Redwood Basin Stormwater Master Plan Development Employing an Integrated 1D/2D xpswmm Model

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Using **xpswmm** for Master Plan Development

Redwood Basin
Josephine County, Oregon
Presentation Overview

Why was this project completed

Overview of Project

1D model development with results and findings

Basics of 2D modeling

Elements of this 2D model explained

2D model results – Open Channel

2D model results – Closed System
Study performed for Josephine County, Oregon, other stakeholders:
- Grants Pass Irrigation District and City of Grants Pass
- No Intergovernmental Agreements for stormwater management
- Management and capital improvement projects are completed independently

The purpose of the master plan was to study the entire catchment to establish problem areas, the source of the problems and detail CIP projects to alleviate the problem areas.
- Flooding (Roadways)
- Water Quality
- Habitat

Flooding became the driving factor due to significant capacity problems throughout the catchment.
• Located in southwest Oregon
• Wet winters and dry summers
• Redwood Basin is 6,400 acres
• Land use
  ▪ Forest
  ▪ Agriculture
  ▪ Low & medium density residential
  ▪ Commercial
  ▪ Transportation
• Soils:
  ▪ Clays
  ▪ Sand
• Aerial photo shows land use, irrigation canals, and creeks
• Canals significantly altered drainage characteristics
• NE corner developed, City Of Grants Pass
• NW corner agriculture South predominantly forest
Redwood Catchment Study – 1D Model

- A complete 1D xpswmm model was built initially.
- The hydrology was included in the 1D model and all major hydraulic elements were included as well. The 1D model was robust.
- At the time a 2D model was not scoped with the client.
- Hydrology was completed utilizing the Runoff and Green Ampt methods:
  - 177 sub-catchments classified with soil type and all Green Ampt parameters were input to xpswmm.
  - Calibration was done with stream gage data collected over the 2010 winter and rain events occurring in 2010.
  - Historic and Design Storms.
Redwood Catchment Study – 1D Model
Irrigation canals, Creeks, Open channels, pipe 12 inches or larger, roadside ditches and culverts

As development increases the level of detail of the 1D model increases as well
- 55 nodes flood – 25 year 24 hour design storm
- Volume and location identified with graphical encoding tool:
  - Flooding occurs – only the volume is known
  - Spatial extent is unknown
  - Depth is unknown
  - Overland velocity is unknown
  - Flooded volume is ‘lost’
  - Where does the flooding go?
- Unable to accurately describe surface flooding with a 1D tool:
  - 2D modeling needed
2D Modeling Summarized

- A representation of the project areas topography and surface characteristics (roughness).

- The project area is split into a ‘grid’ where each square has an associated elevation and roughness for cell center and cell sides.

- Water can move from one ‘grid’ to another in any direction.
2D Model Advantages/Disadvantages

• Advantages
  ▪ More accurate modeling of overland flood flow
  ▪ Flood storage, flood fringe & floodway accurately depicted
  ▪ Suitable for bridges/structures hydraulic analysis
  ▪ Provides spatial extent of flooding, velocity and depth for all areas, a nice picture

• Disadvantages
  ▪ Large amount of data is required (typically LiDAR)
  ▪ More computational power and time required
  ▪ High storage requirement as the output files can be large
  ▪ Tough to model very large areas with small grid size
1D/2D Model Input

Geo-referenced Aerial
1D/2D Model Input

Surface built from LiDAR
Grid Extents for the entire model, Boundary conditions, Grid extent optimization, and Inactive areas
1D/2D Model Input

Green = Impervious
Black = Buildings
Blue = Water
Red = Open Space
White = Grass/Pasture
1D/2D Model Input

Inactive area, Interface and Connection lines

2D Water level interpolated using water levels at 1D nodes

1D Node (1D water level computed)

2D Water level interpolated using water levels at 1D nodes

1D Node (1D water level computed)
1D/2D Model Schematization

- 1D/2D Interface lines (light blue), 1D/2D Connection lines (purple), Inactive area (dark blue hatch)
- The 2D active grid has 998,000 cells, each 100 ft$^2$
- We will examine at the area highlighted with the red circle
Flooding of storm and combined sewers
Flooding due to lack of network capacity or system defects
1D closed system and 2D overland flow system
Better description of dual drainage (i.e. intersections, trap lows, flow outside of right of way)
Transfer of flow to and from 1D can include inlet capacity
Comparison – 1D and 1D/2D Results Open Channel

- Over 50 million ft$^3$, no accounting for flooded volume
- Flooding is captured and properly rerouted, flooding is accurately described and volume is accounted for
1D and 1D/2D Results Open Channel

Movement from 1D to 2D to 1D etc.
Comparison – 1D and 1D/2D Results Closed System

- Flooding volume is lost, model is incomplete
- Flooding exits the closed system and is conveyed down the street
Comparison – 1D and 1D/2D Results Sand Creek

- 1D model has a water surface level of 887.78 feet for last link of Sand Creek.
- 1D/2D model has a water surface level of 888.92 feet for last link of Sand Creek.
- This is 1.14 feet higher than the 1D model.
Discussion

• The cascade effect in one case starts in the South Highline Canal and travel in and out of 6 1D elements utilizing the 2D grid in between each 1D element
  ▪ This could not be modeled in 1D!!!

• The 1D model had 34% volume lost to flooding, while the Integrated 1D/2D model simulated all this flow to the Rogue River

• Establishment of problem areas, sources and development of Capital Improvement Project list for Client was completed with confidence.

• Was able to present a ‘picture’ to stakeholders.
Questions