URS

TECHNICAL MEMO
City of Wilsonville Stormwater Master Plan Update
Hydraulic and Hydrologic Modeling
(Including Discussion of Inventory)

Model Selection

Wilsonville city staff selected the InfoSWMM model for use in the hydrologic and hydraulic modeling of the stormwater system. This decision was made after URS conducted research on a number of models and the City evaluated their overall needs. InfoSWMM has a strong interface with GIS and provides flexibility to allow the user to readily change scenarios and rerun the model with new assumptions. InfoSWMM also has the capability to incorporate Low Impact Development (LID) projects, which is an important component of this Stormwater Master Plan update.

Another major factor that influenced the City's decision was their need to develop new models for the drinking water and wastewater systems and the desire by the City to use a unified platform for all three analyses. InfoSWMM has separate modules for all three system types: potable water, wastewater, and stormwater. Using the same model (although different modules) for all three applications would provide efficiency in training and communication between staff and technical support.

Hydraulic Model Development

Due to limited resources including budget and schedule, only the major components of the stormwater system were modeled. Modeling included pipes that are, in general, 15-inches in diameter and greater, although there were a few exceptions. In addition, as with most public stormwater systems, the locations and functions of existing facilities are not well documented, particularly older systems installed prior to current documentation and stormwater management requirements. Thus, modeling was limited to major systems including interceptors that provide for the primary drainage for each basin. Simplification of the modeled drainage system minimized overall model run time. The existing modeled system was presented, adjusted based on City staff comments, and approved, by the staff stakeholder team.

Hydraulic Parameters

The hydraulic portion of the InfoSWMM Model is primarily comprised of conduits, junctions, and storage nodes. The majority of the hydraulic input data was taken from the GIS data provided by the City, with remaining data gathered from as-built drawings, project design reports, as well as limited field reconnaissance, and staff input in order to qualify and create an updated, comprehensive system directory. The previous HYDRA Model was used to fill in data gaps, and provided additional information related to open channel geometry. URS conducted field work to verify the locations and configurations of select outfalls, culverts under roadways, and detention

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facilities configuration for existing conditions. Major culverts were field inspected and sizes and shapes verified for inclusion in the model, such as the Coffee Lake Creek crossing at Wilsonville Road. Surveying was not a part of the project. Input parameters required for each component of the hydraulic system are described below.

Conduits

Conduits connect all points within the hydraulic system (manholes, flow control devices, ponds, etc.) and transports water through the system. For the Wilsonville model, conduits were either pipes or open channels, and associated input parameters are as follows:

<u>Conduit Length</u>

Conduit length specifies the distance a conduit spans between two points.

<u>Manning's roughness coefficient (n)</u>

Manning's "n" values for conduits were based on pipe material, and taken from the GIS data supplied by the City. Typical values were used based on pipe materials:

n = 0.011 for PVC
n = 0.013 for RCP
n = 0.024 for CMP

Pipes with unknown materials were assigned the manning's "n" for concrete, 0.013. Open channels were assumed to have a Manning's "n" of 0.035, consistent with input from the previous HYDRA Model.

<u>Upstream and Downstream Invert Elevations (feet)</u>

Upstream and downstream invert elevations are inputted into the model, in order for the model to calculate the slope of the pipe.

<u>Cross-Sectional Geometry (feet)</u>

For round pipes, the pipe diameter is used. For arch-shaped conduits, both the width (feet) and height (feet) are specified. All open channels were assumed to be trapezoidal in shape with depths equal to the depth of upstream and downstream conduits, as was used in the existing HYDRA model.

Nodes

Nodes are used to describe points in the conveyance system. The three main types of nodes used in the InfoSWMM model are junctions, outfalls, and storage nodes. Junction nodes can receive runoff from a subbasin, or connect links in the system conveying flow. Outfall nodes can receive flow from a subbasin or a system link, and define the downstream boundary of the system. Storage nodes represent detention facilities, designed to collect runoff, store it, and release it at a slower rate. The discharge from the storage nodes is typically described by a stage-discharge curve provided by the City. In instances where this was not available, pipes and/or orifices were used to simulate the discharge at specific storm events. Input parameters associated with nodes are as follows:

Invert Elevation (feet)
Describes the inside bottom elevation of the node.

Rim Elevation (feet)
Describes the ground elevation at the node. Rim elevations were estimations based on 2-foot contours.

Ponded Area (square feet)
Describes the area around a node that is allowed to pond at the junction, and subsequently drain back into the junction. This parameter is only for junction nodes and was set at 20 square feet for all junctions.

Maximum Depth (feet)
Represents the distance from the ground surface to the invert elevation of a storage node. These values were derived from information provided by the City for the modeled storage nodes.

Storage Curves
Tabular storage curves, representing a depth vs. surface area relationship were used to define the available storage volume.

Hydrologic Model Development

For the hydrologic component of the modeling, subbasins were originally defined based on the City's 2001 Stormwater Master Plan. The subbasins were then checked against topography and updated in accordance with staff details and project as-built information. In some cases, storm system components installed for new development results in redirected drainage from natural or pre-developed runoff patterns and results in discharges into neighboring subbasins. One example is the development located east of SW Parkway Drive and north of SW Maxine Lane.

The model was initially developed using Curve Numbers as the method for modeling infiltration and runoff, similar to the method used by the former HYDRA model. A single curve number (CN) is assigned to each subbasin in accordance with a variety of subbasin characteristics including land use, and subsequent impervious area, soil types, and antecedent moisture conditions.

However, assigning a single value (a Curve Number) to account for a variety of runoff parameters resulted in broad generalizations and difficulties in calibrating the model. Model calibration was attempted by adjusting the CN, but in order to detect significant changes in flows and volumes, large increases to the CN value were required. The CN method did not appear to respond realistically to locally collected rainfall data during the initial calibration process. As a result, an alternative method, the Green Ampt method (described below), was used to estimate runoff and infiltration. This method appeared to produce more realistic results and was therefore used in lieu of the CN method for estimating infiltration of stormwater in the model. A 25-year storm event occurred on January 1, 2009, which provided a check on existing system conditions in comparison with anticipated modeling results. The rainfall event resulted in minor flooding in several low lying areas, such as Rose Lane and Montgomery Way, located near the Willamette River. Another area that flooded was near the Elligsen Road/I-5 interchange. Other than these localized issues, no significant flooding occurred in the City. Modeling results using the Green Ampt method better followed the observed trends, and thus was determined to be the better method for simulating infiltration and runoff of stormwater for the City.

Hydrologic Parameters

The hydrologic input data for the InfoSWMM Model was taken from the GIS data provided by the City, and information from the previous HYDRA Model. The HYDRA Model provided drainage configurations for more recent developments (i.e. Villebois).
The following user-defined hydrologic parameters were specified for each subbasin in the InfoSWMM model:

- Subbasin name or number
- Area of subbasin (acres)
- Width of subbasin (feet)
- Impervious percentage (percent)
- Average ground slope (%)
- Manning's roughness coefficient for impervious areas
- Manning's roughness coefficient for pervious areas
- Depression storage for impervious areas (inches)
- Depression storage for pervious areas (inches)
- Green-Ampt soil infiltration parameters: initial moisture deficit of soil, hydraulic conductivity of soil, and suction head at the wetting front.

A summary is provided below for each user-defined hydrologic parameter entered into the InfoSWMM model.

<u>Subbasin Name/Number</u>
Most subbasins were named in accordance with the Hydra Model. A few additional subbasins were created to simulate additional detention facilities provided by the City after meeting with the stakeholder team. These subbasins were name in accordance with the detention facility they drain to. Subbasins only simulated for the future conditions scenario have the prefix “Fut”.

<u>Subbasin Area (acres)</u>
Subbasins and their areas were originally defined based on the City's 2001 Stormwater Master Plan. The subbasins were then checked against topography and updated in accordance with staff details and project as-built information. In some cases, storm system components installed for new development results in redirected drainage from natural or pre-developed runoff patterns and results in discharges into neighboring subbasins; however, overall flows remained in the major basin. Areas expected to become annexed to the City were included in the future conditions model, using areas provided by the City.

<u>Subbasin Impervious Percentage (%)</u>

The City assigns a percent impervious to each land use type (Table 1). Using GIS, a weighted average of the percent impervious was calculated for each subbasin, reflective of the subbasin's overall land use. Existing condition land use coverage and associated percent impervious values were determined using the City's zoning map (as documented in the Comprehensive Plan) and recent aerial photos (City of Wilsonville 2007) to document undeveloped areas. City zoning was consolidated and classified into the land use categories shown in Table 1. Areas (based on the aerial photos) that were undeveloped were categorized as vacant land use. Future condition land use coverage and associated permit impervious values were calculated assuming the City was fully built-out. All vacant land use areas were redefined in accordance with the associated zoning for that area as documented in the Comprehensive Plan.

Table 1

Land Use Category	**Impervious %**
Agriculture	5
Industrial	85
Open Space	5
Vacant	5
Commercial	80
Commercial - Villebois	85
Residential	35
Residential - Villebois	60
Multi Family Residential	55
Multi Family Residential - Villebois	85

<u>Subbasin Slope</u>
The subbasin slope is the average slope along the pathway of overland flow to the inlet of the drainage system. The subbasin slope was developed based on the digital topographic data contained in GIS, averaged over each basin.

<u>Subbasin Width</u>
The subbasin width describes the geometry of the subbasin, and influences the shape of the runoff hydrograph. Basin width estimates for the model were based on the square root of the basin area for simplification.

<u>Manning's Roughness Coefficient for Impervious Area</u>
Manning's roughness coefficient (n) provides a measure of the friction resistance to flow across a surface or channel. The Manning's roughness coefficient for impervious surfaces used in the previous HYDRA model were used for the InfoSWMM Model, and set at 0.011 for all impervious surfaces.

<u>Manning's Roughness Coefficient for Pervious Area</u>
The Manning's "n" for pervious areas from the previous HYDRA model were used for the InfoSWMM Model, and set at 0.13 for all pervious surfaces.

<u>Depression Storage for Impervious Area</u>

The depression storage is the maximum surface storage provided by ponding, surface wetting, etc. that is filled prior to runoff occurring. The values used for the previous HYDRA model were used for the InfoSWMM Model, and set at 0.05 for all impervious areas.

Depression Storage for Pervious Area

The values for depression storage for pervious areas were set at 0.1 for all pervious areas, consistent with what was used for the previous HYDRA Model.

Green-Ampt Infiltration Parameters (units vary)

The Green Ampt method, was used to estimate runoff and infiltration. The Green Ampt method calculates infiltration of stormwater into soils, by taking into account antecedent moisture conditions, suction head, and hydraulic conductivity of the soil. The values of these three parameters were based on soil types in the City of Wilsonville. Specific soils types and their associated distribution within each watershed were determined using GIS files from the Natural Resources Conservation Service (NRCS). Using GIS, the area-weighted averages were calculated on a subbasin basis, using information in Table 2, and entered into the InfoSWMM model for each subbasin.

