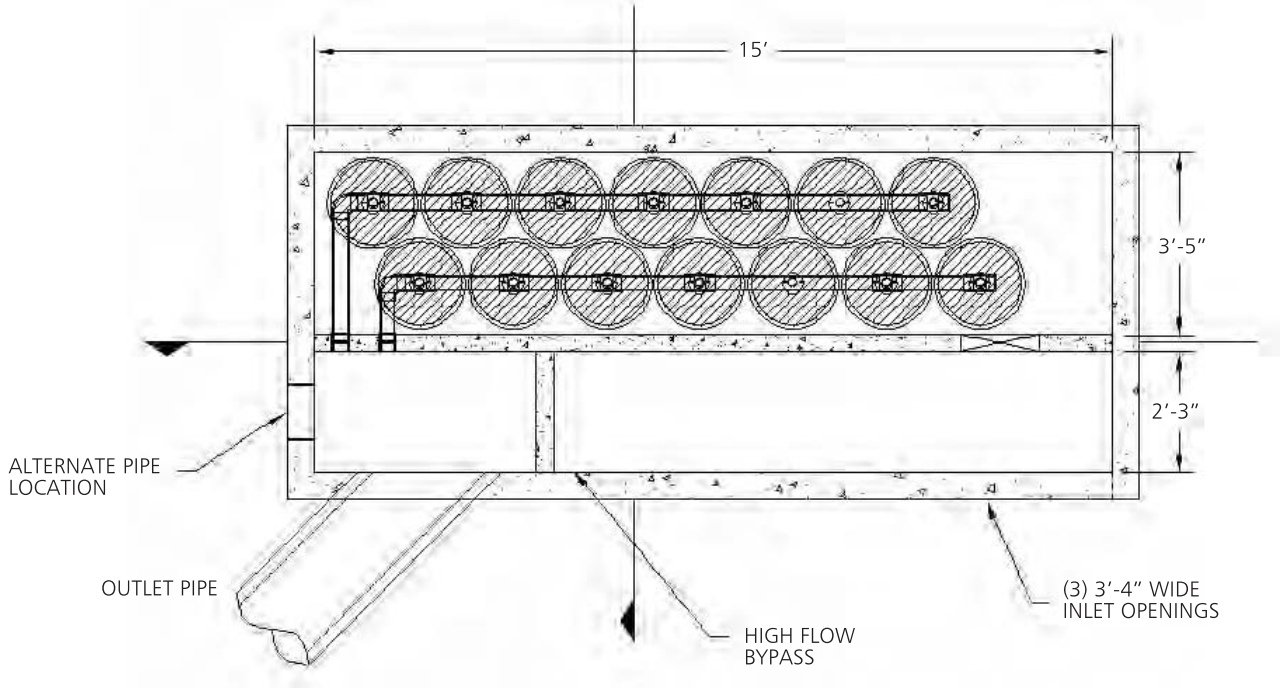
Basic Operation

The Curb Inlet StormFilter is composed of three bays: the inlet bay, the filtration bay, and the outlet bay. Stormwater enters the inlet bay through the curb inlet opening. The design flow is directed through a transfer opening to the filtration bay for full treatment.

Once in the filtration bay, the stormwater percolates horizontally through the media in the filter cartridges to the center tube. Treated water in the cartridge center tube is directed into the outlet bay by an under-drain manifold and discharged through the outlet pipe. Outlet pipes can be placed parallel, perpendicular, or up to 45° to the roadway. Overflow is directed over a weir wall between the inlet bay and the outlet bay, bypassing the filtration bay leaving accumulated pollutants undisturbed.

Curb Inlet Openings

Every Curb Inlet StormFilter is designed to meet local regulations governing the geometry of the curb inlet. This can be accomplished in two ways. One way is with an integrated face plate – the vault lid includes the face plate which is tied into the curb. Another way is with a cast-in-place face plate – the entire face plate is constructed by the contractor pouring the curb. Curb inlet openings can be 4', 7', or 10' in length.



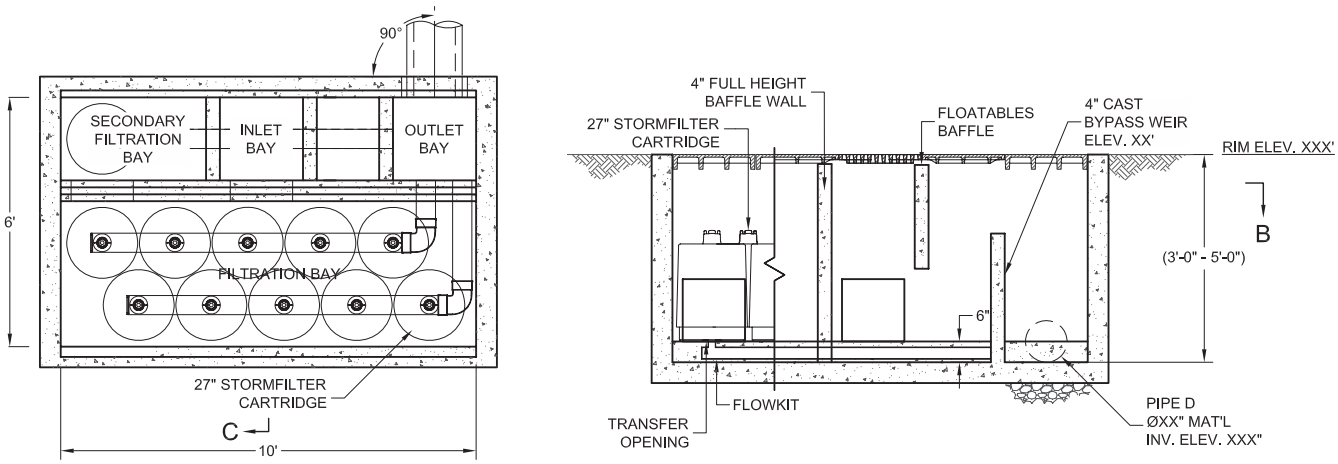
Curb Inlet StormFilter

Linear Grate StormFilter

The Linear Grate StormFilter is a precast vault that acts as the primary receiver of runoff, similar to a standard grated catch basin. The unit has H-20 rated traffic-bearing lids that allow the filter to be installed under parking lots. The system consists of an inlet bay, filtration bay, and an outlet bay. Providing treatment as it enters the conveyance system reduces the overall head loss because the vertical drop from the finished grade into the conveyance system is also used to provide hydraulic pressure on the filter cartridges.

Basic Operation

Runoff enters the inlet bay by sheet flow from a paved surface or from an inlet pipe discharging directly to the unit. The inlet bay's internal baffle traps debris and floating oil and denser pollutants are directed into the filtration bay. Once in the cartridge chamber, polluted water ponds and percolates through a radial media filter cartridge. Treated water collects in the cartridge's center tube where it is directed by an under-drain manifold to the outlet pipe on the downstream side of the overflow weir. When flow rates exceed the water quality design value, excess water spills across the overflow weir, bypassing the cartridge bay and proceed directly to the outlet pipe. This integrated offline bypass ensures pollutants captured in the filtration bay are not washed downstream during peak flow events.



Liner Grate StormFilter

Grated Inlet Openings

The number of inlet grates and the size of the inlet bay are designed to capture the peak flow rates from the drainage area. The remaining area is devoted to the filtration bay and the outlet bay which are covered with removable plates for access during maintenance. The entire inlet bay, filtration bay, and outlet bay can be opened at one time allowing full access. In many cases, due to the shallow nature of the design, confined space entry is not required for maintenance.

Linear StormFilter

The Linear StormFilter consists of one or two precast concrete channels that are 10′ or 20′ in length and 2′ 9″ in width.

The Linear StormFilter is installed flush with the finished grade, functioning similar to a catch basin or trench drain. The top of the unit has either covers or doors for easy access. The Linear StormFilter is typically installed online like the precast StormFilter.

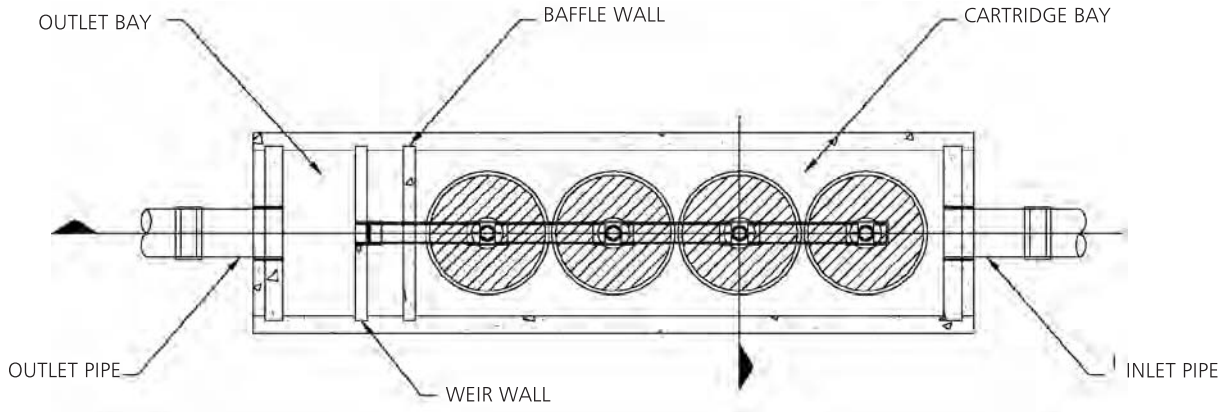
The Linear StormFilter unit treats water quality design flows up to 0.27 cfs.

Basic Operation

The Linear StormFilter can be installed either as the primary receiver of runoff, similar to a grated catch basin, or with an inlet stub and doors to receive runoff collected upstream.

The system is equipped with an internal overflow weir to ensure that there is no local flooding for storm events in excess of the design treatment flow. Maintenance costs for the unit are typically less because there are no confined space entry requirements, and access is quick and easy.

The Linear StormFilter is particularly useful where small flows are being treated or where the site is very flat and there is little available hydraulic head to spare.



Linear StormFilter

Infiltration Configuration

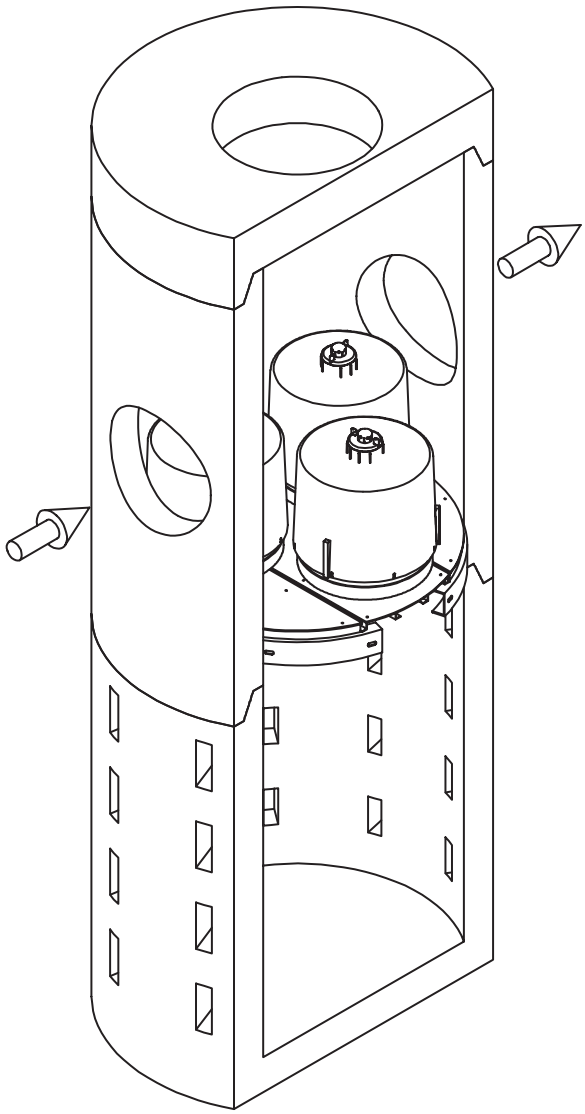
Dry Well StormFilter

The Dry Well StormFilter provides treatment, infiltration and groundwater protection in a single structure. The system is designed to treat conveyed flow or sheet flow from small drainages. Multiple units can be installed to treat any size site. Because it provides treatment and infiltration in a single unit, the total number of structures and the amount of pipe required for the stormwater system are reduced.

The Dry Well StormFilter system is available in 48", 60" and 72-" pre-cast manhole top sections that are designed to be stacked on top of dry well infiltration risers. The StormFilter portion of the unit arrives fully assembled and ready to install, including an integrated concrete deck for the StormFilter cartridges. The system can also be retrofitted into existing 48" manhole dry wells.

Basic Operation

Stormwater enters the dry well unit through one or more entry pipes or channels at its top. It then percolates through the media in the StormFilter cartridge to the center tube. Treated water in the cartridge center tube is discharged to the infiltration section below, and then infiltrates into the surrounding soils through a number of small exit openings at the sides and bottom.



DryWell StormFilter

Roof Runoff Treatment Configuration

Downspout StormFilter

The Downspout StormFilter is an aboveground configuration that can be easily integrated into existing gutter systems to eliminate pollution from rooftop runoff. It typically occupies 2.5'x 5' footprint, and can fit most downspout configurations and sizes. Each unit holds two StormFilter cartridges, and single- and dual-stage options are available. It treats up to 14,000 square feet of rooftop area per dual-cartridge system.

StormFilter Cartridges

There are three cartridge heights available for StormFilter systems: 27", 18", and Low Drop. The most economical is the 27" tall cartridge. It can treat the highest flow rate per cartridge, which creates the smallest system with the lowest installed cost. The 27" cartridge requires 3.05' of driving head to operate. For sites with less driving head available, the 18" cartridge is the next best option. Lower flow rates per cartridge increase the footprint of the overall system but only 2.3' of driving head is required. For sites with very limited drop, the Low Drop cartridge only requires 1.8" of driving head.

Cartridge Flow Rates

Cartridge Type	Hydraulic Drop	Treatment Capacity (gpm)	
		1 gpm/ft2	2 gpm/ft2
StormFilter 27"	3.05'	11.25	22.5
StormFilter 18"	2.30'	7.5	15
StormFilter Low Drop	1.80'	5	10

StormFilter Media

The removal of site-specific pollutants can be maximized with the variety of filtration media available. In many cases, different media types can be combined so as to target a wide spectrum of pollutants. This ability to combine and use various media types allows the system to be easily adjusted to meet ever-changing site conditions and increasingly stringent regulatory requirements.

PhosphoSorb™

PhosphoSorb, a lightweight media comprised of Perlite (a heat-expanded volcanic rock) and activated alumina, removes total phosphorus (TP) by adsorbing dissolved-P and filtering particulate-P simultaneously. The Perlite provides the capability to remove suspended solids while the activated alumina adsorbs soluble phosphorus adsorption.

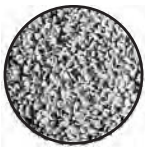
PhosphoSorb is composed of a slightly finer media gradation than the field proven ZPG™ (Zeolite, Perlite, Granular Activated Carbon) media and will provide equivalent - or even better - removal of suspended solids. Initial field tests have indicated an increase in the TSS removal efficiency up to 10% over the field-proven ZPG media. The StormFilter with ZPG media has already received a General Use Level Designation for basic treatment in the State of Washington.

Perlite

Perlite is a natural, volcanic ash, similar in composition to glass and similar in appearance to pumice. To use perlite as a filter medium, it must first go through a heating process to yield a lightweight, multicellular, expanded form. This expanded form has a coarse texture, very low-density, high surface area, and stable, inert chemistry, all of which make perlite an excellent physical filtration medium.

Perlite has proven to be our media of choice for sediment and oil removal. The multicellular nature of expanded perlite is the key to its excellent ability to trap sediments and adsorb oil. The coarse texture of the expanded perlite creates a bed of material with a very high porosity, which allows perlite to have the highest sediment and oil storage capacity of all of the available media options.

Zeolite



The term zeolite defines a family of both natural and synthetic, hydrous aluminosilicate materials with a highly porous mineral matrix that holds light, alkali metal cations (ideally sodium ions).

Zeolite has the ability to use a cation exchange reaction that removes other cations such as zinc, copper, lead, and ammonia from water. In the cation exchange reaction, the light metal cations in the zeolite matrix are displaced by the heavier metal cations, such as copper, in the water.

The zeolite used in our system is clinoptilolite, which has a cation exchange capacity (CEC) of approximately 100 to 220 meq/100 g. Clinoptilolite has inert characteristics that make it an excellent metals removal media option when CSF media cannot be used. It can be combined with other media such as GAC and perlite when metals are not of exclusive concern.

CSF® Leaf Media

CSF Leaf Media is a patented filtration media composed of composted deciduous leaves originating from the City of Portland, Oregon. CONTECH Stormwater Solutions purchases the mature, stable, deciduous leaf compost and then processes it into an odorless, pelletized compost product with physical and chemical characteristics desirable for stormwater filtration.

The patented compost process creates a material with excellent flow-through characteristics and stability in water. Not only do CSF Leaf Media consist of 100% recycled, all natural materials, but it also provides good removal of sediments and excellent removal of a wide range of toxic contaminants.

CSF Leaf Media provides the multitude of beneficial water treatment properties typical of soil in a form that is compatible with the compact, modular, media-based design of the StormFilter system. In addition to the physical filtration provided by the granular nature of the CSF Leaf Media, the complex chemistry of the compost also provides chemical filtration as well.

Sediment and total nutrients are removed through physical filtration. Oil, complexed metals, and anthropogenic organic contaminants such as herbicides and pesticides are removed through adsorption, the physical partitioning of organic compounds, such as pesticides, to carbon-rich materials, such as the compost.

Soluble metals are removed by cation exchange, as well as by complexation of metal ions to the organic chelating agents present in compost. CSF Leaf Media is an excellent, cost-effective, all-purpose media that epitomizes the potential value of recycled materials.

GAC

GAC (Granular Activated Carbon) is a widely accepted water filtration media used for the removal of organic compounds. It consists of pure carbon (originating from coal or charcoal) whose micro-porous structure has been enhanced through steam or acid "activation."

The high carbon content and porous nature of GAC accounts for its excellent ability to remove organic compounds through adsorption. Since adsorption is the physical partitioning of organic compounds to high carbon surfaces, the "activation" of the carbon (which creates GAC) endows it with an enormous surface area upon which adsorption can take place.

In situations where anthropogenic organic contaminants are of exclusive concern, GAC media provide the highest level of stormwater treatment compared to other available media options. However, because it is not very often the case that anthropogenic organic contaminants are of exclusive concern, GAC is usually combined with another media such as perlite or zeolite for the treatment of additional contaminants.

Combination of GAC with perlite constitutes the most cost-effective configuration, as the effectiveness of GAC is drastically reduced if it is coated with high concentrations of heavy oil or sediment, which can restrict access via surface pores to the interior of the GAC granules.

ZPG™ (Zeolite, Perlite, GAC blend)

This proprietary blend of zeolite, perlite, and granular activated carbon media is used to provide an alternative for CSF media for installations where leaf media cannot be used.

Laboratory and Field Testing

The StormFilter system is designed to meet the most stringent regulatory requirements. The field-proven performance of the StormFilter has led to hundreds of regulatory agency approvals nationwide as a standalone BMP.

The Stormwater Management StormFilter® is the first manufactured BMP to receive stand-alone approval through field testing and satisfying the total suspended solids treatment requirements in Washington and New Jersey.

Log on to www.contechstormwater.com/stormfilter to view the following reports in full.

Field Monitoring Reports

Field Proven Performance of the StormFilter using the Technology Assessment Protocol - Ecology (TAPE) and Technology Acceptance Reciprocity Partnership (TARP) Tier II Protocol

1. Washington
   a. Washington State Department of Ecology General Use Level Designation for Basic Treatment
   b. Technical Evaluator Engineering Report (TEER). Gary Minton, Ph.D., P.E.
2. New Jersey
   a. New Jersey State Department of Environmental Protection Final Certification
   b. New Jersey Corporation for Advanced Technology (NJCAT) Field Verification Report

Laboratory Reports

Total Suspended Solids (TSS) Removal Using Different Particle Size Distributions with the Stormwater Management StormFilter.

Influences on TSS removal efficiency

Influence of analytical method, data summarization method, and particle size on total suspended solids (TSS) removal efficiency of the StormFilter

StormFilter removal efficiency with coarse/fine perlite media

Evaluation of the removal of silt loam TSS using coarse/fine perlite at 28 L/min (7.5 gpm).

StormFilter removal efficiency with ZPG media

Evaluation of the removal of SIL-CO-SIL 106 using ZPG media at 28 L/min (7.5 gpm)

StormFilter removal efficiency with coarse perlite

Evaluation of the removal of sandy loam TSS using coarse perlite at 57 L/min (15 gpm)

Support

- Drawings and specifications are available at www.contechstormwater.com.
- Site-specific design support is available from our engineers.

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CONTECH Construction Products Inc. provides site solutions for the civil engineering industry. CONTECH's portfolio includes bridges, drainage, sanitary sewer, stormwater and earth stabilization products. For information on other CONTECH division offerings, visit contech-cpi.com or call 800.338.1122

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The Stormwater Management StormFilter® Specification

Peak Diversion

January 2010

PART 1 GENERAL

1.1 Description

The Contractor shall furnish and install the Stormwater Management StormFilter® stormwater treatment system, complete and operable as shown and as specified herein, in accordance with the requirements of the plans and contract documents.

StormFilter stormwater treatment system shall consist of an underground Precast structure that houses passive siphon-actuated, radial-flow media-filled filter cartridges. The siphon actuated radial flow filter cartridges shall be rechargeable and shall incorporate a self actuated surface cleaning mechanism to increase the effective life of the filter media and to reduce the accumulation of material on the cartridge surface. Each radial flow filter cartridge shall operate at a predetermined flow rate through the use of an integrated flow control orifice located within each filter cartridge outlet manifold.

1.2. Manufacturer

The StormFilter stormwater treatment system shall be of a type that has been installed and in use successfully for a minimum of five (5) or more years. The StormFilter stormwater treatment system shall be supplied by by CONTECH Construction Products Inc. 11835 NE Glenn Widing Dr, Portland OR, 97220 (800 548-4667), without exception.

1.3 Related Sections

A. Section [ ]:

1.4 Submittals

A. CONTECH Stormwater Solutions, or authorized supplier, to submit shop drawings for StormFilter stormwater treatment system with vault, filters cartridges and accessory equipment. Drawings shall include principal dimensions, filter placement, location of piping and unit foundation.

B. CONTECH Stormwater Solutions, or authorized supplier, shall submit an Operation and Maintenance Manual.

PART 2 PRODUCTS

2.1 Internal Components

All internal components including ABS and PVC manifold piping, filter cartridge(s), filter media (as specified on the plans in the StormFilter data block or by the Engineer), sump covers, flow spreaders, and energy dissipators shall be provided by CONTECH Construction Products Inc.

A. ABS manifold pipe shall meet ASTM specification F628. PVC manifold pipe shall meet ASTM specification D1785 and PVC fittings shall meet ASTM specification D2466.

B. Filter cartridge bottom pan, inner ring, and hood shall be constructed from linear low-density polyethylene (LLDPE) or ABS. Filter cartridge screen shall consist of 1" x ½" welded wire fabric (16 gauge minimum) with a bonded PVC coating. Internal parts shall consist of ABS or PVC material. Siphon-priming float shall be constructed from high-density polyethylene (HDPE). All miscellaneous nuts, bolts, screws, and other fasteners shall be stainless steel or aluminum.

An orifice plate shall be supplied with each cartridge to restrict flow rate to a maximum of 22.5 gpm at system design head or as specified on drawings.

C. Underdrain Design: the size of the underdrain will provide a minimum of 0.067 in^2 of underdrain cross sectional area per 1 gpm of design flow rate. (example: 105 gpm maximum design flow rate will require an underdrain with 7.035 in^2 of cross sectional area, which is equal to one 3" diameter pipe)

D. Filter media shall be provided by CONTECH Construction Products Inc. or approved alternate source. Filter media shall consist of one or more of the following, as specified in the StormFilter data block, or by the Engineer:

1. Perlite Media: Perlite media shall be made of natural siliceous volcanic rock free of any debris or foreign matter. The perlite media shall have a bulk density ranging from 6.5 to 8.5 lb/ft^3 and particle sizes ranging from that passing through a 0.50 inch screen and retained on a U.S. Standard #8 sieve.

2. CSF Media: CSF media shall be made exclusively of composted fallen deciduous leaves. Filter media shall be granular. Media shall be dry at the time of installation. The CSF leaf media shall have a bulk density ranging from 40 to 50 lb/ft^3 and particle sizes ranging from that passing through a 0.50 inch screen to that retained on a U.S. Standard #8 sieve.

3. Metal Rx Media: Metal Rx media shall be made exclusively of composted fallen deciduous leaves. Filter media shall be granular. Media shall be dry at the time of installation. The Metal Rx media shall have a bulk density ranging from 40 to 50 lb/ft^3 and particle sizes ranging from that passing through a U.S. Standard #8 sieve to that retained on a U.S. Standard #14 sieve.

4. Zeolite Media: Zeolite media shall be made of naturally occurring clinoptilolite, which has a geological structure of potassium-calcium-sodium aluminosilicate. The zeolite media shall have a bulk density ranging from 44 to 48 lb/ft^3, particle sizes ranging from that passing through a U.S. Standard #4 sieve to that retained on a U.S. Standard #6 sieve, and a cation exchange capacity ranging from 1.0 to 2.2 meq/g.

5. Granular Activated Carbon: Granular activated carbon (GAC) shall be made of lignite coal that has been steam activated. The GAC media shall have a bulk density ranging from 28 to 31 lb/ft^3 and particle sizes ranging from that passing through a U.S. Standard #4 sieve to that retained on a U.S. Standard #8 sieve.

6. Zeolite-Perlite-Granular Activated Carbon (ZPG): ZPG is a mixed media that shall be composed of a 1.3 ft^3 outer layer of 100% Perlite (see above) and a 1.3 ft^3 inner layer consisting of a mixture of 90% Zeolite (see above) and 10% Granular Activated Carbon (see above).

7. Zeolite-Perlite (Zeo/Perl): Zeo/Perl is a mixed media that shall be composed of a 1.3 ft^3 outer layer of 100% Perlite (see above) and a 1.3 ft^3 inner layer consisting of 100% Zeolite.

8. CSF – Granular Activated Carbon (CSF/GAC): CSF/GAC is a mixed media that shall be composed of a 1.3 ft^3 outer layer of 100% CSF media (see above) and a 1.3 ft^3 inner layer consisting of 100% Granular Activated Carbon (see above).

9. Perlite – Metal Rx : Perlite/Metal Rx is a mixed media that shall be composed of a 1.3 ft^3 outer layer of 100% Perlite (see above) and a 1.3 ft^3 inner layer consisting of 100% Metal Rx (see above).

10. PhosphoSorb: PhosphoSorb media shall be made from Perlite pellets with activated alumina bound to the surface. The PhosphoSorb media pellets shall be granular and have a bulk density from 18 to 25 lb/ft^3. The pellet size should range from that passing through a U.S. Standard ¼ inch sieve and retained on a #8 sieve.

2.2 Precast Concrete Vault Components

2.2 Precast concrete vault shall be provided according to ASTM C857 and C858.

2.3 Vault joint sealant shall be Conseal CS-101 or approved equal.

2.4 If interior concrete baffle walls are provided, baffle walls shall be sealed to the interior vault walls and floor with a polyurethane construction sealant rated for use below the waterline, SikaFlex 1a or equal. Contractor to provide sealant material and installation unless completed prior to shipment.

2.5 Frames and covers shall be gray cast iron and shall meet AASHTO H-20 loading requirements, and shall be provided according to ASTM A48.

2.6 Doors shall have hot-dipped galvanized frame and covers. Covers shall have diamond plate finish. Each door to be equipped with a recessed lift handle. Doors shall meet H-20 loading requirements for incidental traffic, at a minimum.

2.7 Steps shall be constructed of copolymer polypropylene conforming to ASTM D-4101. Steps shall be driven into preformed or drilled holes once concrete is cured. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. The ½" Grade 60 deformed reinforcing bar shall meet ASTM A-615.

2.8 Ladders shall be constructed of aluminum and steel reinforced copolymer polypropylene conforming to ASTM D-4101. Ladder shall bolt in place. Ladder shall

meet all ASTM C-497 load requirements. Ladders provided upon request or where required.

2.3 Contractor Provided Components

All contractor-provided components shall meet the requirements of this section, the plans specifications and contract documents. In the case of conflict, the more stringent specification shall apply.

A. Crushed rock base material shall be six-inch minimum layer of ¾-inch minus rock. Compact undisturbed sub-grade materials to 95% of maximum density at +/-2% of optimum moisture content. Unsuitable material below sub-grade shall be replaced to engineer's approval.

B. Concrete shall have an unconfined compressive strength at 28 days of at least 3000 psi, with ¾-inch round rock, a 4-inch slump maximum, and shall be placed within 90 minutes of initial mixing.

C. Silicone Sealant shall be pure RTV silicone conforming to Federal Specification Number TT S001543A or TT S00230C or Engineer approved.

