

working for clean rivers



Conveyance System Stress Testing Pilot Study

WUCA Training 2018:
Building Resilience to a Changing Climate

Nicholas McCullar, P.E.

Engineer

Bureau of Environmental Services

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ENVIRONMENTAL SERVICES
CITY OF PORTLAND

NICK FISH, COMMISSIONER
MICHAEL JORDAN, DIRECTOR

BES: Wastewater and Stormwater



Resiliency Master Plan

Develop prioritized improvements to system resiliency to **earthquakes** and **climate change**

- **Reduce risk of infrastructure failure** due to earthquakes and climate change
- **Increase our ability to bounce back** to provide services after a natural disaster



Range of Climate Change Risks

Local
Flooding



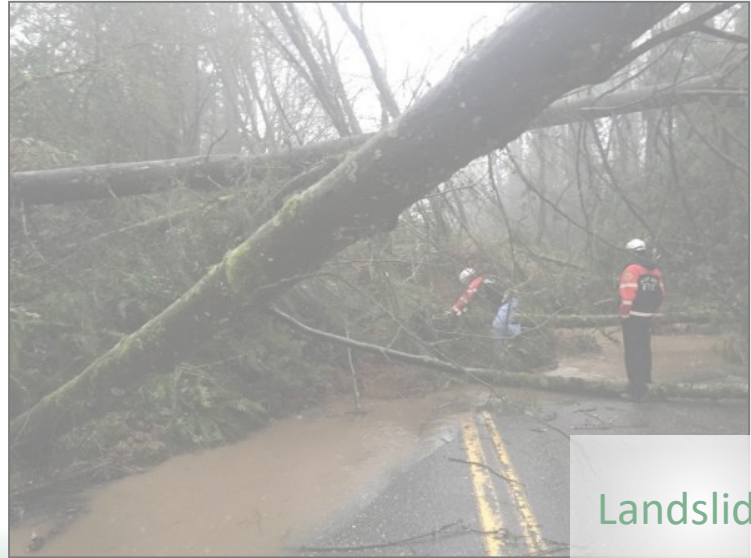
River
Flooding



Vegetation
Impacts

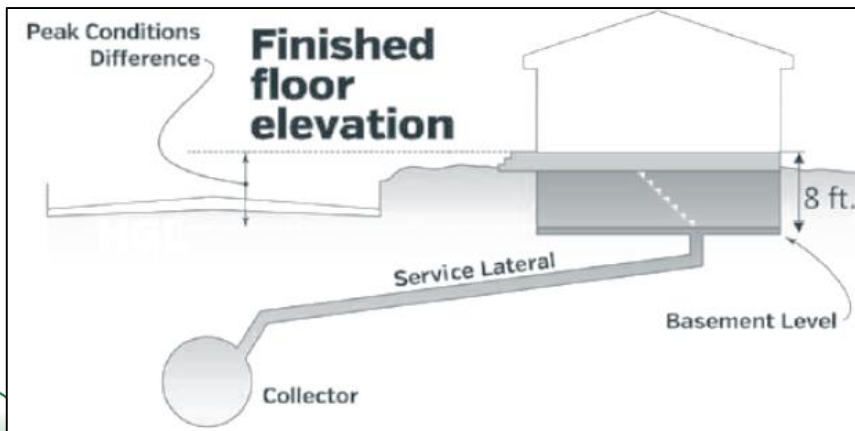


Landslides



Stormwater Management

- Design storms represent historic rainfall intensity
- Rain on roads and roofs concentrates in minutes
- Local combined sewers can back up in basements



https://www.oregonlive.com/weather/index.ssf/2015/12/portland_area_weather_heavy_ra.html

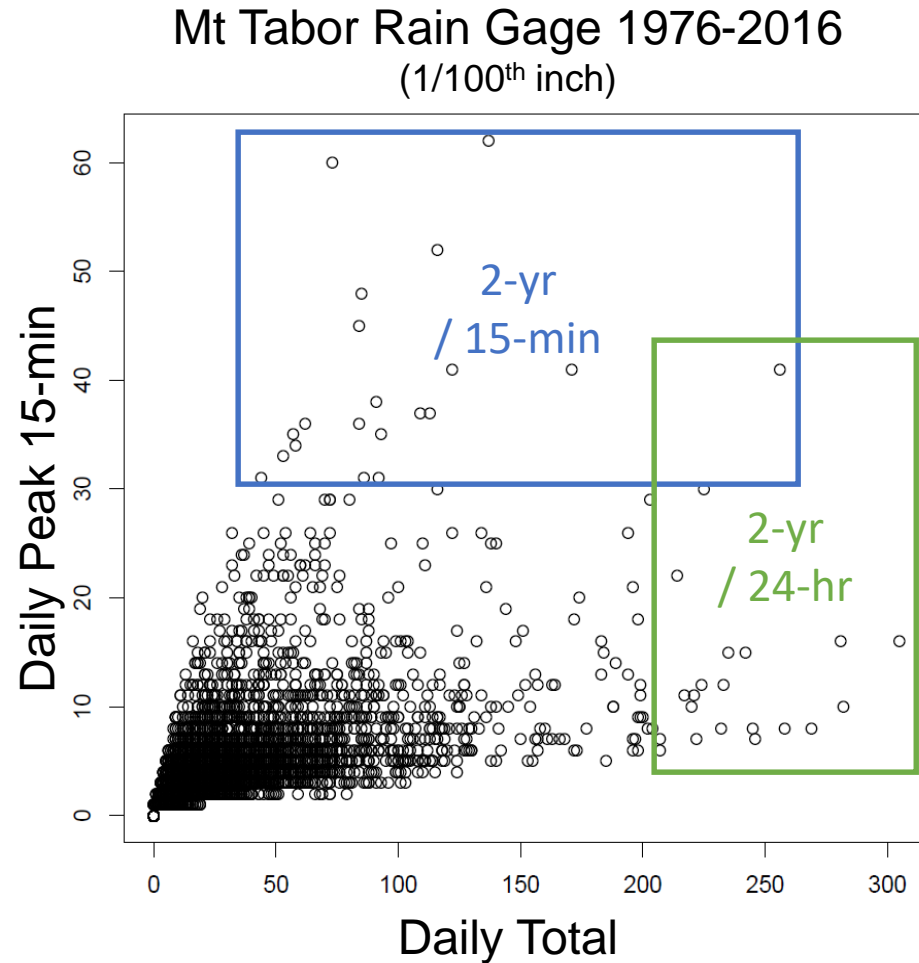
From the
archives
(2017)