Table 2: Green-Ampt Infiltration Parameters by Soil Type

Soil Texture Class	Hydraulic Conductivity (in/hr)	Suction Head (in)	Initial Moisture Deficit (fraction)
Sand	4.74	1.93	0.413
Loamy Sand	1.18	2.4	0.39
Sandy Loam	0.43	4.33	0.368
Loam	0.13	3.5	0.347
Silt Loam	0.26	6.69	0.366
Sandy Clay Loam	0.06	8.66	0.262
Clay Loam	0.04	8.27	0.277
Silty Clay Loam	0.04	10.63	0.261
Sandy Clay	0.02	9.45	0.209
Silty Clay	0.02	11.42	0.228
Clay	0.01	12.6	0.21

Calibration of InfoSWMM Model

Information with which to calibrate the InfoSWMM model originated from three sources: (1) flow monitoring conducted by the City between February and May 2008; (2) locations identified by the City that have existing drainage and conveyance problems; and (3) anecdotal evidence of City flooding during different storm events.

Flow monitoring was conducted by the City on four outfalls: two outfalls adjacent to the Willamette River (one at SW Belknap Court and one at Tauchman Road); one outfall located at the Memorial Park detention pond on Wilsonville Road; and one at Ridder Road, in the northern part of the City. The outfall at Ridder Road has experienced continual build-up of gravel in the outfall due to beaver dam activity upstream. Attempts were made to calibrate flows to adjust for this additional gravel load. However, despite successful calibration of the flow meter, this site was not used due to the widely differing flow measurements from this site and the uncertainty of the accuracy of those flow measurements; therefore, model calibration was performed using data from the other three monitoring sites.

For the three remaining sites, flow data collected in March 2008 was used to calibrate the model, due to the frequency of rainfall events that occurred in that month. Rainfall data for specific storm events was run in the model, and calibration was conducted by comparing the resulting modeled flows with the actual monitored flows for the duration of the storm event. Although the flow monitoring project provided peak flows and volume, the model was not able to calibrate to both parameters. It was decided to calibrate to peak flows to assure adequate sizing of stormwater systems in the City, particularly for future conditions.

To collect storm-specific rainfall data for use in the calibration, nearby rain gages were evaluated to determine which one provides the most accurate data that matches City-specific rainfall information. Four gages total were evaluated: one in Portland, one in Aurora, and two in Washington County that are maintained by Clean Water Services. Rainfall data is also collected at the City of Wilsonville Wastewater Treatment Plant, but is only recorded on a daily basis, which provides limited detail on the variable intensity of a storm over a 24 hour period of time. In evaluating the four gages, it was determined that the Aurora rain gage collects hourly data, which also provides limited detail of the variability of intensity, while the Portland gage is not located in close proximity. The two Clean Water Services gages record rainfall in 15 minute intervals, which provides more detailed information regarding the variability in intensity over storm duration.   The Clean Water Services LTR gage was selected due its closer proximity to the City of Wilsonville than the other gage.

It should be noted that the accuracy of the runoff measurements by the flow meters is dependent on the site-specific rainfall that occurs. Generally rainfall volumes for specific storms are not consistent across the City and especially across a region. Using a non site-specific rainfall gage for model input will not result in modeled flows that are directly comparable with actual measured flows. Therefore, best professional judgment was used during the calibration effort.

Several hydrologic model parameters were adjusted in the calibration process in order to match peak flows in the model to peak flows in measured data. The parameters most likely to impact the peak flows are subbasin impervious percentages and the subbasin widths; therefore these parameters were chosen for the sensitivity analysis prior to adjusting each parameter in the calibration process. The sensitivity analysis determined which parameters to use for calibration of the model.   The impervious percentages were adjusted in the model first. Modeled peak flows changed significantly with varying changes to the impervious percentages while varying basin widths provided very little changes to peak flows.

The best match for peak modeled flow rate and peak observed flow rate occurred with a 25% increase of the modeled impervious percentage value. Basin widths were then adjusted to determine appropriate subbasin-specific adjustments. This parameter was not found to be as sensitive as imperviousness. None of the runs with varying basin width provided better calibration than the initial values estimated for the model, and therefore, calibration of the model was based solely on a 25% increase in the impervious percentage of each subbasin. Some of the subbasins already had high impervious values; thus increasing the impervious percentage by 25% resulted in impervious percentages greater than 100%. Therefore, the maximum impervious percentage was set at 95%, in order to reflect installation of landscape features and minor pervious areas in the City. Due to the sensitivity of impervious percentage as a calibration parameter, it is recommended that the City update the land use-based average impervious percentages to actual impervious percentages by subbasin from the LIDAR data collection currently underway. The model should be recalibrated following updating GIS input data with actual impervious areas.

For calibration of the model, March 13-16 was selected as the calibration period, due to the peak rainfall measured during those days. Calibration focused on matching the general shape of the modeled and observed runoff hydrographs, as well as matching a few of the peaks, particularly the highest peaks recorded. See attached figures.

Model Runs

The calibrated model was run for existing and future development conditions for the following storm events and 24-hour cumulative rainfall:

Table 3: 24-Hour Design Storms for the City of Wilsonville

Storm Event	Rainfall
2-year	2.50 inches
5-year	3.10 inches
10-year	3.45 inches
25-year	3.90 inches
50-year	4.25 inches
100-year	4.50 inches

An SCS Type IA rainfall distribution was used to define the intensity of rainfall for each storm event, in other words, how the rainfall is statistically distributed over a 24-hour period. The existing condition simulations were used to further compare the calibrated model results with City staff identified locations of existing condition flooding and drainage issues, to verify that the existing condition model is reflective of actual drainage patterns. The future condition simulations were used to identify potential flooding associated with future development and land use changes and strategic placement of CIPs.

LID

One of the priorities of this updated Stormwater Master Plan is to incorporate Low Impact Development (LID) techniques into the InfoSWMM model as potential CIPs. In order to simulate Low Impact Development implementation as a retrofit option across a subbasin, two implementation scenarios were developed. The first scenario assumes Low Impact Development implementation across 10 percent of the subbasin and the second assumes Low Impact Development implementation across 25 percent of the basin. These percentages were selected to evaluate the relative effectiveness of various magnitudes of Low Impact Development in a subbasin.

For the storage node method, to simulate these two scenarios in the model, the storage node was sized to hold the equivalent runoff volume for the water quality design storm from 10 percent and 25 percent of the total subbasin area. As described above, flows generated from storm events exceeding the water quality storm were sent to “overflow” into the stormwater conveyance system.

For the adjusting impervious area method, implementation of Low Impact Development in 10 percent and 25 percent of the subbasin area meant reducing the impervious area of the subbasin by 10 percent and 25 percent, respectively.

Recommendations

In order to improve upon the generated InfoSWMM model and allow the model to better reflect existing runoff patterns, recommendations for future data collection efforts are proposed. Due to the temporal nature of rainfall around the City, URS recommends installing two rain gages that record data at 15-minute intervals. One gage is proposed for installation near Elligsen Road and a second gage near Wilsonville Road, perhaps at the new City Hall.

It is also recommended that the City conduct further flow monitoring by installing permanent flow monitors in three locations in the City. The flow monitors should be placed in close proximity to rain gages for optimum accuracy. This will provide data for further validation of the model and allow the City to measure changes to stormwater runoff due to the implementation of stormwater CIPs and construction of LID projects.

As stated earlier, updating the model with LIDAR information on impervious areas will improve the accuracy of the model. Recalibration of the model should occur at that time.

TECHNICAL MEMO
City of Wilsonville Stormwater Master Plan Update
Hydraulic and Hydrologic Modeling Calibration

As requested by the City, URS calibrated the InfoSWMM model that was developed by URS for the City of Wilsonville Stormwater Master Plan Update. The purpose of this memo is to summarize the results of those calibration efforts. Calibration efforts relied on the use of existing flow monitoring data collected by URS, through a contract with the City, and the comparison of modeled and observed flows for a specific storm event. Flow monitoring was conducted by the City during the months of March through May, 2008, on four outfalls: two outfalls adjacent to the Willamette River (one at SW Belknap Court and one at Tauchman Road); one outfall located at the Memorial Park detention pond on Memorial Drive; and one at Ridder Road, in the northern part of the City. During the flow monitoring period, the outfall at Ridder Road experienced continual build-up of gravel due to upstream beaver dam activity. Attempts were made to calibrate flows to adjust for this additional depth of gravel in the pipe. However, despite successful calibration of the flow meter, flow monitoring results provided significantly differing flow measurements from this site, compared with the other three sites, raising concerns over the accuracy of those flow measurements. Therefore, due to the uncertainty of data from the flow monitor at Ridder Road, data from that site was not used for calibration, and the model calibration was performed using data from the other three monitoring sites.

Data from the remaining three flow monitoring sites was used for the InfoSWMM model calibration, specifically: conduits SD5219 (Library), SD6000 (Tauchman), and SD6601 (Belknap Court). The storm events on March 13, 2008 and March 15, 2008 were used for the calibration of the model because they showed the highest peak flows that occurred during the flow monitoring project (see Figures 1-3). Calibration was conducted by comparing the model-simulated flows at conduits SD5219, SD6000, and SD6601 with the respective actual monitored flows for those storm events. Although the model provided peak flows and volume for these storm events, URS was not able to calibrate to both parameters. It was decided to calibrate to peak flows to assure adequate sizing of stormwater systems in the City, particularly for future conditions.

Calibration focused on matching the general shape of the modeled and observed runoff hydrographs, as well as matching peak measured flows of two storm events. These two storm events, on March 13 and March 15, 2008, were chosen for calibration because they were the most consistent storms across the three sampling sites. Results of the modeled and observed flow comparison, prior to calibration, showed that observed flows were often higher than simulated flows (see Figures 4-6).

In an effort to prevent the model from underestimating flows, hydrologic input parameters in the model were adjusted to simulate flows that met or slightly exceeded measured flows. Several model runs were conducted to evaluate the model's sensitivity to changes in certain hydrologic input parameters, specifically basin width and percent impervious. Modeled peak flows changed significantly with varying changes to the impervious percentages while varying basin widths provided very little changes to peak flows. The hydrologic model adjustment that resulted in the best match of peak modeled flow rates and peak observed flow rates was a 25% increase in the modeled impervious percentage value. This adjustment was applied to all modeled subbasins for both existing and future condition simulations conducted for this Master Plan Update. Model results for the different combinations of calibration adjustments are shown on Table 1, and results for the 25% increase in impervious area (the best match) are shaded.

In summary, optimum calibration for the model resulted with a 25% increase in impervious area. This adjustment produced the minimum difference between modeled and observed flows for both storm events, while the other hydrologic input parameter adjustments evaluated tended to underpredict peak flows. To avoid oversizing CIPs, model results should be used for planning purposes only including planning level budgeting; a detailed hydrology and hydraulic study needs to be conducted during the design phase for the CIP(s).