D. Grout shall be non-shrink grout meeting the requirements of Corps of Engineers CRD-C588. Specimens molded, cured and tested in accordance with ASTM C-109 shall have minimum compressive strength of 6,200 psi. Grout shall not exhibit visible bleeding.

E. Backfill material shall be ¾-inch minus crushed rock, or approved equal.

PART 3 EXECUTION

3.1 Precast Concrete Vault

A. Set precast vault on crushed rock base material that has been placed in maximum 12-inch lifts, loose thickness, and compacted to at least 95-percent of the maximum dry density as determined by the standard Proctor compaction test, ASTM D698, at moisture content of +/-2% of optimum water content.

B. Vault floor shall slope 1/4 inch maximum across the width and slope downstream 1 inch per 12 foot of length. Vault top finish grade shall be even with surrounding finish grade surface unless otherwise noted on plans.

C. Inlet and outlet pipes shall be stubbed in and connected to precast concrete vault according to Engineer's requirements and specifications.

D. If grout is used, Contractor to grout all inlet and outlet pipes flush with or protruding up to 2 inches into interior of vault.

3.2 Ballast

A. When required, ballast shall be placed to the dimensions specified by the engineer and noted on the data block. Ballast shall not encase the inlet and/or outlet piping. Provide 12" clearance from outside diameter of pipes.

3.3 Clean Up

A. Remove all excess materials, rocks, roots, or foreign material, leaving the site in a clean, complete condition approved by the engineer. All filter components shall be free of any foreign materials including concrete and excess sealant.

3.4 Filter Cartridges

A. Filter cartridges shall be delivered with the vault. Contractor shall take appropriate action to protect the cartridges from sediment and other debris during construction. Methods for protecting the cartridges include but are not limited to:

1. Remove cartridges from the vault and store appropriately. Cartridges shall be reinstalled to operate according to 3.4 B (see below).

2. If vault is equipped with underdrain bypass piping, Contractor may leave cartridges in the vault and allow stormwater entering collection system to bypass filter bay through underdrain bypass piping.

3. Leave cartridges in the vault and plug inlet and outlet pipe to prevent stormwater from entering the vault.

The method ultimately selected shall be at Contractor's discretion and Contractor's risk.

B. Filter cartridges shall not be placed in operation until the vault is clean and the project site is clean and stabilized (construction erosion control measures no longer required). The project site includes any surface that contributes storm drainage to the StormFilter. All impermeable surfaces shall be clean and free of dirt and debris. All catch basins, manholes and pipes shall be free of dirt and sediments. Contact CONTECH Stormwater Solutions to assist with system activation and/or inspect the system for proper installation once site is clean and stabilized..

C. Contractor to install filter cartridges.

1) *Filter Cartridges With CSF Media and Slip Connector Fittings*: Tape shall be cleanly and completely removed from manifold fitting openings. Spool pieces (slip fittings) shall be inserted without glue into all manifold fittings to be equipped with a filter cartridge. Filter cartridges shall be placed over the spool pieces to contact the vault floor. Plugs shall be inserted without glue in all manifold fittings not equipped with a filter cartridge.

2) *Filter Cartridges with Threaded Connector Fittings:* Tape shall be cleanly and completely removed from manifold fitting openings. Threaded connectors shall be glued and inserted into all manifold fittings to be equipped with a filter cartridge. Filter cartridges shall be threaded onto the connectors until they contact the vault floor. Plugs shall be inserted without glue in all manifold fittings not equipped with a filter cartridge.

3) *Filter Cartridges with ¼-Turn Connector Fittings:* Tape shall be cleanly and completely removed from manifold fitting openings. ¼-turn connects shall be

glued and inserted into all manifold fittings to be equipped with a filter cartridge. Filter cartridges shall be turned onto the connector until they reach the hard stop on the connector – approximately ¼ revolution. Plugs shall be inserted without glue in all manifold fittings not equipped with a filter cartridge.

PART 4 PERFORMANCE

4.1 Cartridge Operation

A. Each stormwater filtration system shall contain one or more siphon actuated media filter cartridges that maintain a uniform pressure profile across the face of the filter during operation. At the design flow rate the maximum filter hydraulic loading rate is not to exceed 2.1 gallons per minute per square foot of filter surface area. Stormwater shall enter the filter cartridges through sides and shall flow through the filter media radially from the outer perimeter to the inner cartridge lumen and shall have an average contact time no less than 38 seconds.

4.2 Documentation of Sediment Removal

A. The Filtration system should have the Washington GULD certification and approval from New Jersey DEP.

4.3 Cartridge Sediment Loading

A. Filter cartridges shall be of a design that has demonstrated a minimum sediment retention capacity of 22 pounds of silty loam per cartridge in laboratory tests without a reduction in hydraulic capacity. Laboratory data shall be corroborated with field observations showing similar longevity without impact to normal hydraulic performance of the stormwater filtration system. All laboratory and field tests submitted in support of this specification must have undergone peer review.

4.4 Overflow

A. Each stormwater filtration system shall include an internal, offline overflow bypass. Water first enters an inlet bay that is separate from the cartridge bay and separate from the outlet bay. Low flows travel from the inlet bay, through a transfer opening and into the cartridge bay. High flows enter the outlet bay by topping a weir separating the inlet and outlet bay. Flow rates beyond the design flow shall not enter the cartridge bay.

CONTECH CONSTRUCTION PRODUCTS INC.

The Stormwater Management StormFilter®

StormFilter Maintenance Guidelines

Maintenance requirements and frequency are dependent on the pollutant load characteristics of each site, and may be required in the event of a chemical spill or due to excessive sediment loading.

Maintenance Procedures

Although there are other effective maintenance options, CONTECH recommends the following two step procedure:

1. Inspection: Determine the need for maintenance.
2. Maintenance: Cartridge replacement and sediment removal.

Inspection and Maintenance Activity Timing

At least one scheduled inspection activity should take place per year with maintenance following as warranted.

First, inspection should be done before the winter season. During which, the need for maintenance should be determined and, if disposal during maintenance will be required, samples of the accumulated sediments and media should be obtained.

Second, if warranted, maintenance should be performed during periods of dry weather.

In addition, you should check the condition of the StormFilter unit after major storms for potential damage caused by high flows and for high sediment accumulation. It may be necessary to adjust the inspection/maintenance activity schedule depending on the actual operating conditions encountered by the system.

Generally, inspection activities can be conducted at any time, and maintenance should occur when flows into the system are unlikely.

Maintenance Activity Frequency

Maintenance is performed on an as needed basis, based on inspection. Average maintenance lifecycle is 1-3 years. The primary factor controlling timing of maintenance of the StormFilter is sediment loading. Until appropriate timeline is determined, use the following:

Inspection:

One time per year

After major storms

Maintenance:

As needed

Per regulatory requirement

In the event of a chemical spill

Inspection Procedures

It is desirable to inspect during a storm to observe the relative flow through the filter cartridges. If the submerged cartridges are severely plugged, then typically large amounts of sediments will be present and very little flow will be discharged from the drainage pipes. If this is the case, then maintenance is warranted and the cartridges need to be replaced.

Warning: In the case of a spill, the worker should abort inspection activities until the proper guidance is obtained. Notify the local hazard control agency and CONTECH immediately.

To conduct an inspection:

Important: Inspection should be performed by a person who is familiar with the StormFilter treatment unit.

1. If applicable, set up safety equipment to protect and notify surrounding vehicle and pedestrian traffic.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the access portals to the vault and allow the system vent.
4. Without entering the vault, visually inspect the inside of the unit, and note accumulations of liquids and solids.
5. Be sure to record the level of sediment build-up on the floor of the vault, in the forebay, and on top of the cartridges. If flow is occurring, note the flow of water per drainage pipe. Record all observations. Digital pictures are valuable for historical documentation.
6. Close and fasten the access portals.
7. Remove safety equipment.
8. If appropriate, make notes about the local drainage area relative to ongoing construction, erosion problems, or high loading of other materials to the system.
9. Discuss conditions that suggest maintenance and make decision as to weather or not maintenance is needed.

Maintenance Decision Tree

The need for maintenance is typically based on results of the inspection. Use the following as a general guide. (Other factors, such as regulatory requirements, may need to be considered)

1. Sediment loading on the vault floor. If >4" of accumulated sediment, then go to maintenance.
2. Sediment loading on top of the cartridge. If >1/4" of accumulation, then go to maintenance.
3. Submerged cartridges. If >4" of static water in the cartridge bay for more that 24 hrs after end of rain event, then go to maintenance.
4. Plugged media. If pore space between media granules is absent, then go to maintenance.
5. Bypass condition. If inspection is conducted during an average rain fall event and StormFilter remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges), then go to maintenance.
6. Hazardous material release. If hazardous material release (automotive fluids or other) is reported, then go to maintenance.
7. Pronounced scum line. If pronounced scum line (say ≥ 1/4" thick) is present above top cap, then go to maintenance.
8. Calendar Lifecycle. If system has not been maintained for 3 years, then go to maintenance.

Assumptions:

No rainfall for 24 hours or more.

No upstream detention (at least not draining into StormFilter).

Structure is online. Outlet pipe is clear of obstruction. Construction bypass is plugged.

Maintenance

Depending on the configuration of the particular system, workers will be required to enter the vault to perform the maintenance.

Important: If vault entry is required, OSHA rules for confined space entry must be followed.

Filter cartridge replacement should occur during dry weather. It may be necessary to plug the filter inlet pipe if base flow is occurring.

Replacement cartridges can be delivered to the site or customers facility. Contact CONTECH for more information.

Warning: In the case of a spill, the worker should abort maintenance activities until the proper guidance is obtained. Notify the local hazard control agency and CONTECH immediately.

To conduct cartridge replacement and sediment removal:

1. If applicable, set up safety equipment to protect workers and pedestrians from site hazards.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the doors (access portals) to the vault and allow the system to vent.
4. Without entering the vault, give the inside of the unit, including components, a general condition inspection.
5. Make notes about the external and internal condition of the vault. Give particular attention to recording the level of sediment build-up on the floor of the vault, in the forebay, and on top of the internal components.
6. Using appropriate equipment offload the replacement cartridges (up to 150 lbs. each) and set aside.
7. Remove used cartridges from the vault using one of the following methods:

Method 1:

A. This activity will require that workers enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Unscrew (counterclockwise rotations) each filter cartridge from the underdrain connector. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

Using appropriate hoisting equipment, attach a cable from the boom, crane, or tripod to the loose cartridge. Contact CONTECH for suggested attachment devices.

Important: Cartridges containing leaf media (CSF) do not require unscrewing from their connectors. Do not damage the manifold connectors. They should remain installed in the manifold and can be capped during the maintenance activity to prevent sediments from entering the under drain manifold.

B. Remove the used cartridges (up to 250 lbs.) from the vault.

Important: Avoid damaging the cartridges during removal and installation.

C. Set the used cartridge aside or load onto the hauling truck.

D. Continue steps A through C until all cartridges have been removed.

Method 2:

A. Enter the vault using appropriate confined space protocols.

B. Unscrew the cartridge cap.

C. Remove the cartridge hood screws (3) hood and float.

D. At location under structure access, tip the cartridge on its side.

Important: Note that cartridges containing media other than the leaf media require unscrewing from their threaded connectors. Take care not to damage the manifold connectors. This connector should remain installed in the manifold and capped if necessary.

E. Empty the cartridge onto the vault floor. Reassemble the empty cartridge.

F. Set the empty, used cartridge aside or load onto the hauling truck.

G. Continue steps a through E until all cartridges have been removed.

8. Remove accumulated sediment from the floor of the vault and from the forebay. Use vacuum truck for highest effectiveness.
9. Once the sediments are removed, assess the condition of the vault and the connectors. The connectors are short sections of 2-inch schedule 40 PVC, or threaded schedule 80 PVC that should protrude about 1" above the floor of the vault. Lightly wash down the vault interior.
   a. Replace any damaged connectors.
10. Using the vacuum truck boom, crane, or tripod, lower and install the new cartridges. Take care not to damage connections.
11. Close and fasten the door.
12. Remove safety equipment.
13. Finally, dispose of the accumulated materials in accordance with applicable regulations. Make arrangements to return the used empty cartridges to CONTECH.

Material Disposal

The accumulated sediment must be handled and disposed of in accordance with regulatory protocols. It is possible for sediments to contain measurable concentrations of heavy metals and organic chemicals. Areas with the greatest potential for high pollutant loading include industrial areas and heavily traveled roads.

Sediments and water must be disposed of in accordance with applicable waste disposal regulations. Coordinate disposal of solids and liquids as part of your maintenance procedure. Contact the local public works department to inquire how they disposes of their street waste residuals.

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BROOKLANE HEIGHTS

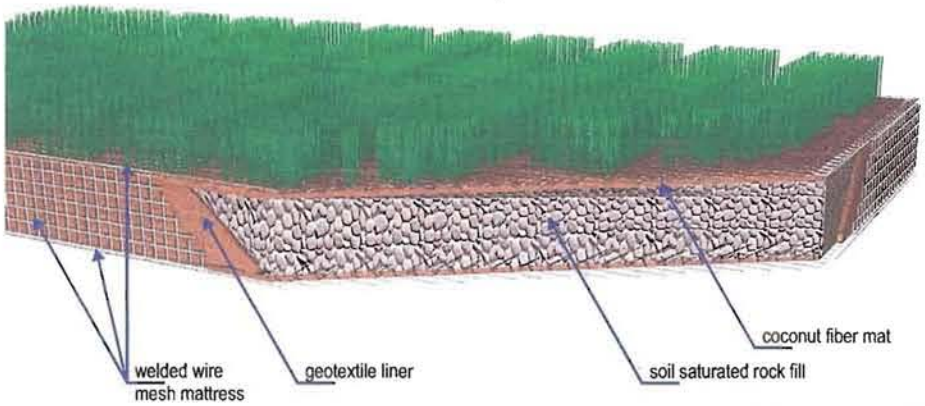
Storm Water Analysis & Design
Corvallis, Oregon

METOLIUS
CONSULTING

"Natural solutions in a changing environment"

Section 14
Channel Stabilization System

EcoMattress Systems



Slope Protection & Naturalized Environment

Modular Gabion Systems EcoMattress combines the proven* slope and channel protection to control erosion and streambank movement while providing a medium for rapid plant growth. (Refer to guidelines below.)

EcoMattresses retain the selected soil media beneath the turf reinforcement mat held securely in place by the welded wire mesh mattress lid. Soil stability is maintained enabling rapid establishment of vegetation. Interior lining of non-woven filter fabric retains soils even in high velocity flows. EcoMattresses quickly become covered with vegetation and appear as a natural slope.

GENERAL GUIDELINES FOR USE OF ECOMATTRESS FOR CHANNEL REVETMENTS

EcoMattress Thickness *In. (cm)*	Stone Diameter *In. (cm)*	Critical Velocity *ft/sec (m/sec)*	Maximum Velocity *ft/sec (m/sec)*
6 (15.2)	3-6 (7.6-15.2)	9 (2.7)	14 (4.3)
9 (22.9)	3-6 (7.6-15.2)	12 (3.7)	17 (5.2)
12 (30.5)	3-6 (7.6-15.2)	15 (4.6)	19 (5.8)

SPECIFICATIONS

Construction of Mattress: .....Meets ASTM A974-97
Mesh Size: .....1½" x 3"
Wire: .....13½ gauge low carbon soft temper
Metallic Coating:.....Meets ASTM A641, Class III galvanized
Plastic Coating: .....Fuse-bonded PVC powder coating
Interior Filter Fabric Liner:.....8 oz/sq. yd. synthetic non-woven
Turf Reinforcement Mat:.....8 oz/sq. yd. polymer reinforced coconut fiber

Weight per square foot of EcoMattress based upon volumes of 70% 3"- 6" limestone and 30% soil fill.

6" Thick .....55 lbs rock fill only / 72 lbs rock and soil
9" Thick .....82 lbs rock fill only / 108 lbs rock and soil
12" Thick.....110 lbs rock fill only / 143 lbs rock and soil

* US Army Corps of Engineers Technical Report H-75-19, December, 1975.

Features

- proven embankment stabilization solution
- provides protection for germinating seeds and tender new growth to promote rapid re-
- soils are better retained in the mattress to support more complete vegetation coverage
- more weight per square foot than concrete block system
- more resistant to high flow rates

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Section 15
Operation & Maintenance

APPENDIX A

MAINTENANCE REQUIREMENTS FOR FLOW CONTROL, CONVEYANCE, AND WQ FACILITIES

This appendix contains the maintenance requirements for the following typical stormwater control facilities and components:

No. 1 – Detention Ponds (p. A-2)

No. 2 – Infiltration Facilities (p. A-3)

No. 3 – Detention Tanks and Vaults (p. A-5)

No. 4 – Control Structure/Flow Restrictor (p. A-7)

No. 5 – Catch Basins and Manholes (p. A-9)

No. 6 – Conveyance Pipes and Ditches (p. A-11)

No. 7 – Debris Barriers (e.g., Trash Racks) (p. A-12)

No. 8 – Energy Dissipaters (p. A- 13)

No. 9 – Fencing (p. A-14)

No. 10 – Gates/Bollards/Access Barriers (p. A-15)

No. 11 – Grounds (Landscaping) (p. A-16)

No. 12 – Access Roads (p. A-17)

No. 13 – Basic Biofiltration Swale (grass) (p. A-18)

No. 14 – Wet Biofiltration Swale (p. A-19)

No. 15 – Filter Strip (p. A-20)

No. 16 – Wetpond (p. A-21)

No. 17 – Wetvault (p. A-23)

No. 18 – Stormwater Wetland (p. A-24)

No. 19 – Sand Filter Pond (p. A-26)

No. 20 – Sand Filter Vault (p. A-28)

No. 21 – Stormfilter (Cartridge Type) (p. A-30)

No. 22 – Baffle Oil/Water Separator (p. A-32)

No. 23 – Coalescing Plate Oil/Water Separator (p. A-33)

No. 24 – Catch Basin Insert (p. A-35)

NO. 3 – DETENTION TANKS AND VAULTS

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash and debris	Any trash and debris which exceed 1 cubic foot per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size office garbage can). In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
	Noxious weeds	Any noxious or nuisance vegetation which may constitute a hazard to County personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Grass/groundcover	Grass or groundcover exceeds 18 inches in height.	Grass or groundcover mowed to a height no greater than 6 inches.
Tank or Vault Storage Area	Trash and debris	Any trash and debris accumulated in vault or tank (includes floatables and non-floatables).	No trash or debris in vault.
	Sediment accumulation	Accumulated sediment depth exceeds 10% of the diameter of the storage area for ½ length of storage vault or any point depth exceeds 15% of diameter. Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than ½ length of tank.	All sediment removed from storage area.
Tank Structure	Plugged air vent	Any blockage of the vent.	Tank or vault freely vents.
	Tank bent out of shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape.	Tank repaired or replaced to design.
	Gaps between sections, damaged joints or cracks or tears in wall	A gap wider than ½-inch at the joint of any tank sections or any evidence of soil particles entering the tank at a joint or through a wall.	No water or soil entering tank through joints or walls.
Vault Structure	Damage to wall, frame, bottom, and/or top slab	Cracks wider than ½-inch, any evidence of soil entering the structure through cracks or qualified inspection personnel determines that the vault is not structurally sound.	Vault is sealed and structurally sound.
Inlet/Outlet Pipes	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.

NO. 3 – DETENTION TANKS AND VAULTS

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Access Manhole	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open manhole requires immediate maintenance.**	Manhole access covered.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to remove	One maintenance person cannot remove cover/lid after applying 80 lbs of lift.	Cover/lid can be removed and reinstalled by one maintenance person.
	Ladder rungs unsafe	Missing rungs, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Large access doors/plate	Damaged or difficult to open	Large access doors or plates cannot be opened/removed using normal equipment.	Replace or repair access door so it can opened as designed.
	Gaps, doesn't cover completely	Large access doors not flat and/or access opening not completely covered.	Doors close flat and covers access opening completely.
	Lifting Rings missing, rusted	Lifting rings not capable of lifting weight of door or plate.	Lifting rings sufficient to lift or remove door or plate.

NO. 4 – CONTROL STRUCTURE/FLOW RESTRICTOR

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Structure	Trash and debris	Trash or debris of more than ½ cubic foot which is located immediately in front of the structure opening or is blocking capacity of the structure by more than 10%.	No Trash or debris blocking or potentially blocking entrance to structure.
		Trash or debris in the structure that exceeds $^1/_3$ the depth from the bottom of basin to invert the lowest pipe into or out of the basin.	No trash or debris in the structure.
		Deposits of garbage exceeding 1 cubic foot in volume.	No condition present which would attract or support the breeding of insects or rodents.
	Sediment	Sediment exceeds 60% of the depth from the bottom of the structure to the invert of the lowest pipe into or out of the structure or the bottom of the FROP-T section or is within 6 inches of the invert of the lowest pipe into or out of the structure or the bottom of the FROP-T section.	Sump of structure contains no sediment.
	Damage to frame and/or top slab	Corner of frame extends more than ¾ inch past curb face into the street (If applicable).	Frame is even with curb.
		Top slab has holes larger than 2 square inches or cracks wider than ¼ inch.	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than ¾ inch of the frame from the top slab.	Frame is sitting flush on top slab.
	Cracks in walls or bottom	Cracks wider than ½ inch and longer than 3 feet, any evidence of soil particles entering structure through cracks, or maintenance person judges that structure is unsound.	Structure is sealed and structurally sound.
		Cracks wider than ½ inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering structure through cracks.	No cracks more than $^1/_4$ inch wide at the joint of inlet/outlet pipe.
	Settlement/ misalignment	Structure has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards.
	Damaged pipe joints	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering the structure at the joint of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of inlet/outlet pipes.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Ladder rungs missing or unsafe	Ladder is unsafe due to missing rungs, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
FROP-T Section	Damage	T section is not securely attached to structure wall and outlet pipe structure should support at least 1,000 lbs of up or down pressure.	T section securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight or show signs of deteriorated grout.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes—other than designed holes—in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or missing	Cleanout gate is missing.	Replace cleanout gate.

NO. 4 – CONTROL STRUCTURE/FLOW RESTRICTOR

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		Cleanout gate is not watertight.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
Orifice Plate	Damaged or missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
	Deformed or damaged lip	Lip of overflow pipe is bent or deformed.	Overflow pipe does not allow overflow at an elevation lower than design
Inlet/Outlet Pipe	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.
Metal Grates (If Applicable)	Unsafe grate opening	Grate with opening wider than $^{7}/_{8}$ inch.	Grate opening meets design standards.
	Trash and debris	Trash and debris that is blocking more than 20% of grate surface.	Grate free of trash and debris. footnote to guidelines for disposal
	Damaged or missing	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.
Manhole Cover/Lid	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open structure requires urgent maintenance**.	Cover/lid protects opening to structure.
	Locking mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to Remove	One maintenance person cannot remove cover/lid after applying 80 lbs. of lift.	Cover/lid can be removed and reinstalled by one maintenance person.

NO. 5 – CATCH BASINS AND MANHOLES

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Structure	Sediment	Sediment exceeds 60% of the depth from the bottom of the catch basin to the invert of the lowest pipe into or out of the catch basin or is within 6 inches of the invert of the lowest pipe into or out of the catch basin.	Sump of catch basin contains no sediment.
	Trash and debris	Trash or debris of more than ½ cubic foot which is located immediately in front of the catch basin opening or is blocking capacity of the catch basin by more than 10%.	No Trash or debris blocking or potentially blocking entrance to catch basin.
		Trash or debris in the catch basin that exceeds $^1/_3$ the depth from the bottom of basin to invert the lowest pipe into or out of the basin.	No trash or debris in the catch basin.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within catch basin.
		Deposits of garbage exceeding 1 cubic foot in volume.	No condition present which would attract or support the breeding of insects or rodents.
	Damage to frame and/or top slab	Corner of frame extends more than ¾ inch past curb face into the street (If applicable).	Frame is even with curb.
		Top slab has holes larger than 2 square inches or cracks wider than ¼ inch.	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than ¾ inch of the frame from the top slab.	Frame is sitting flush on top slab.
	Cracks in walls or bottom	Cracks wider than ½ inch and longer than 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that catch basin is unsound.	Catch basin is sealed and structurally sound.
		Cracks wider than ½ inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	No cracks more than $^1/_4$ inch wide at the joint of inlet/outlet pipe.
	Settlement/ misalignment	Catch basin has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards.
	Damaged pipe joints	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering the catch basin at the joint of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of inlet/outlet pipes.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
Inlet/Outlet Pipe	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.

NO. 5 – CATCH BASINS AND MANHOLES

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Metal Grates (Catch Basins)	Unsafe grate opening	Grate with opening wider than $^{7}/_{8}$ inch.	Grate opening meets design standards.
	Trash and debris	Trash and debris that is blocking more than 20% of grate surface.	Grate free of trash and debris. footnote to guidelines for disposal
	Damaged or missing	Grate missing or broken member(s) of the grate. **Any open structure requires urgent maintenance**.	Grate is in place and meets design standards.
Manhole Cover/Lid	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open structure requires urgent maintenance**.	Cover/lid protects opening to structure.
	Locking mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to Remove	One maintenance person cannot remove cover/lid after applying 80 lbs. of lift.	Cover/lid can be removed and reinstalled by one maintenance person.

NO. 6 – CONVEYANCE PIPES AND DITCHES

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Pipes	Sediment & debris accumulation	Accumulated sediment or debris that exceeds 20% of the diameter of the pipe.	Water flows freely through pipes.
	Vegetation/roots	Vegetation/roots that reduce free movement of water through pipes.	Water flows freely through pipes.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Damage to protective coating or corrosion	Protective coating is damaged; rust or corrosion is weakening the structural integrity of any part of pipe.	Pipe repaired or replaced.
	Damaged	Any dent that decreases the cross section area of pipe by more than 20% or is determined to have weakened structural integrity of the pipe.	Pipe repaired or replaced.
Ditches	Trash and debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet of ditch and slopes.	Trash and debris cleared from ditches.
	Sediment accumulation	Accumulated sediment that exceeds 20% of the design depth.	Ditch cleaned/flushed of all sediment and debris so that it matches design.
	Noxious weeds	Any noxious or nuisance vegetation which may constitute a hazard to County personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Vegetation	Vegetation that reduces free movement of water through ditches.	Water flows freely through ditches.
	Erosion damage to slopes	Any erosion observed on a ditch slope.	Slopes are not eroding.
	Rock lining out of place or missing (If Applicable)	One layer or less of rock exists above native soil area 5 square feet or more, any exposed native soil.	Replace rocks to design standards.

NO. 7 – DEBRIS BARRIERS (E.G., TRASH RACKS)

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed.
Site	Trash and debris	Trash or debris plugging more than 20% of the area of the barrier.	Barrier clear to receive capacity flow.
	Sediment accumulation	Sediment accumulation of greater than 20% of the area of the barrier	Barrier clear to receive capacity flow.
Structure	Cracked broken or loose	Structure which bars attached to is damaged - pipe is loose or cracked or concrete structure is cracked, broken of loose.	Structure barrier attached to is sound.
Bars	Bar spacing	Bar spacing exceeds 6 inches.	Bars have at most 6 inche spacing.
	Damaged or missing bars	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than ¾ inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Repair or replace barrier to design standards.

NO. 8 – ENERGY DISSIPATERS

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed.
Site	Trash and debris	Trash and/or debris accumulation.	Dissipater clear of trash and/or debris.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
Rock Pad	Missing or moved Rock	Only one layer of rock exists above native soil in area five square feet or larger or any exposure of native soil.	Rock pad prevents erosion.
Dispersion Trench	Pipe plugged with sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not discharging water properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench).	Water discharges from feature by sheet flow.
	Perforations plugged.	Over 1/4 of perforations in pipe are plugged with debris or sediment.	Perforations freely discharge flow.
	Water flows out top of "distributor" catch basin.	Water flows out of distributor catch basin during any storm less than the design storm.	No flow discharges from distributor catch basin.
	Receiving area over-saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Gabions	Damaged mesh	Mesh of gabion broken, twisted or deformed so structure is weakened or rock may fall out.	Mesh is intact, no rock missing.
	Corrosion	Gabion mesh shows corrosion through more than ¼ of its gage.	All gabion mesh capable of containing rock and retaining designed form.
	Collapsed or deformed baskets	Gabion basket shape deformed due to any cause.	All gabion baskets intact, structure stands as designed.
	Missing rock	Any rock missing that could cause gabion to loose structural integrity.	No rock missing.
Manhole/Chamber	Worn or damaged post, baffles or side of chamber	Structure dissipating flow deteriorates to ½ or original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure is in no danger of failing.
	Damage to wall, frame, bottom, and/or top slab	Cracks wider than ½-inch or any evidence of soil entering the structure through cracks, or maintenance inspection personnel determines that the structure is not structurally sound.	Manhole/chamber is sealed and structurally sound.
	Damaged pipe joints	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering the structure at the joint of the inlet/outlet pipes.	No soil or water enters and no water discharges at the joint of inlet/outlet pipes.