-
- The diagram illustrates the structure of a global climate model. The top part shows a globe with a grid overlay, representing the spatial discretization of the atmosphere. Two labels point to the grid components:
- Horizontal Grid (Latitude-Longitude)**: Points to the grid lines on the globe's surface.
 - Vertical Grid (Height or Pressure)**: Points to the vertical layers of the atmosphere.
- The bottom part, titled **Physical Processes in a Model**, shows a cross-section of the atmosphere and ocean. It details the following processes:
- ATMOSPHERE**: Includes clouds, wind, and various fluxes (momentum, heat, water, sea ice) between the surface and the air.
 - CONTINENT**: Shows land surface processes and vegetation.
 - OCEAN**: Shows the mixed layer ocean and bottom ocean, with an associated circulation diagram.
 - Fluxes**: Arrows indicate the exchange of momentum, heat, water, and sea ice between the atmosphere and the ocean/land surface.
 - Radiation**: Wavy arrows represent solar radiation and terrestrial radiation.



Limits of Downscaling

- Proposed downscaling methods try to infer sub-daily intensities from daily volumes
- Monitored data shows that peak intensities don't match up with peak volumes
- Results are sensitive to methodology



Top down / bottom up

Top down

Future society, GHG emissions, GCMs

Select downscaled projections

Model system impacts

Mitigate deficiencies

Adaptation

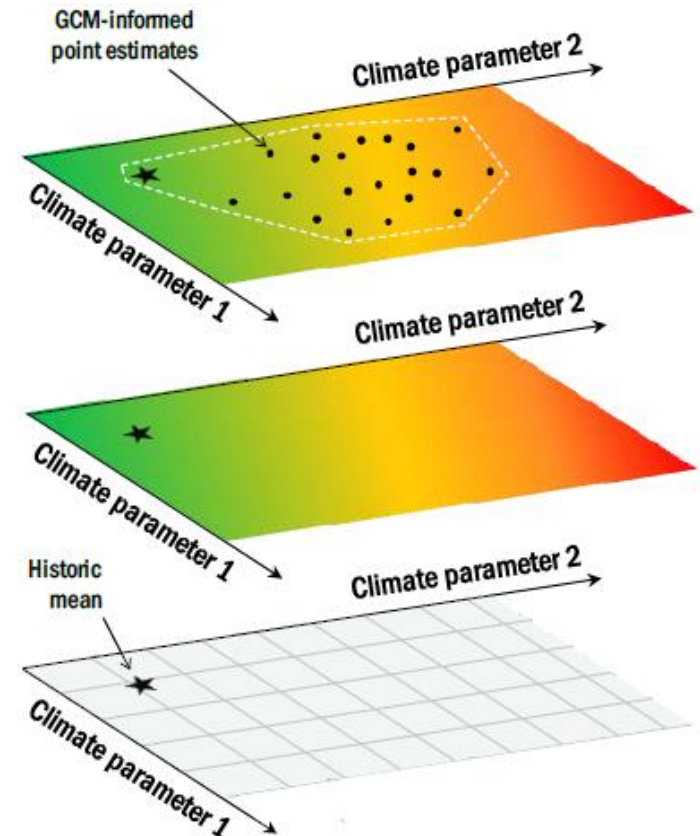
Build robustness

Stress testing of system

Plausible climate conditions

Range of possible future conditions

Bottom up

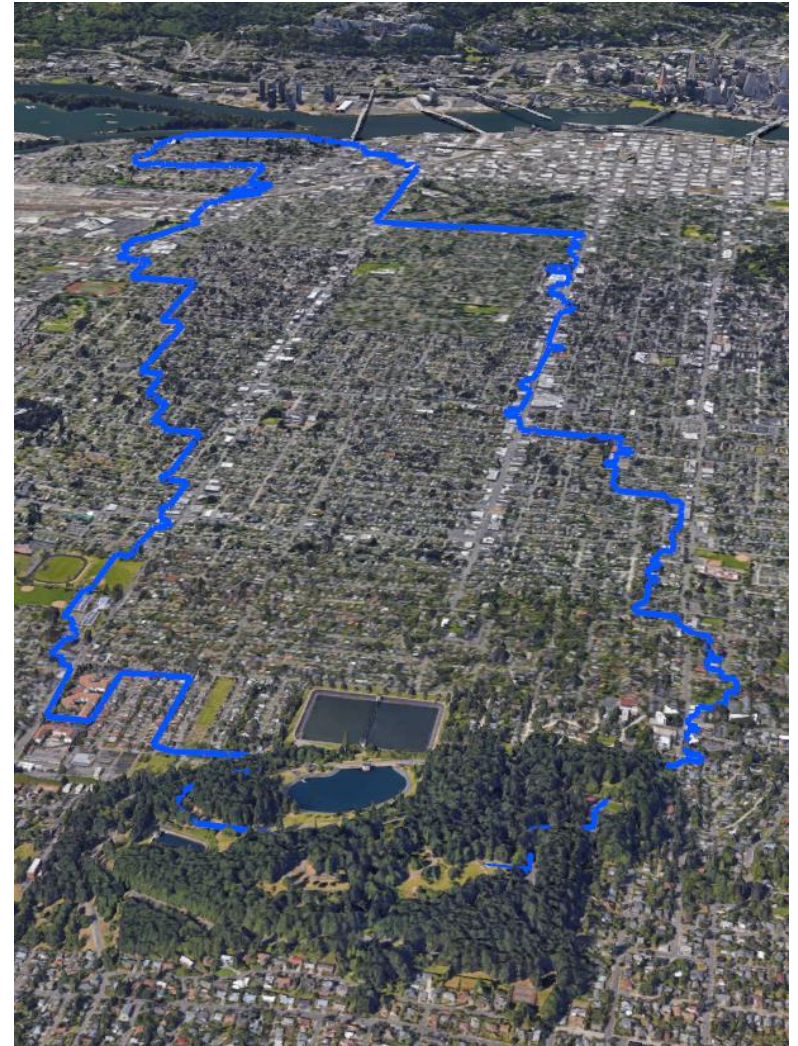


Stress-Testing Concept



Pilot Study Area Selection

- Taggart D Basin
- Pipe capacity problems were causing basement backups
- Green/gray projects targeted risk
- Community engagement
- Model for future programs



Parameterizing/modifying design storms

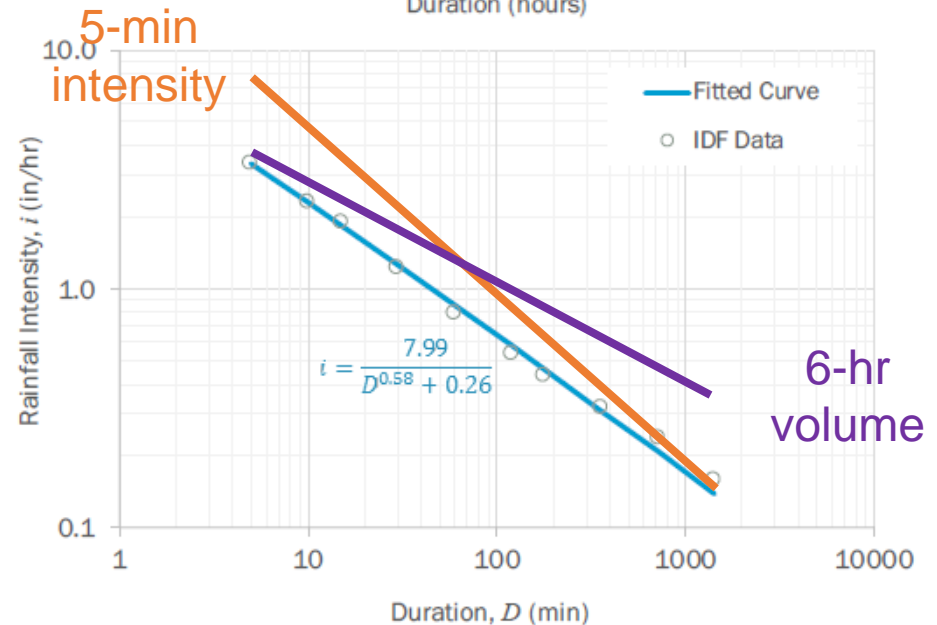
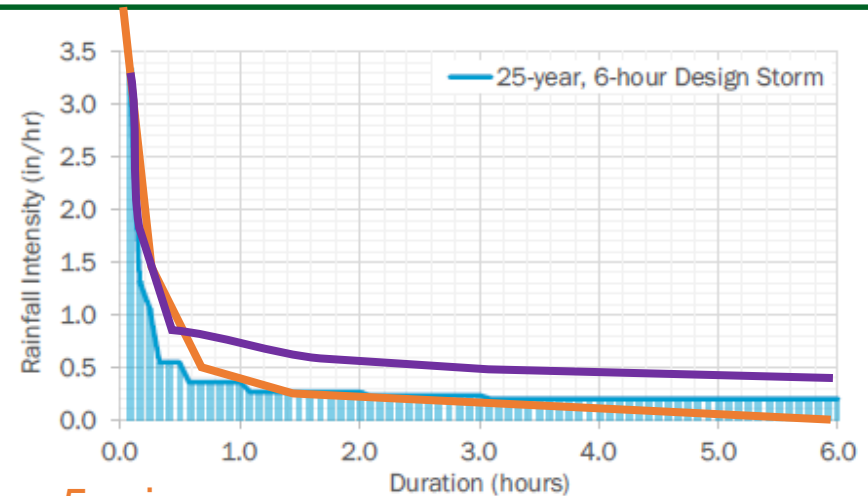
- Fit a curve to existing design storm
- Adjust peak intensity and total volume