Table 1 – Parameter Sensitivity Analysis and Calibration Results

Alternative Model Adjustments	Conduit	Simulated Flow (cfs)	Measured Flow (cfs)	Percent Difference
Storm Date: 3/13/2008				
	5219	9.909	11.663	-15%
	6000	3.875	4.586	-16%
No initial Changes	6601	1.333	1.461	-9%
	5219	11.996	11.663	3%
	6000	4.75	4.586	4%
25% increase Impervious %	6601	1.66	1.461	14%
	5219	7.864	11.663	-33%
	6000	2.964	4.586	-35%
25% Reduction Impervious %	6601	1.002	1.461	-31%
	5219	10.047	11.663	-14%
20% increase Impervious % &	6000	4.164	4.586	-9%
50% Reduction Subbasin Width	6601	1.544	1.461	6%
	5219	10.369	11.663	-11%
25% increase Impervious % &	6000	4.311	4.586	-6%
50% Reduction Subbasin Width	6601	1.603	1.461	10%
	5219	10.369	11.663	-11%
20% increase Impervious % &	6000	4.311	4.586	-6%
25% Reduction Subbasin Width	6601	1.603	1.461	10%
	5219	10.1	11.663	-13%
25% increase Impervious % &	6000	3.973	4.586	-13%
25% Increase Subbasin Width	6601	1.38	1.461	-6%

Alternative Model Adjustments	Conduit	Simulated Flow (cfs)	Measured Flow (cfs)	Percent Difference
Storm Date: 3/15/2008				
No initial Changes	5219	3.869	4.53	-15%
	6000	1.827	1.636	12%
	6601	0.83	0.879	-6%
25% increase Impervious %	5219	4.368	4.53	-4%
	6000	2.134	1.636	30%
	6601	0.999	0.879	14%
25% Reduction Impervious %	5219	3.301	4.53	-27%
	6000	1.469	1.636	-10%
	6601	0.642	0.879	-27%
20% increase Impervious % & 50% Reduction Subbasin Width	5219	3.14	4.53	-31%
	6000	1.489	1.636	-9%
	6601	0.795	0.879	-10%
25% increase Impervious % & 50% Reduction Subbasin Width	5219	3.203	4.53	-29%
	6000	1.523	1.636	-7%
	6601	0.816	0.879	-7%
20% increase Impervious % & 25% Reduction Subbasin Width	5219	3.203	4.53	-29%
	6000	1.523	1.636	-7%
	6601	0.816	0.879	-7%
25% increase Impervious % & 25% Increase Subbasin Width	5219	3.941	4.53	-13%
	6000	1.867	1.636	14%
	6601	0.828	0.879	-6%

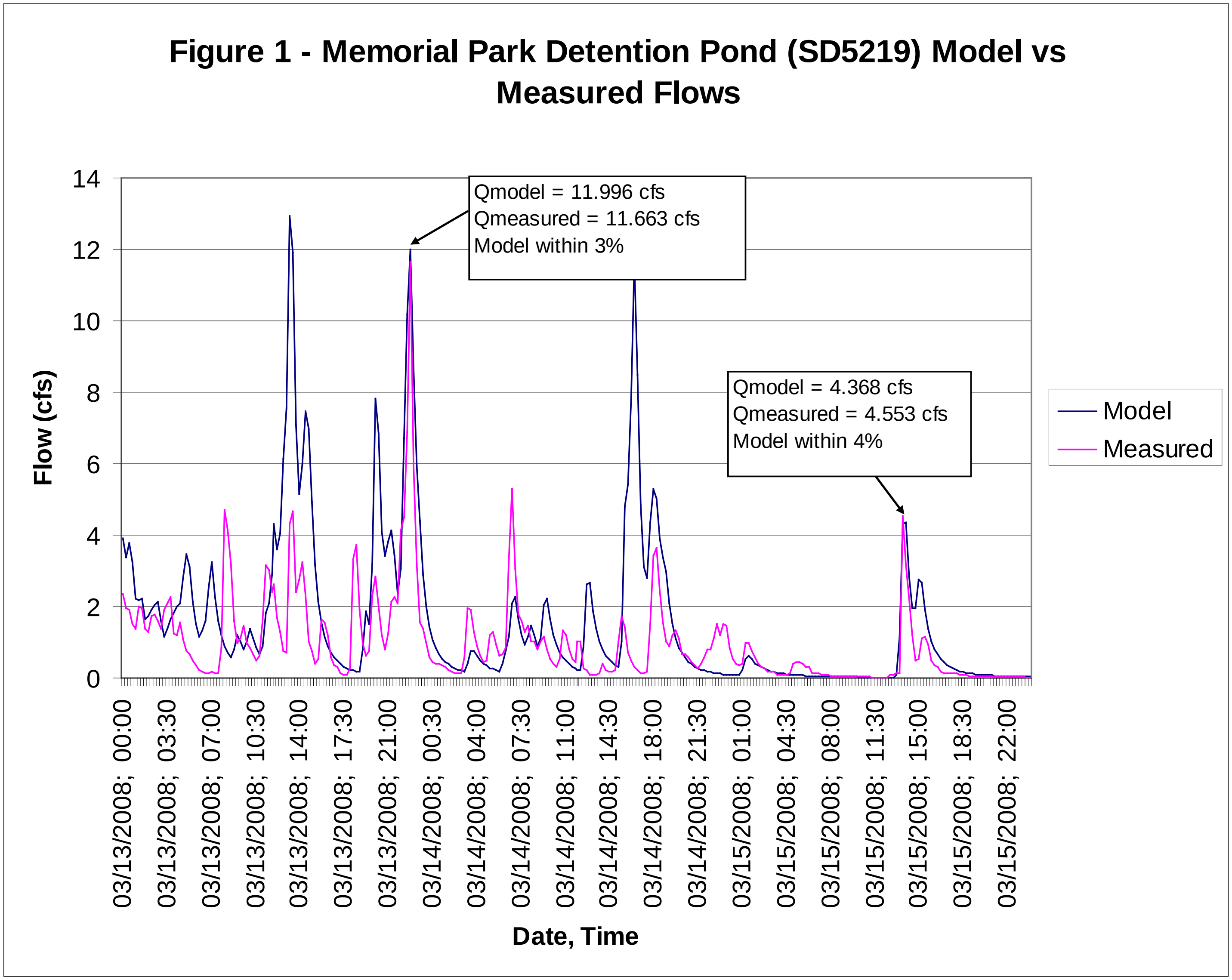

Figure 1 - Memorial Park Detention Pond (SD5219) Model vs Measured Flows
Qmodel = 11.996 cfs
Qmeasured = 11.663 cfs
Model within 3%
Qmodel = 4.368 cfs
Qmeasured = 4.553 cfs
Model within 4%
Model
Measured
Flow (cfs)
0
2
4
6
8
10
12
14
03/13/2008; 00:00
03/13/2008; 03:30
03/13/2008; 07:00
03/13/2008; 10:30
03/13/2008; 14:00
03/13/2008; 17:30
03/13/2008; 21:00
03/14/2008; 00:30
03/14/2008; 04:00
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03/14/2008; 14:30
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03/15/2008; 04:30
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03/15/2008; 22:00
Date, Time

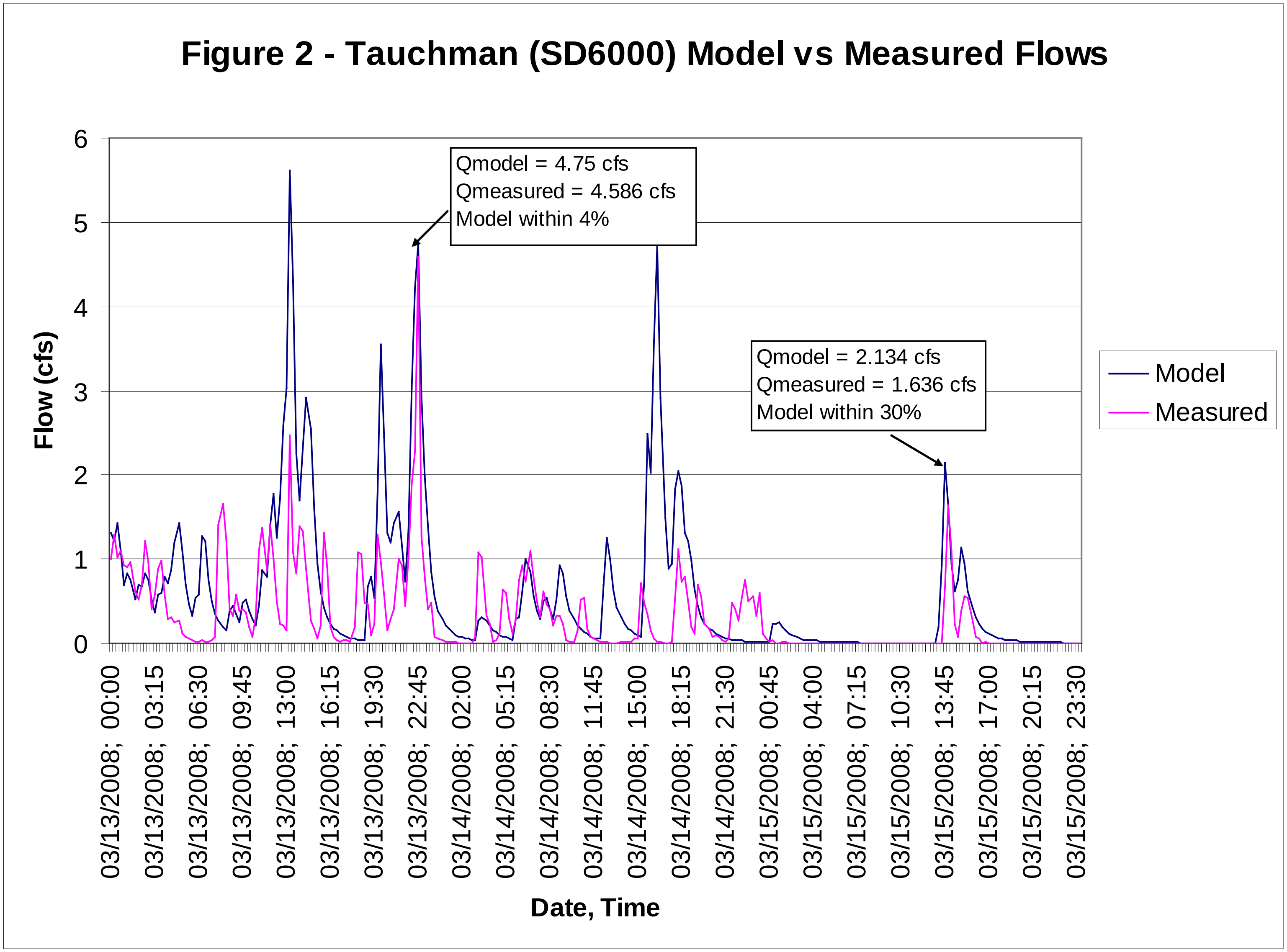
Figure 2 - Tauchman (SD6000) Model vs Measured Flows
Flow (cfs)
0
1
2
3
4
5
6
Qmodel = 4.75 cfs
Qmeasured = 4.586 cfs
Model within 4%
Qmodel = 2.134 cfs
Qmeasured = 1.636 cfs
Model within 30%
Model
Measured
03/13/2008; 00:00
03/13/2008; 03:15
03/13/2008; 06:30
03/13/2008; 09:45
03/13/2008; 13:00
03/13/2008; 16:15
03/13/2008; 19:30
03/13/2008; 22:45
03/14/2008; 02:00
03/14/2008; 05:15
03/14/2008; 08:30
03/14/2008; 11:45
03/14/2008; 15:00
03/14/2008; 18:15
03/14/2008; 21:30
03/15/2008; 00:45
03/15/2008; 04:00
03/15/2008; 07:15
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03/15/2008; 23:30
Date, Time