NO. 9 – FENCING

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Erosion or holes under fence	Erosion or holes more than 4 inches high and 12-18 inches wide permitting access through an opening under a fence.	No access under the fence.
Wood Posts, Boards and Cross Members	Missing or damaged parts	Missing or broken boards, post out of plumb by more than 6 inches or cross members broken	No gaps on fence due to missing or broken boards, post plumb to within 1½ inches, cross members sound.
	Weakened by rotting or insects	Any part showing structural deterioration due to rotting or insect damage	All parts of fence are structurally sound.
	Damaged or failed post foundation	Concrete or metal attachments deteriorated or unable to support posts.	Post foundation capable of supporting posts even in strong wind.
Metal Posts, Rails and Fabric	Damaged parts	Post out of plumb more than 6 inches.	Post plumb to within 1½ inches.
		Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
		Any part of fence (including post, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
		Missing or loose tension wire.	Tension wire in place and holding fabric.
	Deteriorated paint or protective coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
	Openings in fabric	Openings in fabric are such that an 8-inch diameter ball could fit through.	Fabric mesh openings within 50% of grid size.

NO. 10 – GATES/BOLLARDS/ACCESS BARRIERS

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Chain Link Fencing Gate	Damaged or missing members	Missing gate.	Gates in place.
		Broken or missing hinges such that gate cannot be easily opened and closed by a maintenance person.	Hinges intact and lubed. Gate is working freely.
		Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
		Missing stretcher bar, stretcher bands, and ties.	Stretcher bar, bands, and ties in place.
	Locking mechanism does not lock gate	Locking device missing, no-functioning or does not link to all parts.	Locking mechanism prevents opening of gate.
	Openings in fabric	Openings in fabric are such that an 8-inch diameter ball could fit through.	Fabric mesh openings within 50% of grid size.
Bar Gate	Damaged or missing cross bar	Cross bar does not swing open or closed, is missing or is bent to where it does not prevent vehicle access.	Cross bar swings fully open and closed and prevents vehicle access.
	Locking mechanism does not lock gate	Locking device missing, no-functioning or does not link to all parts.	Locking mechanism prevents opening of gate.
	Support post damaged	Support post does not hold cross bar up.	Cross bar held up preventing vehicle access into facility.
Bollards	Damaged or missing	Bollard broken, missing, does not fit into support hole or hinge broken or missing.	No access for motorized vehicles to get into facility.
	Does not lock	Locking assembly or lock missing or cannot be attached to lock bollard in place.	No access for motorized vehicles to get into facility.
Boulders	Dislodged	Boulders not located to prevent motorized vehicle access.	No access for motorized vehicles to get into facility.
	Circumvented	Motorized vehicles going around or between boulders.	No access for motorized vehicles to get into facility.

NO. 11 – GROUNDS (LANDSCAPING)

Maintenance Component	Defect or Problem	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash or litter	Any trash and debris which exceed 1 cubic foot per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size office garbage can). In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
	Noxious weeds	Any noxious or nuisance vegetation which may constitute a hazard to County personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Grass/groundcover	Grass or groundcover exceeds 18 inches in height.	Grass or groundcover mowed to a height no greater than 6 inches.
Trees and Shrubs	Hazard	Any tree or limb of a tree identified as having a potential to fall and cause property damage or threaten human life. **A hazard tree identified by a qualified arborist must be removed as soon as possible.**	No hazard trees in facility.
	Damaged	Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub.	Trees and shrubs with less than 5% of total foliage with split or broken limbs.
		Trees or shrubs that have been blown down or knocked over.	No blown down vegetation or knocked over vegetation. Trees or shrubs free of injury.
		Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Tree or shrub in place and adequately supported; dead or diseased trees removed.

NO. 12 – ACCESS ROADS

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash and debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet (i.e., trash and debris would fill up one standards size garbage can).	Roadway drivable by maintenance vehicles.
		Debris which could damage vehicle tires or prohibit use of road.	Roadway drivable by maintenance vehicles.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Blocked roadway	Any obstruction which reduces clearance above road surface to less than 14 feet.	Roadway overhead clear to 14 feet high.
		Any obstruction restricting the access to a 10- to 12 foot width for a distance of more than 12 feet or any point restricting access to less than a 10 foot width.	At least 12-foot of width on access road.
Road Surface	Erosion, settlement, potholes, soft spots, ruts	Any surface defect which hinders or prevents maintenance access.	Road drivable by maintenance vehicles.
	Vegetation on road surface	Trees or other vegetation prevent access to facility by maintenance vehicles.	Maintenance vehicles can access facility.
Shoulders and Ditches	Erosion	Erosion within 1 foot of the roadway more than 8 inches wide and 6 inches deep.	Shoulder free of erosion and matching the surrounding road.
	Weeds and brush	Weeds and brush exceed 18 inches in height or hinder maintenance access.	Weeds and brush cut to 2 inches in height or cleared in such a way as to allow maintenance access.
Modular Grid Pavement	Contaminants and pollution	Any evidence of contaminants or pollution such as oil, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Damaged or missing	Access surface compacted because of broken on missing modular block.	Access road surface restored so road infiltrates.

NO. 21 – STORMFILTER (CARTRIDGE TYPE)

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Site	Trash and debris	Any trash or debris which impairs the function of the facility.	Trash and debris removed from facility.
	Contaminants and pollution	Any evidence of contaminants or pollution such as oils, gasoline, concrete slurries or paint.	Materials removed and disposed of according to applicable regulations. Source control BMPs implemented if appropriate. No contaminants present other than a surface oil film.
	Life cycle	System has not been inspected for three years.	Facility is re-inspected and any needed maintenance performed.
Vault Treatment Area	Sediment on vault floor	Greater than 2 inches of sediment.	Vault is free of sediment.
	Sediment on top of cartridges	Greater than ½ inch of sediment.	Vault is free of sediment.
	Multiple scum lines above top of cartridges	Thick or multiple scum lines above top of cartridges. Probably due to plugged canisters or underdrain manifold.	Cause of plugging corrected, canisters replaced if necessary.
Vault Structure	Damage to wall, Frame, Bottom, and/or Top Slab	Cracks wider than ½-inch and any evidence of soil particles entering the structure through the cracks, or qualified inspection personnel determines the vault is not structurally sound.	Vault replaced or repaired to design specifications.
	Baffles damaged	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Repair or replace baffles to specification.
Filter Media	Standing water in vault	9 inches or greater of static water in the vault for more than 24 hours following a rain event and/or overflow occurs frequently. Probably due to plugged filter media, underdrain or outlet pipe.	No standing water in vault 24 hours after a rain event.
	Short circuiting	Flows do not properly enter filter cartridges.	Flows go through filter media.
Underdrains and Clean-Outs	Sediment/debris	Underdrains or clean-outs partially plugged or filled with sediment and/or debris.	Underdrains and clean-outs free of sediment and debris.
Inlet/Outlet Pipe	Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
	Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
	Damaged	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering at the joints of the inlet/outlet pipes.	No cracks more than ¼-inch wide at the joint of the inlet/outlet pipe.
Access Manhole	Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open manhole requires immediate maintenance.**	Manhole access covered.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
	Cover/lid difficult to remove	One maintenance person cannot remove cover/lid after applying 80 lbs of lift.	Cover/lid can be removed and reinstalled by one maintenance person.
	Ladder rungs unsafe	Missing rungs, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Large access doors/plate	Damaged or difficult to open	Large access doors or plates cannot be opened/removed using normal equipment.	Replace or repair access door so it can opened as designed.

NO. 21 – STORMFILTER (CARTRIDGE TYPE)

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Gaps, doesn't cover completely	Large access doors not flat and/or access opening not completely covered.	Doors close flat and cover access opening completely.
	Lifting Rings missing, rusted	Lifting rings not capable of lifting weight of door or plate.	Lifting rings sufficient to lift or remove door or plate.

METOLIUS CONSULTING

"Natural solutions in a changing environment"

February 10, 2011

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FEB 10 2011

Community Development
Planning Division

Bob Richardson
City of Corvallis
Planning Department
PO Box 1083
Corvallis, Oregon 97339

SUBJECT: Response to LUBA remand of Brooklane Heights (PLD06-00018, SUB06-0006).

Mr. Richardson,

We are submitting additional updates to the stormwater design for Brooklane Heights consistent with the necessary public hearing required for addressing Condition 20 of the City Council Notice of Disposition (02/03/10). Staff has asked us to provide a detailed stormwater design for the project that fully calculates all aspects of the project stormwater runoff and water quality. Staff has been adamant that the information submitted for review is at or higher than the level required for a public improvement permit for stormwater. Attached are revised drawings 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, and 1.14, along with revised calculations and detailed responses for the stormwater design review.

In addition to the engineering design review, there was a request to provide additional detail for the stormwater design from a planning perspective. In particular, the application must address the Corvallis Comprehensive Plan (CCP) section 4.6.7 (Hillside Development) and CCP 4.11 (Wetlands). The overall development pattern and project layout have already been approved by the City Council, thus, a response to CCP 4.6.7 and 4.11 are provided only for the stormwater design. Specifics for the stormwater system and how they relate to the comprehensive plan policies are summarized below.

CCP4.6.7.A "Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development."

Multiple geotechnical investigations have been performed on the site that included several on-site visits, laboratory soil sampling and slope stability analyses. Eighteen on-site test pits were excavated throughout the site in key locations to determine soil properties and characteristics. Based on the geotechnical properties of the soils and the site characteristics, there is a low potential for landslides or instability of the area and development of the site will not change this scenario. A more detailed geotechnical investigation was performed in May 2008 and a copy of that geotechnical report was submitted in a prior application that outlines the recommendations to ensure the creation of a stable site during and after development. This geotechnical report already meets the intent of the 2006 LDC for Hillside Development.

To further enhance the compatibility of the site and maintain existing stormwater routing, drainage corridors have been maintained and utilized for stormwater routing. The main drainage corridor on the west side of the property is utilized for a detention vault and water quality treatment area. The detailed stormwater calculations demonstrate that we have more than met the water quality and water quantity requirements for the project. Geotechnical recommendations were developed for the site based on actual field test plots and the stormwater design is consistent with the geotechnical recommendations to ensure slope stability and safety.

CCP4.6.7.B "Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities."
The proposed stormwater design has no impacts to the ridgeline as there is already development upslope and around the area. The upslope development consists of residential homes on large lots that exceed 1-acre.

CCP4.6.7.C "Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees."
The existing site is approximately 26 acres and of that area over 42% (11 acres) is set aside as open space to protect existing natural features that include tree groves and existing oak woodlands. There is over 3 acres provided for public right-of-way. The remaining developed area for residential development is 11 acres, which is less than half of the 26 acre parcel. The stormwater design tries to minimize the impacts to open space and trees by allowing as much overland flow of stormwater as possible. The significant underground detention vault located on Badger Place has been minimized in size and buried below ground to reduce visual impacts while complying with the City's standards for water quality and quantity. Trees and vegetation will be planted around the vault to restore trees that will be required to be removed during construction of the vault.

CCP4.6.7.D "Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments."

The July 5, 2007 grading plan (Drawing X and Y) for the site was approved with the prior City Council's decision. As part of the original plan, sidewalks were placed curbside in areas near trees and at drainage corridors to help reduce impacts and minimize the overall footprint of the cuts and fills. The proposed stormwater detention systems further support alignment with existing topography by placing them underground to minimize large structures that are visible from surrounding viewsheds.

CCP4.6.7.E "Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated."
The stormwater system will be built during dry months to minimize potential sediment and sediment laden waters from being created. Likewise, no grading will be done during winter months to help reduce erosion and soil impacts. Grading for the streets and utilities will take place during summer months, likely during June through October.

CCP4.6.7.F "Design developments and utilize construction techniques that minimize erosion and surface water runoff."

The primary surface water drainage corridor is proposed to remain in place and provide a natural filtering system for the majority of storm water runoff. This drainageway will be improved with a detention pond and water quality facilities that utilizes underground detention vaults and vegetation to improve water quality by removing suspended sediment. Construction will be required to comply with city and state erosion control standards through the NPDES 1200-C construction permit. Under this permit, erosion control measures must be designed and installed to ensure sediment and sediment laden waters do not leave the site during and after construction. Erosion control measures would include silt fences, silt screens around drainage structures, vegetated buffer strips to filter stormwater runoff, seeding and mulching disturbed slopes and similar erosion control practices approved by the city and state.

CCP4.6.7.G "Demonstrate a concern for the view of the hills as well as the view from the hills."

Looking at the hill from the south the most distinct feature is the canopy of oak trees in and around the site. The development plan protects the tree canopy by providing over 40% open space primarily protecting trees and developing the space where no trees are present. The existing grass area is severely degraded as a meadow due to the fact that it is mowed on a regular basis during summer months and the City's Municipal Code requires that grass and weeds be kept under 10 inches in height from June 1 through September 30.

The tree canopy provides contrast when looking at the hillside. The proposed development aims to protect the existing trees to the maximum extent possible by locating roads, homes, and infrastructure outside the treed areas. This will ensure that distant views looking at the hillside will see a break up of homes and patches of tree cover that are existing, mature trees. The development will create lots that require custom homes that are contoured to the existing terrain. This will be created by meeting the requirements of the 2006 LDC for home construction.

The detailed stormwater design requires the removal of an additional 12 deciduous trees (maple and one oak tree) as a result of the central detention vault located at Badger Place and one oak tree in the location of water quality swale "E" (drawing 1.12). The removal of these trees will not impact the view of the hill due to the dense canopy and trees down slope of the detention vault. In addition, the grading and landscaping plan will completely hide the detention vault from views below and around the vault. In addition to the landscaping features, all water quality and detention vaults have been located underground to protect the visual aspects of the development from all points of view. Removal of the 13 additional trees will be offset and mitigated by planting 12 maple trees and two Willamette Valley Ponderosa Pines around the central detention vault.

In addition to meeting the Comprehensive Plan Policy guidance for the stormwater design, the project design must take into account Section 2.5.40.04 of the LDC. This section requires that the following compatibility factors be considered for approval of the plan:

- **Basic site design (the organization of uses on a site);**

This project has been designed with an emphasis on preserving the majority of the significant white oak trees on the site. This development pattern is consistent with surrounding development and helps the project "fit into" the surrounding area. Most of the trees on the site were identified on the City's 2004 Natural Features Inventory as highly protected significant vegetation. There are a total of 454 significant trees currently on the property, of which 98% are white oaks. The applicants plan calls for the removal of 34 trees in order to develop the proposed roads and lots. A certified arborist has evaluated the health and safety of the trees and provided guidance as to which ones should be removed. This results in the project having more than 42% of the site set aside as permanent open space in private tracts. The high degree of sensitivity towards these trees ensure the project is in compliance with the hillside and tree preservation provisions found in CCP 4.2.2, 4.6.2, 4.6.3, 4.6.5, 4.6.6, 4.6.9, and 4.6.12.

The detailed stormwater design requires the removal of two additional oak tree and several maple trees. The removal of these trees still leaves 90% of the significant trees in place and ensures an optimal design based on the site conditions. In addition, a minimum 50-foot wide vegetative buffer has been retained along the southern project boundary (between the new lots and the alley below) to provide a buffer to the existing homes in Brooklane Park Estates. Mitigation efforts are also being proposed in the form of planting additional trees around the central detention vault.

- **Visual elements (scale, structural design and form, materials, and so forth)**

The stormwater detention vaults will all be located below ground to reduce visual impacts. The one exception is the central vault downhill from Badger Place. This vault will be graded into the hillside and graded into the existing lot areas to ensure compatibility with the surrounding area.

- **Noise attenuation, noxious odors, lighting and signage**

By placing the stormwater detention system underground, it reduces the potential for noxious odors caused by standing, open water systems such as ponds.

- **Landscaping for buffering and screening**

No landscaping is necessary for the underground stormwater detention system other than the central vault located at Badger Place. The central vault will be landscaped on the downhill side to ensure compatibility with the surrounding views.

- **Traffic**

Not applicable.

- **Effects on off-site parking**

Not applicable.

- **Effects on air and water quality**

The City has clear and objective water quantity and water quality standards. It has been demonstrated through standard engineering calculations and product performance standards that the proposed drainage and water quality plan meets the City's stormwater detention and water quality standards for new development. By

meeting these standards, the project minimizes detrimental changes in water quality for waters discharging into the public storm drainage system and further minimizes detrimental changes in water quality downstream of the site. Effects on air quality will be typical of residential development and nothing is proposed that would have an abnormal effect.

CCP4.11.12 "Development upslope of wetlands shall minimize interference with water patterns discharging to the wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands."

The proposed stormwater design meets the City's Land Development Code and Stormwater Master Plan and design standards. The City's design standards prescribe exact water quality standards that must be met and provide various options for achieving these requirements. Stormwater and water quality calculations have been provided that clearly demonstrate how the stormwater system meets the requirements and thus, minimizes detrimental changes in water quality. Likewise, the project drains into an approved public storm drain system that collects water and routes it through the public infrastructure and is out of the control of this project.

If you would like additional information or have questions please feel free to contact Scott Wright or Steve Schaberg at your convenience.

Respectfully,

Scott Wright, P.E.
Project Manager

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"Natural solutions in a changing environment"

January 10, 2011

Bob Richardson
City Planning
501 SW Madison Ave.
Corvallis, Oregon 97333

SUBJECT: Brooklane Heights Subdivision (PLD06-00018, SUB06-00006, LUBA 2009-042)

Dear Mr. Richardson,

Thank you for your itemized review of our public hearing application documents and for the follow-up staff review comments of November 12, 2010. Our engineering design staff has addressed the issues as explained below. City's plan review comments of November 12, 2010 are printed in italics, followed by our responses in standard font. Again, it is our intent to address all of the City staff's expressed technical concerns.

DRAINAGE - STORM WATER ANALYSIS & DESIGN

1. *The Runoff Conveyance Analysis of the gabion-lined channel gives slopes of 40% to 50%. The steep slopes are fine for checking velocities, however the shallowest slopes for each basin should be used to check the channels capacity. The shallowest slope in the Central basin appears to be 4%. At this slope the 12" deep channel is not adequate to carry the 100-year flow. Please include calculations at the lowest slopes.*

   Engineers Response: Page 4 of 9 of the Mathcad worksheet titled Gabion Swale Hydraulics in Engineering Notebook Section 9 Runoff Conveyance Analyses, shows channel capacity for a range of mild channel gradients from 0 to 0.05 ft/ft. The lined channel depth is 24 inches.

2. *The Runoff Conveyance Analysis of the gabion lined channel gives a depth of 12" and width of 6'. Please update the calculations to show the proposed channel section.*

   Engineers Response: As above, the current gabion lined channel calculations can be found in Section 6 of the Engineering Notebook.

3. *In addition to pipe and open channel flows, the Runoff Conveyance Analysis shall show compliance with Appendix F of the SWMP that water quality facilities must be designed to safely pass storms up to the 100 year, 24 hour storm event. Please show the calculations showing the proposed water quality facilities can pass the 100-year storm event.*

   Engineers Response: The capacity of the flow control standpipe has been added to the Mathcad worksheet titled Central Flow Control Hydraulics. The standpipes for each of the three detention tanks are the same size, have the same overflow weirs, thus each

has approximately the same hydraulic capacity. The hydraulic capacity of the flow control standpipe exceeds 31 cfs.

4. *The Runoff Conveyance Analysis for the existing 12" pipe in Brooklane Park Estates is a calculation for capacity and velocity only. Please include calculations showing it has capacity to carry the 100 year storm event that bypasses the detention facility. The 100 year flow numbers going into the detention facility exceed the capacity of the existing 12" pipe. Also to be included in the 100 year calculations should be any runoff from the alley and slope above the alley.*

   Engineers Response: This stormwater plan includes a detention facility which limits the flow from the 100-year storm event to 1.59 cfs. The downstream pipe has an estimated capacity of 14.5 cfs.

5. *The water quality design storm (0.9" 24 hour) is not the same as the mean annual storm used in the pre-settling design for pre-treatment of stormwater before a media filtration facility. Please use the mean annual storm or show how the water quality design storm is equal to or greater than the mean annual storm.*

   Engineers Response: We have revised our calculations, based on an estimate of the mean annual storm precipitation for Corvallis. Figure 6.4.1.A of the KCSWDM is a rainfall map showing that the estimated mean annual storm at SeaTac Airport is 0.47 inch. Rainfall data from the weather station at SeaTac indicates a 2-year 24-hour precipitation of 2.11 inches. Corvallis reports a 2-year 24-hour precipitation of 2.55 inches, approximately 120% of the SeaTac value. Without having mean annual storm data available for Corvallis, we have simply used 120% of the SeaTac value, 0.56 inch, as a basis for using the KCSWDM algorithm for establishing the minimum required pre-settling volume. These revised calculations are shown in each of the WQ Facility Design Matchcad worksheets found in Section 11 of the Engineering Notebook.

<u>DRAINAGE -PLAN AND DETAILS, SHEETS 1.7 THROUGH 1.14</u>

1. *Sheet 1.7 - Access easements shall be shown around all public utilities located outside of ROW's. It is not the City's desire to have a blanket easement placed over the entirety of the open spaces.*

   Engineers Response: We have shown easements around the proposed public storm drain facilities.

2. *Sheet 1.10 - Previously approved utility plans show a public water line in the southern portion of Wolverine Drive. Scaling the plans indicates the proposed detention vault will not fit where it is proposed. The City requires a 10' separation between street trees (3' from the curb face) and public utilities. A 10' separation will also be required between public water and sanitary sewer lines and a 7'separation from other utilities. Please show a configuration of the detention vault with appropriate offsets of other utilities and street trees.*

   Engineers Response: We have shown the West Water Quality Facility located beneath

the sidewalk and park strip adjacent to the southbound lane of Wolverine Drive as it approaches Brooklane.

3. *Sheet 1.11 - While the 15% slope meets the City's maximum allowed, the transition at the sidewalk (to -2% slope) will create a 17% grade break. According to City Standard Detail 108, section A-A, the maximum grade brake for a crest is 8% at 10' intervals. Please revise the driveway access to accommodate this requirement*

   Engineers Response: The service access to the Central tank has been revised, and a more refined grading plan provided. Note that the tank now is located proximate to Badger Place, providing more convenient access for public operation and maintenance.

4. *Sheet 1.11 - The uppermost elevation given for the driveway access is 271.0'. This appears to be a typo, please clarify*

   Engineers Response: This is a remnant graphics note, should be ignored.

5. *Sheet 1.11 - A profile and proposed contour lines were not included for the area within the extent of the "earthwork limits" as was discussed at the November 5 review meeting. Please revise the drawings to include a profile of the access as well as proposed contours for all proposed grading outside of the already approved mass grading limits.*

   Engineers Response: As mentioned in Item 3 above, a more refined grading plan has been provided, including finished 1-foot contours and six cross-sections through the tank location site.

6. *Sheet 1.11 - Interpolating from the elevations given for the proposed access to existing contour lines, and to the "earthwork limits", there are areas near detention vault that have a side slope of ½:1 and 1:1 slopes. The included Geotechnical report recommends a maximum cut or fill slope of 2:1. Please revise the grading plans in accordance with the Geotechnical report.*

   Engineers Response: As mentioned in Item 3 above, a more refined grading plan has been provided, including finished 1-foot contours and six cross-sections through the tank location site. The grading plan is intended to be consistent with the recommendations of the Geotechnical Engineer.

7. *Sheet 1.11 - With 2:1 side slopes, the limits of fill required for the access will be well within the drip-line of the tree shown to be preserved within the "C" shaped cut out of the detention vault.*

   Engineers Response: With the currently proposed location of the Central tank, all three trees shown will be mitigated with replacement plantings.

8. *Sheet 1.11 - The tree to be preserved that is located with the "C" shaped cut out ,as described above is not likely to survive. The detention vault, that averages between 4' and 8' above grade around the tree, and the access that is also 8 feet above the tree will create drainage issues trapping water. Public Works would rather the tree be removed and mitigated, and a fully rectilinear detention vault constructed in its place.*

   Engineers Response: With the currently proposed location of the Central tank, all three trees shown will be mitigated with replacement plantings.

9. *Sheet 1.11 and 1.14 - All grading associated with the detention vault shall be shown. It should clearly show how there is positive drainage around the structure as well as incorporating any backfill against the structure per section A on sheet 1.14.*

   Engineers Response: At its currently proposed location, the tank will appear to be depressed into the finished grade hillside. The tank roof will include appropriate surface drains to prevent ponding.

10. *Sheet 1.11 - Please show the City's utility easement associated with Brooklane Park Estates and verify all new public stormwater facilities fall within this easement. As stated previously, please indicate how access is provided to these facilities.*

    Engineers Response: During the course of developing this stormwater plan, we have learned that the City does not have vehicular access to the Brooklane Park Estates termini of sewer and storm drain piping in the upper service road. We have configured the Central tank and ancillary stormwater facilities to be accessed from Badger Place.

11. *Sheet 1.11 - Please show or describe how the City will access the water quality filter vault. Large level areas will be required for a boom truck and a service truck to lift and transport new/used filter-cartridges.*

    Engineers Response: As mentioned in Item 11, the water quality filter can now be accessed at the end of the service road from Badger Place. The tank roof will be designed to carry service equipment loads, and is large enough for service truck turn-around.

12. *Sheet 1.11 and 1.14 - Please show a railing or guard rail around all sections of the vault that are more than 36" above the adjacent grade.*

    Engineers Response: We have eliminated the vertical drop.

13. *Sheet 1.14 - On section D, please move the "20' max" dimension to the lowest portion of the vault invert.*

    Engineers Response: We have revised the note to 20-foot max at access, which is the intended safety purpose of the standard.

Attached find the revised drawings and amended sections of the Engineering Notebook for your review.

Respectfully submitted,

/s/ electronic signature

Scott Wright, P.E.
Project Engineer

Enc: Revised Drawings
Revised Mathcad worksheets

RENEWAL 6/30/12

BEFORE THE LAND USE BOARD OF APPEALS

OF THE STATE OF OREGON

ARTHUR BOUCOT, BARBARA BOUCOT,
LANCE CADDY, SHERYL OAKES CADDY,
JOE CASPROWIAK, PAM CASPROWIAK,
LAURIE CHILDERS, WILLIAM KOENITZER,
SUSAN MORRE, JEFFREY MORRE, JOHN SELKER,
ROBERT SMYTHE, JUSTIN SOARES, LINA SOARES,
GEORGE TAYLOR, LUCINDA TAYLOR,
CAROLYN VER LINDEN and ELIZABETH WALDRON,
Petitioners,

vs.

CITY OF CORVALLIS,
Respondent.

LUBA No. 2010-014

FINAL OPINION
AND ORDER

Appeal from Corvallis.

Arthur Boucot, Barbara Boucot, Lance Caddy, Sheryl Oakes Caddy, Joe Casprowiak, Pam Casprowiak, Laurie Childers, William Koenitzer, Susan Morre, Jeffrey Morre, John Selker, Robert Smythe, Justin Soares, Lina Soares, George Taylor, Lucinda Taylor, Carolyn Ver Linden and Elizabeth Waldron, Corvallis, filed the petition for review. Susan Morre argued on her own behalf.

James K, Brewer, Corvallis, filed the response brief and argued on behalf of the respondent. With him on the brief was Fewel, Brewer & Coulombe.

RYAN, Board Member; HOLSTUN, Board Chair; BASSHAM, Board Member; participated in the decision.

AFFIRMED 07/15/2010

You are entitled to judicial review of this Order. Judicial review is governed by the provisions of ORS 197.850.

Opinion by Ryan.

NATURE OF THE DECISION

Petitioners appeal a decision by the city approving conceptual and detailed development plans and a tentative subdivision plat for a 45-lot subdivision.

FACTS

The challenged decision is the city's third decision approving the proposed development, and is the city's decision on remand following our opinion in *Boucot v. City of Corvallis*, __ Or LUBA __ (LUBA No. 2009-042, October 29, 2009) (*Boucot II*). We take the facts from *Boucot II*:

> "The subject property is an approximately 26-acre parcel located on the southeast slope of Country Club Hill in southwest Corvallis near the confluence of the Marys River and Willamette River. The property is zoned Low Density Residential with a Planned Development Overlay. The property is currently vacant except for gravel roads. The applicant proposes 45 residential lots." *Boucot II* at slip op 2.

The city's initial decision approving the same development was remanded in *Boucot v. Corvallis*, 56 Or LUBA 662 (2008) (*Boucot I*). As we explained in *Boucot I*, various provisions of the Corvallis Comprehensive Plan (CCP) apply directly to the application:

> "The 2006 version of the [Corvallis Land Development Code] LDC was adopted to implement the policies of the 1998 CCP, but the challenged decision was deemed complete before the 2006 LDC went into effect. Thus the 2006 LDC is not directly applicable. The city explains that the 1998 CCP is applicable to the challenged decision, and that CCP anticipated that there would be a period of time between the effective date of the CCP and the effective date of the 2006 LDC where the CCP policies to be implemented by the 2006 LDC would be directly applicable." 56 Or LUBA at 670, n 4.[1]

---

[1] In particular, CCP 4.6.7 and CCP 4.11.12 apply to the application. CCP 4.6.7 provides in relevant part:

> "In areas where development is permitted, standards in the Land Development Code for hillside areas will achieve the following:
>
> "A. Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development.

