4.0 MODEL METHODOLOGY

A stormwater model correlates interactions of natural events with natural and manmade systems. Because there are countless variables with broad ranges of reasonable values in each system, a well-coordinated and strategic data collection effort is required, along with practical assumptions and good judgment for data that cannot be feasibly obtained. This section outlines the model construction process, beginning with data collection to how key assumptions were incorporated to construct the model of the Grants Pass existing stormwater system.

The stormwater model consists of two components: a hydrologic model and a hydraulic model. The hydrologic model consists of drainage basins, or geographic areas that drain to a specific point, and a temporal distribution of storm events (hyetograph). Input parameters such as area, surface slope, width, soil infiltration, and percent impervious surface define each of these minor basins. Input parameters determine how much rainfall is converted to runoff, and when the runoff reaches the outlet point. The hydraulic model then routes the hydrologic model's runoff through the storm drain network of open channels, detention ponds, and pipelines.

Each component of the stormwater model requires numerous input parameters to adequately simulate the actual rainfall events and the resulting effects on the storm drain network. The parameters and input assumptions are explained and summarized in this chapter.

XPSWMM is the software modeling package utilized for modeling the City's stormwater collection system. XPSWMM was used for the 2007 master planning efforts and remains an appropriate choice for continuing the modeling and planning efforts. Phases 2 and 5 of this project updated the four XPSWMM models from version 9.10 to version 15.0 (or XPSWMM 2014 as it is commonly referenced).

The area within the Grants Pass urban growth boundary was delineated into six major drainage basins. These six major basins were further divided into minor basins to incorporate into the model. Major basins are shown in Figure 4 in Appendix A. Minor drainage basins are shown in Figures 6A-6D.

There are four unique models that correspond to one or two of the major drainage basins. Many parameters were updated based on more detailed information collected since the 2007 model was developed. These included survey data from irrigation canals, flow monitoring data, operating scenarios for Grants Pass Irrigation District (GPID) facilities, and the Redwood Drainage Study and associated 2D storm drainage computer model developed for Josephine County. The links updated with more available information by this master plan can be found in Figure 7 of Appendix A.

4.1 KEY ASSUMPTIONS

Due to the nature and uncertainty of stormwater, hundreds of assumptions and "what if" scenarios go into the creation of a stormwater master plan. The goal is to capture a storm significant enough to simulate flooding in the majority of situations. It is entirely possible that an actual 5-year storm event could flood the City, even though improvements are recommended for the textbook 25-year event.

4.1.1 Basins and Boundary Conditions

The following assumptions were made for basins and boundary conditions:

- For the purposes of this study, a 60 cfs GPID inflow (an estimate for the amount of upland stormwater flow that overtops the South Highline Canal in the Sand Creek model, and runs overland in the model) was split between two input locations. Each was input as a direct inflow Type 1A distribution with a peak flow of 30 cfs.
- All upland stormwater not draining to known storm and irrigation system components in Allen-Fruitdale and Skunk-Jones was assumed to drain directly to the creek, and was therefore not entered in the model.

4.1.2 Pipes, Ponds, and Channels

The following assumptions were made for pipes, ponds, and channels:

- All pipes are in good repair.
- All pipes are free of debris.
- All channels have been dredged on a regular schedule to maintain the sizes documented in the site surveys, videos, and photos.
- Natural channels and detention ponds have been mowed to remove excess vegetation, with only the plants intended to be used as water quality features remaining.
- It is assumed that the river and creeks have sufficient capacity to carry away all water discharged to them from the stormwater and canal network.

4.1.3 Flow Redirection and Connectivity

Previous XPSWMM versions often used a parameter called flow redirection to add flow from basins that did not contain a modeled line. The Grants Pass XPSWMM models have been updated to remove flow redirection. An alternative method of inputting flow locations was used. This method directs the flow from minor basins in which all lines are un-modeled to the location where the flow would actually enter the modeled network. As part of the model update process, every runoff node was checked to verify that the parameters were reasonable, and that each basin flows to the correct node.