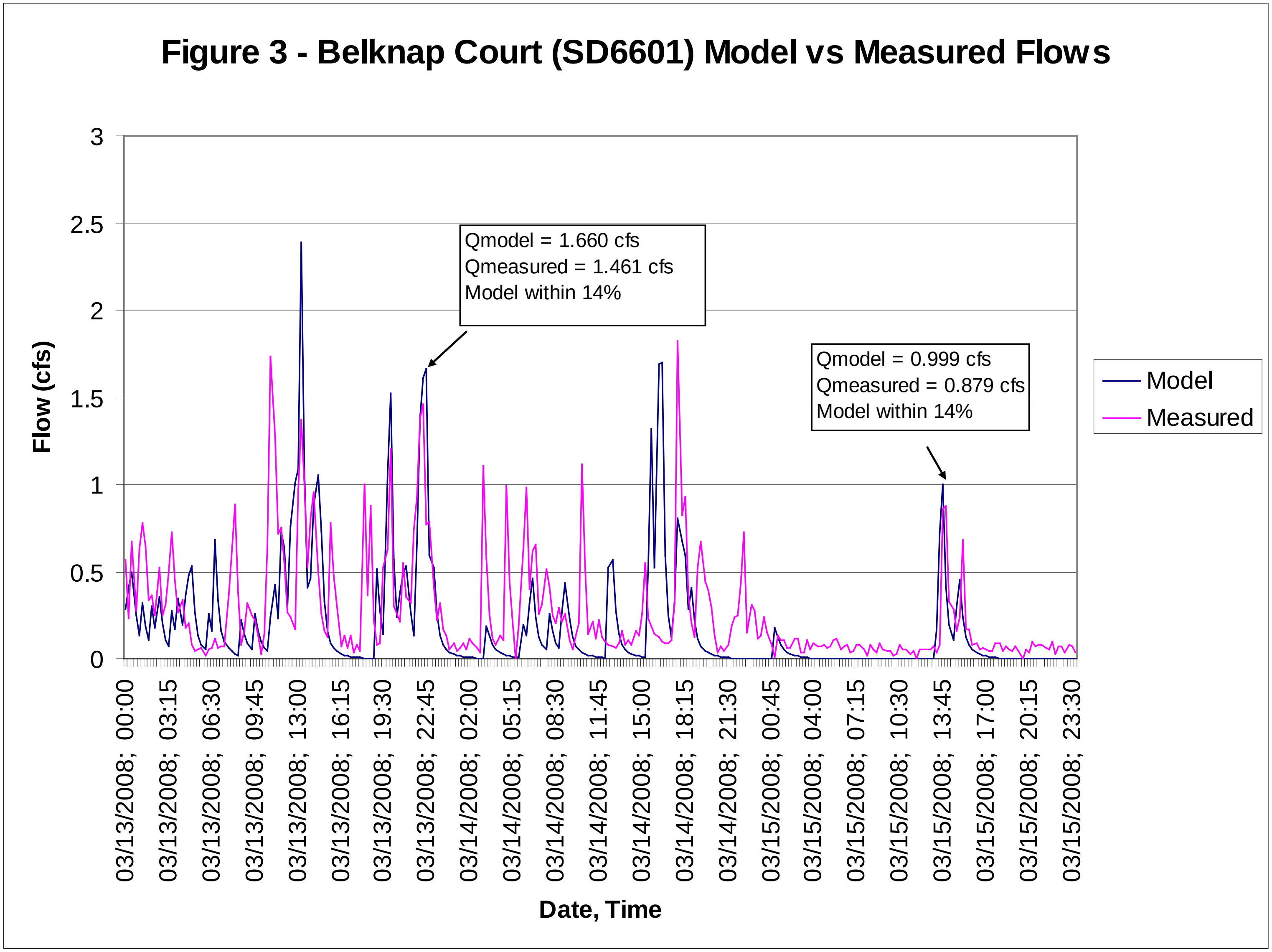


Figure 3 - Belknap Court (SD6601) Model vs Measured Flows
Qmodel = 1.660 cfs
Qmeasured = 1.461 cfs
Model within 14%
Qmodel = 0.999 cfs
Qmeasured = 0.879 cfs
Model within 14%
Model
Measured
Flow (cfs)
3
2.5
2
1.5
1
0.5
0
03/13/2008; 00:00
03/13/2008; 03:15
03/13/2008; 06:30
03/13/2008; 09:45
03/13/2008; 13:00
03/13/2008; 16:15
03/13/2008; 19:30
03/13/2008; 22:45
03/14/2008; 02:00
03/14/2008; 05:15
03/14/2008; 08:30
03/14/2008; 11:45
03/14/2008; 15:00
03/14/2008; 18:15
03/14/2008; 21:30
03/15/2008; 00:45
03/15/2008; 04:00
03/15/2008; 07:15
03/15/2008; 10:30
03/15/2008; 13:45
03/15/2008; 17:00
03/15/2008; 20:15
03/15/2008; 23:30
Date, Time

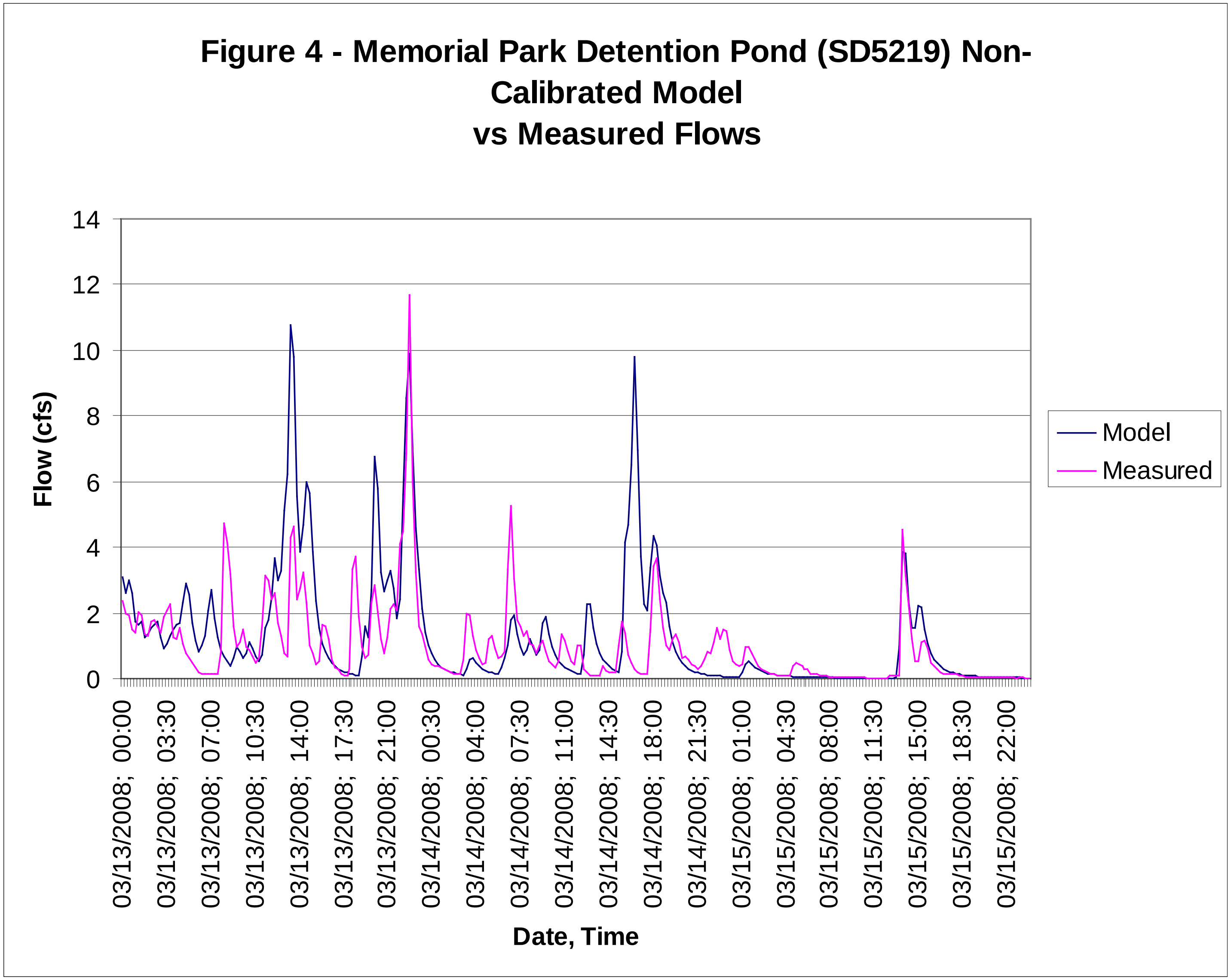
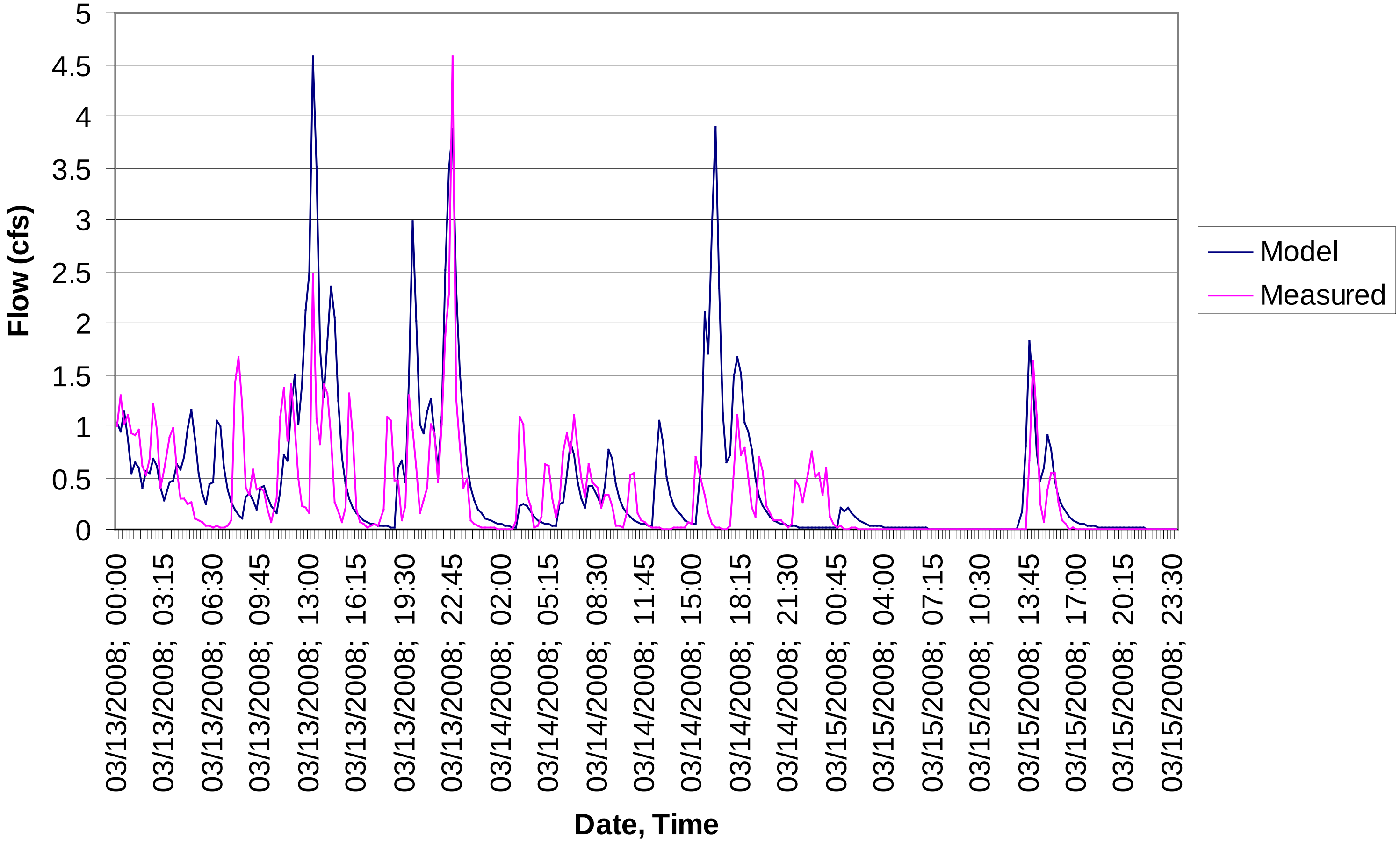