On remand, the city again approved the proposed development, and petitioners appealed that approval to LUBA. In *Boucot II*, we agreed with petitioners that the city's findings that deferred a determination as to whether the applicant's proposal complied with provisions of the Corvallis Comprehensive Plan (CCP) to a future proceeding that did not allow for public participation were impermissible. First, we concluded that the city could not lawfully defer a determination as to whether individual lot grading complies with CCP 4.6.7 to a future proceeding that did not allow for public participation. *Boucot II* at slip op 8. Second, we concluded that the city could not lawfully defer a determination as to whether the applicant's proposal to use a combination of detention ponds and new public storm drain pipes to detain and capture runoff complied with CCP 4.11.12 to a future proceeding that did not allow for public participation.[2] *Id.* at slip op 16. However, in sustaining those portions of petitioners' assignments of error in *Boucot II*, we did not in any way conclude that deferral

---

"B. Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities.

"C. Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees.

"D. Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments.

"E. Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated.

"F. Design developments and utilize construction techniques that minimize erosion and surface water runoff.

"G. Demonstrate a concern for the view of the hills as well as the view from the hills.

"H. Provide landscaping that enhances the identified open space resources.

"I. Design developments that consider landscaping management that will minimize the threat of fire on improved property spreading to wildland habitat."

CCP 4.11.12 provides:

"Development upslope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands."

of a determination of compliance with an applicable criterion was impermissible, but only that such a deferral must include a public process that was "'infuse[d] * * * with the same participatory rights that would have been required if the decision making had not been deferred." *Id*. at slip op 8 (citing *Gould v. Deschutes County*, 216 Or App 150, 162, 171 P3d 1017 (2007)).

In sustaining petitioners' second assignment of error in *Boucot II*, we also concluded that CCP 4.6.7, rather than the 2006 LDC, applied to the application, including proposed individual lot grading, even though, we noted, the applicant had apparently agreed to have the arguably more stringent provisions of the 2006 LDC Chapter 4.5 apply in place of CCP 4.6.7:

> "* * * [P]etitioners are incorrect that 2006 LDC Chapter 4.5 applies directly to this application for subdivision approval, which predates 2006 LDC Chapter 4.5. It is CCP Policy 4.6.7 that applies directly to the application. Because 2006 LDC Chapter 4.5 does not apply directly to the application, the city was not required to determine whether the applicant's proposed grading of the property satisfies those provisions. Rather, the city was required to determine whether those activities satisfy CCP 4.6.7, which is the relevant approval standard. The city appears to have made that determination, based on evidence in the record in the form of the applicant's revised grading plan. Petitioners do not argue that that plan does not constitute substantial evidence that the city could rely on in determining that the applicant's mass grading activities comply with CCP 4.6.7. For that reason, we need not address the numerous challenges that petitioners raise regarding whether the grading plan satisfies all the requirements of the 2006 LDC Chapter 4.5, with respect to mass grading, and petitioners' argument provides no basis for reversal or remand." *Id*. at slip op 6.

In the above-quoted part of our decision in *Boucot II*, we concluded that the city's finding that the proposed mass grading of the subject property complies with CCP 4.6.7 was supported by substantial evidence in the record.

On remand from our opinion in *Boucot II*, the city again approved the proposed development. This appeal followed.

FIRST ASSIGNMENT OF ERROR

In their first assignment of error, we understand petitioners to argue that the city erred in failing to make a current determination as to whether the proposed development complies with CCP 4.11.12. *See* n 1. On remand, the city imposed Condition 20, which requires the applicant to provide information regarding proposed storm drainage plans and provides:

> "The applicant shall submit the information required in this condition of approval. This information shall be reviewed for consistency with [CCP] 4.11.12 and approved through a City Council Public Hearing review process prior to issuance of [Public Improvement by Private Contract] PIPC permits." Record 21.

To the extent petitioners argue that it was unlawful for the city to defer a determination of compliance with CCP 4.11.12, we reject that argument. The city's decision deferred a current finding of compliance with CCP 4.11.12 to a later proceeding that apparently includes a city council review process and the public participation rights we stated were required in order to lawfully defer a current finding of compliance in *Boucot II*. That is all that is required.

The first assignment of error is denied.

SECOND, THIRD AND FOURTH ASSIGNMENTS OF ERROR

These assignments of error challenge the city's decision regarding CCP 4.6.7. *See* n 1.

A. Second and Fourth Assignments of Error

In their second and fourth assignments of error, petitioners argue that (1) the proposed mass grading of the property (as opposed to individual lot grading) does not comply with CCP 4.6.7, (2) the city erred in failing to determine whether the mass grading of the property complies with CCP 4.6.7, and (3) there is no substantial evidence in the record to allow the city to determine whether the application complies with CCP 4.6.7.

The city responds first that petitioners are precluded from challenging the city's previous determination in *Boucot II* that the proposed mass grading satisfies CCP 4.6.7. *See*

Beck v. Tillamook County, 313 Or 148, 831 P2d 678 (1992) (parties are foreclosed from raising old, resolved issues). We agree with the city that petitioners may not challenge in the present appeal the city's determination, which we sustained in *Boucot II*, that the proposed mass grading complies with CCP 4.6.7.

With respect to individual lot grading, the city also responds that in approving the application on remand, the city imposed Condition 27, which provides in relevant part that:

> "[p]rior to grading and excavation activities in areas not approved for mass grading * * * the applicant shall obtain approval by the City Council through a public hearing review process, detailing how the grading plan(s) for development on individual lots are consistent with [CCP] 4.6.7." Record 23.

To the extent petitioners argue that it was unlawful for the city to defer a determination of compliance with CCP 4.6.7 with respect to individual lot grading, we reject that argument. As with the first assignment of error, the city's decision deferred a current finding of compliance with CCP 4.6.7 to a later proceeding that includes a city council review process and the public participation rights we stated were required in order to lawfully defer a current finding of compliance in *Boucot II*. That is all that is required.

The second and fourth assignments of error are denied.

B. Third Assignment of Error

In the third assignment of error, petitioners argue:

> "Respondent erred in changing the applicable review criteria for future lot development from 2006 LDC 4.5 to the 1998 CCP 4.6.7.
>
> "This change was in response to [LUBA's opinion in *Boucot II*] which petitioners believe misinterpreted the city's reason to apply 2006 LDC to future lot development and house construction, rather than CCP 4.6.7. We are unsure how LUBA handles a request to reconsider a previous decision based on such misinterpretation, but feel it is relevant to note it here." Petition for Review 9.

There is no provision in the statutes governing LUBA's review authority to reconsider a final opinion. If we committed error in *Boucot II*, the remedy was for petitioners to appeal that decision to the Court of Appeals pursuant to ORS 197.850. *Sarti v. City of Lake Oswego*, 20

Or LUBA 562 (1991). Accordingly, the third assignment of error provides no basis for reversal or remand of the decision.

The city's decision is affirmed.

CITY COUNCIL
NOTICE OF DISPOSITION

ORDER: 2010-007

CASE: **Brooklane Heights Planned Development**
(PLD06-00018, SUB06-00006)

REQUEST: Approval of a Conceptual and Detailed Development Plan and Tentative Subdivision Plat to create 45 residential lots and 4 common tracts on 25.88 acres of land, and to vary from certain Land Development Code standards.

On September 4, 2007, the City Council approved the subject application, with conditions. This decision was appealed to the Oregon Land Use Board of Appeals (LUBA), and LUBA remanded the decision. On February 2, 2009, the City Council reviewed the remand issues and approved the application, with conditions. This decision was also appealed to LUBA, and the decision was remanded. On February 1, 2010, the City Council considered the remand issues, and approved the application, with conditions, including revisions to Conditions of Approval 20 and 27.

APPLICANT/OWNER: Stephen Schaberg
2535 SW Whiteside Drive
Corvallis, Oregon 97333

LOCATION: The 25.88 acre site is located northwest of Brooklane Drive and north of Agate Avenue, east of Fairmont Drive, and south of Whiteside Drive. The site consists of one parcel which is identified on Benton County Assessor's Map 12-5-01 C as Tax Lot 1000.

On February 1, 2010, the City Council held a duly-advertised public hearing to consider the issues remanded by LUBA. The public hearing was opened to allow the public the opportunity to rebut Councilor declarations, after which, the public hearing was closed. The Council deliberated on the matter, and voted to approve the Conceptual and Detailed Development Plan and Tentative Subdivision Plat requests, with conditions, including revisions to previously approved Conditions of Approval 20 and 27. This decision upheld the two previous Council decisions to approve the subject application.

If you wish to appeal these decisions, an appeal must be filed with the State Land Use Board of Appeals within 21 days from the date of the decision.

The proposal, staff report, hearing minutes, memoranda to City Council, and findings and conclusions may be reviewed at the Community Development Department, Planning Division, City Hall, 501 SW Madison Avenue.

Charles C. Tomlinson
Mayor, City of Corvallis

Signed: February 3, 2010
Appeal Deadline: February 24, 2010

Expiration Date(s) (If Not Appealed): February 24, 2013
(Conceptual and Detailed Development Plan)

February 24, 2012
(Tentative Subdivision Plat)

If an appeal is not filed by the appeal deadline, the Conceptual and Detailed Development Plan shall be valid for three years. If the applicant has not begun construction of the development or its phases within this period, the approval shall expire on February 24, 2013. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to two additional years if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

If an appeal is not filed by the appeal deadline, the Tentative Subdivision Plat shall be valid for two years. If the applicant has not submitted a final subdivision plat within two years (with appropriate assurances for improvements, if applicable), the approval shall expire on February 24, 2012. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to one additional year if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

Attachments:

- Revised Conditions of Approval (Pages 3-12 of this Disposition)
- Excerpts of Approved Plans (Tentative Subdivision Plat, Revised Grading and Tree Preservation Plan, Cut/Fill Analysis)

CONDITIONS OF APPROVAL

The City Council applied the following conditions to the approval of the Brooklane Heights Conceptual and Detailed Development Plan, and Tentative Subdivision Plat (PLD06-00018, SUB06-00006). Condition numbers 20 and 27, which were approved via the previous Council decision (Order 2009-00007), were revised by the Council on February 1, 2010. These conditions are written below as approved by the City Council.

1. **Consistency with Plans** – Development shall comply with the narrative and plans identified in or referenced in **Attachment IX** of the August 10, 2007, Memorandum to the City Council from Community Development Director, Ken Gibb, except as modified by the conditions below or unless a requested modification otherwise meets the criteria for a Planned Development Modification and/or a Tentative Plat Modification. Such changes may be processed in accordance with Chapters 2.4 and 2.5 of the Land Development Code.

   A Home Owners Association (HOA) shall be established and shall be subject to the requirements stated in the following Conditions of Approval.

2. **Secondary Access** - Per LDC section 4.0.70.c.3, development of lots shall be limited to Lot 1, and 18 additional lots on a street segment not to exceed 600 feet, or 150 feet beyond an emergency turn-around until secondary access, as proposed, is achieved. If development occurs on the 600 foot street segment, prior to development of secondary access, the street terminus shall be constructed with turn-arounds to accommodate emergency vehicles. The turn-around area shall comply with applicable Oregon Uniform Fire Codes, or as specified by the Corvallis Fire Marshall.

3. **Landscaping Construction and Maintenance** – The following landscaping provisions shall apply to overall development of the site:

   Landscape Construction Documents – Prior to issuance of PIPC permits, the applicant shall submit to the Community Development Director, a Detailed Landscape Plan for this site that contains a specific planting plan (including correct plant names in the Latin format), construction plans, irrigation plans, details, and specifications for all required landscaped areas on the site in sufficient detail to show the relationship between required landscaping and public utilities, franchise utilities, driveways, and other streetscape elements such as light poles, signs and mailboxes. Where conflicts arise between landscaping and streetscape elements and public facilities, flexibility in the location of trees may be permitted. However, a reduction in the number of required streets trees shall not be permitted unless modified through a Planned Development Modification approval.

   Plantings shall comply with LDC Section 4.2 and other conditions of this approval. Required street trees shall have at least a 1½-inch trunk diameter at the time of installation and shall be chosen from the list of species provided in LDC Section 4.2.60, or as approved by the Community Development Director. The plans must have been

reviewed and approved prior to installation of landscape materials.

The landscape plans shall address the following additional requirements:

Landscape Installation and Maintenance – Street trees and ground cover in planter strips in Brooklane Drive shall be installed with PIPC improvements, except for street trees adjacent to Lot 1. Street trees and ground cover in planter strips fronting Lot 1 shall be installed prior to issuance of Final Inspection for Lot 1. Street trees and ground cover in planter strips in other proposed local streets shall be installed on lot frontages as individual lots are developed, and shall be installed prior to Final Inspection for homes on the associated lot. Street trees on Wolverine Drive northeast of lot 13 shall be installed prior to Final Inspection for lot 45.

The locations of all required trees will be shown on all site plans submitted for public improvement design. A maintenance plan for all plantings shall be provided prior to the City's on-site approval of the landscape installation. This plan shall provide measures to assure all new plantings attain the minimum 90 percent ground cover required by LDC Section 4.2.20 within three years from the date of installation approval.

Security for Landscape Installation and Maintenance – Prior to the approval of the landscaping plan, a Performance Bond (or other LDC-approved financial security) will be provided to the City to secure installation of all required landscaping along new local streets and within Tracts. Prior to Final Plat approval, A 3-year maintenance Bond (or other LDC-approved financial security) shall be provided to the City to cover 50 percent of the costs for landscape materials and labor (plus costs for administration) associated with landscaping installed along all new local streets and Tracts.

Home Owners' Association Landscape Maintenance Responsibilities – After completion of the required three-year maintenance period, the Home Owners' Association created for this subdivision will be responsible for the perpetual maintenance of any landscaping and management of wooded areas within in Tracts. Prior to final plat approval, the applicant shall submit for approval by the Community Development Director, the Home Owners' Association's Codes, Covenants and Restrictions (CC&Rs) and or bylaws. The Homeowners' Association's CC&R's or bylaws shall include all language from this Condition of Approval.

4. **Erosion Control** - Prior to issuance of excavation and grading permits, the applicant shall obtain erosion control permits. Where required by Development Services staff, the applicant shall install an erosion control and re-vegetation product capable of functioning on a 2:1 slope, that will result in 90% vegetation coverage within 3 years, without using irrigation.

5. **Tree Preservation and Planting** – Prior to issuance of any permits, the applicant shall submit a report by a certified arborist that identifies all significant trees proposed to be removed in this application. Identified trees shall include those identified in the arborist report submitted with the subject application (Attachments S and R.55 of the May 25, 2007, staff report to the Planning Commission) trees impacted by construction of the

pedestrian path between Badger Place and Wolverine Drive, trees impacted by construction of the stormwater swale in the north portion of the site, and trees potentially impacted by construction and use of the detention ponds in Tracts B and C.

Unless approved for removal through this application , trees in Tracts A, B, C, an D, as identified in the approved Revised Tentative Subdivision Plat shall be preserved unless a tree is determined to be a hazard tree, or its removal is necessary to protect the health and longevity of an Oregon White Oak tree. Prior to removal of any tree a certified aborist's report shall be submitted to the Community Development Department for review, and trees shall only be removed if the City's Urban Forester concurs with the analysis and recommendations in the arborist's report.

Regarding the pedestrian path, stormwater swale, and ponds, the arborist's report shall detail methods to preserve as many significant trees as possible in or adjacent to these site components. The applicant shall follow tree preservation methods outlined by the arborist. Unless already approved for removal, (any) significant trees may be removed only if a certified arborist recommends removal and the City Forester concurs with the arborist's recommendation.

The arborist's report shall also illustrate all trees approved/proposed to be preserved. To ensure protection of trees, there shall be no cutting, filling, trenching, nor compaction of the soil under tree canopies and to a minimum distance of 5 feet outside the canopy's dripline, consistent with Section 4.2.20.c of the Land Development Code. To assure this protection, a minimum 5-foot high construction fence (constructed of metal chain link, and supported by metal posts sunk into the ground) shall be installed 5 feet outside the canopy's dripline for all trees to be preserved, prior to any excavation and grading of the development site. An exception may occur upon inspection and a recommendation by a certified arborist.

Existing trees, including trees on adjacent properties with driplines within 10 feet of the subject site, and construction protection fences shall be illustrated on all site plans submitted for excavation, erosion control, PIPC, and building permits. Tree protection plans shall be submitted to the City for review and approval, and tree preservation fencing shall be installed and inspected, prior to issuance of any excavation and grading, erosion control, PIPC, or building permits.

6. **Wetland Determination** - Prior to issuance of PIPC permits, the applicant shall submit a wetland determination report indicating the presence of wetlands. If wetlands are found to be present on the site, prior to issuance of excavation and grading permits, the applicant shall submit documentation from the Department of State Lands verifying that the site development and wetland mitigation plans comply with all applicable local, state, and federal wetland regulations.

7 **Archaeological Resources** - Prior to issuance of excavation and grading permits, the applicant shall have the site surveyed by a State Historic Preservation Office (SHPO) qualified archaeologist to determine the presence of archaeological resources on the site, in addition to those identified as site 35-BE-67. The archaeologist shall submit

findings and recommendations regarding site development to the applicant/developer, Corvallis Development Services Division, and SHPO for review. The applicant shall comply with all State and Federal regulations pertaining to archaeological, cultural, and historic materials. Prior to issuance of grading and excavation permits and any earth disturbing activities the applicant shall submit a letter from the SHPO verifying that the proposed development complies with applicable State and Federal regulations relative to archaeological, cultural, and historic materials. During construction of the site, the applicant shall continue to comply with applicable regulations.

8. **Public Improvement Plans** - Any plans for public improvements referenced within the application or this staff report shall not be considered final engineered public improvement plans. Prior to issuance of any structural or site utility construction permits, the applicant shall obtain approval of, and permits for, engineered plans for public improvements from the City's Engineering Division. The applicant shall submit necessary engineered plans and studies for public utility and transportation systems to ensure that adequate street, water, sewer, storm drainage and street lighting improvements are provided. Final utility alignments (including locations for detention facilities) that maximize separation from adjacent utilities and street trees shall be engineered with the plans for public improvements in accordance with all applicable LDC criteria and City, DEQ and Oregon Health Division requirements for utility separations Public improvement plan submittals will be reviewed and approved by the City Engineer under the procedures outlined in Land Development Code Section 4.0.90. **Note:** Land Development Code Section 4.0.70 has been amended to establish street lights as public utilities. Under the revised Code Section, developers shall provide an engineered design for street light installation; obtain appropriate electrical permits from the Development Services Division; and install the street light system concurrent with public improvements.

9 **Right-of-Way Dedication** - As part of Phase I, additional ROW shall be dedicated along SW Brooklane Drive in order to achieve the minimum half street standard width of 33 ft from the original ROW centerline.

Also as part of Phase I, 50 ft of ROW shall be dedicated in Tract D to allow the proposed Oakmont Addition to construct Hawkeye Avenue between the Oakmont Addition subdivision and SW Brooklane Drive.

In addition, an environmental assessment for all land to be dedicated must be completed in accordance with LDC Section 4.0.110.h.

10. **Frontage Improvements** - At the time of development, curbside sidewalk shall be installed along the north side of SW Brooklane Drive between SW Agate Avenue and the private alley located along the northwest portion of Brooklane Park Estates. The sidewalk will connect to existing sidewalk located at SW Agate Avenue to the west. Curb cuts will be provided on both sides of SW Brooklane Drive just west of the private alley described above. New and existing curb cuts shall be constructed or re-constructed to meet current ADA standards.

11. **Public Improvements** - Prior to Final Plat approval the applicant shall construct or secure all public improvements within the subject site.

12. **Vision Clearance** - The City's Off-Street Parking and Access Standards require a vision clearance triangle be maintained between an elevation of 2 feet and 8 feet above the roadway height for all intersecting streets. The legs of the vision clearance triangle shall be determined from table 3 of the City of Corvallis Off-Street Parking and Access Standards. Site plans showing an unobstructed vision clearance triangle as outlined shall be submitted concurrent with application for public improvement permits.

13. **Construction Traffic Plan** - Prior to issuance of excavation and grading permits, the applicant shall prepare a detailed construction traffic plan that outlines proposed hours of operation, route maps, and direction of travel for loaded and empty trucks. This plan shall prohibit construction traffic from using Local Streets as classified in the 1996 Corvallis Transportation Plan. Additionally, construction traffic on the new section of SW Brooklane Drive shall be limited to vehicles of less than 12,000 lbs loaded weight. The construction traffic plan shall be submitted to the City of Corvallis, Development Review for review and approval.

14. **Public Sidewalk/Landscape Strip Improvements** - At the time of development, park strips and setback sidewalks shall be constructed adjacent to Tracts A, B, and C. All other park strips and setback sidewalks will be constructed when individual lots are developed as specified in the LDC 4.0.40.a.3.b.

15. **Transit Improvements** - The applicant shall place a bus shelter easement and provide a flat, graded pad, adjacent to the Brooklane Drive ROW. The location should be selected in cooperation with City of Corvallis, Transportation Division.

16. **Looped Waterline** - City standards are to loop all waterlines to eliminate dead-end runs. The waterline in Buckeye Place shall be looped. When the waterline leaves the ROW, it shall installed in an utility easement. A 15 ft utility easement will be required with a single utility, and a 20 ft utility easement will be required if two utilities run parallel to each other.

17. **Deed Restrictions for Pressure Reducing Valves** - In order to ensure that future owners of lots 33 thru 36 are aware of the need to install pressure reducing valves (PRV), and as part of the building permit process, the developer shall record deed restrictions outlining this need against lots 33 thru 36 concurrent with the final plat. All costs related to PRV installation and maintenance shall be borne by the property owners.

18. **Public Drainage** - All public storm drainage facilities located outside of ROW shall be placed in public drainage easements. This includes pipes, water quality manholes, drainageways, swales, and detention ponds. The minimum required easement width is 15 ft for a single utility and 20 ft for two utilities, or, for drainageways, the 1.5X + 5 LDC 4.5.80 (d)(3) formula. The easement must fully encompass drainageways, swales,

and detention ponds. All weather accesses must also be provided to the water detention facilities.

19. **Public Detention Facility Design & Maintenance Agreement** - The design of the storm water detention facilities shall incorporate all recommendations of the March 16, 2007, Geotechnical report that was conducted by Foundation Engineering, Inc. The geomembrane liner recommended in the Geotechnical report shall be placed on a slope of 3(h):1(v), or flatter and it shall be covered with at least 12 inches of soil. The detention pond shall remain in the same location and footprint as shown on the submitted Utility Plan. Any alteration to the placement of the pond and its associated structural features may require a Planned Development Modification.

    As part of the plans for public improvements the applicant shall provide engineered calculations for pre-development and post-development peak storm water run-off flows, and demonstrate that the storm drainage facilities are designed to match pre and post development flows based on the 2-year, 5-year, and 10-year storm events. The detention facilities shall be designed consistent with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting detention requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The detention analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons.

    The design for the public detention facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the detention facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.

    All detention facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for one year after build-out of all portions of the site that drain to the facilities. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington, Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the detention facilities are accepted by the City.

20. **Public Water Quality Facility Design & Maintenance** - The applicant shall submit the information required in this condition of approval. This information shall be reviewed for consistency with Comprehensive Plan Policy 4.11.12 and approved through a City Council Public Hearing review process prior to issuance of PIPC permits.

As part of the plans for public improvements the applicant shall provide engineered calculations for storm water quality facilities demonstrating compliance with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting water quality requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The water quality analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons.

All water quality facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for two years after acceptance by the City. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the warranty for storm water quality facilities is terminate.

The design for the public water quality facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.

21. **Tree Protection on Private Lots** - Homes on lots 1, 2, 5, 13, 24, and 43 shall be designed to minimize impacts to trees. Prior to issuance of permits for excavation and grading for home construction, a minimum 5-foot high, metal, chain-link construction fence, supported by metal poles sunk into the ground, shall be installed 5-feet outside the tree canopy driplines. If an alteration proposed by a certified arborist is reviewed and approved by City staff, an exception to this fencing location standard may occur.

22. **House Size Deed Restrictions** - Concurrent with final plat approval, the applicant shall record the following deed restrictions: Dwelling unit size on lots 19-29 shall not exceed 1,200 square feet. Buildings on Lots 2-13 and 44 and 45 shall be limited to one story above grade, with the option to construct daylight basements. The roof pitch of all buildings on all lots shall not exceed a 6:12 (rise:run) ratio. Cuts within any building footprint may exceed eight feet.

23. **Tentative Subdivision Plat and Grading Plans** - The approved Tentative Subdivision Plat shall be the revised Plat submitted with the July 5, 2007, appeal letter (Attachment I.6 of the August 10, 2007, Staff Memorandum to the City Council). The approved grading plan shall be the revised grading plan submitted with the July 5, 2007, appeal

letter (Attachments I.7, 8 of the August 10, 2007, Staff Memorandum to the City Council).

24. **Cul-de-Sac Length** - As reflected in the revised Tentative Subdivision Plat submitted on July 5, 2007, the length of cul-de-sacs shall be limited to 600 feet.

25. **Trail Width** - The width of the paved portion of the pedestrian and bicycle trail between Badger Place and Wolverine Drive shall be 8 feet.

26. **Off-Site Drainage** - Prior to final plat approval, the applicant shall develop a storm water drainage plan that ensures site surface drainage is captured in area drains before it crosses the Brooklane Park Estates alleyway. If new off-site area drains are required above the alleyway, the applicant will utilize the existing utility easements, which were specifically designed for storm drainage and sanitary sewer, and will construct such facilities to discourage storm water from crossing the alleyway.

27. **Lot Grading and Structures** -Mass grading shall be limited to the areas shown on the grading plan identified as Drawing X – Brooklane Heights Grading and Tree Preservation Plan, and Drawing Y – Brooklane Heights Cut/Fill Analysis (Exhibits D.1, 2). Cuts and fills in the areas permitted to be mass graded shall not exceed the measurements shown in Drawing Y. All mass graded areas, as shown in Drawing Y shall be engineered and constructed such that retaining walls are neither required nor used.

    Prior to grading and excavation activities in areas not approved for mass grading, as shown in Drawing Y (Exhibit D.2), the applicant shall obtain approval by the City Council through a public hearing review process, detailing how the grading plan(s) for development on individual lots are consistent with Comprehensive Plan Policy 4.6.7.

28. **Maintenance Obligations** - Individual homeowners shall be prohibited from applying pesticides, herbicides, fungicides, or fertilizers to their property. For the entire subdivision, the Homeowners Association (HOA) shall hire a Licensed Commercial Operator to apply any and all pesticides or herbicides on the site. The commercial operator shall be licensed by the Oregon Department of Agriculture, with licenses in the categories of Ornamental and Turf/Herbicide and Ornamental and Turf/Herbicide and Fungicide, or other applicable categories, with the appropriate insurance for that license. The Licensed Commercial Operator is to practice Integrated Pest Management as defined in Oregon Revised Statute 634.650. The use of any pesticide material that contains any of the top ten leachable ingredients, as identified by the Oregon Department of Agriculture, Department of Environmental Quality, and/or USGS for Oregon is strictly prohibited. Prior to recordation of the final plat, the applicant shall submit for review and approval by the Planning Division manager draft CC&Rs for the development that provide notice to homeowners of this condition of approval. The CC&Rs shall clearly state that the obligation for maintenance of all tracts within the subdivision will be held by the HOA.

DEVELOPMENT RELATED CONCERNS

A. **Mailbox Locations** - Mailbox locations shall be coordinated between the developer and the Post Office as part of the public improvements construction process.

B. **Excavation and Grading Plans** - Prior to issuance of any construction permits, the applicant shall submit an excavation and grading plan, including erosion control methods, to the City's Development Services Department for review and approval.

C. **Other Permits** - Prior to issuance of any construction permits, the applicant shall be required to obtain a National Pollutant Discharge Elimination System (NPDES) permit if construction activity will disturb, through clearing, grading, and/or excavation, one acre of the site. Additionally, any permits required by other agencies such as the Division of State Lands; Army Corps of Engineers; Railroads; County; or Oregon Department of Transportation, shall be approved and submitted to the City prior to issuance of any City permits.

D. **Infrastructure Cost Recovery** - Where it is determined that there will be Infrastructure Cost Recovery payments from past public improvements the developer shall pay their required share of the costs prior to receiving any building permits in accordance with Corvallis Municipal Code 2.18.040.

E. **Franchise Utility Plans** - Prior to issuance of public improvement permits, the applicant shall submit, as part of the public improvement plan set, an overall site utility plan that shows existing and proposed franchise utility locations, including vaults, poles, and pedestals. The proposed franchise utilities shall conform to requirements outlined in Land Development Code Section 4.0.100 - Franchise Utility Installations, including provision of appropriate public utility easements.

F. **Streetscape Plan** - As part of the public improvement plans, the applicant shall include a "streetscape" plan that incorporates the following features: composite utility plan; street lights; proposed driveway locations; vision clearance triangles for each intersection; street striping and signing (in conformance with the MUTCD); and proposed street tree locations.