4.2 SURVEYING ACTIVITIES

As a part of this project, the City Surveyor collected field information to better define the features to be modeled. The surveyor walked the entire length of the four major irrigation canals within the city limits and gathered typical cross-sections, channel bottom elevations at grade changes, and location, type, size, dimensions, and inverts of all canal spill points. Digital photography and video were recorded during this process. Datum accuracy was checked by taking survey shots at locations already existing in the XPSWMM model. The datum of the most recent survey and the XPSWMM model are the same.

The surveyor also gathered more detailed data on locations that were vague or contradictory in the City's existing stormwater system mapping. Discrepancies were found between model connectivity and pipe sizes compared to those shown in the City's records. These discrepancies were investigated and updated in the model.

During the calibration process, flow at several locations did not match between the modeled and the monitored flow. These areas were further investigated by the City Surveyor and Keller Associates' staff, and the model was updated to reflect observed conditions.

4.3 FLOW MONITORING

Temporary stormwater flow meters with data loggers were installed at strategic points in the stormwater system to observe runoff resulting from actual storm events. The intent of flow monitoring is to adjust the model parameters to reflect observed conditions for the same storm event. Locations of flow meters were selected to isolate basins and land use types, to better understand the interaction of irrigation canals with the City's storm system, and to further define the effects of wetlands, detention and retention facilities. Selected flow monitoring locations for the most recent round of flow monitoring are shown in Figure C.1 in Appendix C.

Flow monitoring was completed twice during this phase of the project. The first round occurred in February and March of 2013. Even though the flow meters were installed during a typically rainy period, unfortunately no significant storms were recorded.

The second round of flow monitoring was more successful than the first in capturing the necessary data for model calibration. It occurred in December 2013 and January 2014, and recorded one significant storm event. While more storms are typically used in the calibration process, it was determined that the data available would have to suffice, due to the time associated with further extending the flow monitoring process.

Both flow monitoring periods included 16 locations and used Hach Sigma 910 flow meters.

4.4 CALIBRATION

The XPSWMM model was calibrated to match field observed flows. Peak flows were targeted for calibration (as this reflects the design criteria of the stormwater facilities), but often the model matched much more than the peak flow. Pipes that were not circular were calibrated to water surface elevation. This provides a similar result to calibration based on flows. Chart 4-1 shows an example graph comparing flow monitoring data and modeled data.

Chart 4-1: Comparison of Modeled Flow to Flow Monitoring Results at Ballinger Drive & Greenwood Avenue

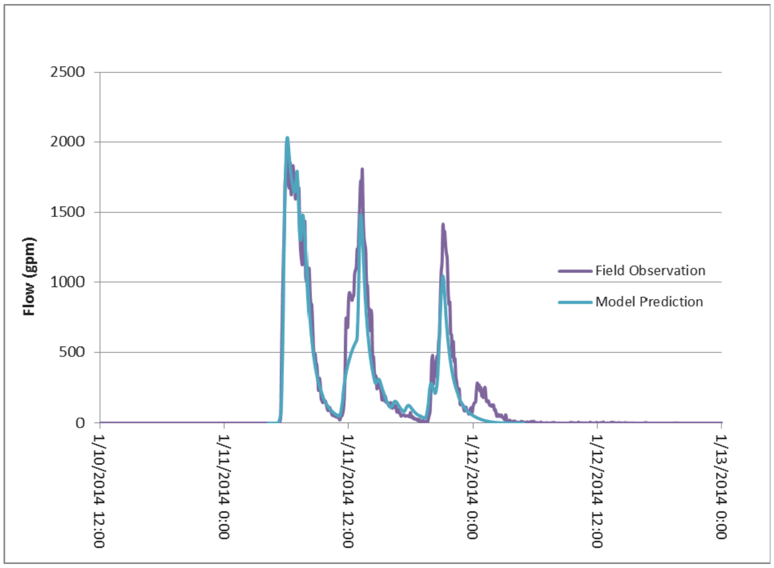

Table 4-1 compares peak flows from the flow monitoring data and the calibrated model. One of the monitored locations did not provide sufficient data. Out of the other 15 locations, all but one matched within 5% of peak flows, with the majority of the locations within 1.5%.