Figure 4 - Memorial Park Detention Pond (SD5219) Non-Calibrated Model
vs Measured Flows
Flow (cfs)
14
12
10
8
6
4
2
0
03/13/2008; 00:00
03/13/2008; 03:30
03/13/2008; 07:00
03/13/2008; 10:30
03/13/2008; 14:00
03/13/2008; 17:30
03/13/2008; 21:00
03/14/2008; 00:30
03/14/2008; 04:00
03/14/2008; 07:30
03/14/2008; 11:00
03/14/2008; 14:30
03/14/2008; 18:00
03/14/2008; 21:30
03/15/2008; 01:00
03/15/2008; 04:30
03/15/2008; 08:00
03/15/2008; 11:30
03/15/2008; 15:00
03/15/2008; 18:30
03/15/2008; 22:00
Date, Time
Model
Measured

Figure 5 - Tauchman (SD6000) Non-Calibrated Model vs Measured Flows



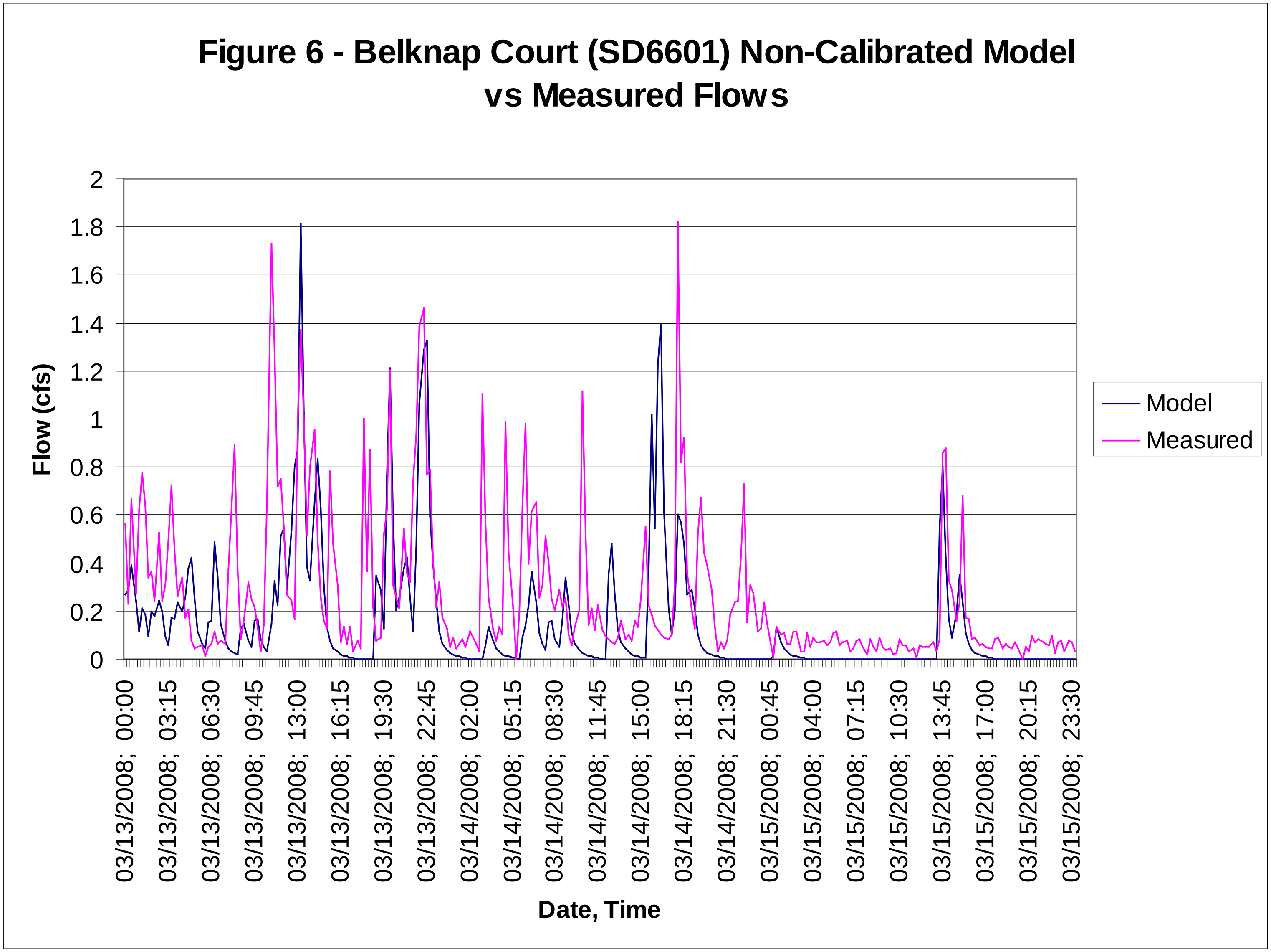


Figure 6 - Belknap Court (SD6601) Non-Calibrated Model
vs Measured Flows
Flow (cfs)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
03/13/2008; 00:00
03/13/2008; 03:15
03/13/2008; 06:30
03/13/2008; 09:45
03/13/2008; 13:00
03/13/2008; 16:15
03/13/2008; 19:30
03/13/2008; 22:45
03/14/2008; 02:00
03/14/2008; 05:15
03/14/2008; 08:30
03/14/2008; 11:45
03/14/2008; 15:00
03/14/2008; 18:15
03/14/2008; 21:30
03/15/2008; 00:45
03/15/2008; 04:00
03/15/2008; 07:15
03/15/2008; 10:30
03/15/2008; 13:45
03/15/2008; 17:00
03/15/2008; 20:15
03/15/2008; 23:30
Date, Time
Model
Measured

URS

City of Wilsonville Stormwater Master Plan Update
Technical Memo for Hydraulic and Hydrologic Model Results

Introduction

The InfoSWMM, a hydrologic, hydraulic, and water quality computer simulation model that is integrated with ArcGIS and used to simulate and predict conditions for existing and future land use to aid in effective management of urban stormwater and wastewater collection systems, was used to simulate hydrologic and hydraulic conditions of the City of Wilsonville's stormwater conveyance system for both existing and future conditions. The results of the model were used to identify locations of existing and future condition flooding and to identify appropriate CIPs to address both existing and future flooding problems.

Model Results & Analyses

As described in previous memos, the City's stormwater conveyance system was simplified for modeling purposes. Modeling was limited to pipes that are, in general, 15-inches in diameter and greater and to major systems including interceptors that provide for the primary drainage for each basin. Impervious area and drainage basin geometry are all approximations that simulate the City's stormwater system, but may not be an exact depiction of the existing system. The modeled system is meant to provide insight into the overall conditions and adequate function of the City's stormwater system under varying intensities of storms and build out of landuse. When analyzing the model results, this degree of accuracy was considered in order to better interpret model output.

In looking for existing and future flooding areas, results were reviewed for the 2-year, 10-year, and 25-year storm events. These results were reviewed, then used to predict areas of potential future flooding for identification and development of CIPs. The InfoSWMM model indicates flooding by identifying nodes, or points in the model connecting two different conduits, with a water surface elevation calculated above the rim elevation of that particular node. The volume of water above the rim elevation and the duration in which the water surface elevation is above the rim elevation is also provided. By identifying nodes that experience flooding, the conduits that are potential candidates for CIPs are also identified.

During existing and future conditions, there are several conduits that the model predicts to be undersized but do not result in the flooding of adjacent nodes. In other words, the pipes experience brief surcharge, but not sufficient enough to cause flooding in the upstream or downstream node. Given the model's degree of accuracy, these conduits were not considered a problem area since no flooding was expected.

In addition, some of the as-built information did not match the GIS topographic mapping that was used to supplement the model, indicating that rim elevations may not be accurate in some areas. Therefore, minor flooding predicted by the model was not considered a flooding problem, and no CIPs were generated for these locations.

Existing Conditions

Existing conditions were modeled in order to identify nodes where flooding has been observed. Conduits flooding during existing conditions were given highest priority when developing CIPs.

During the project modeling efforts, the City experienced a storm event on January 1, 2009, with a total of four inches of rain in 24 hours, equivalent to the City's defined 25-year, 24 hour storm. During this storm, the City did not experience much flooding. The existing condition model results for the 25-year storm were discussed with City staff and compared to field observations, in order to assess the accuracy of the model. It was determined that the model was relatively conservative in predicting areas of flooding and surcharging of pipes, and was possibly overestimating flooding conditions. This is not surprising, as impervious values throughout the City were increased by 25% for calibration purposes (see Technical Memo on Model Development). When quantifying the flooding in the areas predicted to flood that contradicted observations in the field, it was found that these areas were only predicted to flood by small amounts; approximately 0.10 acre-inch or less. Due to these observations, 0.10 acre-inch was determined to be the threshold, and nodes predicted by the model to flood by volumes less than 0.10 acre-inch were not considered problem areas.