G. **Development Standards** - Construction of homes on the site will be subject to the development standards of the 2006 LDC, including, but not limited RS-5 Development Standards and development standards in Article IV, to, Chapter 4.10-Pedestrian Oriented Design Standards, Chapter 4.11-Minimum Assured

Development Area, and Chapter 4.12-Significant Vegetation Provisions

H. **Spring** - Application materials reference a spring that is believed to be located in the East Drainage. Development on the site should be designed with consideration given to the spring and its potential impacts to future buildings and infrastructure.

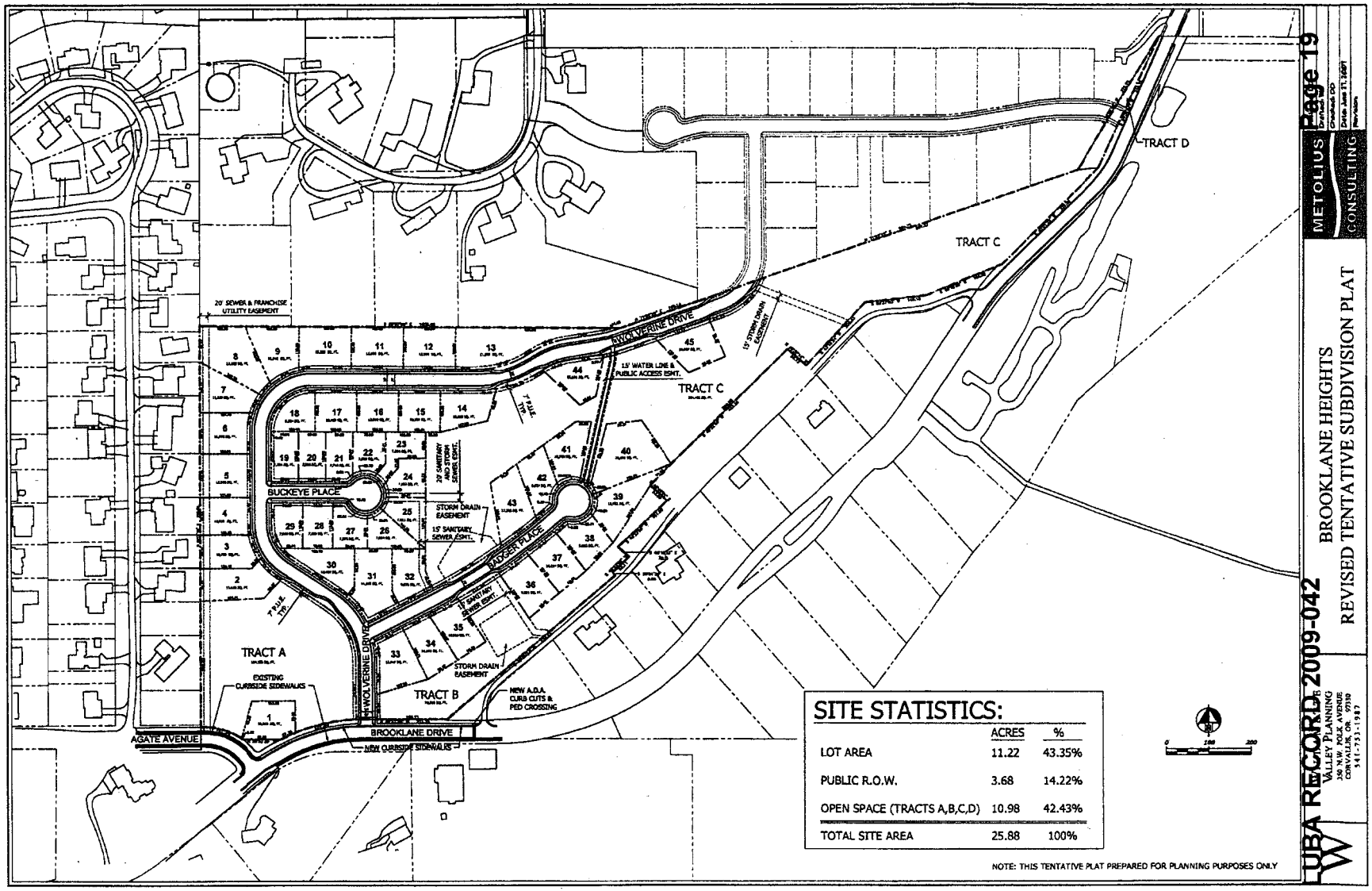

Exhibit B.3
CC EXHIBIT IV - 13

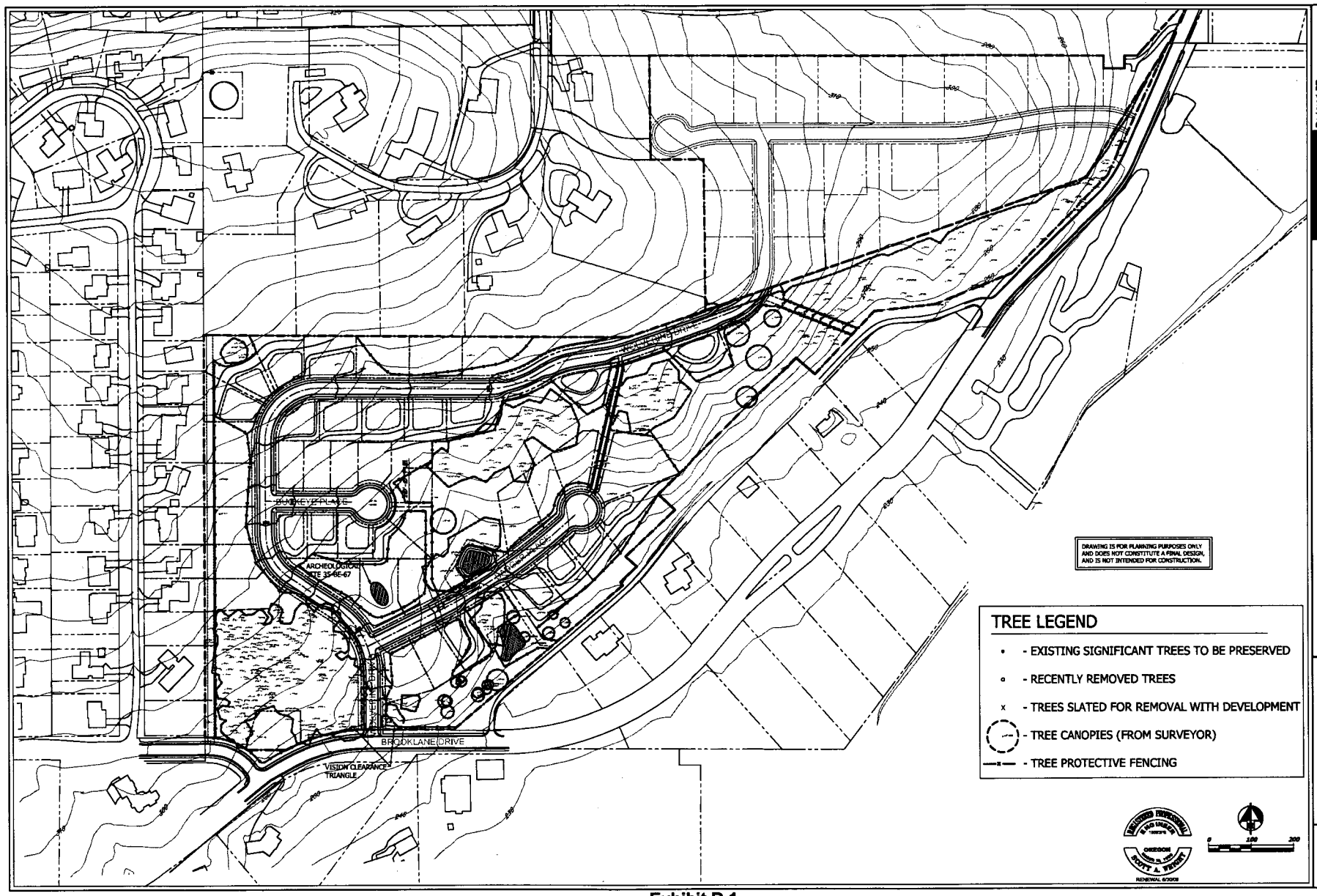

Exhibit D.1

CC EXHIBIT IV - 14

Exhibit D.2

CC EXHIBIT IV - 15

BEFORE THE LAND USE BOARD OF APPEALS

OF THE STATE OF OREGON

ARTHUR BOUCOT, BARBARA BOUCOT,
LANCE CADDY, SHERYL OAKES CADDY,
JOE CASPROWIAK, PAM CASPROWIAK,
LAURIE CHILDERS, BALZ FREI, SIMONE FREI,
MARK HOMMER, WILLIAM KOENITZER,
SUSAN MORRE, JEFFREY MORRE, JOHN SELKER,
ROBERT SMYTHE, JUSTIN SOARES, LINA SOARES,
GEORGE TAYLOR, LUCINDA TAYLOR,
CAROLYN VER LINDEN and ELIZABETH WALDRON,
Petitioners,
vs.

CITY OF CORVALLIS,
Respondent.

LUBA No. 2009-042

FINAL OPINION
AND ORDER

Appeal from City of Corvallis.

Anne C. Davies, Eugene, filed the petition for review and argued on behalf of petitioners.

David E. Coulombe, Corvallis, filed the response brief and argued on behalf of respondent. With him on the brief was Fewel, Brewer & Coulombe.

RYAN, Board Member; BASSHAM, Board Chair; HOLSTUN, Board Member, participated in the decision.

REMANDED 10/29/2009

You are entitled to judicial review of this Order. Judicial review is governed by the provisions of ORS 197.850.

Opinion by Ryan.

NATURE OF THE DECISION

Petitioners appeal a city decision approving conceptual and detailed development plans and a tentative subdivision plat for a 45-lot subdivision.

FACTS

The challenged decision is the city's decision on remand following our opinion in *Boucot v. Corvallis*, __ Or LUBA __ (LUBA No. 2007-200, May 30, 2008) (*Boucot I*). The subject property is an approximately 26-acre parcel located on the southeast slope of Country Club Hill in southwest Corvallis near the confluence of the Marys River and Willamette River. The property is zoned Low Density Residential with a Planned Development Overlay. The property is currently vacant except for gravel roads. The applicant proposes 45 residential lots.

In *Boucot I*, we sustained four of the petitioners' assignments of error and remanded the city's decision. On remand, the city council held a hearing and again approved the applications, adopting 75 pages of findings in support of the decision. This appeal followed.

FIRST ASSIGNMENT OF ERROR

On remand, the city adopted several pages of findings that purported to clarify whether and how various Corvallis Comprehensive Plan (CCP) policies provide review criteria that apply to the application. Record 38-41. We understand the city to take the position that because many CCP policies do not contain measurable development standards, those CCP policies are not approval criteria against which the proposed development must be evaluated. The city has taken similar positions in other appeals. *See Burgess v. Corvallis*, 55 Or LUBA 482, 502-03 (2008) (rejecting city's position that certain Corvallis Land Development Code provisions did not provide applicable approval criteria). In their first assignment of error, petitioners argue that to the extent the city attempted on remand to determine that certain provisions of the CCP are not applicable approval criteria, that

determination is inconsistent with the city's previous position in the proceedings that led to the city's first decision, and is inconsistent with LUBA's decision in *Boucot I*, and with *Beck v. City of Tillamook*, 313 Or 148, 153, 831 P2d 678 (1992) (issues that were raised and resolved by the city in the local proceedings that led to the city's first decision generally may not be revisited in the local proceedings following LUBA's remand of the first decision). Petitioners do not assign error to any specific finding, however, and do not argue that the city's findings that certain CCP provisions are not applicable approval criteria provide an independent basis for reversal or remand of the decision. Thus, we need not and do not reach the issue.

SECOND ASSIGNMENT OF ERROR

CCP Policy 4.6.7, while literally written as a planning directive for future amendments to the LDC, in this case applies directly to the disputed development as an approval criterion.[1] In *Boucot I*, the city found that the applicant's proposed grading plan would satisfy CCP Policy 4.6.7.[2] The city based that determination on its imposition of a

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[1] As we explained in *Boucot I*:

> " * * * [T]he challenged decision was deemed complete before the 2006 LDC went into effect. Thus the 2006 LDC is not directly applicable. The city explains that the 1998 CCP is applicable to the challenged decision, and that CCP anticipated that there would be a period of time between the effective date of the CCP and the effective date of the 2006 LDC where the CCP policies to be implemented by the 2006 LDC would be directly applicable." *Boucot I* at slip op 10, n 4.

The city adopted amendments to the 1993 version of the Corvallis Land Development Code (LDC) in 2006. The challenged decision and the parties' arguments reference both the 1993 LDC and the 2006 LDC. In this opinion, we refer to the 1993 version of the LDC as "LDC" and the 2006 version of the LDC as "2006 LDC."

[2] CCP Policy 4.6.7 provides:

> "In areas where development is permitted, standards in the Land Development Code for hillside areas will achieve the following:
>
> "A. Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development.

condition of approval (Condition 27), which required that the applicant demonstrate that the proposed development complies with 2006 LDC Chapter 4.5 at a time in the future when the lots on the property are developed. We sustained petitioners' assignment of error challenging Condition 27:

> "[W]e agree with petitioners that the city's findings regarding whether the provisions of CCP 4.6.7 are satisfied are inadequate. First, the city's adopted findings do not address compliance with each of the provisions of CCP 4.6.7. Instead, the city appears to have concluded that compliance with the 2006 LDC hillside development provisions in a future review process will suffice to demonstrate compliance with CCP 4.6.7. However, even assuming that is the case, the city cannot defer such a demonstration of compliance with CCP 4.6.7 to a future review process that does not provide notice or opportunity for public participation. * * * If the city is going to rely on compliance with the 2006 hillside development standards to demonstrate compliance with CCP 4.6.7, it must address those 2006 standards in a process that provides notice and opportunity for public participation." *Boucot I* at slip op 11-12 (*citing Rhyne v. Multnomah County*, 23 Or LUBA 442 (1992)).

On remand, the city adopted the following findings:

> "The City Council notes that grading of the site consists of two phases. The first is grading to install the streets and utilities (mass grading). The Council notes that some lot grading will occur at this time to minimize the need to haul

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"B. Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities.

"C. Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees.

"D. Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments.

"E. Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated.

"F. Design developments and utilize construction techniques that minimize erosion and surface water runoff.

"G. Demonstrate a concern for the view of the hills as well as the view from the hills.

"H. Provide landscaping that enhances the identified open space resources.

"I. Design developments that consider landscaping management that will minimize the threat of fire on improved property spreading to wildland habitat."

materials off-site. The Council notes that this grading will be accomplished in compliance with the applicants' exhibit 'Y' – Brooklane Heights Cut/Fill Analysis (Attachment I.8 of the August 10, 2008, Staff Memorandum to City Council).

"The City Council notes that the second phase of grading will consist of grading for the development of individual lots. The Council notes that this grading will be done in compliance with the 2006 LDC Chapter 4.5 – Hillside Development Standards as described in Condition 27.

"The Council notes that Condition 27 requires all areas not proposed and approved to be mass graded to comply with the Hillside Development Standards in LDC Section 4.5.80. Council notes that these standards limit cuts and fills to eight feet, as defined in LDC Section 4.5.80.03. Council notes that based on Condition 27, exceptions to this standard may only be granted if approved through the Planned Development Major Modification process, which requires a public hearing.

" * * * * *

"On remand, Council finds that the Hillside Development Standards applied through Condition 27, and Condition 22, which permits cuts to exceed 8 feet only if within the building footprint, are clear and objective and do not require discretion or a future review proceeding to determine compliance. Council finds that development that does not comply with these standards shall not be permitted, unless a variation to the standards is approved through the major modification process, which will require a quasi-judicial public hearing. * * *" Record 68-69.

Revised Condition 27 provides:

"Mass grading shall be limited to the areas shown on the grading plan identified as Attachments I.7 and I.8 of the August 10, 2007, Staff Memorandum to the City Council. Cuts and fills in the areas permitted to be mass graded shall not exceed the measurements shown in Attachment I.8. All mass graded areas, as shown in Attachment I.8 shall be engineered and constructed such that retaining walls are neither required nor used. Grading and excavation activities in areas not approved for mass grading as shown in Attachment I.8 shall comply with Section 4.5.80 – Hillside Development Standards of the 2006 LDC Chapter 4.5 – Natural Hazards and Hillside Development Provisions. Regardless of the presence of extenuating circumstances, cuts and fills in areas not mass-graded shall comply with the eight-foot standard as defined in LDC Section 4.5.80.03 – Definitions. Exceptions or alterations to these standards shall only be permitted through the Planned Development process. * * *" Record 30.

In adopting the above-quoted findings, the city determined that the applicant's proposed "mass grading" activities on the property, such as grading for roads and utilities and other cuts and fills that do not involve development of specific lots, satisfy CCP 4.6.7. With respect to the grading of individual lots, we understand the city to have found that CCP 4.6.7 will be satisfied when the applicant demonstrates at some time in the future that individual lot grading meets the requirements of 2006 LDC Chapter 4.5.

In the second assignment of error, petitioners argue that the city's findings addressing CCP 4.6.7 are inadequate and are not supported by substantial evidence. Petitioners first argue that the applicant's grading plan fails to satisfy various provisions of 2006 LDC Chapter 4.5, which petitioners argue sets out the relevant approval criterion because the city has previously determined that 2006 LDC Chapter 4.5 implements CCP Policy 4.6.7. However, petitioners are incorrect that 2006 LDC Chapter 4.5 applies directly to this application for subdivision approval, which predates 2006 LDC Chapter 4.5. It is CCP Policy 4.6.7 that applies directly to the application. Because 2006 LDC Chapter 4.5 does not apply directly to the application, the city was not required to determine whether the applicant's proposed grading of the property satisfies those provisions. Rather, the city was required to determine whether those activities satisfy CCP 4.6.7, which is the relevant approval standard. The city appears to have made that determination, based on evidence in the record in the form of the applicant's revised grading plan. Petitioners do not argue that that plan does not constitute substantial evidence that the city could rely on in determining that the applicant's mass grading activities comply with CCP 4.6.7. For that reason, we need not address the numerous challenges that petitioners raise regarding whether the grading plan satisfies all the requirements of the 2006 LDC Chapter 4.5, with respect to mass grading, and petitioners' argument provides no basis for reversal or remand.

But with regard to proposed grading of individual lots, for reasons known only to the city, the city determined that it would apply 2006 LDC Chapter 4.5, instead of CCP 4.6.7,

and apply 2006 LDC Chapter 4.5 at some unspecified future date when the lots are developed and would do so without providing the public hearing process that is required for conceptual and detailed development plan approval. Petitioners argue that the city's condition requiring that the applicant's proposed grading of individual lots for development will comply with 2006 LDC Chapter 4.5 continues to suffer from the same flaw that led LUBA to remand the decision in *Boucot I*. In adopting the above-quoted findings, we understand the city to have concluded that, contrary to our decision in *Boucot I*, its decision to apply 2006 LDC Chapter 4.5 instead of CCP 4.6.7 to grading of individual lots, and its decision to apply 2006 LDC Chapter 4.5 in the future without the public hearing process that is required for conceptual and detailed development plan approval is permissible because application of 2006 LDC Chapter 4.5 in the future will not require the exercise of judgment. Petitioners argue that that finding contravenes our decision in *Boucot I* that in order for the city to defer its finding of compliance with LDC Chapter 4.5, the city was required to address LDC Chapter 4.5 in a future process that provides notice and opportunity for public participation, consistent with our decision in *Rhyne*.[3]

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[3] In *Rhyne*, we stated:

> "Where the evidence presented during the first stage approval proceedings raises questions concerning whether a particular approval criterion is satisfied, a local government essentially has three options potentially available. First, it may find that although the evidence is conflicting, the evidence nevertheless is sufficient to support a finding that the standard is satisfied or that feasible solutions to identified problems exist, and impose conditions if necessary. Second, if the local government determines there is insufficient evidence to determine the feasibility of compliance with the standard, it could on that basis deny the application. Third, if the local government determines that there is insufficient evidence to determine the feasibility of compliance with the standard, instead of finding the standard is not met, it may defer a determination concerning compliance with the standard to the second stage. In selecting this third option, the local government is not finding all applicable approval standards are complied with, or that it is feasible to do so, as part of the first stage approval (as it does under the first option described above). Therefore, the local government must assure that the second stage approval process to which the decision making is deferred provides the statutorily required notice and hearing, even though the local code may not require such notice and hearing for second stage decisions in other circumstances. *Holland v. Lane County*, 16 Or LUBA 583, 596-97 (1988)." *Rhyne v. Multnomah County*, 23 Or LUBA 442, 447-48 (1992) (footnotes omitted).

We agree with petitioners. On remand, the city had at least three options regarding application of CCP 4.6.7 to individual lot grading, if it wished to again approve the disputed subdivision. First, similar to its decision regarding the applicant's mass grading activities, the city could have made a present determination that the proposed lot grading complies with CCP 4.6.7, provided there is substantial evidence in the record that supports that determination. Second, the city could have made a present determination that the applicant's lot grading plan complies with the provisions of 2006 LDC Chapter 4.5 that the applicant apparently has agreed to have apply to that lot grading in place of CCP 4.6.7. Third, the city could have deferred a determination as to whether the individual lot grading complies with CCP 4.6.7 (or 2006 LDC Chapter 4.5) to a future proceeding that allows for public participation.

There are at least two problems with the city's decision to demonstrate that individual lot grading will comply with CCP 4.6.7 by applying LDC Chapter 4.5 to that lot grading in the future, without providing the public process that would be required for a current determination concerning CCP 4.6.7 or LDC Chapter 4.5. First, there is nothing in either our *Rhyne* decision or *Boucot I* decision that recognizes an exception that would allow the city to decide not to apply the criteria that the city's land use laws require to be applied in a public process when granting conceptual or detailed plan approval and instead defer application of those criteria (or substitute criteria) to a future non-public process, simply because those criteria are "nondiscretionary" or "clear and objective." The Court of Appeals' recent decision in *Gould v. Deschutes County*, 216 Or App 150, 171 P3d 1017 (2007), does not seem to recognize such an exception and in fact explicitly states that the deferred decision making must be "infuse[d] * * * with the same participatory rights" that would have been required if the decision making had not been deferred. Second, even if such an exception did exist, the city does not adequately explain why all of the applicable standards in LDC Chapter 4.5 are clear and objective and could be applied in the future without requiring any

exercise of judgment, no matter what circumstances are encountered on the lots, and we do not see that they are.[4]

The second assignment of error is sustained, in part.

THIRD ASSIGNMENT OF ERROR

In *Boucot I*, we remanded the city's decision in part because we agreed with petitioners that, absent the existence in the record of typical building elevation drawings for the proposed houses that appeared to be required by LDC 2.5.50.01(a)(3), there was not substantial evidence in the record to support the city's conclusion that the proposal complied with CCP Policy 4.6.7(G), CCP Policy 9.2.5 and CCP Policy 9.2.1. We held:

> "On remand, the city must either require submission of the typical building elevations, or in their absence identify a sufficient evidentiary basis to conclude that the development complies with applicable criteria." *Boucot I* at slip op 8.

Although we sustained petitioners' challenges to the decision in *Boucot I* on an evidentiary basis, on remand, the city adopted findings explaining how the city believes the proposal complies with CCP Policy 4.6.7(G), CCP Policy 9.2.1 and 9.2.5 notwithstanding the absence of typical building elevation drawings.[5] Petitioners argue that the findings are not supported by substantial evidence in the absence of typical building elevation drawings and that the findings are inadequate. We address those findings in turn.

1. CCP Policy 4.6.7(G)

CCP Policy 4.6.7(G) requires in relevant part that development "demonstrate a concern" for views from and to the hillside. On remand, the city found in part that the proposal satisfies CCP Policy 4.6.7(G) because Condition 27 requires development on

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[4] For example, maximum cut and fill height varies depending on whether there are one or two "Extenuating Conditions," and whether the lot would "otherwise be unbuildable." 2006 LDC 4.5.80.04(d)(1). While the LDC provides some guidance regarding extenuating conditions, even with that guidance, those are not clear and objective criteria.

[5] On remand, the applicant did not submit typical building elevations, but provided images and illustrations that it claimed were examples of houses that could be built on the lots. Record 901-903.

individually graded lots to comply with 2006 LDC Chapter 4.5. Record 55. For the reasons we explained in our resolution of the second assignment of error, deferring a present finding of compliance with CCP 4.6.7(G) to a future proceeding that does not allow public participation is inconsistent with our decision in *Boucot I* and *Rhyne*.

However, the city also found that because 90 percent of the significant trees on the property will be preserved, and conditions 22 and 27 impose building height restrictions and limits on the types of buildings allowed, the proposal "demonstrates a concern" for views to and from the hillside and satisfies CCP Policy 4.6.7(G). Record 54. Petitioners do not challenge that finding. That finding appears to provide a sufficient explanation on its own for the city to conclude that CCP Policy 4.6.7(G) is satisfied.[6]

2. CCP Policies 9.2.1 and 9.2.5

a. General Findings

CCP Policy 9.2.1 requires that land use decisions "protect and maintain" the neighborhood characteristics that are defined in CCP Policy 9.2.5. CCP Policy 9.2.5 requires a demonstration that the development "reflects neighborhood characteristics appropriate to the site and area."[7] On remand, the city explained that condition 22 limits buildings on lots

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[6] The city also determined that Policy 4.6.7(G) is not an applicable approval criterion. Record 54. However, because the city made alternative findings that CCP Policy 4.6.7(G) is satisfied, we need not determine whether the city's finding that Policy 4.6.7(G) does not apply is correct.

[7] CCP Policy 9.2.5 provides:

> "Development shall reflect neighborhood characteristics appropriate to the site and area. New and existing residential, commercial, and employment areas may not have all of these neighborhood characteristics, but these characteristics shall be used to plan the development, redevelopment, or infill that may occur in these areas. These neighborhood characteristics are as follows:
>
> "A. Comprehensive neighborhoods have a neighborhood center to provide services within walking distance of homes. Locations of comprehensive neighborhood centers are determined by proximity to major streets, transit corridors, and higher density housing. Comprehensive neighborhoods use topography, open space, or major streets to form their edges.

1 on the west and north sides of the property to one story with a daylight basement and limits

2 roof pitches and that such a limitation will be compatible with adjacent developments, which

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"B Comprehensive neighborhoods support effective transit and neighborhood services and have a wide range of densities. Higher densities generally are located close to the focus of essential services and transit.

"C. Comprehensive neighborhoods have a variety of types and sizes of public parks and open spaces to give structure and form to the neighborhood and compensate for smaller lot sizes and increased densities.

"D. Neighborhood development provides for compatible building transitions in terms of scale, mass, and orientation.

"E. Neighborhoods have a mix of densities, lot sizes, and housing types.

"F. Neighborhoods have an interconnecting street network with small blocks to help disperse traffic and provide convenient and direct routes for pedestrians and cyclists. In neighborhoods where full street connections cannot be made, access and connectivity are provided with pedestrian and bicycle ways. These pedestrian and bicycle ways have the same considerations as public streets, including building orientation, security-enhancing design, enclosure, and street trees.

"G. Neighborhoods have a layout that makes it easy for people to understand where they are and how to get to where they want to go. Public, civic, and cultural buildings are prominently sited. The street pattern is roughly rectilinear. The use and enhancement of views and natural features reinforces the neighborhood connection to the immediate and larger landscape.

"H. Neighborhoods have buildings (residential, commercial, and institutional) that are close to the street, with their main entrances oriented to the public areas.

"I. Neighborhoods have public areas that are designed to encourage the attention and presence of people at all hours of the day and night. Security is enhanced with a mix of uses and building openings and windows that overlook public areas.

"J. Neighborhoods have automobile parking and storage that does not adversely affect the pedestrian environment. Domestic garages are behind houses or otherwise minimized (e.g., by setting them back from the front facade of the residential structure.) Parking lots and structures are located at the rear or side of buildings. On-street parking may be an appropriate location for a portion of commercial, institutional, and domestic capacity. Curb cuts for driveways are limited, and alleys are encouraged.

"K. Neighborhoods incorporate a narrow street standard for internal streets which slows and diffuses traffic.

"L. Neighborhood building and street proportions relate to one another in a way that provides a sense of enclosure.

"M. Neighborhoods have street trees in planting strips in the public right-of-way."

contain a variety of housing sizes and types.[8] The city also explained that Condition 27 limits houses on the site to single family detached houses and accessory buildings, matching the development on adjacent properties.[9] The city concluded:

> "[B]ecause the uses permitted on the subject site are limited to those of uses on adjacent sites, the proposed development will reflect the neighborhood characteristics appropriate to the site and area. * * *" Record 62.

The city's findings on remand appear to rely on the illustrations and images provided by the applicants and pictures provided by the opponents of the proposal, and the similarity between existing houses in adjacent and close by developments, as well as the architectural features required by the LDC. The city's findings also relied on the conditions of approval limiting certain houses to a single story and limiting the development to single family detached homes as its reasons for determining that the development is consistent with the identified neighborhood characteristics. Although it is a close call, the required considerations under CCP Policies 9.2.1 and 9.2.5 are subjective and we agree with the city that the city's findings that the development will be compatible with the neighborhood are supported by substantial evidence in the record.