Design Storm: 06HR 40-40

Duration: 06 6
 Change Peak Intensity (in/hr): 40% 6
 Change Rainfall Depth (inches): 40% 6

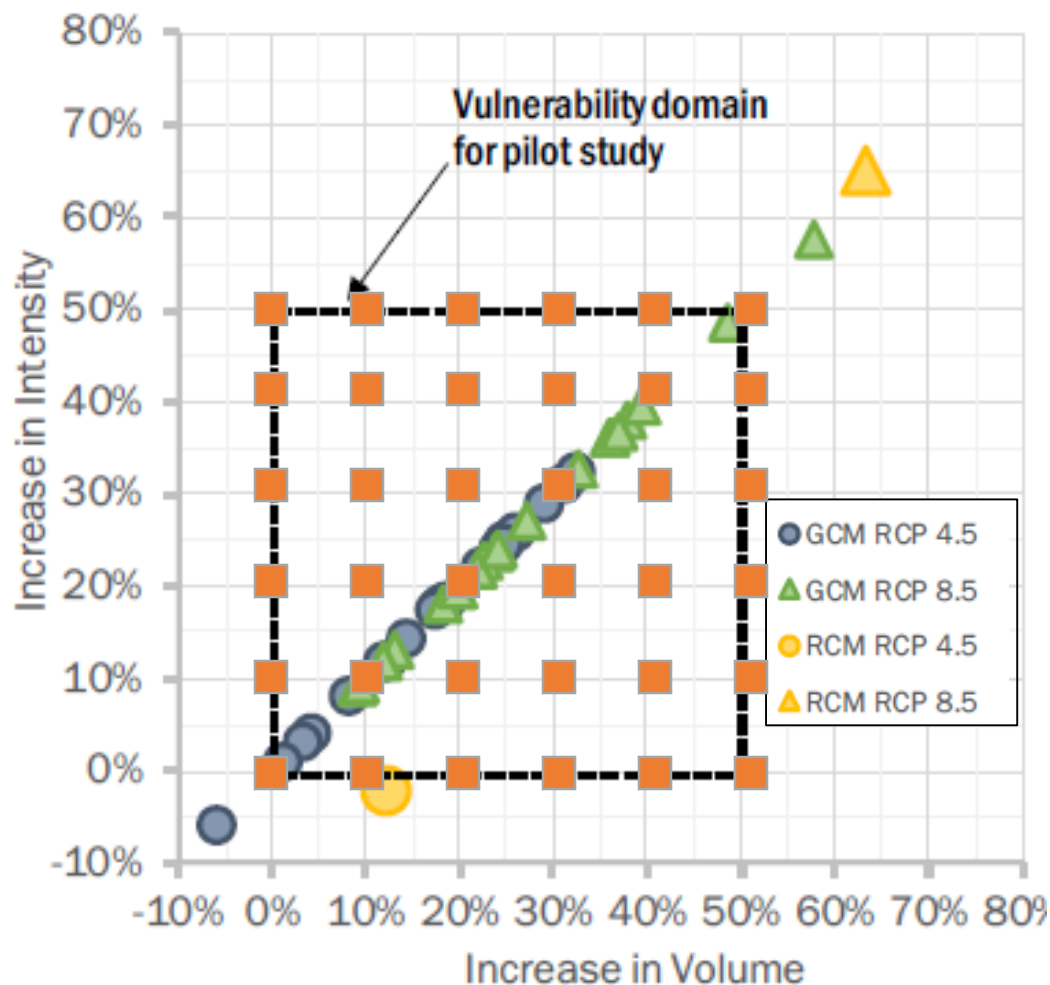
Regression Parameters for IDF Curves							
$i = \frac{a}{D^e + b}$		1	2	3	4	5	6
		002	005	010	025	050	100
Regression	Parameter	2-year	5-year	10-year	25-year	50-year	100-year
Kimijima Equation	a	5.40	6.92	7.99	9.29	10.60	11.60
	b	0.26	0.26	0.26	0.26	0.26	0.26
	e	0.58	0.58	0.58	0.58	0.58	0.58

Baseline Event Parameters						
Parameter	2-year	5-year	10-year	25-year	50-year	100-year
Peak Intensity (in/hr):	2.707	3.465	4.001	4.656	5.309	5.813
Rainfall Depth (inches):	1.504	1.925	2.224	2.587	2.950	3.230