General areas that are predicted by the model to experience flooding during existing conditions and that are confirmed by City staff observations are described below:

Commerce Circle – Commerce Circle is a business park development in the northwest area of the City. The stormwater conveyance system in this area is comprised of culverts and open channels of Basalt Creek, which were predicted to overtop its banks and flood nodes along the channel, to the northwest of the Commerce Circle business development. This area has been historically known to flood by the City, and parking lots in the development were designed to flood and provide detention storage. Therefore, some flooding is to be expected in this area. Additionally, the open channel has segments with a reverse slope, contributing to flooding predicted by the model and observed in the field. Flooding was observed in this area during the January 1, 2009 storm.

Coffee Lake Creek wetlands – The Coffee Lake Creek wetlands are a low, flat area adjacent to Coffee Lake Creek, in the western area of the City. As a designated wetland, this area is expected to flood. The flooding predicted by the model matches expectations and field observations made by City staff.

South Tributary Coffee Lake Creek – A segment of South Tributary Coffee Lake Creek, north of SW Barber Street, west of its crossing with SW Boberg Road is predicted to overtop its banks, causing flooding of upstream and downstream nodes at the 2-year, 24-hour design storm. Without field verification, it is unknown if the predicted flooding is due to the simplified geometry of the channel that was used for modeling purposes, or if a CIP (i.e., widening of the channel) would be necessary to adequately convey flows from contributing drainage areas.

SW Boberg Road north of SW Barber Street – The piped system predicted by the model to flood in this area are upstream from a section of South Tributary Coffee Lake Creek, just north of SW Barber Street. As described above, the model predicts the section of South Coffee Lake Creek, downstream of the pipe network along SW Boberg Road is not large enough to convey flows from high-frequency events, and likely the cause of the predicted flooding along SW Boberg Road.

Hillman Court and 95th Avenue – Flooding of nodes was identified along SW 95th Avenue, just north of SW Freeman Drive to SW Hillman Court. The stormwater system is a pipe network at this location, and a small 12” pipe downstream of larger pipes is assumed to be the main contribution to predicted flooding at this location. This is discussed further in the Capital Improvement Projects Technical Memo.

Charbonneau Community – The Charbonneau Community is aresidential development (approximately 40 years old) on the south side of the Willamette River. The flooding predicted by the model was generally concentrated in the northeast area of the development. The pipe network in this area is mainly comprised of CMP, and known by the City to be in need of repair and/or replacement for sometime, including upsizing of some pipes (see further discussion in Problem Areas Technical Memo). Some small areas of flooding were observed throughout the Charbonneau Community during the January 1, 2009 storm.

Future Conditions

Flooding locations predicted by the model under the future conditions were consistent with those identified for current conditions, although the volume of flooding was typically higher. General areas that are predicted by the model to experience flooding during future conditions are described below.

Commerce Circle – This area is also predicted to flood during existing conditions, as described above. During future conditions, an area north of Commerce Circle is expected to develop (part of which is within the City of Tualatin UGB), increasing flows to the conveyance system, and subsequently, the degree of flooding (both volume and frequency) in this area. Information on potential CIPs for this area is described in the Capital Improvement Projects Technical Memo.

Coffee Creek wetlands – This area is predicted to flood during existing conditions, although to a greater degree for the future conditions scenario. Since this is a wetland, this is consistent with expectations for this area.

South Tributary Coffee Lake Creek – The nature of flooding predicted in this area for future conditions is generally consistent with that predicted for existing conditions. The volume of flooding increased as a result of the future condition scenario, and additional nodes were predicted to flood sooner (i.e. at more frequent storm events) than was predicted for the existing conditions. As mentioned above, it is unknown if the predicted flooding is due to the simplified geometry of the channel that was used for modeling purposes.

SW Boberg Road north of SW Barber Street – Flooding predicted in this area is generally consistent with that predicted for existing conditions. The volume of flooding increased as a result of the future condition scenario, and additional nodes were predicted to flood at more frequent events. As mentioned above, flooding predicted in this area is likely due to conditions in South Tributary Coffee Lake Creek, downstream of the pipe network.

SW Barber Street – Some flooding of the piped stormwater system along SW Barber Street was predicted for the future condition scenario. A 42” pipe drains into a 36” pipe just prior to connecting to South Tributary Coffee Lake Creek, which likely contributes to the problem. A recommended project for addressing predicted flooding in this area is described in the Capital Improvement Projects Technical Memo.

Hillman Court and 95th Avenue – The flooding predicted in this area is consistent with that predicted for existing conditions, including the flooding frequency.

Charbonneau Development – This area is predicted to flood in some locations during existing conditions and described previously. The area is considered built-out and the extent of flooding for future conditions is predicted to be equal to that of existing conditions.

A comprehensive review of model results show that there are several additional conduits, not previously indicated with the existing condition model, that the model predicts to be undersized in the future conditions analysis, but do not result in flooding of adjacent nodes. Therefore, these conduits were not included as problem areas, as no surface flooding was expected as a result of the surcharge. It should also be noted that additional nodes were predicted to flood in future conditions as compared to the existing conditions; however, the majority of these nodes had volumes beneath the threshold of 0.1 acre-inch.

Findings

Results and analysis of the InfoSWMM model indicate there are no predicted, major existing or future condition flooding locations within the City. As listed above, there are a few locations under both the existing and future condition model that will be considered for development of CIPs, due to predicted flooding above the assigned threshold (i.e., 0.1 inch-acre of volume). CIPs will include a combination of detention systems and pipe upsizing to address existing and potential flooding.

The City of Wilsonville’s stormwater conveyance system also includes several open channels. The dimensions of these channels were approximated for the InfoSWMM model, consistent with the level of effort in the previous HYDRA Model. Constant changes in the channels, mostly due to erosion, suggest that these conveyances may be substantially different in the field than shown in the model. Several of the areas predicted to flood are at or adjacent to an open channel, such as SW Boberg Road, which is upstream of South Coffee Creek, and the drainage system near Commerce Circle, which is largely composed of a combination of culverts and open channels of Basalt Creek. In order to best understand flooding potential in these areas and to further refine the hydraulic model, surveying of open channels should be conducted and results of the survey used to update channel geometry inputs of the model.

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TECHNICAL MEMO
City of Wilsonville Stormwater Master Plan Update
Problem Areas

Introduction and Background Information

As part of the efforts to update the City of Wilsonville's Stormwater Master Plan, problem areas were identified around the City. Problem areas typically involved areas of flooding and evidence of significant erosion. Identifying problem areas helped to determine potential CIPs and to verify accuracy of the hydrologic and hydraulic model. Information on existing problem areas was generally provided by City staff and field observations. Mid-way during the project, the City experienced a 25-year storm on January 1, 2009, and observations were made during this event to identify additional problem areas.

Descriptions of Problem Areas

The following problem areas are identified on the attached map, by number (map not included at this time).

<u>P1. Commerce Circle Industrial Area</u>
Location: Day Road to Stafford Business Park
This area has poor drainage, and in turn, is prone to flooding. Coffee Lake Creek overtops its banks during moderate storm events, flooding the parking lot along the West side of the Commerce Circle Business Park. There are some segments of Coffee Lake Creek in this vicinity that have negative slopes, preventing flooding from occurring further downstream. The hydraulic model showed some flooding and overtopping of channel banks in the 2-year storm near Commerce Circle. Negative channel slopes along various sections along the channel at this location, are believed to contribute to the flooding in this area.

<u>P2. Agricultural Field East of Pheasant Ridge</u>
Location: East of Pheasant Ridge, North of Elligsen Road
Runoff from the agricultural field adds a significant amount of silt to Boeckman Creek. The problem is believed to be largely due to how close the field is plowed to the west and south edges of the road. The area is not currently within the city limits, and would benefit from collaboration with the Soil and Water Conservation District to address the issue.

<u>P3. Colvin Lane Ditch</u>
Location: Ditch South of Colvin Lane
The bank south of Colvin Lane shows evidence of scouring, likely due to a pipe installed in the creek channel by a private property owner. This pipe should be removed, and the drainage way should be vegetated to stabilize the steep slopes.

<u>P4. Corrugated Metal Pipes Under I-5</u>
Location: Various locations along Parkway Avenue and Boones Ferry Road
There are several pipes that cross under I-5 along Parkway Avenue and Boones Ferry Road made of corrugated metal. These pipes are at the end of their design life, and in need of replacement.

However, one pipe under I-5, north of Barber St., provides detention for upstream areas east of the freeway. If this pipe is replaced and upsized, the pipe would no longer offer detention and a new facility will need to be constructed to avoid downstream flooding.

P5. South Coffee Lake Creek at Boberg Road

Location: East of Boberg Road at South Coffee Lake Creek

There are currently (2) 42” parallel concrete culverts conveying South Coffee Lake Creek underneath Boberg Road. On the West side of Boberg Road, the two parallel culverts, and a 21” corrugated metal pipe from the north both discharge into Coffee Lake Creek. There is evidence of scouring at this location in South Coffee Lake Creek from heavy flows. At the inlet side of the parallel culverts, west of Boberg Road there is vegetation that appears to be impeding flows, causing erosion and scour behind the headwall of the culvert. The sides slopes of the channel are also excessively steep.

P6. Culvert at West End of Barber Street

Location: Culvert underneath Young property access gate, running north to south, at the west end of Barber Street

This culvert restricts flow. After the 25-year storm the City experienced on January 1, 2009, the ditch downstream of the culvert experienced severe scour, eroding a majority of the ditch banks, and subsequently flushing a large amount of sediment into the Creek.

P7. 18” Storm Drain Under I-5

Location: Underneath I-5 from Town Center Loop West to Boones Ferry Road

Drainage is poor in this area, and the condition of the pipe is uncertain.

P8. Outfall South of Les Schwab

Location: Just East of I-5 and North of Town Center Loop West

The outfall restricts discharges from neighboring properties to ODOT right-of-way, causing street flooding at Town Center Loop West during heavy rainstorms.

P9. Boeckman Creek Outfall West of Gesellschaft Water Well

Location: West of Gesellschaft Water Well northeast of the UGB

Extreme scouring has occurred in this drainage to Boeckman Creek. Previous attempts to control runoff include installation of asphalt aprons at two pipe outfall locations and the installation of gabions in three locations along the drainageway. Water has bypassed and undermined the gabion structures rendering them ineffective for energy dissipation. The Gesellschaft Water Well discharges water once a week to maintain freshness of the water as a backup supply source, increasing the flows into the drainage way.

P10. Undersized Culvert Under Montgomery Way

Location: Montgomery Way at culvert for a small creek in the Southeast portion of the City, north of the Willamette River.