Table 4-1: Comparison of Modeled Flow to Flow Monitoring Results at Flow Monitoring Locations

Location	Monitored Peak	Recalibration Modeled Peak
1	7.34 in.	7.37 in.
2	2970 gpm	3011 gpm
3	3424 gpm	3396 gpm
4	6735 gpm	6731 gpm
5	5041 gpm	4826 gpm
6	2010 gpm	2033 gpm
7	1367 gpm	1416 gpm
8	5175 gpm	5223 gpm
9	insufficient data	N/A
10	3550 gpm	3546 gpm
11	2246 gpm	2220 gpm
12	1558 gpm	1564 gpm
13	4643 gpm	4661 gpm
14	6978 gpm	6777 gpm
15	12.81 in.	12.61 in.
16	1698 gpm	1665 gpm

As the stormwater model continually evolves as additional and improved information becomes available, the calibration accuracy will also become more refined. To calibrate flows, several modeling parameters were evaluated and adjusted including: minor basin width, slope, overland flow roughness, percent impervious ground cover, area, flow direction, soil infiltration capacity, open/closed status of gates, and pipe connectivity.

Width is one of the most versatile calibration tools. It is a number that changes the hydrograph, both in shape and time. The initial assumption is based on the flow length before channelized flow, but that can vary depending on many conditions. SWMM's published calibration methods call for changing width as the major driver for calibrating models. This is possible since width is not a physical quality in basins, but rather a theoretical calculated value.

Slope affects the time it takes for water to attenuate. It can only be used for fine-tuning changes to the model.

Percent impervious ground cover was reevaluated for each minor basin as a part of this phase. This is more than just a measure of how much impervious surface there is in an area; it determines how much of the area acts like an impervious surface (e.g. highly compacted soils). Similar land uses were assigned similar percent impervious within each model.

Infiltration parameters work in cooperation with percent impervious, and are not independent variables. Extra care was taken to balance these parameters to produce expected model flows. Infiltration affects the magnitude of peak and total flows. The Green-Ampt method was the primary infiltration method used.

Both overland flow ground roughness and pipe roughness are accounted for in the model. Ground roughness is used as a calibration parameter to change the timing of flows entering certain drainage features, and changes peak attenuation. Pipe and channel roughness were adjusted with the new data collected.

As part of this phase, system connectivity and minor basin boundaries were evaluated to determine if flow was being input into the correct locations in the model. Some discrepancies were found in the previous model. It appeared as if the minor basins in the 2007 model were drawn only around modeled pipes. For this model, all known pipes, ditches, and channels were included in the delineation of minor basins. In several places, there were fairly large changes to basin boundaries when the minor basin details were included. With the addition of more detail to the irrigation canals, it became possible to direct the flow from the surrounding basins to a more accurate place of entry into the model. Figures 5A-5D in Appendix A show the modeled lines in the system.

The gates (referred to as spills) from the irrigation canals are typically open to allow flow into the creeks and river. A few exceptions to this were discovered in the calibration process using the flow monitoring data. For example, two spill locations were closed when they were assumed to be open.

Stormwater models constantly improve as more information and flow monitoring results become available and are incorporated into the models. This master plan represents the first step towards having a detailed city-wide model. The amount of information available at this time provides a model detailed enough to evaluate regional areas of approximately 30 acres or larger. Each time the City or a developer performs a stormwater analysis on a smaller scale (less than 30 acres), the results of those evaluations should be incorporated into the city-wide stormwater model. Additional flow monitoring from small scale evaluations targeting smaller basins will improve the accuracy.

The stormwater model will continually evolve as additional and improved information becomes available. A good example of this is that for this phase of the SWMP, the accuracy of the model greatly increased by adding more detail to the canals in the system and calibrating to flow monitored locations.