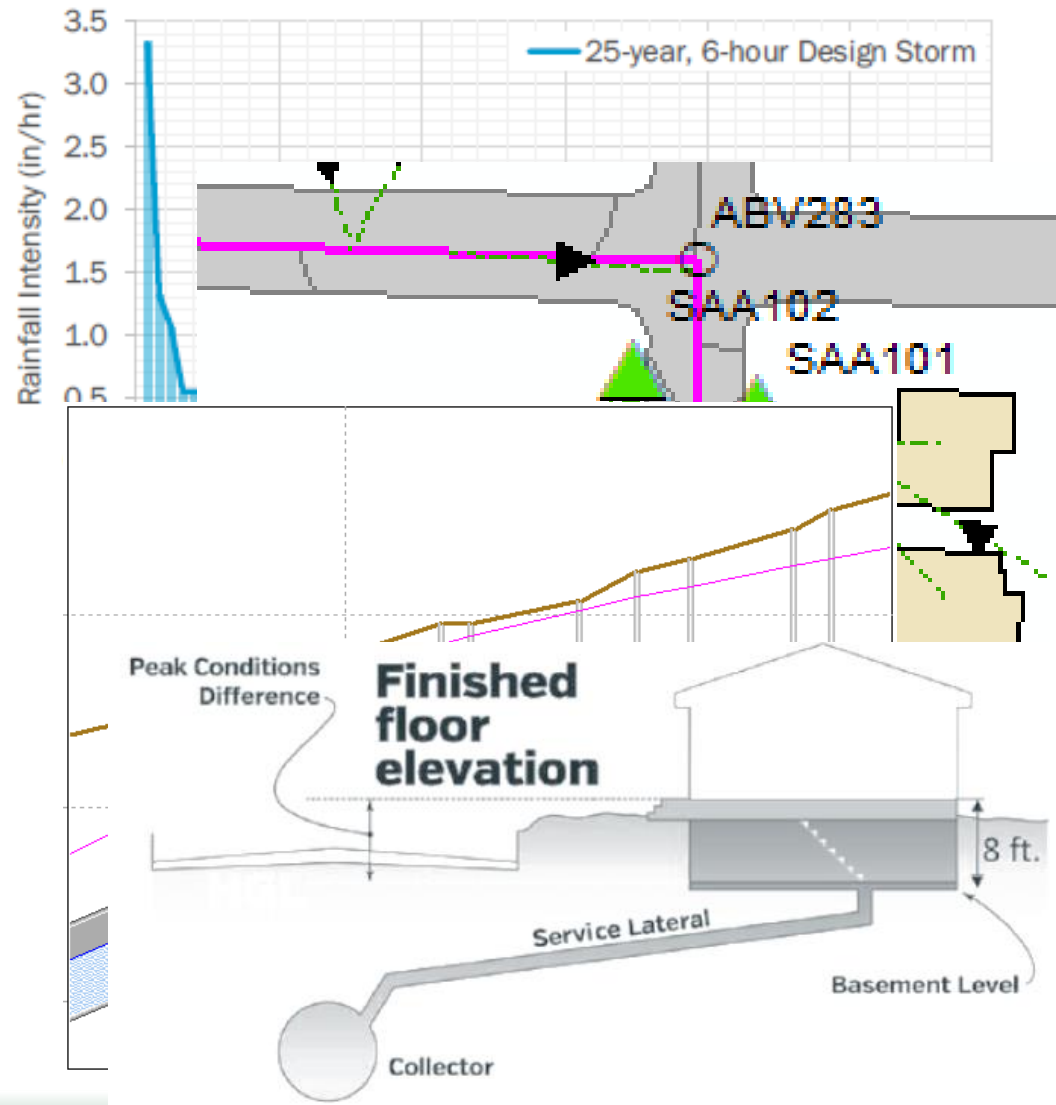
Scenarios

- 4 Return Periods
 - 2, 5, 10, 25 yr
- 6 Increments
 - 0% to 50%
- 2 Parameters
 - Intensity
 - Volume
- 144 total models