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[8] Condition 22 provides:

> "Concurrent with final plat approval, the applicant shall record the following deed restrictions: Dwelling unit size on lots 19-29 shall not exceed 1,200 square feet. Buildings on Lots 2-13 and 44 and 45 shall be limited to one story above grade, with the option to construct daylight basements. The roof pitch of all buildings on all lots shall not exceed a 6:12 (rise:run) ratio. Cuts within any building footprint may exceed eight feet." Record 29-30.

[9] Condition 27 provides in relevant part:

> "Lots shall only be developed with single-family, detached homes and accessory structures consistent with conditions of this approval and 2006 LDC Sections 3.2.30 (except subsections 3.2.30.m – q), 3.2.40, and LDC Sections 4.3.30 and 4.3.40 for accessory structures. Landscaping shall be in accordance with the provision of 1993 LDC Chapter 4.2 – Landscaping, Buffering, and Screening. Development on all lots shall comply with the 2006 LDC Chapter 4.10 – Pedestrian Oriented Design Standards and criteria in LDC Sections 4.10.10 through 4.10.50.
>
> "Modifications to applicable LDC standards, or standards established through this approval may only occur through a planned development major modification process." Record 31.

b. 2006 LDC Chapter 4.10 (Pedestrian Oriented Design Standards)

The city found that the proposal complies with CCP Policy 9.2.5. *See* n 7. However, the city also imposed Condition 27, which requires the development of individual lots to comply with 2006 LDC Chapter 4.10, which the parties refer to as Pedestrian Oriented Design Standards or PODS. PODS require dwellings to be oriented towards the street and contain other requirements that the city believes makes developments more pedestrian friendly. The city council found that certain provisions of CCP Policy 9.2.5 were satisfied by imposition of that condition, and went on to conclude that because PODS are "clear and objective standards," no public participation will be required when the applicant seeks to demonstrate compliance with those provisions. Record 64-65.

Petitioners argue that the city's attempt to defer a finding of compliance with CCP 9.2.5 through the imposition of condition 27 requiring future compliance with the PODS standards is inconsistent with our decision in *Boucot I*. If the city had completely failed to consider whether the proposal complies with CCP Policy 9.2.5, and instead deferred that consideration to a requirement that the applicants comply with the PODS standards in a future proceeding that does not involve participatory rights for the public, we would agree. However, as explained above, the city made a current finding that CCP Policy 9.2.5 is satisfied, and imposed an *additional* obligation on the applicants to comply with otherwise non-applicable criteria (the PODS standards.) That is not inconsistent with our decision in *Boucot I* or with *Rhyne*.

3. CCP Policies 3.2.2 and 3.2.7

Petitioners also assert that there is not substantial evidence in the record that supports the city's findings that the application complies with CCP Policy 3.2.2 and 3.2.7. The city responds that petitioners are precluded from raising the issue of compliance with comprehensive plan policies that were not raised in *Boucot I*. Response Brief 21-22. We agree with the city that petitioners may not raise the issue of the applications' compliance

with those plan policies for the first time in this appeal. *Beck v. City of Tillamook*, 313 Or 148, 831 P2d 678 (1992).

The third assignment of error is denied.

FOURTH ASSIGNMENT OF ERROR

In *Boucot I*, we remanded the city's decision in part because we concluded that the city's findings were inadequate to explain how the development satisfied CCP Policy 4.11.12, and that the city improperly deferred compliance with that approval criterion to a future proceeding with no opportunity for public participation.[10]

On remand, the city adopted findings that first explained that CCP Policy 4.11.12 is met by a showing of compliance with the city's 2002 Storm Water Master Plan (SWMP), which is part of the CCP:

> "City Council notes that CCP 4.11.12 is not a measurable development standard. Council notes that the City has adopted clear and objective stormwater quality and quantity standards in the City's 2002 Storm Water Master Plan (SWMP) that must be met for development to occur. Council notes that upon the adoption of the SWMP, that the SWMP became an amendment to the City's Comprehensive Plan, implementing the CCP along with CCP 4.11.12." Record 76-77.

The city found that the applicant proposed to use a combination of detention ponds and new public storm drain pipes to detain and capture runoff. The city also imposed Condition 19, which requires the applicant to design storm water facilities consistent with Appendix F of the SWMP. The city then determined that the standards set forth in Appendix F are "clear and objective * * *." Record 79.

In the fourth assignment of error, petitioners first argue that Appendix F requires all water quality facilities and detention facilities to be designed in accordance with the King

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[10] CCP 4.11.12 provides:

> "Development upslope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands."

County, Washington Surface Water Design Manual (King County Manual), and that that manual requires that a drainage plan be submitted at the time of application. Thus, we understand petitioners to argue, a drainage plan is required to be submitted at the time the application is submitted, and because no drainage plan has been submitted, the proposal does not satisfy the relevant standards.

The city responds initially that petitioners did not raise this issue during the evidentiary proceedings on remand and are thus precluded under ORS 197.763(1) and ORS 197.835(3) from raising the issue in their appeal to LUBA. Petitioners responded to the city's waiver assertion during petitioners' rebuttal portion of oral argument, with a general response that did not include citations to places in the record where the issue was raised below. Given that lack of specificity, we treat the city's waiver argument as if there had been no response to it.[11] However, even if the issue was not waived, we also agree with the city's response that the SWMP's incorporation of *design standards* set forth in the King County Manual does not also incorporate *application requirements* that are part of that manual.

Petitioners also argue that a drainage plan is required by LDC 2.5.50.01.a.5.[12] We do not agree. That LDC provision requires submission of a utility plan. A utility plan is generally understood to identify the location of utilities such as power, gas, sewer and water on the property. It may also contain a plan for storm drainage. But that does not mean the code requires submission of a drainage plan.

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[11] It is generally inappropriate to wait until the rebuttal portion of oral argument to respond to a waiver argument that was raised in the response brief. *See Laurance v. Douglas County*, 45 Or LUBA 393, 398 (2003) (a petitioner at LUBA may not cite to evidence supporting petitioners' arguments for the first time during rebuttal at oral argument.)

[12] LDC 2.5.50.01.a.5 requires a detailed development plan to contain in relevant part:

> "[A] [d]etailed utilities plan indicating how sanitary sewer, storm sewer, drainage, and water systems will function[.]"

Finally, petitioners argue that the city's deferral of a present finding of compliance with CCP Policy 4.11.12 to a time in the future when a drainage plan is submitted is inconsistent with our decision in *Boucot I* and *Rhyne* because it is not clear that that future decision will allow for public participation. Although the city's findings regarding this criterion do not expressly state that because the SWMP contains "clear and objective" standards no public proceeding will be required, the city takes the position in its response brief that:

> "Because the City's SWMP regulations are clear and objective, and because the city council approved the [applications] varying from certain standards, but subject to compliance with the City's SWMP regulations, the *Rhyne* concern noted by LUBA in *Boucot I* is obviated." Response Brief 34.

If that is what the city intended in finding the SWMP standards to be "clear and objective," then we agree with petitioners. As we explained in *Boucot I*:

> "[T]he city appears to have completely deferred consideration of proposed drainage plans and facilities to a subsequent review process that does not provide for notice or opportunity for public input. As we explained above * * * such a deferral is inadequate to justify a finding of compliance with an applicable criterion." *Id*. at slip op 16.

We explained above in our resolution of the second assignment of error why the city's attempt to defer a determination regarding compliance with an applicable approval criterion to a non-public process is inconsistent with *Rhyne*. Because the city deferred a finding of compliance with CCP Policy 4.11.12 to a future proceeding involving a determination regarding compliance with the SWMP standards, and failed to ensure that that future proceeding will be a public proceeding, those findings are inadequate. *See Soares v. Corvallis*, 56 Or LUBA 551, 566 (2008) (city improperly deferred consideration of SWMP design standards to a later process that did not involve public participation). On remand, the city must clarify that a future proceeding to determine compliance with the SWMP standards will be subject to public participation.

Petitioners also argue that the proposed development violates certain SWMP provisions. However, we need not address the numerous challenges that petitioners raise at this stage regarding whether the application can satisfy all the requirements of the SWMP. Petitioners will have the opportunity during the future public proceeding to determine compliance with the SWMP to raise challenges under it.

The fourth assignment of error is sustained, in part.

FIFTH ASSIGNMENT OF ERROR

In their fifth assignment of error, petitioners argue that the city's findings regarding CCP Policy 4.2.2 and Policy 4.10.9 are inadequate. CCP Policy 4.2.2 requires that "natural features" and "areas determined to be significant" shall be preserved, mitigated or reclaimed. CCP Policy 4.10.9 provides that negative impacts on habitat and migration corridors for birds and wildlife, and on open space, shall be minimized.

The city council concluded:

> "[T]he proposal protects the majority of significant trees and nearly 42% of the site will be retained in tracts, protecting the habitat created, primarily, by the preserved oak groves. Council finds that protection of this habitat area is consistent with CCP 4.2.2 and 4.10.9. The City Council finds that protection of the significant trees and oak groves, amounting to 42% of the site, is sufficient mitigation for any loss to the other natural features on the site. The City Council finds that protection of significant trees and oak groves minimizes the negative impacts on habitat for birds, wildlife, aquatic life and on open space. Accordingly, the City Council concludes that the proposal as conditioned in consistent with CCP Policies 4.2.2 and 4.10.9." Record 93-94.

Although their arguments are difficult to follow, we understand petitioners to argue that the city erred in not recognizing other significant natural features on the site, including wildlife habitat, upland prairie, oak woodlands, natural hazard slopes, scenic views, archaeological resources, and open space, and in failing to determine whether CCP Policy 4.2.2 was met regarding these other features. Petition for Review 34.

As far as we can tell, the city council determined that significant natural features on the site are oak groves, upland prairie habitat, and wetlands, and that the open space values

of the property were not a significant natural feature under CCP Policy 4.2.2. The city council concluded that the proposal to preserve tracts of the property containing the oak groves satisfies CCP 4.2.2 and CP 4.10.9, because it will preserve both a significant natural feature and also identified habitat located within the oak groves. Record 92. The council also concluded that the property is not a migration corridor for birds or other wildlife, and that the upland prairie habitat has been degraded, but that mitigation through protection of other natural features on the site will satisfy CCP 4.2.2 and 4.10.9. Petitioners do not explain why those findings are inadequate to demonstrate compliance with the CCP.

Regarding the protection of wetlands, the city council concluded that adverse impacts to the wetlands will not occur or will be minimized by the applicants' proposed storm detention ponds and use of a manhole-based water quality system in addition to compliance with the city's water quality and quantity standards. Record 88-89. We understand petitioners to argue that the city erred in making this finding without the required drainage plan that petitioners argued in their fourth assignment of error is required by the LDC, and further that a manhole based water treatment facility is not typically allowed under the SWMP's standards. We also understand petitioners to argue that the city erred in failing to assess the impacts of the development on western pond turtles, which petitioners assert may be present south of the property.

We disagree with petitioners that the city erred in finding that wetlands located on the property would be preserved or impacts on them minimized through mitigation and water treatment methods. Even in the absence of a detailed drainage plan, the city could find that the use of detention ponds and compliance with city water quality treatment standards was sufficient to preserve or mitigate the impact on wetlands. In addition, the city concluded that the quantity of water entering pond turtle habitat will not be so significant as to impact turtle habitat, and that compliance with water quality standards will also minimize any negative

impacts on pond turtle habitat. Record 104. Petitioners have not explained why these findings are insufficient to demonstrate compliance with CCP 4.2.2 and Policy 4.10.9.

The fifth assignment of error is denied.

The city's decision is remanded.

Community Development
Planning Division
501 SW Madison Avenue
P.O. Box 1083
Corvallis, OR 97339-1083
(541) 766-6908
FAX (541) 754-1792

CITY COUNCIL
NOTICE OF DISPOSITION

ORDER: 2009-00007

CASE: **Brooklane Heights Planned Development**
(PLD06-00018, SUB06-00006)

REQUEST: Approval of a Conceptual and Detailed Development Plan and Tentative Subdivision Plat to create 45 residential lots and 4 common tracts on 25.88 acres of land, and to vary from certain Land Development Code standards.

The City Council approved the applicant's proposal on September 17, 2007, and this decision was appealed to the Oregon Land Use Board of Appeals (LUBA). On May 30, 2008, LUBA remanded the City Council decision to approve the Brooklane Heights Planned Development and Subdivision. The applicant requested that the City Council consider the issues remanded by LUBA and uphold Council's previous decision to approve the application.

APPLICANT/OWNER: Stephen Schaberg
2535 SW Whiteside Drive
Corvallis, Oregon 97333

LOCATION: The 25.88 acre site is located northwest of Brooklane Drive and north of Agate Avenue, east of Fairmont Drive, and south of Whiteside Drive. The site consists of one parcel which is identified on Benton County Assessor's Map 12-5-01 C as Tax Lot 1000.

On January 5, 2009, the City Council held a duly-advertised public hearing to consider the issues remanded by LUBA. The public hearing was continued until January 20, 2009. The hearing was closed, but the written record was held open for seven additional days. On February 2, 2009, the Council deliberated on the matter, and after consideration of all the testimony and evidence, the Council voted to approve Conceptual and Detailed Development Plan and Tentative Subdivision Plat requests, with conditions, subject to adoption of Formal Findings and Conclusions. On March 2, 2009, the City Council adopted Formal Findings and Conclusions, thereby upholding the previous Council decision to approve.

If you wish to appeal these decisions, an appeal must be filed with the State Land Use Board of Appeals within 21 days from the date of the decision.

The proposal, staff report, hearing minutes, memoranda to City Council, and findings and conclusions may be reviewed at the Community Development Department, Planning Division, City Hall, 501 SW Madison Avenue.

Charles C. Tomlinson
Mayor, City of Corvallis

Signed: March 2, 2009
Appeal Deadline: March 23, 2009

Expiration Date(s) (If Not Appealed): March 2, 2012
(Conceptual and Detailed Development Plan)

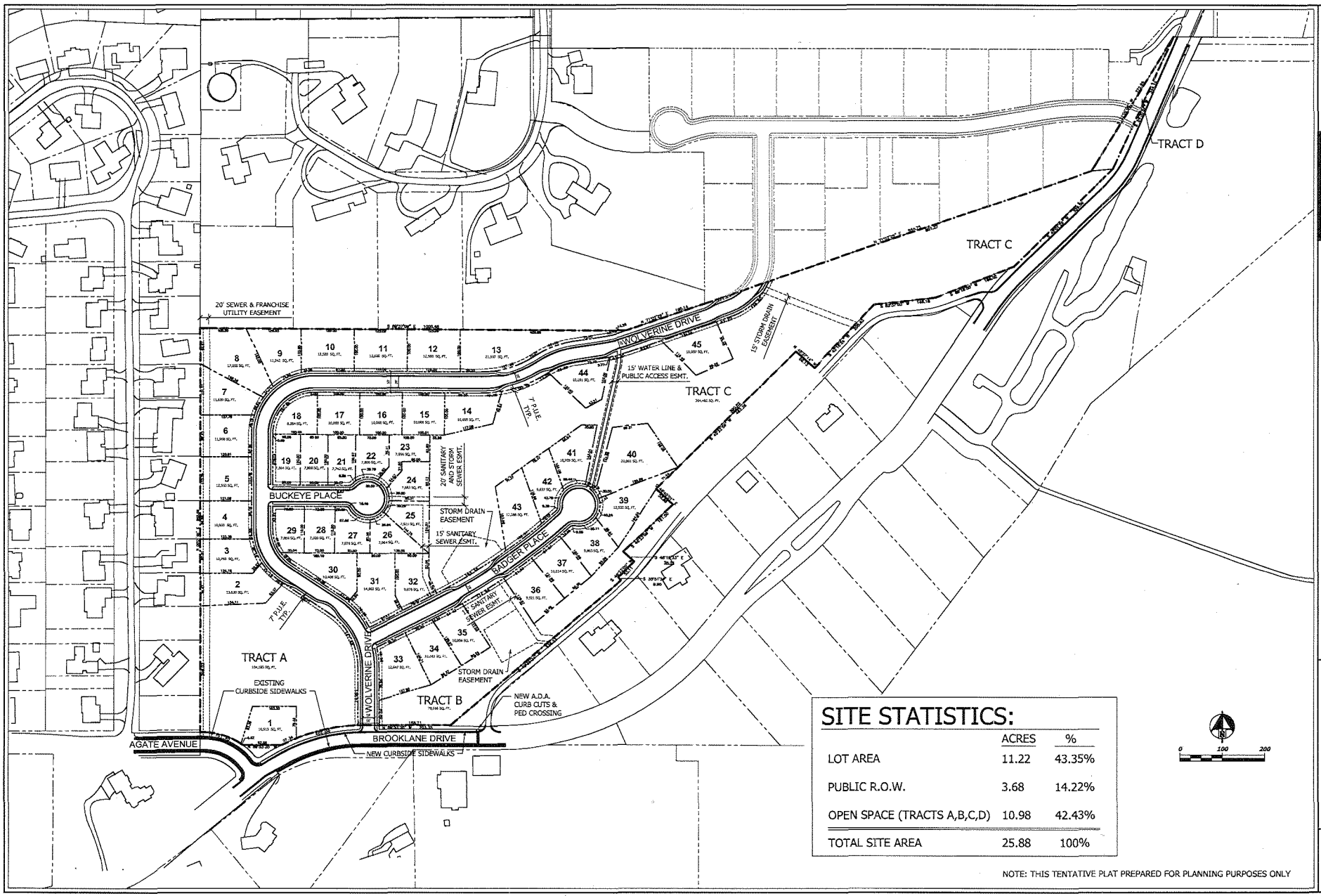
March 2, 2011
(Tentative Subdivision Plat)

If no appeal is filed by the appeal deadline, the Conceptual and Detailed Development Plan shall be valid for three years. If the applicant has not begun construction of the development or its phases within this period, the approval shall expire on March 2, 2012. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to two additional years if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

If no appeal is filed by the appeal deadline, the Tentative Subdivision Plat shall be valid for two years. If the applicant has not submitted a final subdivision plat within two years (with appropriate assurances for improvements, if applicable), the approval shall expire on March 2, 2011. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to one additional year if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

Attachments:

- Conditions of Approval
- Excerpt of approved plans (Tentative Subdivision Plat, Cut/Fill Analysis)
- City Council Adopted Formal Findings and Conclusions



SITE STATISTICS:

	ACRES	%
LOT AREA	11.22	43.35%
PUBLIC R.O.W.	3.68	14.22%
OPEN SPACE (TRACTS A,B,C,D)	10.98	42.43%
TOTAL SITE AREA	25.88	100%

NOTE: THIS TENTATIVE PLAT PREPARED FOR PLANNING PURPOSES ONLY

METOLIUS CONSULTING

Designed: DD
Drafted: MB
Checked: DD
Date: June 21, 2001
Revision:

BROOKLANE HEIGHTS
REVISED TENTATIVE SUBDIVISION PLAT

WILLAMETTE VALLEY PLANNING
330 NW. POLK AVENUE
CORVALLIS, OR 97330
541-753-1987

CC EXHIBIT VI - 3

METOLIUS CONSULTING

Designed: DD
Drafted: HS
Checked: DD
Date: June 27, 2001
Revision

BROOKLANE HEIGHTS CUT/FILL ANALYSIS

WILLAMETTE VALLEY PLANNING
350 N.W. POLK AVENUE
CORVALLIS, OR. 97330
541-753-1987

Y

CC EXHIBIT VI - 4

Conditions of Approval
Brooklane Heights (PLD06-00018, SUB06-00006)

The following Conditions of Approval have been applied on remand and contain new Conditions and revisions not included in the City Council Order 2007-111. These Conditions of Approval supplant those in Order 2007-111.

Condition No.	Condition Language
1	**Consistency with Plans** – Development shall comply with the narrative and plans identified in or referenced in **Attachment IX** of the August 10, 2007, Memorandum to the City Council from Community Development Director, Ken Gibb, except as modified by the conditions below or unless a requested modification otherwise meets the criteria for a Planned Development Modification and/or a Tentative Plat Modification. Such changes may be processed in accordance with Chapters 2.4 and 2.5 of the Land Development Code. A Home Owners Association (HOA) shall be established and shall be subject to the requirements stated in the following Conditions of Approval.
2	**Secondary Access -** Per LDC section 4.0.70.c.3, development of lots shall be limited to Lot 1, and 18 additional lots on a street segment not to exceed 600 feet, or 150 feet beyond an emergency turn-around until secondary access, as proposed, is achieved. If development occurs on the 600 foot street segment, prior to development of secondary access, the street terminus shall be constructed with turn-arounds to accommodate emergency vehicles. The turn-around area shall comply with applicable Oregon Uniform Fire Codes, or as specified by the Corvallis Fire Marshall.
3	**Landscaping Construction and Maintenance** – The following landscaping provisions shall apply to overall development of the site: Landscape Construction Documents – Prior to issuance of PIPC permits, the applicant shall submit to the Community Development Director, a Detailed Landscape Plan for this site that contains a specific planting plan (including correct plant names in the Latin format), construction plans, irrigation plans, details, and specifications for all required landscaped areas on the site in sufficient detail to show the relationship between required landscaping and public utilities, franchise

Condition No.	Condition Language
	utilities, driveways, and other streetscape elements such as light poles, signs and mailboxes. Where conflicts arise between landscaping and streetscape elements and public facilities, flexibility in the location of trees may be permitted. However, a reduction in the number of required streets trees shall not be permitted unless modified through a Planned Development Modification approval. Plantings shall comply with LDC Section 4.2 and other conditions of this approval. Required street trees shall have at least a 1½-inch trunk diameter at the time of installation and shall be chosen from the list of species provided in LDC Section 4.2.60, or as approved by the Community Development Director. The plans must have been reviewed and approved prior to installation of landscape materials. The landscape plans shall address the following additional requirements: <u>Landscape Installation and Maintenance</u> – Street trees and ground cover in planter strips in Brooklane Drive shall be installed with PIPC improvements, except for street trees adjacent to Lot 1. Street trees and ground cover in planter strips fronting Lot 1 shall be installed prior to issuance of Final Inspection for Lot 1. Street trees and ground cover in planter strips in other proposed local streets shall be installed on lot frontages as individual lots are developed, and shall be installed prior to Final Inspection for homes on the associated lot. Street trees on Wolverine Drive northeast of lot 13 shall be installed prior to Final Inspection for lot 45. The locations of all required trees will be shown on all site plans submitted for public improvement design. A maintenance plan for all plantings shall be provided prior to the City's on-site approval of the landscape installation. This plan shall provide measures to assure all new plantings attain the minimum 90 percent ground cover required by LDC Section 4.2.20 within three years from the date of installation approval. <u>Security for Landscape Installation and Maintenance</u> – Prior to the approval of the landscaping plan, a Performance Bond (or other LDC-approved financial security) will be provided to the City to secure installation of all required landscaping along new local streets and within Tracts. Prior to Final Plat approval, A 3-year maintenance Bond (or other LDC-approved financial security) shall be provided to the City to cover

Condition No.	Condition Language
	50 percent of the costs for landscape materials and labor (plus costs for administration) associated with landscaping installed along all new local streets and Tracts. Home Owners' Association Landscape Maintenance Responsibilities – After completion of the required three-year maintenance period, the Home Owners' Association created for this subdivision will be responsible for the perpetual maintenance of any landscaping and management of wooded areas within in Tracts. Prior to final plat approval, the applicant shall submit for approval by the Community Development Director, the Home Owners' Association's Codes, Covenants and Restrictions (CC&Rs) and or bylaws. The Homeowners' Association's CC&R's or bylaws shall include all language from this Condition of Approval.
4	**Erosion Control** - Prior to issuance of excavation and grading permits, the applicant shall obtain erosion control permits. Where required by Development Services staff, the applicant shall install an erosion control and re-vegetation product capable of functioning on a 2:1 slope, that will result in 90% vegetation coverage within 3 years, without using irrigation.
5	**Tree Preservation and Planting** – Prior to issuance of any permits, the applicant shall submit a report by a certified arborist that identifies all significant trees proposed to be removed in this application. Identified trees shall include those identified in the arborist report submitted with the subject application (Attachments S and R.55 of the May 25, 2007, staff report to the Planning Commission) trees impacted by construction of the pedestrian path between Badger Place and Wolverine Drive, trees impacted by construction of the stormwater swale in the north portion of the site, and trees potentially impacted by construction and use of the detention ponds in Tracts B and C. Unless approved for removal through this application , trees in Tracts A, B, C, an D, as identified in the approved Revised Tentative Subdivision Plat shall be preserved unless a tree is determined to be a hazard tree, or its removal is necessary to protect the health and longevity of an Oregon White Oak tree. Prior to removal of any tree a certified aborist's report shall be submitted to the Community Development Department for review, and trees shall only be removed if the City's Urban Forester concurs with the analysis and recommendations in the arborist's report.

Condition No.	Condition Language
	Regarding the pedestrian path, stormwater swale, and ponds, the arborist's report shall detail methods to preserve as many significant trees as possible in or adjacent to these site components. The applicant shall follow tree preservation methods outlined by the arborist. Unless already approved for removal, (any) significant trees may be removed only if a certified arborist recommends removal and the City Forester concurs with the arborist's recommendation. The arborist's report shall also illustrate all trees approved/proposed to be preserved. To ensure protection of trees, there shall be no cutting, filling, trenching, nor compaction of the soil under tree canopies and to a minimum distance of 5 feet outside the canopy's dripline, consistent with Section 4.2.20.c of the Land Development Code. To assure this protection, a minimum 5-foot high construction fence (constructed of metal chain link, and supported by metal posts sunk into the ground) shall be installed 5 feet outside the canopy's dripline for all trees to be preserved, prior to any excavation and grading of the development site. An exception may occur upon inspection and a recommendation by a certified arborist. Existing trees, including trees on adjacent properties with driplines within 10 feet of the subject site, and construction protection fences shall be illustrated on all site plans submitted for excavation, erosion control, PIPC, and building permits. Tree protection plans shall be submitted to the City for review and approval, and tree preservation fencing shall be installed and inspected, prior to issuance of any excavation and grading, erosion control, PIPC, or building permits.
6	**Wetland Determination** - Prior to issuance of PIPC permits, the applicant shall submit a wetland determination report indicating the presence of wetlands. If wetlands are found to be present on the site, prior to issuance of excavation and grading permits, the applicant shall submit documentation from the Department of State Lands verifying that the site development and wetland mitigation plans comply with all applicable local, state, and federal wetland regulations.
7	**Archaeological Resources** - Prior to issuance of excavation and grading permits, the applicant shall have the site surveyed by a State Historic Preservation Office (SHPO) qualified archaeologist to determine the presence of archaeological resources on the site, in addition to those identified as site 35-BE-67. The archaeologist shall submit findings and

Condition No.	Condition Language
	recommendations regarding site development to the applicant/developer, Corvallis Development Services Division, and SHPO for review. The applicant shall comply with all State and Federal regulations pertaining to archaeological, cultural, and historic materials. Prior to issuance of grading and excavation permits and any earth disturbing activities the applicant shall submit a letter from the SHPO verifying that the proposed development complies with applicable State and Federal regulations relative to archaeological, cultural, and historic materials. During construction of the site, the applicant shall continue to comply with applicable regulations.
8	**Public Improvement Plans** - Any plans for public improvements referenced within the application or this staff report shall not be considered final engineered public improvement plans. Prior to issuance of any structural or site utility construction permits, the applicant shall obtain approval of, and permits for, engineered plans for public improvements from the City's Engineering Division. The applicant shall submit necessary engineered plans and studies for public utility and transportation systems to ensure that adequate street, water, sewer, storm drainage and street lighting improvements are provided. Final utility alignments (including locations for detention facilities) that maximize separation from adjacent utilities and street trees shall be engineered with the plans for public improvements in accordance with all applicable LDC criteria and City, DEQ and Oregon Health Division requirements for utility separations Public improvement plan submittals will be reviewed and approved by the City Engineer under the procedures outlined in Land Development Code Section 4.0.90. **Note:** Land Development Code Section 4.0.70 has been amended to establish street lights as public utilities. Under the revised Code Section, developers shall provide an engineered design for street light installation; obtain appropriate electrical permits from the Development Services Division; and install the street light system concurrent with public improvements.
9	**Right-of-Way Dedication** - As part of Phase I, additional ROW shall be dedicated along SW Brooklane Drive in order to achieve the minimum half street standard width of 33 ft from the original ROW centerline. Also as part of Phase I, 50 ft of ROW shall be dedicated in Tract D to allow the proposed Oakmont Addition to construct Hawkeye Avenue between the Oakmont Addition subdivision and SW Brooklane Drive.