The existing 30-inch CMP culvert is partially filled, reducing the capacity of an already undersized culvert, resulting in some flooding during heavy rainstorms. Residences north of the culvert have reported sheet flow flooding in the area.

P11. Culverts under Jobsey Lane at Arrowhead Creek
Location: Jobsey Lane South of Wilsonville Road
Existing culvert is damaged, inhibiting flow, and in need of replacement.

P12. Chantilly and Churchill Neighborhoods outlet to "Bubbler" Outfall
Location: Southwest corner of the City
These areas currently outlet to a bubbler outfall. Pipe could be daylighted to adjacent open area although there is no evidence of problematic erosion at the outfall.

P13. Charbonneau Pipe replacement
Location: Throughout Charbonneau Community
The conditions of the pipes making up the stormwater drainage system in the Charbonneau Community, South of the Willamette River are approximately 30 – 40 years old and in poor condition. Although no comprehensive list has been compiled, drainage issues have been identified throughout the community. The majority of the pipes in this area are corrugated metal material, in serious decay, and nearing the end of service life. Model results for the existing condition scenario suggest some pipes, especially those in the northern portion of the Community, are undersized. Additionally, catch basins within the development are currently spaced approximately 800 – 1000' apart, roughly twice the distance that would be required based on current design standards. The entire pipe network within the Charbonneau Community is in need of replacement with more durable pipe, and catch basins should be replaced according to current City standards.

P14. Wall Built Over Storm Drainage Pipes in Charbonneau Community
Location: Southern boundary of Charbonneau Community, west of French Prairie East Entrance
A wall has been built over the existing storm drain pipes along NE Miley Road in the Charbonneau Community. The wall is settling and breaking, most likely contributing to the degrading condition of the stormdrain pipes in this location. The wall also inhibits access to the existing pipe system in that area for maintenance and/or repair.

P15. Property northeast of I-5 at Elligsen Road
Location: Northeast of the I-5/Elligsen Road Interchange
During the 25-year storm on January 1, 2009, flooding was reported in the basement of the La Quinta Hotel. Possible contributing factors include a detention facility to the south of the Hotel in need of maintenance, or a high groundwater table. The 36" diameter pipe installed by ODOT designed to pass water from the La Quinta site underneath Elligsen Road appears to be in good condition. There are pumps in the hotel basement for removal of water, and this area is not considered a high priority.

P16. Rose Lane Culvert
Location: Rose Lane at Southeast corner of City
A 12" CMP culvert at Rose Lane is not large enough to adequately convey flows underneath Rose Lane. In addition, the roadway, and pipe, are lower in topography than upstream or downstream areas, causing water to collect and flood over the roadway until the water slowly infiltrates or evaporates. In addition to exploring the opportunities to rehabilitate wetlands on both sides of the roadway, the City can install a larger pipe and raise the roadway to alleviate some of the flooding.

If a larger pipe is installed, it could allow more flow to the downstream culvert at Montgomery Way (P10). Culvert improvements should be completed in an appropriate sequence, in order to prevent additional flooding at Montgomery Way.

P17. Outfalls in Boeckman Creek
Location: Boeckman Creek
A number of outfalls drain stormwater to steep slopes in Boeckman Creek with little or no energy dissipation at the outfall location and have caused serious erosion problems along the steep slopes adjacent to the creek. Rebuilding the last sections of the outfalls to redirect discharge to align with creek flow, adding vegetation and providing energy dissipation at the outfall will reduce the erosion that is currently occurring at these sites.

Conclusion:

With the exception of isolated problem areas, detailed previously, the City does not have serious flooding problems for existing land use. The largest pipe replacement project involves rebuilding Charbonneau, a large development south of the Willamette River. As the system deteriorates, more sediment and debris is entering the pipe, increasing the concern over the water quality of the runoff. Replacement of the stormdrains can also be tied into replacement of other utilities and upgrading the roadway. This would be a good opportunity to install LID facilities throughout the development enhancing water quality benefits for this project.

Outfalls into the steep canyons of Boeckman Creek and other steep slopes is also an increasing concern. With increasing upstream impervious areas, flows will increase with the potential to destabilize the steep canyon slopes. High priority projects have been identified as part of the Capital Improvement Program to address the rehabilitation of the outfalls while also reducing upstream flows. Policies have been identified to assist with implementation of LID projects and reducing upstream flows.

To: Kerry Rappold, City of Wilsonville

From: Angela Brown, URS and Ela Whelan, URS

Date: February 24, 2009

Subject: Water Quality Approach for City of Wilsonville

This technical memo provides background information on urban stormwater quality; background information on regulatory measures for stormwater quality specific for the City of Wilsonville; a summary of existing source control and structural controls for water quality implemented in the City of Wilsonville; and a discussion of current pollutant loadings analysis conducted for the City as part of their MS4 NPDES permit including anticipated pollutant removal effectiveness associated with typical structural controls for water quality implemented in the City.

In addition, with implementation of new structural controls for water quality associated with this Master Plan (i.e., development and installation of proposed water quality CIPs), this technical memo also describes how the existing pollutant loadings analysis can be used to prioritize locations of future water quality projects.

Background – General

The purpose of this section is to outline the general water quality problems that occur in urbanized environments, like the City of Wilsonville.

As urbanization occurs, changes in the quality and quantity of stormwater runoff adversely affect the health of receiving waters. Historically, stormwater management has primarily focused on drainage and flood control. Increased development or urbanization results in an increase in the quantity and peak flow rate of runoff. As a result, drainage system components are often undersized to manage the increased load. While urban area flooding problems have historically been addressed through capital improvements for stormwater conveyance, other adverse impacts associated with urbanization, specifically the degraded quality of stormwater runoff is also a concern.

Typical parameters of concern with respect to stormwater runoff and receiving surface waters include bacteria, heavy metals, oil & grease, sediments, nutrients and temperature. Recently, more attention is also being paid to toxics (such as pesticides) and chemicals\contaminants of emerging concern such as pharmaceuticals. These types of contaminants are currently receiving more attention from the regulators. The sources of these pollutants typically vary; some sources are anthropogenic in nature, while others are not directly attributed to human activities. Typical stormwater pollutants and pollutant sources are summarized in Table 1.

Table 1: Typical Problem Pollutants in Stormwater

Typical Stormwater Pollutant*	Description	Major Sources Potentially Associated with Stormwater Runoff	Potential In stream Water Quality Problem
Bacteria**	- E. Coli - Enterococcus, - Fecal coliform, and - Fecal streptococcus	- Animal Wastes (droppings from wild/domestic animals), - Human Wastes (leaking sanitary sewer pipes, and seepage from septic tanks as well as illicit discharges).	These are commonly used as indicators of human microbial pathogens. Water contact may cause eye and skin irritations and gastro-intestinal diseases if water is swallowed.
Heavy Metals	Antimony Arsenic Beryllium Cadmium Chromium Copper Lead Mercury Nickel Selenium Silver Thallium Zinc	- Vehicles (combustion of fossil fuels, improper disposal of car batteries, wear/tear of tires and brake pads), - Metal Corrosion (rain gutters, metal roofs, etc.), - Pigments for Paints, - Solder, - Moss killers, - Fungicides, - Pesticides, - Wood Preservatives	Heavy metals are <u>toxic</u> to aquatic ecosystems. These metals are considered to be the most significant toxic substances that are commonly found in urban stormwater runoff.
Oil & Grease	A broad group of pollutants including: - Animal fats, and - Petroleum products.	- Food Wastes (animal and vegetable fats from garbage), - Petroleum Products (gas, oils, lubricants, etc.).	These compounds can coat the surface of the water limiting oxygen exchange, clog fish gills, and cling to waterfowl feathers. When ingested these compounds can be toxic to birds, animals and other aquatic life.
Total Suspended Solids	Sediments in the water are considered to be pollutants when they exceed natural concentrations and adversely affect water quality and/or beneficial uses of the water.	- Erosion due to increased stream flows, - Construction site runoff, - Landscaping activities, - Agricultural activities, - Logging, - Other ground disturbing activities.	Sediments cause increased turbidity, reduced prey capture for sight feeding predators, clogging of gills/filters of fish and aquatic insects, reduced oxygen levels, and blocked light which limits food production available for fish. Sediments also accumulate in stream bottoms which reduces the capacity of the stream (and hence increases the potential for flooding) and covers stream bottom habitats. Sediment also acts as a carrier of toxic pollutants such as metals and organics.
Nutrients	- Nitrogen - Phosphorus	- Landscaping activities, - Yard debris, - Human wastes (leaks from septic tanks and sanitary sewers), - Animal wastes, - Vehicle exhausts, - Agricultural activities, - Detergents (car washing), - Food Processing	Excess levels of nutrients can lead to eutrophication in downstream receiving waters. Problems include surface algal scum, odors, reduced oxygen levels, and dense mats of algae. In addition to water quality problems, these effects have an adverse impact to the aesthetic quality of water bodies.
Organics	There are many organic compounds both natural and synthetic; however,	- Illegal dumping, - Illicit connections, - Spills,	Most synthetic organics are highly toxic to aquatic life at very low concentrations, and many are carcinogenic (cancer causing) or

Table 1: Typical Problem Pollutants in Stormwater

Typical Stormwater Pollutant*	Description	Major Sources Potentially Associated with Stormwater Runoff	Potential In stream Water Quality Problem
	the synthetic organics are of most concern and include pollutants from: - Fuels - Solvents - Pesticides - Herbicides.	- Leaks from drums and storage tanks, - Landscaping activities - Agricultural activities.	suspected carcinogens.
Litter and other Floatable Debris	- Plastics, - Paper products, - Yard debris, - Tires, - Metal, - Glass, - Appliances, - Old Electronics.	- Littering, - Dumping, - Spills.	These pollutants degrade the aesthetic quality of water bodies. In addition, they contribute pollutants as they decompose, and they can reduce the capacity of the water body. Excess yard debris contributes to high levels of nutrients and it reduces oxygen levels as it decomposes. Some discarded materials such as appliances, tires, and auto wreckage may contain toxic/ heavy metals such as mercury, cadmium and copper.

* Note: While elevated temperatures are a problem in many streams statewide, urban stormwater runoff has not been implicated as a source of this problem in the Willamette Valley. However, proposed capital improvement projects (CIPs) that are related to natural resource enhancement (i.e., wetland enhancement, riparian enhancement, and stream restoration) are proposed to help address instream temperature issues.

** Note: Several regional DNA tracking studies have shown that the largest portion of bacteria in streams is associated with birds and rodents which are not sources typically controlled by municipalities. The controllable sources (pet waste, cross-connections and failing septic systems) were shown to represent only a very small percentage of the problem.

Background – Regulatory Requirements for the City of Wilsonville

To address stormwater quality, the Oregon Department of Environmental Quality (ODEQ) has the responsibility of developing water quality standards and ensuring that the standards are met in order to protect beneficial uses of rivers, streams, lakes, and estuaries. To assist in regulation of these water quality standards, DEQ issues National Pollutant Discharge Elimination System (NPDES) permits for municipal separate storm sewer systems (MS4). A municipalities MS4 system is comprised of the stormwater conveyance system that discharges to surface waters.