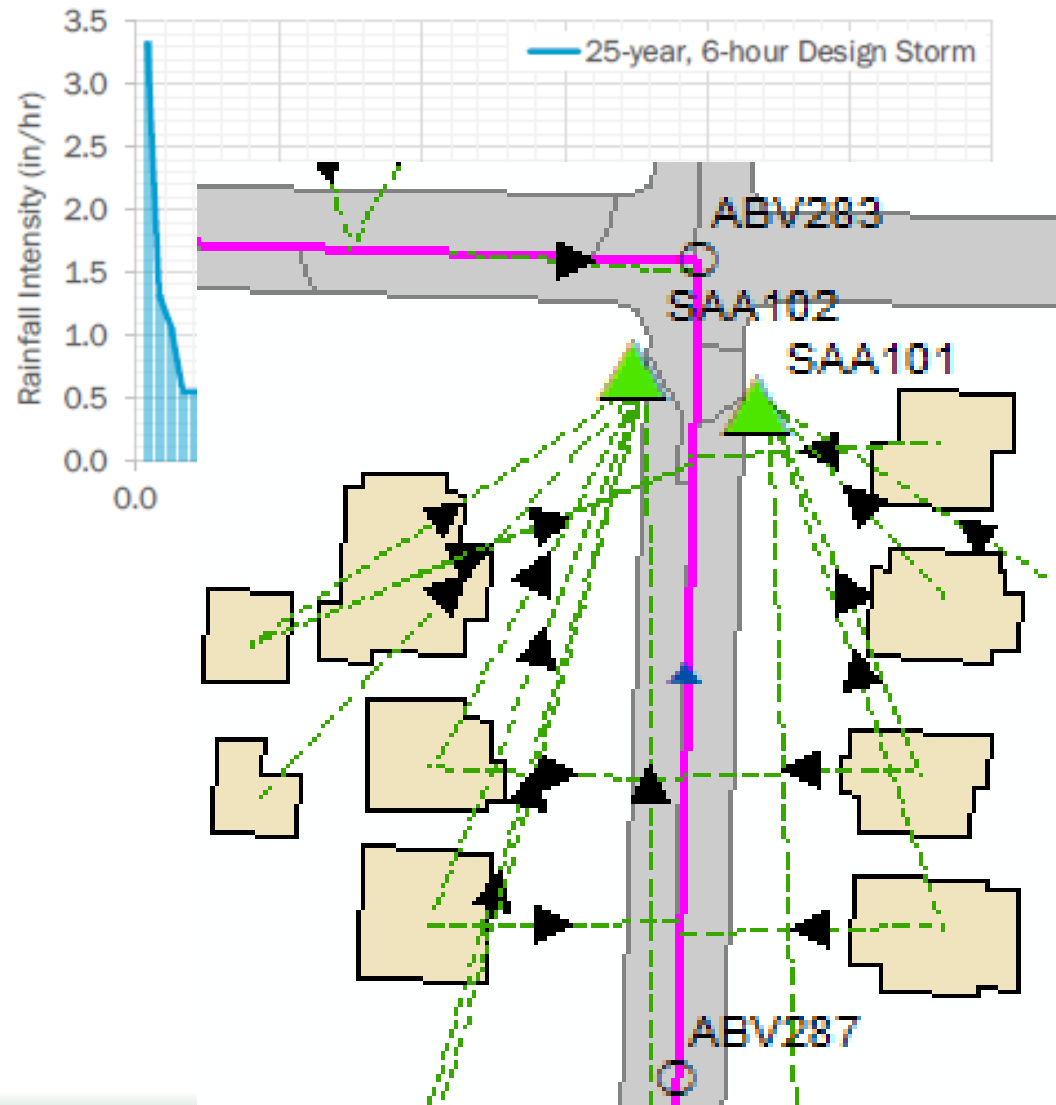
Use of Models for System planning

- Design Storm input
- Hydrologic model
- Hydraulic model
- Check HGL vs basements
- Add up risk \$
- Test solutions
- Compare cost/benefit