Condition No.	Condition Language
	In addition, an environmental assessment for all land to be dedicated must be completed in accordance with LDC Section 4.0.110.h.
10	**Frontage Improvements** - At the time of development, curbside sidewalk shall be installed along the north side of SW Brooklane Drive between SW Agate Avenue and the private alley located along the northwest portion of Brooklane Park Estates. The sidewalk will connect to existing sidewalk located at SW Agate Avenue to the west. Curb cuts will be provided on both sides of SW Brooklane Drive just west of the private alley described above. New and existing curb cuts shall be constructed or re-constructed to meet current ADA standards.
11	**Public Improvements** - Prior to Final Plat approval the applicant shall construct or secure all public improvements within the subject site.
12	**Vision Clearance** - The City's Off-Street Parking and Access Standards require a vision clearance triangle be maintained between an elevation of 2 feet and 8 feet above the roadway height for all intersecting streets. The legs of the vision clearance triangle shall be determined from table 3 of the City of Corvallis Off-Street Parking and Access Standards. Site plans showing an unobstructed vision clearance triangle as outlined shall be submitted concurrent with application for public improvement permits.
13	**Construction Traffic Plan** - Prior to issuance of excavation and grading permits, the applicant shall prepare a detailed construction traffic plan that outlines proposed hours of operation, route maps, and direction of travel for loaded and empty trucks. This plan shall prohibit construction traffic from using Local Streets as classified in the 1996 Corvallis Transportation Plan. Additionally, construction traffic on the new section of SW Brooklane Drive shall be limited to vehicles of less than 12,000 lbs loaded weight. The construction traffic plan shall be submitted to the City of Corvallis, Development Review for review and approval.
14	**Public Sidewalk/Landscape Strip Improvements** - At the time of development, park strips and setback sidewalks shall be constructed adjacent to Tracts A, B, and C. All other park strips and setback sidewalks will be constructed when individual lots are developed as specified in the LDC 4.0.40.a.3.b.
15	**Transit Improvements** - The applicant shall place a bus shelter easement and provide a flat, graded pad, adjacent to the Brooklane Drive ROW. The location should be selected in cooperation with City of

Condition No.	Condition Language
	Corvallis, Transportation Division.
16	**Looped Waterline** - City standards are to loop all waterlines to eliminate dead-end runs. The waterline in Buckeye Place shall be looped. When the waterline leaves the ROW, it shall installed in an utility easement. A 15 ft utility easement will be required with a single utility, and a 20 ft utility easement will be required if two utilities run parallel to each other.
17	**Deed Restrictions for Pressure Reducing Valves** - In order to ensure that future owners of lots 33 thru 36 are aware of the need to install pressure reducing valves (PRV), and as part of the building permit process, the developer shall record deed restrictions outlining this need against lots 33 thru 36 concurrent with the final plat. All costs related to PRV installation and maintenance shall be borne by the property owners.
18	**Public Drainage** - All public storm drainage facilities located outside of ROW shall be placed in public drainage easements. This includes pipes, water quality manholes, drainageways, swales, and detention ponds. The minimum required easement width is 15 ft for a single utility and 20 ft for two utilities, or, for drainageways, the 1.5X + 5 LDC 4.5.80 (d)(3) formula. The easement must fully encompass drainageways, swales, and detention ponds. All weather accesses must also be provided to the water detention facilities.
19	**Public Detention Facility Design & Maintenance Agreement** - The design of the storm water detention facilities shall incorporate all recommendations of the March 16, 2007, Geotechnical report that was conducted by Foundation Engineering, Inc. The geomembrane liner recommended in the Geotechnical report shall be placed on a slope of 3(h):1(v), or flatter and it shall be covered with at least 12 inches of soil. The detention pond shall remain in the same location and footprint as shown on the submitted Utility Plan. Any alteration to the placement of the pond and its associated structural features may require a Planned Development Modification. As part of the plans for public improvements the applicant shall provide engineered calculations for pre-development and post-development peak storm water run-off flows, and demonstrate that the storm drainage facilities are designed to match pre and post development flows based on the 2-year, 5-year, and 10-year storm events. The detention facilities

Condition No.	Condition Language
	shall be designed consistent with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting detention requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The detention analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons. The design for the public detention facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the detention facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site. All detention facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for one year after build-out of all portions of the site that drain to the facilities. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington, Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the detention facilities are accepted by the City.
20	**Public Water Quality Facility Design & Maintenance** - As part of the plans for public improvements the applicant shall provide engineered calculations for storm water quality facilities demonstrating compliance with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting water quality requirements where soil and slope conditions (not

Condition No.	Condition Language
	more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The water quality analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons. All water quality facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for one year after build-out of all portions of the site that drain to the facilities. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the water quality facilities are accepted by the City. The design for the public water quality facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.
21	**Tree Protection on Private Lots** - Homes on lots 1, 2, 5, 13, 24, and 43 shall be designed to minimize impacts to trees. Prior to issuance of permits for excavation and grading for home construction, a minimum 5-foot high, metal, chain-link construction fence, supported by metal poles sunk into the ground, shall be installed 5-feet outside the tree canopy driplines. If an alteration proposed by a certified arborist is reviewed and approved by City staff, an exception to this fencing location standard may occur.
22	**House Size Deed Restrictions** - Concurrent with final plat approval, the applicant shall record the following deed restrictions: Dwelling unit size on lots 19-29 shall not exceed 1,200 square feet. Buildings on Lots 2-13 and 44 and 45 shall be limited to one story above grade, with the option

Condition No.	Condition Language
	to construct daylight basements. The roof pitch of all buildings on all lots shall not exceed a 6:12 (rise:run) ratio. Cuts within any building footprint may exceed eight feet.
23	**Tentative Subdivision Plat and Grading Plans** - The approved Tentative Subdivision Plat shall be the revised Plat submitted with the July 5, 2007, appeal letter (Attachment I.6 of the August 10, 2007, Staff Memorandum to the City Council). The approved grading plan shall be the revised grading plan submitted with the July 5, 2007, appeal letter (Attachments I.7, 8 of the August 10, 2007, Staff Memorandum to the City Council).
24	**Cul-de-Sac Length** - As reflected in the revised Tentative Subdivision Plat submitted on July 5, 2007, the length of cul-de-sacs shall be limited to 600 feet.
25	**Trail Width** - The width of the paved portion of the pedestrian and bicycle trail between Badger Place and Wolverine Drive shall be 8 feet.
26	**Off-Site Drainage** - Prior to final plat approval, the applicant shall develop a storm water drainage plan that ensures site surface drainage is captured in area drains before it crosses the Brooklane Park Estates alleyway. If new off-site area drains are required above the alleyway, the applicant will utilize the existing utility easements, which were specifically designed for storm drainage and sanitary sewer, and will construct such facilities to discourage storm water from crossing the alleyway.
27	**Lot Grading and Structures** - Mass grading shall be limited to the areas shown on the grading plan identified as Attachments I.7 and I.8 of the August 10, 2007, Staff Memorandum to the City Council. Cuts and fills in the areas permitted to be mass graded shall not exceed the measurements shown in Attachment I.8. All mass graded areas, as shown in Attachment I.8 shall be engineered and constructed such that retaining walls are neither required nor used. Grading and excavation activities in areas not approved for mass grading as shown in Attachment I.8 shall comply with Section 4.5.80 - Hillside Development Standards of the 2006 LDC Chapter 4.5 - Natural Hazards and Hillside Development Provisions. Regardless of the presence of extenuating circumstances, cuts and fills in areas not mass-graded shall comply with the eight-foot standard as defined in LDC Section 4.5.80.03 - Definitions. Exceptions or alterations to these standards shall only be permitted through the Planned Development process.

Condition No.	Condition Language
	Lots shall only be developed with single-family, detached homes and accessory structures consistent with conditions of this approval and 2006 LDC Sections 3.2.30 (except subsections 3.2.30.m - q), 3.2.40, and LDC Sections 4.3.30 and 4.3.40 for accessory structures. Landscaping shall be in accordance with the provisions of 1993 LDC Chapter 4.2 - Landscaping, Buffering, and Screening. Development on all lots shall comply with the 2006 LDC Chapter 4.10 - Pedestrian Oriented Design Standards and criteria in LDC Sections 4.10.10 through 4.10.50. Modifications to applicable LDC standards, or standards established through this approval may only occur through a planned development major modification process.
28	**Maintenance Obligations** - Individual homeowners shall be prohibited from applying pesticides, herbicides, fungicides, or fertilizers to their property. For the entire subdivision, the Homeowners Association (HOA) shall hire a Licensed Commercial Operator to apply any and all pesticides or herbicides on the site. The commercial operator shall be licensed by the Oregon Department of Agriculture, with licenses in the categories of Ornamental and Turf/Herbicide and Ornamental and Turf/Herbicide and Fungicide, or other applicable categories, with the appropriate insurance for that license. The Licensed Commercial Operator is to practice Integrated Pest Management as defined in Oregon Revised Statute 634.650. The use of any pesticide material that contains any of the top ten leachable ingredients, as identified by the Oregon Department of Agriculture, Department of Environmental Quality, and/or USGS for Oregon is strictly prohibited. Prior to recordation of the final plat, the applicant shall submit for review and approval by the Planning Division manager draft CC&Rs for the development that provide notice to homeowners of this condition of approval. The CC&Rs shall clearly state that the obligation for maintenance of all tracts within the subdivision will be held by the HOA.

DEVELOPMENT RELATED CONCERNS

A. **Mailbox Locations** - Mailbox locations shall be coordinated between the developer and the Post Office as part of the public improvements construction process.

B. **Excavation and Grading Plans** - Prior to issuance of any construction permits, the applicant shall submit an excavation and grading plan, including erosion control methods, to the City's Development Services Department for review and approval.

C. **Other Permits** - Prior to issuance of any construction permits, the applicant shall be required to obtain a National Pollutant Discharge Elimination System (NPDES) permit if construction activity will disturb, through clearing, grading, and/or excavation, one acre of the site. Additionally, any permits required by other agencies such as the Division of State Lands; Army Corps of Engineers; Railroads; County; or Oregon Department of Transportation, shall be approved and submitted to the City prior to issuance of any City permits.

D. **Infrastructure Cost Recovery** - Where it is determined that there will be Infrastructure Cost Recovery payments from past public improvements the developer shall pay their required share of the costs prior to receiving any building permits in accordance with Corvallis Municipal Code 2.18.040.

E. **Franchise Utility Plans** - Prior to issuance of public improvement permits, the applicant shall submit, as part of the public improvement plan set, an overall site utility plan that shows existing and proposed franchise utility locations, including vaults, poles, and pedestals. The proposed franchise utilities shall conform to requirements outlined in Land Development Code Section 4.0.100 - Franchise Utility Installations, including provision of appropriate public utility easements.

F. **Streetscape Plan** - As part of the public improvement plans, the applicant shall include a "streetscape" plan that incorporates the following features: composite utility plan; street lights; proposed driveway locations; vision clearance triangles for each intersection; street striping and signing (in conformance with the MUTCD); and proposed street tree locations.

G. **Development Standards** - Construction of homes on the site will be subject to the development standards of the 2006 LDC, including, but not limited RS-5 Development Standards and development standards in Article IV, to, Chapter 4.10-

Pedestrian Oriented Design Standards, Chapter 4.11-Minimum Assured Development Area, and Chapter 4.12-Significant Vegetation Provisions

H. **Spring** - Application materials reference a spring that is believed to be located in the East Drainage. Development on the site should be designed with consideration given to the spring and its potential impacts to future buildings and infrastructure.

BEFORE THE LAND USE BOARD OF APPEALS

OF THE STATE OF OREGON

AUTHUR BOUCOT, BARBARA BOUCOT,
LANCE CADDY, JOE CASPROWIAK,
PAM CASPROWIAK, LAURI CHILDERS,
THERESA HANOVER, WILLIAM KOENITZER,
SUSAN MORRE, JEFF MORRE, ROBERT SMYTHE,
JUSTIN SOARES, LINA SOARES,
GEORGE TAYLOR, LUCINDA TAYLOR
and CAROLYN ver LINDEN,
Petitioners,

vs.

CITY OF CORVALLIS,
Respondent.

LUBA No. 2007-200

FINAL OPINION
AND ORDER

Appeal from City of Corvallis.

Anne C. Davies, Eugene, filed the petition for review and argued on behalf of petitioners.

David E. Coulombe, Corvallis, filed the response brief and argued on behalf of respondent. With him on the brief was Fewel, Brewer & Coulombe.

RYAN, Board Chair; BASSHAM, Board Member, participated in the decision.

HOLSTUN, Board Member, did not participate in the decision.

REMANDED 05/30/2008

You are entitled to judicial review of this Order. Judicial review is governed by the provisions of ORS 197.850.

Opinion by Ryan.

NATURE OF THE DECISION

Petitioners appeal a city decision approving conceptual and detailed development plans and a tentative subdivision plat for a 45-lot subdivision.

FACTS

The subject property is an approximately 26-acre parcel located on the southeast slope of Country Club Hill in southwest Corvallis near the confluence of the Marys River and Willamette River. The property is zoned Low Density Residential with a Planned Development Overlay (PD RS 3.5). The property is currently vacant except for gravel roads. The applicant originally proposed to create 42 residential lots and four common tracts. The planning commission denied the application, and the applicant appealed to the city council. After filing the local appeal, the applicant revised the application to include three additional residential lots as well as revised plot, grading/excavation, and tree preservation plans. The city council overturned the planning commission decision and approved the application with conditions. This appeal followed.

MOTION TO FILE REPLY BRIEF AND MOTION TO STRIKE

Petitioners move to file a reply brief to respond to new matters raised in the response brief. The city objects to the reply brief and moves that portions of the reply be stricken. The reply brief contains three sections (A, B, and C) that respectively address: (1) the statement of facts in the petition for review, (2) whether comprehensive plan policies are approval criteria, and (3) whether issues were waived because they were not raised below.

In the statement of facts in the petition for review, petitioners stated that the subject property was located on a significant hillside under the city code. In the response brief, the city argues that the subject property is not located on a significant hillside. In the reply brief, petitioners respond to that argument. We agree with the city that that is not a new matter as

required under OAR 661-010-0039 to file a reply brief. We will not consider section A of the reply brief.

In the petition for review, petitioners treated certain comprehensive plan policies as applicable approval criteria because they were listed as applicable criteria in the city's notice. In the response brief, the city argues that while the policies may be "applicable criteria" they are not "approval" criteria. This is a new matter that petitioners may respond to in a reply brief. We will consider section B.

Section C replies to waiver arguments raised in the response brief. The city argues that portions of section C should be stricken because petitioners should have anticipated a waiver challenge. We do not agree. The reply to the waiver challenge properly responds to a new matter. We will consider section C.

FIRST ASSIGNMENT OF ERROR

Prior to the planning commission hearings, planning staff prepared a staff report recommending denial of the application. The planning commission adopted that staff report as its final decision. After the applicant appealed the planning commission decision to the city council, planning staff prepared a second staff report that again recommended denial. In approving the application, the city council adopted the findings from both staff reports that support the application, but not the findings in the staff reports adverse to the application. The city also adopted as findings the minutes of the two planning commission hearings and two city council hearings that support the application, but not the portions adverse to the application. Petitioners argue that the city improperly attempted to adopt and incorporate portions of the staff reports and minutes in approving the application. The city responds that it has adequately identified the documents that were adopted.

A. Staff Reports

In *Ellis v. City of Bend*, 28 Or LUBA 332, 333 (1994), we held that the city's denial of an application was not supported by adequate findings, where the city council

incorporated as findings a hearings officer's decision *approving* the application, purporting to reject any findings in the hearings officer's decision inconsistent with the city's denial. We remanded because we could not tell which portions of the hearings officer's decision had been incorporated and which rejected, and concluded that the incorporation failed and the city's decision was not supported by adequate findings. Similarly, in the present case, both staff reports recommended denial of the application, but the city council approved the application based on the staff reports, without identifying which portions of those staff reports are incorporated and which are rejected. We agree with petitioners that incorporation of the staff reports fails and the findings are inadequate.

B. Minutes

Petitioners also argue that the city erred in incorporating those portions of the minutes that support the application. This case is similar to *Soares v. City of Corvallis*, ___ Or LUBA ___ (LUBA No. 2007-232, May 8, 2008), in that the city council attempted to incorporate the portions of the minutes that support the application as findings while rejecting those adverse to the application, without adequately identifying which portions are incorporated and which are rejected. As we explained in *Soares*, the limitation to those portions of the minutes that support the application is too imprecise and is therefore ineffective. *Id*. at slip op 5.

In *Soares*, however, we also explained that an ineffective incorporation of documents or minutes is not necessarily an independent basis for reversal or remand. If there are other findings that are adequate to demonstrate compliance with applicable approval criteria, the ineffective incorporation of other findings may be harmless error. In the first assignment of error, petitioners' only reference to applicable approval criteria concerns solar access standards. That reference is insufficiently developed to constitute an argument in support of the first assignment of error, and is insufficient for our review.

We address petitioners' challenges to other adopted findings below, and sustain some of those challenges. However, petitioners' arguments under the first assignment of error do not add anything to those bases for remand or provide an independent basis for remand. Therefore, the first assignment of error provides no independent basis for reversal or remand.

The first assignment of error is denied.

SECOND ASSIGNMENT OF ERROR

Petitioners argue that the city erred in failing to provide proper notice of the amended proposal for a 45-lot subdivision. According to petitioners, the city violated ORS 197.830(5) because the change from a 42-lot subdivision to a 45-lot subdivision occurred after the appeal from the planning commission and that fact was not provided in the notice for the city council hearing.[1]

Even assuming petitioners are correct that the notice was inadequate, the remedy under ORS 197.830(5) is a tolling of the usual 21-day deadline for appealing final limited land use decisions to LUBA. There is no issue regarding the timeliness of petitioners' appeal. ORS 197.830(5) does not provide a basis for reversal or remand, and petitioners do not provide any other authority for reversal or remand for inadequate notice.

The second assignment of error is denied.

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[1] ORS 197.830(5) provides:

> "If a local government makes a limited land use decision which is different from the proposal described in the notice to such a degree that the notice of the proposed action did not reasonably describe the local government's final actions, a person adversely affected by the decision may appeal the decision to the board under this section:
>
> "(a) Within 21 days of actual notice where notice is required; or
>
> "(b) Within 21 days of the date a person knew or should have known of the decision where no notice is required."

THIRD ASSIGNMENT OF ERROR

Petitioners argue that that the city's findings are inadequate because the city organized the findings into general categories and failed to specifically address individual approval criteria. Although petitioners reference in this assignment of error their later challenges to findings of compliance with individual approval criteria under separate assignments of error, an allegation of improper organization of the findings is not in itself an independent basis for reversal or remand.

The third assignment or error is denied.

FOURTH ASSIGNMENT OF ERROR

The applicant filed applications for both Conceptual Development Plan (CDP) and Detailed Development Plan (DDP) approvals. Corvallis Land Development Code (LDC) 2.5.50.01.a.3 requires the applicant to provide as part of DDP application "[ty]pical elevations of buildings and structures (which may be submitted on additional sheets) sufficient to indicate the architectural intent and character of the proposed development[.]" Under LDC 2.5.50.04, a DDP is deemed to conform to the CDP provided the DDP complies with the review standards for CDP approval, at LDC 2.5.40.04.

LDC 2.5.40.04 requires that a CDP must be consistent with the city's comprehensive plan.[2] Corvallis Comprehensive Plan (CCP) 4.6.7(G) requires in relevant part that development "demonstrate a concern" for views from and to the hillside. CCP 9.2.5

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[2] LDC 2.5.40.04 provides in relevant part:

> "Requests for approval of a Conceptual Development Plan shall be reviewed to assure consistency with the purposes of this chapter, policies and density requirements of the Comprehensive Plan, and any other applicable policies and standards adopted by the City Council. In addition, the following compatibility factors shall be considered:
>
> "* * * * *
>
> "Visual elements (scale, structural design and form, materials, and so forth)
>
> " * * * * *"

requires development to "reflect neighborhood characteristics." CCP 9.2.5 provides that "[d]evelopment shall reflect neighborhood characteristics appropriate to the site and area," and CCP 9.2.1 provides that land use decisions "protect and maintain" these neighborhood characteristics.

In their fourth assignment of error, petitioners argue that the city's findings regarding the applications' compliance with visual compatibility and neighborhood characteristics compatibility criteria found in the CCP are not supported by substantial evidence because the applicant was required to but did not provide a graphic of typical elevations for the proposed houses. Absent that graphic, petitioners argue, the city could not find that the development complies with code and comprehensive plan visual and neighborhood compatibility requirements. Petitioners also argue that the city's findings regarding visual and neighborhood compatibility are inadequate because the findings rely in part on the applicant's agreement to comply with inapplicable 2006 LDC provisions. We address each argument in turn.

In supplemental findings adopted by the city council, the city found in relevant part:

> "The Council notes that the application does not propose typical building elevations, floor plans, or building footprints to demonstrate compliance with the neighborhood characteristics outlined in CCP 9.2.5. The Council notes that the absence of typical building elevations, floor plans, and building footprints was raised as a concern by the Planning Commission and in public testimony. The Council notes that * * * construction of homes on the site will be subject to development standards in the 2006 LDC. * * * Council notes that LDC 4.10 provides a menu of Code permitted design options that development will be required to adhere to. * * *
>
> "The Council finds that the proposed site design responds to the prevalent site characteristics noted above, and to the desired neighborhood characteristics specified in CCP 9.2.5 * * * Given these findings, * * * the City Council finds that the * * * development is compatible with the housing types in the surrounding neighborhood, including one and two-story detached single family housing to the north, south and west.
>
> "The City Council notes that concerns were raised through public testimony that building heights would be excessive and would negatively impact views from and of the hillside of the proposed development. Council notes that the

> application does not seek to vary from LDC standards for building heights. The City Council notes that nearly 90% of the trees on the site will be preserved, most in open space tracts.
>
> "The City Council finds that building to permitted heights of the underlying low density residential zone will not result in negative impacts and will protect views from the hill to the maximum extent practicable given the desire to locate development outside of tree groves. The Council finds that the preservation of the majority of the site's trees, and the installation of the street trees will buffer views of development when looking at the site from points off the subject site." Record 29-30.

The city does not dispute that the required typical building elevation drawings are intended to help demonstrate compliance with the criteria at LDC 2.5.40.04, including consistency with the cited CCP policies regarding neighborhood characteristics. However, the city relies in large part on the applicant's agreement to demonstrate, in a future review proceeding, compliance with Section 4.10 of the 2006 LDC standards governing design to conclude that the development complies with LDC 2.5.40.04, including the requirements for compatible visual elements and compatibility with neighborhood characteristics. *See* n 4, *infra*. As we explain below in our discussion of the fifth assignment of error, the city's reliance on the applicant's agreement to comply in the future with inapplicable 2006 LDC design standards is insufficient to show that the development currently meets the applicable code and comprehensive plan requirements regarding compatibility with neighborhood characteristics.

The city's remaining findings do not demonstrate a basis to conclude that the proposed development complies with the code and plan compatibility requirements, in the absence of the required typical building elevations. On remand, the city must either require submission of the typical building elevations, or in their absence identify a sufficient evidentiary basis to conclude that the development complies with applicable criteria. *See Save Oregon's Cape Kiwanda v. Tillamook Cty.*, 177 Or App 347, 362, 34 P3d 745 (2001) (failure to submit required application materials may be a basis to remand a permit approval

if the record as a whole does not contain information sufficient to support a finding of compliance with applicable approval criteria).

The fourth assignment of error is sustained.

FIFTH ASSIGNMENT OF ERROR

Petitioners argue that the city misapplied the applicable criteria relevant to hillside development and that the findings addressing those criteria are inadequate and not supported by substantial evidence. The applicant submitted two possible grading and excavation plans before the planning commission. The planning commission found neither plan was adequate to demonstrate compliance with CCP 4.6.7.[3] After filing its local appeal with the city council, the applicant submitted a revised grading plan that staff again recommended denying for failure to comply with CCP 4.6.7. The city council approved the revised grading plan

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[3] CCP 4.6.7 provides:

> "In areas where development is permitted, standards in the Land Development Code for hillside areas will achieve the following:
>
> "A. Plan development to fit the topography, soil, geology, and hydrology of hillsides and to ensure hillside stability both during and after development.
>
> "B. Preserve the most visually significant slopes and ridgelines in their natural state by utilizing techniques such as cluster development and reduced densities.
>
> "C. Preserve significant natural features such as tree groves, woodlands, the tree-meadow interface, and specimen trees.
>
> "D. Align the built surface infrastructure, such as roads and waterways, with the natural contours of terrain and minimize cutting and filling in developments.
>
> "E. Minimize soil disturbances and the removal of native vegetation and avoid these activities during winter months unless impacts can be mitigated.
>
> "F. Design developments and utilize construction techniques that minimize erosion and surface water runoff.
>
> "G. Demonstrate a concern for the view of the hills as well as the view from the hills.
>
> "H. Provide landscaping that enhances the identified open space resources.
>
> "I. Design developments that consider landscaping management that will minimize the threat of fire on improved property spreading to wildland habitat."

with conditions, in particular, condition 27. We address each of petitioners' subassignments of error in turn.

A. Whether City Applied the Correct Standard

Petitioners argue that the city applied the wrong standard to evaluate whether the revised grading plan complied with the applicable CCP provisions. According to petitioners, the city council found that the revised plan was acceptable because it minimized cuts and fills "compared to the plans submitted to the Planning Commission." Record 35.

If that were the only finding made by the city council, we would agree with petitioners that the city failed to apply the correct approval criteria, the CCP policies. As petitioners recognize, however, the city also adopted other findings explaining why it believed the applicable CCP provisions were satisfied. Petitioners state that those findings are conclusory and not supported by substantial evidence and challenge them in a separate subassignment of error. We address those findings in turn. The city's finding regarding the difference between the revised and original plans is surplusage, however, and does not provide an independent basis for reversal or remand.

This subassignment of error is denied.

B. Adequacy of Condition 27

The 2006 LDC hillside development standards are not applicable to the challenged decision. Rather, CCP 4.6.7 is applicable.[4] After the planning commission denied the application for noncompliance with CCP policies including CCP 4.6.7, the applicant proposed what became condition 27, requiring the lots to be developed in accordance with

[4] The 2006 version of the LDC was adopted to implement the policies of the 1998 CCP, but the challenged decision was deemed complete before the 2006 LDC went into effect. Thus the 2006 LDC is not directly applicable. The city explains that the 1998 CCP is applicable to the challenged decision, and that CCP anticipated that there would be a period of time between the effective date of the CCP and the effective date of the 2006 LDC where the CCP policies to be implemented by the 2006 LDC would be directly applicable.

2006 LDC Chapter 4.5 – Natural Hazards and Hillside Development Provisions and 2006 LDC Chapter 4.10 – Pedestrian Oriented Design Standards. Record 21. The city council accepted that condition, and based on the condition and a future demonstration of compliance with the 2006 LDC hillside development standards found that the proposed grading plan complies with applicable criteria, including CCP 4.6.7.

According to petitioners, the city cannot demonstrate that CCP 4.6.7 is satisfied by imposing a condition that the 2006 LDC hillside provisions will be complied with in the future, for two reasons. First, petitioners argue, that condition amounts to an unlawful deferral of a finding of compliance with an applicable approval criterion under *Rhyne v. Multnomah County*, 23 Or LUBA 442 (1992). Second, petitioners argue, even if such a condition did not amount to an unlawful deferral of a finding of compliance with an applicable approval criterion, the revised grading plan does not and cannot comply with the 2006 LDC hillside development standards.

We need not address the numerous challenges that petitioners raise regarding whether the application can satisfy all the requirements of the 2006 LDC hillside development provisions, because we agree with petitioners that the city's findings regarding whether the provisions of CCP 4.6.7 are satisfied are inadequate. First, the city's adopted findings do not address compliance with each of the provisions of CCP 4.6.7. Instead, the city appears to have concluded that compliance with the 2006 LDC hillside development provisions in a future review process will suffice to demonstrate compliance with CCP 4.6.7. However, even assuming that is the case, the city cannot defer such a demonstration of compliance with CCP 4.6.7 to a future review process that does not provide notice or opportunity for public participation. *Rhyne*, 23 Or LUBA at 447-48.[5] If the city is going to

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[5] In *Rhyne*, we stated:

> "Where the evidence presented during the first stage approval proceedings raises questions concerning whether a particular approval criterion is satisfied, a local government essentially

rely on compliance with the 2006 hillside development standards to demonstrate compliance with CCP 4.6.7, it must address those 2006 standards in a process that provides notice and opportunity for public participation.

Second, even if the city had addressed the 2006 hillside development standards in this proceeding or required that those standards be addressed as part of a review process that provides notice and opportunity for public participation, it is not clear why the city believes that compliance with the 2006 LDC will suffice to demonstrate compliance with CCP 4.6.7. The city states in its brief that the 2006 LDC hillside development provisions implement CCP 4.6.7. However, the findings do not state that position, and the relationship between the CCP policy and the 2006 code standards is not clear to us. Because the city's findings do not specifically address the CCP policies and do not explain how compliance with 2006 LDC hillside development standards is sufficient to demonstrate compliance with those policies, the city's findings are inadequate.

This subassignment of error is sustained.

C. DOGAMI or Department of Forestry Review

Petitioners argue that the city failed to comply with ORS 195.260(1)(b), which provides that a local government:

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has three options potentially available. First, it may find that although the evidence is conflicting, the evidence nevertheless is sufficient to support a finding that the standard is satisfied or that feasible solutions to identified problems exist, and impose conditions if necessary. Second, if the local government determines there is insufficient evidence to determine the feasibility of compliance with the standard, it could on that basis deny the application. Third, if the local government determines that there is insufficient evidence to determine the feasibility of compliance with the standard, instead of finding the standard is not met, it may defer a determination concerning compliance with the standard to the second stage. In selecting this third option, the local government is not finding all applicable approval standards are complied with, or that it is feasible to do so, as part of the first stage approval (as it does under the first option described above). Therefore, the local government must assure that the second stage approval process to which the decision making is deferred provides the statutorily required notice and hearing, even though the local code may not require such notice and hearing for second stage decisions in other circumstances. *Holland v. Lane County*, 16 Or LUBA 583, 596-97 (1988)." (footnotes omitted).