4.5 IRRIGATION FACILITIES AND OPERATING SCENARIOS

The four major irrigation canals were added or further refined in the model based on information gathered from the survey. This refinement included cross-sections at grade-breaks and other major cross section transformations identified by the City surveyor. It also includes information about changes in materials.

In the summer months, the irrigation system runs water through the canals, thus, the irrigation spills to the drainage system are generally closed. This normally is a functional operation until a storm event occurs. In the event of a storm, the canals can overtop and flood low-lying areas rather than conveying drainage through the city.

In the winter months, when the weather is typically wetter, the irrigation canals are not conveying water to irrigation customers; thus all spills should be open, and the system functions as part of the storm drainage system. During the process of calibration and flow monitoring, it was discovered that two reportedly open spills were closed or otherwise obstructed. The lack of tracking for the process of opening and closing spills and valves can cause issues, resulting in additional potential flooding if all spills are not completely open as expected. Given the potential for damage to public and private property, a streamlined communication network and a clear delineation of responsibilities between the irrigation district and the City is recommended. This organizational effort is being addressed further in a separate Memorandum of Understanding and Agreement between the City and the Grants Pass Irrigation District.

The operating scenario chosen for evaluation was the winter operating scenario in which all irrigation spills were assumed to be open to allow drainage directly into the City's system.

4.6 COMPARISON WITH REDWOOD AVE. DRAINAGE STUDY

The Redwood Avenue Drainage Study used the 2D model produced for the County by the consulting firm Cardno WRG to evaluate existing stormwater drainage conditions, and proposed solutions. Table 4-2 compares results from the City's newly updated 1D model and the County's 2D model. A portion of a map presented in the County's SWMP that Keller Associates annotated to compare results of the two models is included in Appendix D. In a 1D model, locations are evaluated as points at the ends of pipes, culverts, or channels. On the map in Appendix D, the black and white screenshot with red dots shows the location of City modeled lines in the selected area. The red dots represent the points of concern for the City model. In a 2D model, locations are evaluated as part of a grid. Flooding grid squares for the 2D model are shown in blue in the color screenshot on the map in Appendix D. The two models indicate flooding in similar areas, which further validates the 1D model.

4.7 COMPARISON WITH COUNTY 2 D MODEL

In addition to the Redwood Avenue section discussed earlier, the County's 2D model encompassed an area similar to the Sand Creek Basin allowing for a valid comparison. Four comparison locations modeled in both models are shown in Table 4-2 and Figure D.1 of Appendix D. The first three locations in the table were flow monitored locations, so they are the best calibrated locations in the 1D model. The fourth location was chosen to show an area of the City that is not covered by flow monitoring, and highlights the importance of flow monitoring in calibration.

Table 4-2: Comparison of 1D and 2D Model Locations

Location # on Figure D.1	City Model Link ID	County Model Link ID	City 1D Flow 25-year (cfs)	County 2D Flow 25-year (cfs)
1	SA-N140L*	6-DRNL-LR	28	27
2	SA-N089L*	SA-N089LR	15	25
3	SA-N070L	SA-N069LR	54	28
4	SA-N066L	SA-N066LR	97	971

*Calibrated model before redwood Avenue Improvements were incorporated

The three flow monitored locations came within a reasonable range of the County's 2D model (the results are not expected to be identical due to the nature of 1D vs. 2D models). The fourth location needs further investigation as part of a future phase of the stormwater master plan to determine the cause of the discrepancy. In the 2D model, the links are shown overtopping their banks and flooding the area, causing flow to reenter the system further downstream. The source of the extra water is unclear from the reference materials provided, but the amount appears to be excessive based on observed runoffs from similar basin areas. The discrepancy is likely due to improved information about pipe connectivity gained through the field observations in this phase. In the 1D model the pipes are not surcharging, and thus no water is lost. When this discrepancy was discovered, basin details were further evaluated to confirm the 1D model had been set up properly, and no errors were discovered.