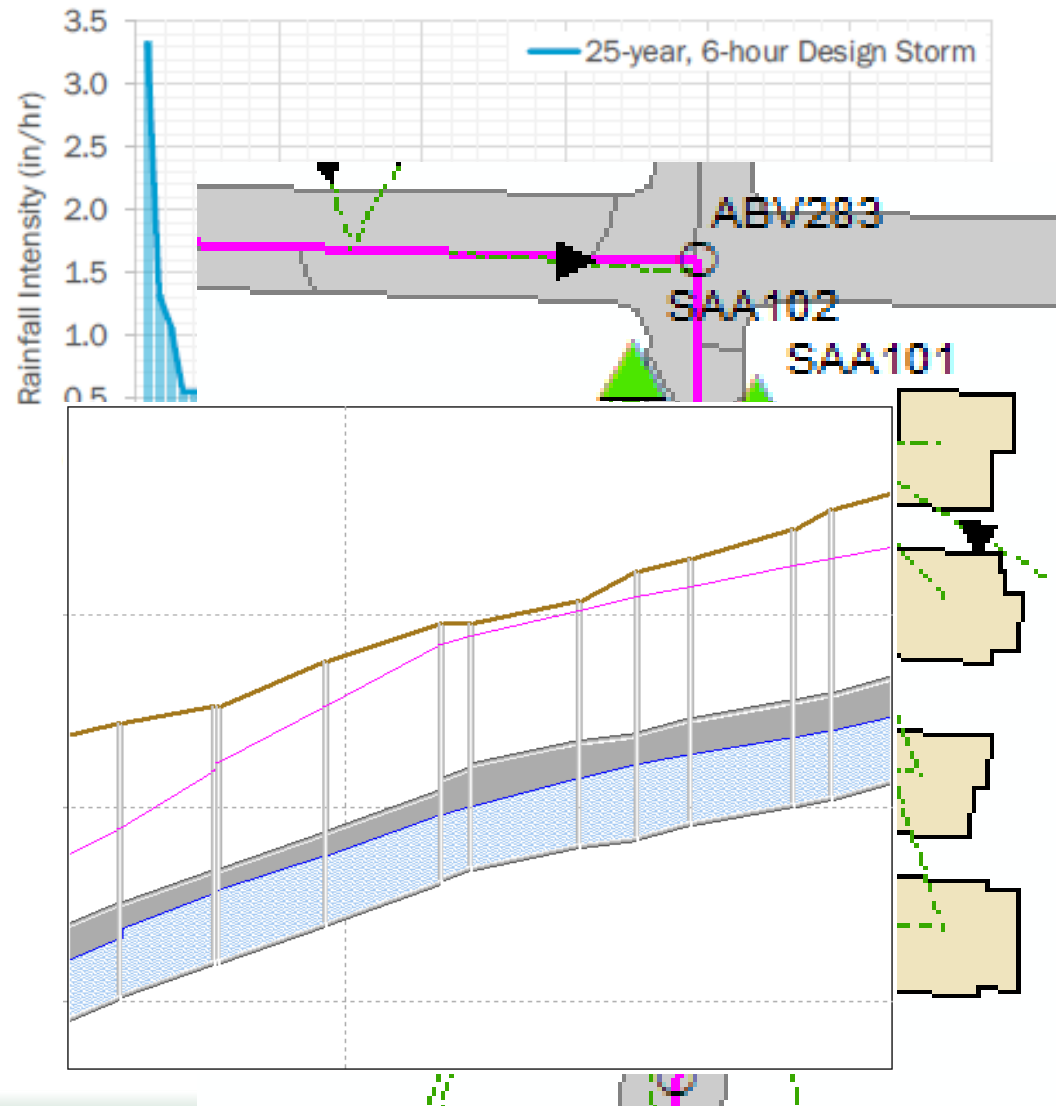
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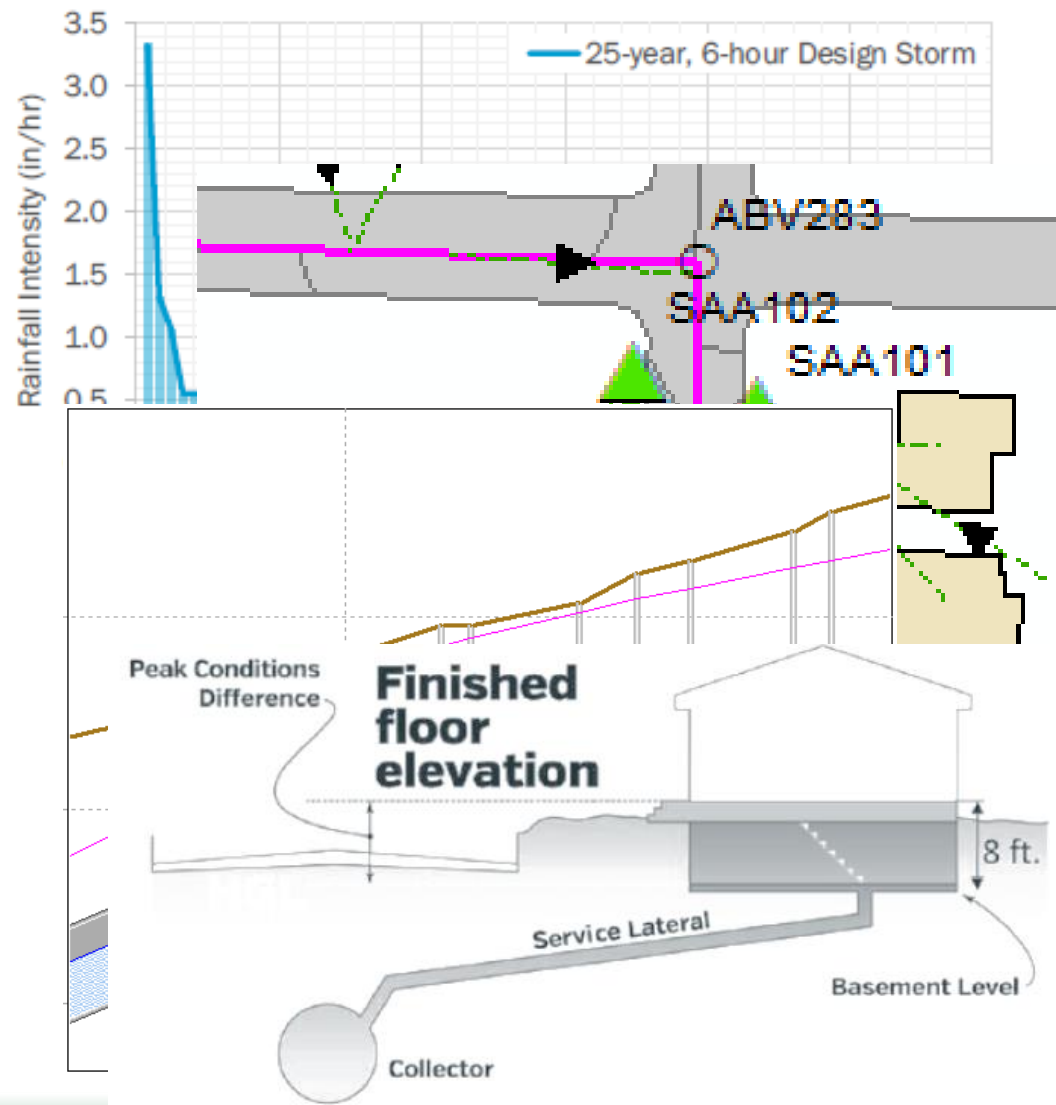
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