The state monitors water quality and reviews available data and information to determine if instream water quality standards are being met and the surface waterbody is protected. Section 303(d) of the Federal Clean Water Act requires each state to develop a list of water bodies that do not meet the standards. The list serves as a guide for developing and implementing watershed pollution reduction plans to achieve water quality standards and protect beneficial uses. These watershed pollution reduction plans are referred to as total maximum daily loads or TMDLs. The City of Wilsonville's piped and open channel stormwater conveyance system includes major outfalls that discharge into one primary water body: the Willamette River. In 2006, the Willamette River TMDL was finalized, which addresses the parameters of temperature, bacteria, and mercury. Wasteload allocations are documented in the TMDL for each parameter with the exception of mercury, which is being addressed by DEQ in a phased approach. During the first phase, DEQ will collect monitoring data for mercury, and in the second phase, DEQ will establish wasteload allocations for mercury specific for the various point and non point source dischargers including the City of Wilsonville. The City must address TMDLs as part of their Stormwater Management Program (required under their NPDES MS4 permit, as described below) and TMDL Implementation Plans.

The City of Wilsonville is one of 13 co-permittees on the Clackamas County Phase I MS4 NPDES permit, which requires the City to implement a Stormwater Management Program to address various sources of stormwater pollution. As part of their Program, the City developed a Stormwater Management Plan (SWMP) which includes best management practices (BMPs) to address the four major components of their MS4 NPDES permit: structural and source control BMPs to reduce pollutants from commercial and residential areas; a program to detect and remove illicit discharges and improper disposal into the storm sewer system; a program to monitor and control pollutants from industrial facilities; and a program to reduce pollutants in stormwater discharges from construction sites. The City most recently updated their SWMP in 2008 as part of the MS4 NPDES permit renewal submittal (City of Wilsonville MS4 NPDES Permit Renewal, September 2008). Issuance of a new MS4 NPDES permit for the City is expected in 2009.

As summarized in the City's SWMP, a variety of source control and structural BMPs are implemented in order to reduce pollutant discharge associated with urban stormwater runoff to receiving surface waters. Details of both types of BMPs are described below.

Source Control Measures

As described above, the City's SWMP is comprised of a number of BMPs to address the four major components of their MS4 NPDES permit. Such BMPs outlined in the SWMP are generally considered source control BMPs, which are activities targeted at preventing the discharge of pollutants to the MS4 as opposed to a system that removes pollutants from the MS4. Stormwater pollutant control at the source is generally the most cost-effective type of pollution control. Source control BMPs, described in the City's SWMP, include public education activities, maintenance activities (i.e., catch basin cleaning, street sweeping, structural control facility maintenance), and programmatic activities targeted at pollutant removal through inspection, education, and response.

Although source controls are considered effective for the removal of stormwater pollutants, it is generally difficult to quantify the effectiveness due to the number of variables that influence the implementation of such measures. Effectiveness of source controls is difficult to quantify.

Structural Control Measures

As described in the City's SWMP (BMP # CD4), the City of Wilsonville requires stormwater quality and quantity structural controls on all development of new impervious area over 5,000 square feet. Structural controls are structural BMP facilities (extended detention ponds, wet ponds, constructed wetlands, bioswales, filters, sediment manholes) that directly remove pollutants from stormwater through a variety of unit processes including sedimentation, filtration, infiltration, and vegetated uptake. Effective structural controls generally utilize multiple removal unit processes. For example, low impact development practices such as rain gardens and pervious pavement promote reduced stormwater runoff volumes by utilizing infiltration while natural vegetation promotes filtration and vegetative uptake of pollutants.

The removal efficiency of structural controls can vary in accordance with design and sizing, maintenance, and influent stormwater characteristics. However, monitoring data is available for a variety of structural control systems, which allows for estimates of the overall system effectiveness to be quantified.

Pollutant Loads Analysis

In accordance with their 2008 Phase I MS4 NPDES permit renewal, the City of Wilsonville submitted benchmarks, or total pollutant load reduction estimates, for each parameter (pollutant) with an established TMDL and wasteload allocation (WLA). The calculation of benchmarks required the City to estimate pollutant load generation for the TMDL parameters using land use and drainage areas served by structural BMP (controls). As described previously, it is difficult to quantify the effectiveness of source control BMPs; therefore only structural controls were directly used in the analysis.

In an urbanized environment, the general characteristics of urban runoff may be attributed to the land use associated with the source of discharge. The Oregon Association of Clean Water Agencies funded a study in 1996 and created a report titled "Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990 to 1996" that was based on a series of statistical analyses of stormwater monitoring data collected by the Oregon Municipal Stormwater NPDES applicants and permitted agencies in the Willamette Valley. The report indicates that stormwater pollutant concentrations from different land uses are statistically different from each other, and as development occurs and changes to land use are observed (e.g., transition of open space or undeveloped land use to a developed land use), pollutants in the stormwater runoff generally increase. Results of this analysis were revisited by representatives from various Phase I jurisdictions in 2006 and again in 2008 in accordance with the Phase I permit renewal submittals in order to develop updated land use-based event mean concentrations for use in the benchmarking effort.

Representatives from various Phase I jurisdictions also reviewed structural BMP (controls) monitoring data in order to assess the effectiveness of various structural controls in terms of effluent concentration for use in the benchmarking effort.

Using the updated, land use-based event mean concentrations and the effluent concentrations of various structural controls, the City of Wilsonville used a spreadsheet model that utilizes the EPA simple method to calculate pollutant loads. The model calculates loads for a variety of pollutants based on the area information entered into the spreadsheet. Prior to running the model, the City of Wilsonville inventoried their existing land use coverage (including vacant areas) and existing structural controls and calculated the associated drainage areas in order to populate the model. Results of the inventory indicate that residential land use, followed by industrial land use, open space, and commercial land use are the most prevalent land use categories in the City. In addition, the City of Wilsonville also has a variety of existing structural controls including bioswales, extended detention ponds, wet retention ponds, and constructed wetlands that cover approximately 30% of the total City area. Pollutant loads and associated benchmarks are summarized in the City's permit renewal submittal (City of Wilsonville Permit Renewal Submittal, September 2008).

Projected Pollutant Load Reduction Potential

Review of the data used in preparation of the City's pollutant load calculations can provide insight into the loading potential of various land use categories and the effectiveness of various types of structural controls, based on the upstream land use and pollutant of concern.

Based on the land use event mean concentration data used in preparation of the City's pollutant load calculations, industrial land use generally shows the highest pollutant concentrations, and residential and open space (i.e., undeveloped) land use represent the lowest pollutant concentrations, although depending on the type of pollutant, this ranking could vary. Based on the BMP effluent data used in the preparation of the City's pollutant load calculations, structural controls that utilize infiltration in addition to other unit processes achieve the greatest pollutant removal because pollutant loads are reduced as a function of runoff volume reduction and pollutant removal capabilities. Therefore, low impact development techniques (porous pavement, rain gardens), followed by wetlands, bioswales, and ponds generally achieve the highest pollutant removal; however, pollutant removal due to structural controls is also a function of the land use (and contributing influent pollutant concentrations) and the type of pollutant itself. Thus, this ranking could vary.

As the relative effectiveness of certain types of structural controls can vary as a function of the contributing land use and the type of pollutant, Table 2 was developed as a tool for the City to use in order to determine what type of structural control may provide the most benefit in accordance with the contributing area land use and the pollutant of concern. This table was developed using the updated land use-based event mean concentrations and the effluent concentrations of various structural controls, consistent with the data used in the City's 2008 benchmarking effort, and the spreadsheet loads model. The spreadsheet model was run, assuming an arbitrary 50-acre area with constant land use coverage (either industrial, commercial, or residential); 40" of annual rainfall; and complete coverage of one type of structural control (bioswale, wetland, detention pond, green street, or filter) that is sized to treat 80% of the average annual runoff. Pollutant reduction is presented in terms of a total percent anticipated reduction.

Table 2: Effectiveness of Typical Structural Controls by Land Use and Pollutant of Concern (%)

	Bioswale				Constructed Wetland				Extended Detention Pond				Green Street (Raingarden and Pervious Pavement)				Filters (sand, compost)			
	TSS	**E Coli**	**TP**	**Total Zinc**	**TSS**	**E Coli**	**TP**	**Total Zinc**	**TSS**	**E Coli**	**TP**	**Total Zinc**	**TSS**	**E Coli**	**TP**	**Total Zinc**	**TSS**	**E Coli**	**TP**	**Total Zinc**
Industrial Land Use	73%	23%	56%	75%	69%	0%	55%	76%	66%	18%	38%	69%	80%	80%	80%	80%	61%	66%	56%	78%
Residential Land Use	59%	23%	45%	47%	50%	56%	43%	53%	40%	18%	20%	13%	80%	80%	80%	80%	28%	76%	45%	67%
Commercial Land Use	63%	23%	49%	62%	56%	48%	46%	64%	48%	19%	23%	36%	80%	80%	80%	80%	38%	75%	48%	74%

Note:

1) The source control is applied throughout the target drainage area.
2) TSS = total suspended solids; TP = total phosphorus

Planning for Future Structural Controls using Pollutant Load Reduction Projections

The calculation of pollutant load reduction estimates (benchmarks) is a permit requirement for the City of Wilsonville. In conjunction with the City's permit renewal submittal (180 days prior to permit expiration), pollutant loads reflecting current and future (5+ years) conditions will need to be calculated based on existing and projected land use coverage and structural control coverage. Continual update of the existing land use and structural control coverage will allow the City to more effectively meet future permit deadlines associated with the benchmarking effort.

As part of the City of Wilsonville Master Plan, additional structural controls in the form of capital improvement projects (CIPs) are proposed. As these CIPs are designed and constructed, drainage areas associated with the facilities can be added to the existing structural control coverage for incorporation into future benchmarking efforts. Figure 1 (not included with this memo) shows the existing land use and structural control coverage, in addition to the locations of proposed CIPs. As the CIPs are constructed and drainage areas added to the structural control coverage, additional pollutant load reduction associated with the increased area which is covered by structural controls will be reflected in future spreadsheet model simulations.

In Figure 1, locations of high pollutant generation potential are identified. These areas, called high source areas for purposes of pollutant load calculations, are represented by land use that tends to be relatively high in pollutant generation potential (i.e., industrial or commercial land use) and a lack of existing and projected (via the specific CIPs developed as part of this Master Plan) structural control coverage. This figure provides the City with areas where focused public education and partnership projects may be conducted. Selection and implementation of certain structural controls, using Table 2 as a guide, can result in significant pollutant load reductions in these areas. The high source areas may represent areas that the City wishes to focus the additional CIP funds (see CIP LID) for low impact development (LID activities); per Table 2, use of raingardens and pervious pavement (LID systems) result in the greatest projected pollutant load reduction for all assessed land use and pollutant categories.