> "May require a geotechnical report and, if a report is required, shall provide for a coordinated review of the geotechnical report by the State Department of Geology and Mineral Industries [DOGAMI] or the State Forestry Department, as appropriate, before issuing a building permit for a site in a further review area."

Petitioners argue that the subject property is identified as having high landslide risks. According to petitioners, because the city required a geotechnical report and that report was not reviewed by DOGAMI, the city violated ORS 195.260(1)(b).

While it is true that the city required a geotechnical report and that DOGAMI did not review that report, petitioners do not contend and it does not appear to be the case that the subject property is a "site in a further review area." OAR 632-007-0010(1) provides the definition for a "further review area":

> "'Further review area' for the purpose of this division, means an area of land that may be subject to rapidly moving landslides as specifically mapped by [DOGAMI] for the purpose of implementing ORS 195.260(4)(a)."

While petitioners' experts testified that the subject property is in a high landslide risk area, there is no dispute that DOGAMI has not identified the subject property as a further review area pursuant to ORS 195.260. Because the subject property is not in a "further review area" the city was not required to have DOGAMI review the geotechnical report and the city did not violate ORS 195.260(1)(b).[6]

This subassignment of error is denied.

D. Whether Grading Will Exceed Eight Feet

In order to demonstrate compliance with CCP 4.6.7(D), the city found that the revised grading plan "will generally limit cuts and fills to eight feet." Record 36. Petitioners argue that that finding is not supported by substantial evidence. While petitioners appear to be correct, the city will need to adopt new findings on remand that either explain how the 2006

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[6] We also agree with the city that ORS 195.260(1)(b) applies to the issuance of building permits, not the issuance of land use permits. Because the challenged decision does not issue any building permits, it would not violate ORS 195.260 even if the statute were applicable.

LDC hillside grading standards implement each of the CCP 4.6.7 provisions or find compliance with each of the provisions of CCP 4.6.7. Because the city will have to adopt new findings, it would serve no purpose to address petitioners' substantial evidence challenge to the current findings.

We do not reach this subassignment of error.

The fifth assignment of error is sustained, in part.

SIXTH ASSIGNMENT OF ERROR

Petitioners argue that the city misapplied the criteria applicable to stormwater drainage and that the findings addressing those criteria are not supported by substantial evidence.

A. Whether the City Erred in Allowing Activities Within Natural Drainageways

The applicant's geotechnical report identified two potential "drainages" on the subject property – the east drainage and the west drainage. The city found that the east drainage met the LDC definition of natural drainageway and therefore certain restrictions apply to development in the drainageway. The city found that the west drainage did not meet the LDC definition of natural drainageway and thus development in that area was not subject to the same restrictions. Petitioners first argue that the city erred in determining that the west drainage was not a natural drainageway.

The city responds that this issue is waived under ORS 197.763(1) and 197.835(3) because the issue was not raised below with sufficient specificity for the city to address the issue. Petitioners respond that there were substantial discussions regarding development in drainageways and that the city itself specifically raised the issue of whether the west drainage was a natural drainageway. We have reviewed the record citations provided by petitioners regarding where they argue they raised the issue below. While petitioners are correct that the issue of development in drainageways was discussed, we see nothing indicating that the issue of whether the west drainage met the definition of a natural drainageway under the LDC was

ever raised. We have also reviewed the record citation where petitioners argue the city raised the issue. In the staff report to the planning commission, staff discusses the applicable criteria and explains why the east drainage is a natural drainageway and why the west drainage is not a natural drainageway. The staff report does not consider alternative points of view or conflicting evidence in making the determination that the west drainage is not a natural drainageway. As far as we are directed, the only position taken by the applicant, staff, or opponents below was that the west drainageway was not a natural drainageway. That is not sufficient to raise the issue below. The issue is waived.

Petitioners also argue that the city misapplied LDC 4.5.110(b), which prohibits most activities in drainageways and wetlands, and LDC 4.5.120, which requires mitigation for disturbances to drainageways and wetlands. The city allowed crossings to be constructed in drainageways when the drainageways must be crossed to allow appropriate development of the property. The city interpreted the LDC to allow such crossings when necessary despite the restrictions of LDC 4.5.110(b), as long as mitigation occurred pursuant to LDC 4.5.120. While we are inclined to agree with the city's interpretation, we also agree with the city that the issue was not raised below with sufficient specificity to preserve the issue at LUBA. ORS 19.763(1); ORS 197.835(3).

This subassignment of error is denied.

B. Compliance With Drainage Criteria

Petitioners argue that the city's findings of compliance with CCP 4.11.12 are inadequate and are not supported by substantial evidence. CCP 4.11.12 provides:

> "Development upslope of wetlands shall minimize interference with water patterns discharging to wetlands, and shall minimize detrimental changes in water quality for waters discharging to wetlands."

According to petitioners, due to the steep slopes on the subject property, drainage is especially important due to the potential for flooding on downslope properties. Because the applicant did not submit a drainage plan, petitioners argue there is no way to demonstrate

that CCP 4.11.12 is satisfied. The city relies on the supplemental findings at Record 42-44 and conditions of approval imposed regarding drainage, including conditions 8, 18, 19, and 20. In particular, condition 19 requires that the applicant submit engineered calculations demonstrating that the storm drainage facilities will match pre-and post-development flows.

The problems with the city's findings are similar to the problems identified by petitioners in the first and third assignments of error. While there are a page and a half of supplemental findings regarding drainage, it is difficult to tell which findings concern CCP 4.11.12. A greater problem is that the supplemental findings also repeatedly reference the "incorporated findings" in which the city attempted to incorporate the portions of staff reports and minutes that were favorable to the application. As we discussed in the first assignment of error, that purported incorporation was ineffective. Further, the city appears to have completely deferred consideration of proposed drainage plans and facilities to a subsequent review process that does not provide for notice or opportunity for public input. As we explained above in our resolution of the fifth assignment of error, such a deferral is inadequate to justify a finding of compliance with an applicable criterion.

Because the supplemental findings themselves do not adequately demonstrate that CCP 4.11.12 is satisfied, and the purportedly incorporated findings cannot bolster the city's determination, the city's finding that CCP 4.11.12 is satisfied is inadequate. This subassignment of error is sustained.

The sixth assignment of error is sustained, in part.

SEVENTH ASSIGNMENT OF ERROR

Petitioners argue that the city's findings regarding protection of environmentally significant resources, including upland prairie and habitat, tree preservation, wetlands, and pond turtles, are inadequate and not supported by substantial evidence.

A number of CCP policies cited by petitioners require that city minimize negative impacts on environmentally significant resources. As in the second subassignment of the

sixth assignment of error, the findings addressing these CCP policies lump numerous approval criteria together in a manner that makes it difficult to determine which findings are applicable to which approval criteria. An even greater problem is that the city relies on purportedly incorporated findings from staff reports and minutes. As discussed earlier, those purported incorporations were ineffective, and because the findings rely on those ineffective incorporations, the findings are inadequate.

The seventh assignment of error is sustained.

The city's decision is remanded.

CORVALLIS
ENHANCING COMMUNITY LIVABILITY

CITY COUNCIL
NOTICE OF DISPOSITION

ORDER: 2007-111

CASE: **Brooklane Heights Planned Development**
(PLD06-00018, SUB06-00006)

REQUEST: An appeal of a Planning Commission decision to deny a Conceptual and Detailed Development Plan and Tentative Subdivision Plat to create 42 residential lots and 4 common tracts on 25.88 acres of land zoned PD(RS-3.5) at the time the application was submitted. The site was zoned PD(RS-5) as part of a legislative action implementing the 2006 Corvallis LDC. As part of the Planned Development request, the applicant is requesting to vary from a number of Land Development Code standards, mostly related to street design. The Conceptual and Detailed Development Plan proposes to develop lots for the construction of custom built single family detached homes on approximately 14.9 acres of the subject site. The remaining approximately 10.98 acres are proposed to be set aside as open space tracts that also incorporate public utilities. The tracts are proposed to be maintained by a Homeowners Association.

APPLICANT/OWNER: Stephen Schaberg
2535 SW Whiteside Drive
Corvallis, Oregon 97333

LOCATION: The 25.88 acre site is located northwest of Brooklane Drive and north of Agate Avenue, east of Fairmont Drive, and south of Whiteside Drive. The site consists of one parcel which is identified on Benton County Assessor's Map 12-5-01 C as Tax Lot 1000.

The City Council held a duly-advertised *de novo* public hearing on the appeal on August 20, 2007. The hearing was closed, and the City Council deliberated and reached a decision on the appeal on September 4, 2007. After consideration of all the testimony and evidence, the City Council voted to reverse the Planning Commission's decision to deny the request, and approved the Conceptual and Detailed Development Plan and Tentative Subdivision Plat requests, with conditions.

If you wish to appeal these decisions, an appeal must be filed with the State Land Use Board of Appeals within 21 days from the date of the decision.

The proposal, staff report, hearing minutes, memoranda to City Council, and findings and conclusions may be reviewed at the Community Development Department, Planning Division, City Hall, 501 SW Madison Avenue.

Hal Brauner
Acting Mayor, City of Corvallis

Signed: September 17, 2007
Appeal Deadline: October 8, 2007

Expiration Date(s) (If Not Appealed): October 8, 2010
(Conceptual and Detailed Development Plan)

October 8, 2009
(Tentative Subdivision Plat)

If no appeal is filed by the appeal deadline, the Conceptual and Detailed Development Plan shall be valid for three years. If the applicant has not begun construction of the development or its phases within this period, the approval shall expire on October 8, 2010. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to two additional years if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

If no appeal is filed by the appeal deadline, the Tentative Subdivision Plat shall be valid for two years. If the applicant has not submitted a final subdivision plat within two years (with appropriate assurances for improvements, if applicable), the approval shall expire on October 8, 2009. At its discretion, and without a public hearing, the Planning Commission may extend the approval one time for up to one additional year if it finds that conditions have not changed. If an extension is desired, the applicant is required to file a written request for the extension with the City's Planning Division prior to the expiration date.

Attachments: Conditions of Approval and City Council Adopted Formal Findings

Conditions of Approval
Brooklane Heights (PLD06-00018, SUB06-00006)

The page numbers in the table below reference pages where discussion relating to the Condition of Approvals occur in the May 25, 2007, Staff Report to the Planning Commission (Attachment VIII of the August 10, 2007, Staff Memorandum to Council).

Page No.	Condition No.	Condition Language
All	**1**	**Consistency with Plans** – Development shall comply with the narrative and plans identified in or referenced in **Attachment IX** of the August 10, 2007, Memorandum to the City Council from Community Development Director, Ken Gibb, except as modified by the conditions below or unless a requested modification otherwise meets the criteria for a Planned Development Modification and/or a Tentative Plat Modification. Such changes may be processed in accordance with Chapters 2.4 and 2.5 of the Land Development Code.
20	**2**	**Secondary Access** - Per LDC section 4.0.70.c.3, development of lots shall be limited to Lot 1, and 18 additional lots on a street segment not to exceed 600 feet, or 150 feet beyond an emergency turn-around until secondary access, as proposed, is achieved. If development occurs on the 600 foot street segment, prior to development of secondary access, the street terminus shall be constructed with turn-arounds to accommodate emergency vehicles. The turn-around area shall comply with applicable Oregon Uniform Fire Codes, or as specified by the Corvallis Fire Marshall.
23	**3**	**Landscaping Construction and Maintenance** – The following landscaping provisions shall apply to overall development of the site: Landscape Construction Documents – Prior to issuance of PIPC permits, the applicant shall submit to the Community Development Director, a Detailed Landscape Plan for this site that contains a specific planting plan (including correct plant names in the Latin format), construction plans, irrigation plans, details, and specifications for all required landscaped areas on the site in sufficient detail to show the

Page No.	Condition No.	Condition Language
		relationship between required landscaping and public utilities, franchise utilities, driveways, and other streetscape elements such as light poles, signs and mailboxes. Where conflicts arise between landscaping and streetscape elements and public facilities, flexibility in the location of trees may be permitted. However, a reduction in the number of required streets trees shall not be permitted unless modified through a Planned Development Modification approval. Plantings shall comply with LDC Section 4.2 and other conditions of this approval. Required street trees shall have at least a 1½-inch trunk diameter at the time of installation and shall be chosen from the list of species provided in LDC Section 4.2.60, or as approved by the Community Development Director. The plans must have been reviewed and approved prior to installation of landscape materials. The landscape plans shall address the following additional requirements: <u>Landscape Installation and Maintenance</u> – Street trees and ground cover in planter strips in Brooklane Drive shall be installed with PIPC improvements, except for street trees adjacent to Lot 1. Street trees and ground cover in planter strips fronting Lot 1 shall be installed prior to issuance of Final Inspection for Lot 1. Street trees and ground cover in planter strips in other proposed local streets shall be installed on lot frontages as individual lots are developed, and shall be installed prior to Final Inspection for homes on the associated lot. Street trees on Wolverine Drive northeast of lot 13 shall be installed prior to Final Inspection for lot 45. The locations of all required trees will be shown on all site plans submitted for public improvement design. A maintenance plan for all plantings shall be provided prior to the City's on-site approval of the landscape installation. This plan shall provide measures to assure all new plantings attain the minimum 90 percent ground cover

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		required by LDC Section 4.2.20 within three years from the date of installation approval. Security for Landscape Installation and Maintenance – Prior to the approval of the landscaping plan, a Performance Bond (or other LDC-approved financial security) will be provided to the City to secure installation of all required landscaping along new local streets and within Tracts. Prior to Final Plat approval, A 3-year maintenance Bond (or other LDC-approved financial security) shall be provided to the City to cover 50 percent of the costs for landscape materials and labor (plus costs for administration) associated with landscaping installed along all new local streets and Tracts. Home Owners' Association Landscape Maintenance Responsibilities – After completion of the required three-year maintenance period, the Home Owners' Association created for this subdivision will be responsible for the perpetual maintenance of any landscaping and management of wooded areas within in Tracts. Prior to final plat approval, the applicant shall submit for approval by the Community Development Director, the Home Owners' Association's Codes, Covenants and Restrictions (CC&Rs) and or bylaws. The Homeowners' Association's CC&R's or bylaws shall include all language from this Condition of Approval.
30	**4**	**Erosion Control** - Prior to issuance of excavation and grading permits, the applicant shall obtain erosion control permits. Where required by Development Services staff, the applicant shall install an erosion control and re-vegetation product capable of functioning on a 2:1 slope, that will result in 90% vegetation coverage within 3 years, without using irrigation.
35	**5**	**Tree Preservation and Planting** – Prior to issuance of any permits, the applicant shall submit a report by a certified arborist that identifies all significant trees proposed to be removed in this application, including those identified in the arborist report submitted with the subject application (**Attachments S** and **R.55** of the May 25, 2007, staff report

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		to the Planning Commission) and trees impacted by construction of the pedestrian path between Badger Place and Wolverine Drive, and trees impacted by construction of the stormwater swale in the north portion of the site, and trees potentially impacted by construction and use of the detention ponds in Tracts B and C. Regarding the pedestrian path, stormwater swale, and ponds, the arborist's report shall detail methods to preserve as many significant trees as possible in or adjacent to these site components. The applicant shall follow tree preservation methods outlined by the arborist. Unless already approved for removal, (any) significant trees may be removed only if a certified arborist recommends removal and the City Forester concurs with the arborist's recommendation. The arborist's report shall also illustrate all trees approved/proposed to be preserved. To ensure protection of trees, there shall be no cutting, filling, trenching, nor compaction of the soil under tree canopies and to a minimum distance of 5 feet outside the canopy's dripline, consistent with Section 4.2.20.c of the Land Development Code. To assure this protection, a minimum 5-foot high construction fence (constructed of metal chain link, and supported by metal posts sunk into the ground) shall be installed 5 feet outside the canopy's dripline for all trees to be preserved, prior to any excavation and grading of the development site. An exception may occur upon inspection and a recommendation by a certified arborist. Existing trees, including trees on adjacent properties with driplines within 10 feet of the subject site, and construction protection fences shall be illustrated on all site plans submitted for excavation, erosion control, PIPC, and building permits. Tree protection plans shall be submitted to the City for review and approval, and tree preservation fencing shall be installed and inspected, prior to issuance of any excavation and grading, erosion control, PIPC, or building permits.

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42	6	**Wetland Determination** - Prior to issuance of PIPC permits, the applicant shall submit a wetland determination report indicating the presence of wetlands. If wetlands are found to be present on the site, prior to issuance of excavation and grading permits, the applicant shall submit documentation from the Department of State Lands verifying that the site development and wetland mitigation plans comply with all applicable local, state, and federal wetland regulations.
46	7	**Archaeological Resources** - Prior to issuance of excavation and grading permits, the applicant shall have the site surveyed by a State Historic Preservation Office (SHPO) qualified archaeologist to determine the presence of archaeological resources on the site, in addition to those identified as site 35-BE-67. The archaeologist shall submit findings and recommendations regarding site development to the applicant/developer, Corvallis Development Services Division, and SHPO for review. The applicant shall comply with all State and Federal regulations pertaining to archaeological, cultural, and historic materials. Prior to issuance of grading and excavation permits and any earth disturbing activities the applicant shall submit a letter from the SHPO verifying that the proposed development complies with applicable State and Federal regulations relative to archaeological, cultural, and historic materials. During construction of the site, the applicant shall continue to comply with applicable regulations.
50, 61	8	**Public Improvement Plans** - Any plans for public improvements referenced within the application or this staff report shall not be considered final engineered public improvement plans. Prior to issuance of any structural or site utility construction permits, the applicant shall obtain approval of, and permits for, engineered plans for public improvements from the City's Engineering Division. The applicant shall submit necessary engineered plans and studies for public utility and transportation systems to ensure that adequate street, water, sewer, storm drainage and street lighting improvements are provided. Final utility alignments (including locations for detention facilities) that maximize separation from adjacent utilities and street trees

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		shall be engineered with the plans for public improvements in accordance with all applicable LDC criteria and City, DEQ and Oregon Health Division requirements for utility separations Public improvement plan submittals will be reviewed and approved by the City Engineer under the procedures outlined in Land Development Code Section 4.0.90. **Note:** Land Development Code Section 4.0.70 has been amended to establish street lights as public utilities. Under the revised Code Section, developers shall provide an engineered design for street light installation; obtain appropriate electrical permits from the Development Services Division; and install the street light system concurrent with public improvements.
50, 51	**9**	**Right-of-Way Dedication** - As part of Phase I, additional ROW shall be dedicated along SW Brooklane Drive in order to achieve the minimum half street standard width of 33 ft from the original ROW centerline. Also as part of Phase I, 50 ft of ROW shall be dedicated in Tract D to allow the proposed Oakmont Addition to construct Hawkeye Avenue between the Oakmont Addition subdivision and SW Brooklane Drive. In addition, an environmental assessment for all land to be dedicated must be completed in accordance with LDC Section 4.0.110.h.
55	**10**	**Frontage Improvements** - At the time of development, curbside sidewalk shall be installed along the north side of SW Brooklane Drive between SW Agate Avenue and the private alley located along the northwest portion of Brooklane Park Estates. The sidewalk will connect to existing sidewalk located at SW Agate Avenue to the west. Curb cuts will be provided on both sides of SW Brooklane Drive just west of the private alley described above. New and existing curb cuts shall be constructed or re-constructed to meet current ADA standards.
52	**11**	**Public Improvements** - Prior to Final Plat approval the applicant shall construct or secure all public improvements within the subject site.

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51	12	**Vision Clearance** - The City's Off-Street Parking and Access Standards require a vision clearance triangle be maintained between an elevation of 2 feet and 8 feet above the roadway height for all intersecting streets. The legs of the vision clearance triangle shall be determined from table 3 of the City of Corvallis Off-Street Parking and Access Standards. Site plans showing an unobstructed vision clearance triangle as outlined shall be submitted concurrent with application for public improvement permits.
52	13	**Construction Traffic Plan** - Prior to issuance of excavation and grading permits, the applicant shall prepare a detailed construction traffic plan that outlines proposed hours of operation, route maps, and direction of travel for loaded and empty trucks. This plan shall prohibit construction traffic from using Local Streets as classified in the 1996 Corvallis Transportation Plan. Additionally, construction traffic on the new section of SW Brooklane Drive shall be limited to vehicles of less than 12,000 lbs loaded weight. The construction traffic plan shall be submitted to the City of Corvallis, Development Review for review and approval.
56	14	**Public Sidewalk/Landscape Strip Improvements** - At the time of development, park strips and setback sidewalks shall be constructed adjacent to Tracts A, B, and C. All other park strips and setback sidewalks will be constructed when individual lots are developed as specified in the LDC 4.0.40.a.3.b.
57	15	**Transit Improvements** - The applicant shall place a bus shelter easement and provide a flat, graded pad, adjacent to the Brooklane Drive ROW. The location should be selected in cooperation with City of Corvallis, Transportation Division.
59	16	**Looped Waterline** - City standards are to loop all waterlines to eliminate dead-end runs. The waterline in Buckeye Place shall be looped. When the waterline leaves the ROW, it shall installed in an utility easement. A 15 ft utility easement will be required with a single utility, and a

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		20 ft utility easement will be required if two utilities run parallel to each other.
60	17	**Deed Restrictions for Pressure Reducing Valves** - In order to ensure that future owners of lots 33 thru 36 are aware of the need to install pressure reducing valves (PRV), and as part of the building permit process, the developer shall record deed restrictions outlining this need against lots 33 thru 36 concurrent with the final plat. All costs related to PRV installation and maintenance shall be borne by the property owners.
43, 60, 62	18	**Public Drainage** - All public storm drainage facilities located outside of ROW shall be placed in public drainage easements. This includes pipes, water quality manholes, drainageways, swales, and detention ponds. The minimum required easement width is 15 ft for a single utility and 20 ft for two utilities, or, for drainageways, the 1.5X + 5 LDC 4.5.80 (d)(3) formula. The easement must fully encompass drainageways, swales, and detention ponds. All weather accesses must also be provided to the water detention facilities.
62	19	**Public Detention Facility Design & Maintenance Agreement** - The design of the storm water detention facilities shall incorporate all recommendations of the March 16, 2007, Geotechnical report that was conducted by Foundation Engineering, Inc. The geomembrane liner recommended in the Geotechnical report shall be placed on a slope of 3(h):1(v), or flatter and it shall be covered with at least 12 inches of soil. The detention pond shall remain in the same location and footprint as shown on the submitted Utility Plan. Any alteration to the placement of the pond and its associated structural features may require a Planned Development Modification. As part of the plans for public improvements the applicant shall provide engineered calculations for pre-development and post-development peak storm water run-off flows, and demonstrate that the storm drainage facilities are designed to match pre and post development flows based on the 2-

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		year, 5-year, and 10-year storm events. The detention facilities shall be designed consistent with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting detention requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The detention analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons. The design for the public detention facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the detention facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site. All detention facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for one year after build-out of all portions of the site that drain to the facilities. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington, Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the detention facilities are accepted by the City.

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62	20	**<u>Public Water Quality Facility Design & Maintenance</u>** - As part of the plans for public improvements the applicant shall provide engineered calculations for storm water quality facilities demonstrating compliance with both criteria outlined in Appendix F of the Storm Water Master Plan, and criteria outlined in the King County, Washington, Surface Water Design Manual. Infiltration facilities are a recommended means of meeting water quality requirements where soil and slope conditions (not more that 10%) permit the use of infiltration facilities and where the facilities will not have an adverse impact on the subject site or adjacent or downhill properties. The water quality analysis shall contain a discussion on the feasibility of implementing infiltration during both wet and dry seasons. All water quality facilities that are part of the public storm drainage system shall be dedicated to the public and shall be subject to a maintenance agreement requiring the developer to maintain the facilities for one year after build-out of all portions of the site that drain to the facilities. The maintenance agreement shall be executed prior to acceptance of public improvements and shall incorporate a maintenance plan and a maintenance bond. The maintenance plan shall be submitted as part of the plans for public improvements and shall be consistent with maintenance requirements for stormwater facilities identified in the King County, Washington Surface Water Design Manual. The maintenance bond shall be submitted with the maintenance agreement and shall reference the maintenance plan. The maintenance bond shall remain in effect until the water quality facilities are accepted by the City. The design for the public water quality facilities shall include a landscape plan that details all landscaping essential to ensure the proper function of the water quality facilities. This functional landscape plan shall be submitted as part of the plans for public improvements. All associated functional landscaping shall be installed and well established prior to any paving activity on the development site.

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	21	**Tree Protection on Private Lots** - Homes on lots 1, 2, 5, 13, 24, and 43 shall be designed to minimize impacts to trees. Prior to issuance of permits for excavation and grading for home construction, a minimum 5-foot high, metal, chain-link construction fence, supported by metal poles sunk into the ground, shall be installed 5-feet outside the tree canopy driplines. If an alteration proposed by a certified arborist is reviewed and approved by City staff, an exception to this fencing location standard may occur.
9 -14	22	**House Size Deed Restrictions** - Concurrent with final plat approval, the applicant shall record a deed restriction on lots 19-29 that restricts dwelling size to 1,200 square feet or less.
All	23	**Tentative Subdivision Plat and Grading Plans** - The approved Tentative Subdivision Plat shall be the revised Plat submitted with the July 5, 2007, appeal letter (Attachment I.6 of the August 10, 2007, Staff Memorandum to the City Council). The approved grading plan shall be the revised grading plan submitted with the July 5, 2007, appeal letter (Attachments I.7, 8 of the August 10, 2007, Staff Memorandum to the City Council).
19 - 51	24	**Cul-de-Sac Length** - As reflected in the revised Tentative Subdivision Plat submitted on July 5, 2007, the length of cul-de-sacs shall be limited to 600 feet.
53 - 56	25	**Trail Width** - The width of the paved portion of the pedestrian and bicycle trail between Badger Place and Wolverine Drive shall be 8 feet.
38- 45	26	**Off-Site Drainage** - Prior to final plat approval, the applicant shall develop a storm water drainage plan that ensures site surface drainage is captured in area drains before it crosses the Brooklane Park Estates alleyway. If new off-site area drains are required above the alleyway, the applicant will utilize the existing utility easements, which were specifically designed for storm drainage and sanitary sewer, and will construct such facilities to discourage storm water from crossing the alleyway.

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26-47	27	Lot Grading and Structures - All cuts and fills shown on the grading plan identified as Attachments I.7 and I.8 of the August 10, 2007, Staff Memorandum to the City Council shall be engineered and constructed such that retaining walls are not required. All lots shall be developed in accordance with Chapter 4.5 - Natural Hazards and Hillside Development Provisions and Chapter 4.10 - Pedestrian Oriented Design Standards from the December 31, 2006 Land Development Code.

DEVELOPMENT RELATED CONCERNS

A. **Mailbox Locations** - Mailbox locations shall be coordinated between the developer and the Post Office as part of the public improvements construction process.

B. **Excavation and Grading Plans** - Prior to issuance of any construction permits, the applicant shall submit an excavation and grading plan, including erosion control methods, to the City's Development Services Department for review and approval.

C. **Other Permits** - Prior to issuance of any construction permits, the applicant shall be required to obtain a National Pollutant Discharge Elimination System (NPDES) permit if construction activity will disturb, through clearing, grading, and/or excavation, one acre of the site. Additionally, any permits required by other agencies such as the Division of State Lands; Army Corps of Engineers; Railroads; County; or Oregon Department of Transportation, shall be approved and submitted to the City prior to issuance of any City permits.

D. **Infrastructure Cost Recovery** - Where it is determined that there will be Infrastructure Cost Recovery payments from past public improvements the developer shall pay their required share of the costs prior to receiving any building permits in accordance with Corvallis Municipal Code 2.18.040.

E. **Franchise Utility Plans** - Prior to issuance of public improvement permits, the applicant shall submit, as part of the public improvement plan set, an overall site utility plan that shows existing and proposed franchise utility locations, including vaults, poles, and pedestals. The proposed franchise utilities shall conform to

requirements outlined in Land Development Code Section 4.0.100 - Franchise Utility Installations, including provision of appropriate public utility easements.

F. **Streetscape Plan** - As part of the public improvement plans, the applicant shall include a "streetscape" plan that incorporates the following features: composite utility plan; street lights; proposed driveway locations; vision clearance triangles for each intersection; street striping and signing (in conformance with the MUTCD); and proposed street tree locations.

G. **Development Standards** - Construction of homes on the site will be subject to the development standards of the 2006 LDC, including, but not limited RS-5 Development Standards and development standards in Article IV, to, Chapter 4.10-Pedestrian Oriented Design Standards, Chapter 4.11-Minimum Assured Development Area, and Chapter 4.12-Significant Vegetation Provisions

H. **Spring** - Application materials reference a spring that is believed to be located in the East Drainage. Development on the site should be designed with consideration given to the spring and its potential impacts to future buildings and infrastructure.