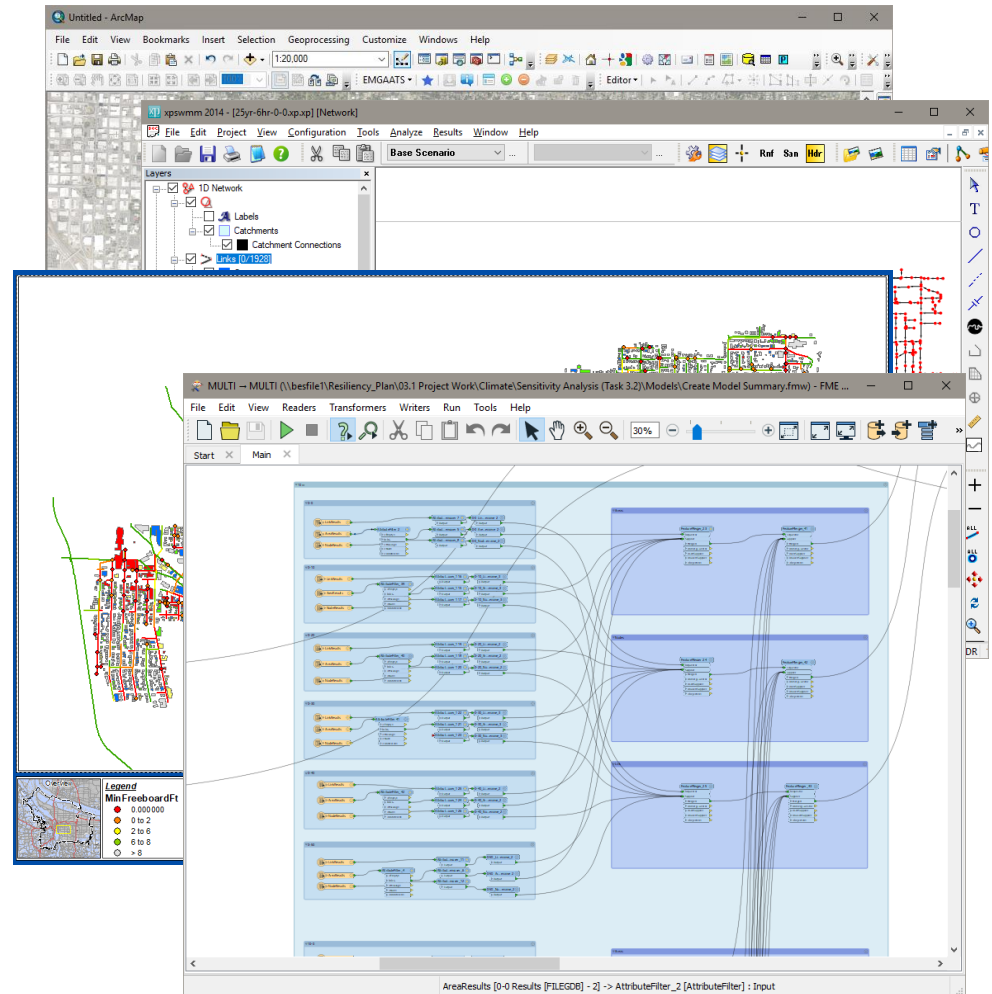
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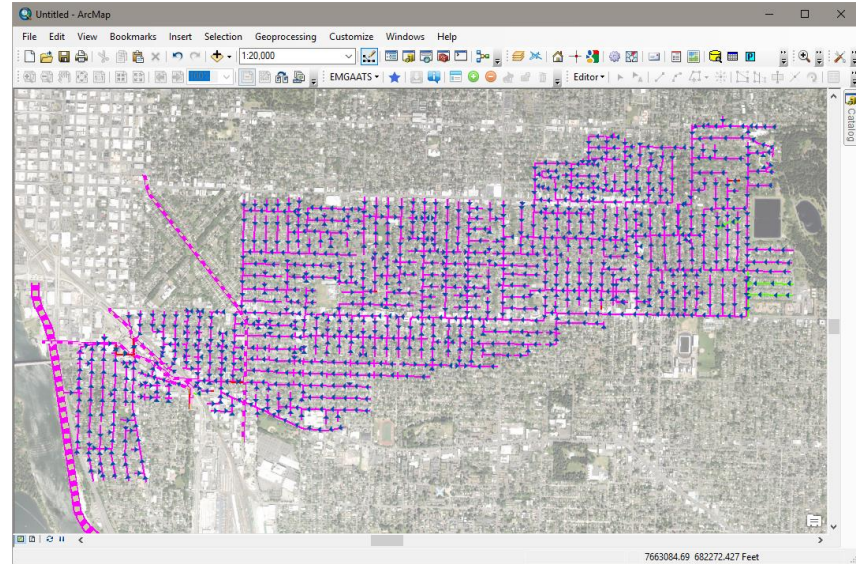
Setting up, running, processing models

