Integrated Winter Gardens Drainage Plan

Leveraging Technology for an Integrated Drainage and Water Quality Master Plan

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Highlights

- Creation of a horizontally and vertically connected model for the project by dynamically coupling continuous 2-dimensional (2D) surface to the 1-dimensional (1D) storm drain network.
- Comparison between Non-Linear Reservoir Routing and more traditional modified rational method hydrology.
- Integration of water quality analysis with the hydrologic and hydraulic (H&H) model.

Introduction

The Winter Gardens watershed is primarily located within the Winter Gardens neighbourhood, an unincorporated community of Lakeside within the County of San Diego. The watershed consists of semi-urban development with relatively steep terrain. The goals of the project included detailed updates to the existing GIS storm drain inventory, identifying existing deficiencies in the conveyance system and associated flooding risk, and providing recommendations on a watershed scale for both drainage and water quality improvements in the 3.8 square kilometre subwatershed which outlets to the San Diego River. The presentation will highlight the 1D-2D modeling methodology, use of NOAA Atlas 14 rainfall data, comparisons between different hydrologic methods, share the results of 1D-2D modeling in the existing and proposed condition, and the water quality modeling performed to identify multi-benefit projects.

Methodology

Hydrology and Hydraulics (H&H)

The project used Non-Linear Reservoir Routing (NLRS) which accounts for flow attenuation. PCSWMM, a proprietary software which uses the Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) was used as a computational tool. PCSWMM was selected as the modeling program for this integrated drainage plan for its ability to model storm water flow rates and volumes in watersheds with complex drainage networks, such as those with multiple laterals and split flow conditions, and its ability to provide 2D modeling with storage attenuation, and water quality modeling. A comparison was made between NOAA Atlas 14 precipitation intensity and the intensity equation per the 2003 San Diego County Hydrology Manual (SDCHM). Ultimately, a rainfall hyetograph developed per the 2003 SDCHM intensity equation, centered at two-thirds, one-thirds was used to comply with regional standards in place at the time of the study. The project also compared NLRS with the hydrology methodology per the 2003 SDCHM (rational method).

Hydraulic calculations in SWMM are governed by the equations for conservation of mass and momentum also known as the Saint-Venant flow equations. These equations can be solved either by steady flow, kinematic wave, or dynamic wave routing methods. Dynamic wave was chosen for modeling because it is more accurate for calculation of pressure flow and also allows surcharging within conduits. A continuous hydraulic model of the storm water conveyance system was prepared to include subsurface conveyance (one-dimensional storm drain) as well as surface conveyance (two-dimensional mesh to represent streets, ditches and open channels). Refer to Table 1 for a comparison between one-dimensional modeling and two-dimensional modeling in PCSWMM and the rational method in AES.

Water Quality

The objective of the water quality analysis is to identify projects to improve the surface water quality in the Winter Gardens watershed by identifying opportunities to reduce fecal indicator bacteria loads along with assessing other constituents to meet water quality objectives. The process for water quality assessment included characterizing existing conditions, establishing targets, identifying opportunities, developing scenarios, and quantifying scenario results. Quantification was performed using the H&H information from PCSWMM, land-based pollutant loading rates, and standard structural treatment best management practices performance curves.

Table 1. Comparison of results between 1D, 2D modeling in PCSWMM and Rational Method in AES

Precipitation Source	SDCHM 2003 – 1D	SDCHM 2003 – 2D	SDCHM Rational Method
Software	PCSWMM	PCSWMM	AES
Rainfall Distribution	Centered at two-thirds	Centered at two-thirds	Centered at two-thirds
Area (Sq Km)	3.8	3.8	3.8
Time of concentration (minutes)	15	33	22
Q100 (cms)	44.6	55.9	43.3

Results and discussion

The results in Table 1 show that the 100-year peak flow for 2D model is 55.9 cms which is greater than 100-year peak flow for 1D model in PCSWMM (44.6 cms) and Rational Method in AES (43.3 cms). The 2D model in PCSWMM is unique in that it is a fully connected surface and sub-surface model which considers the flood attenuation and conveyance provided by the surface and also models split flow conditions which occur in reality. The model also renders the extents of inundations highlighting potential problem areas. The maximum depth of inundation ranging from minimum to maximum is represented by blue to purple in Figure 1 and Figure 2. There is a significant decrease in the maximum depth of inundation in Figure 2 after modeling an upgraded backbone storm drain along Winter Gardens Boulevard and associated downstream improvements.

Key outcomes of the project were categorized into drainage and water quality improvements.

<u>Drainage improvements</u>

- A two phased backbone storm drain along Winter Gardens Boulevard (and immediately downstream) will result in the reduction of inundation for surrounding roadways.

<u>Water quality improvements</u>

- A new regional infiltration basin and optimization of an existing water quality basin at Woodside Avenue were identified as the cost-effective strategies for the County to meet the water quality objectives for the study area.

Figure 1. Inundation extents along Winter Gardens Boulevard in the existing condition during the 100-year 24-hour storm event.

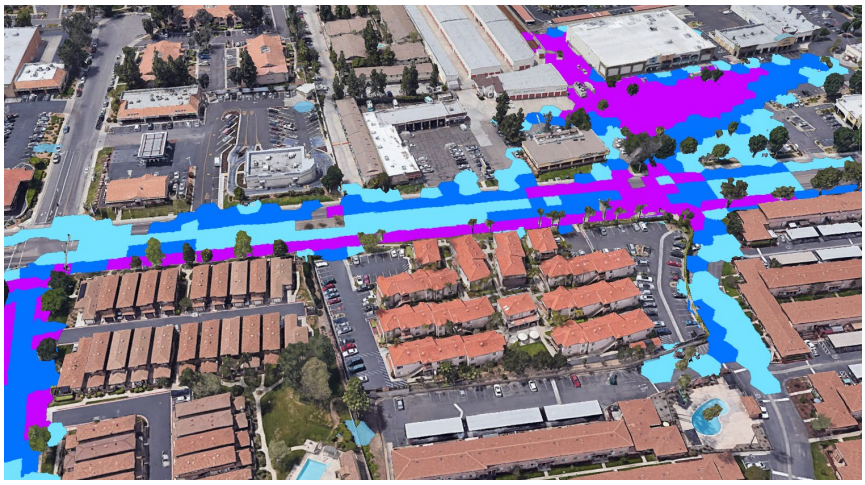

Figure 2. Inundation extents along Winter Gardens Boulevard in the proposed condition after upgrading storm drain backbone during the 100-year 24-hour storm event.

Conclusions and future work

Hydrology methodology plays an important role in predicting the peak flow rates and associated flood extents. The project has compared non-linear reservoir routing with traditional peak flow calculations (rational method) and found that non-linear reservoir routing can offer a valuable depiction of large-scale watersheds as it accounts for surface storage and flow attenuation. 2D Inundation results serve as a great visual communication tool that may be used for communicating with the public and stakeholders. Strategically located Regional BMP improvements were also identified which yield significant pollutant load reductions and helps improve water quality for the San Diego River.

Lessons learned from this project have informed four other integrated drainage studies that are currently under development.

References

County of San Diego (2019): Integrated Winter Gardens Drainage Plan Report