- GIS Model Export
- EPA SWMM
Hydrologic Model
- XP-SWMM
Hydraulic Model
- GIS Post-Processing
- FME Merge Results



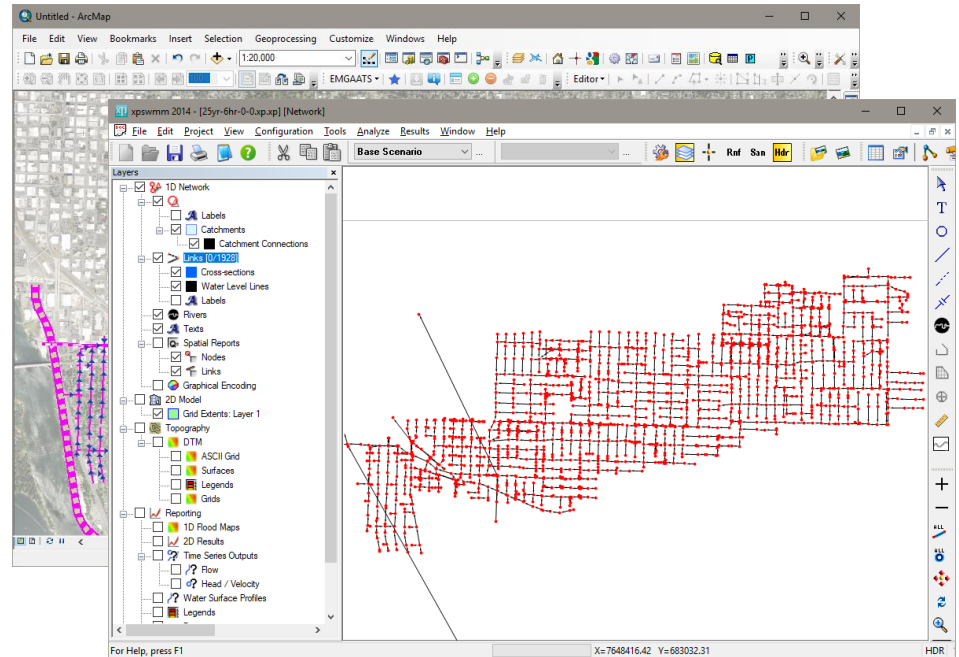
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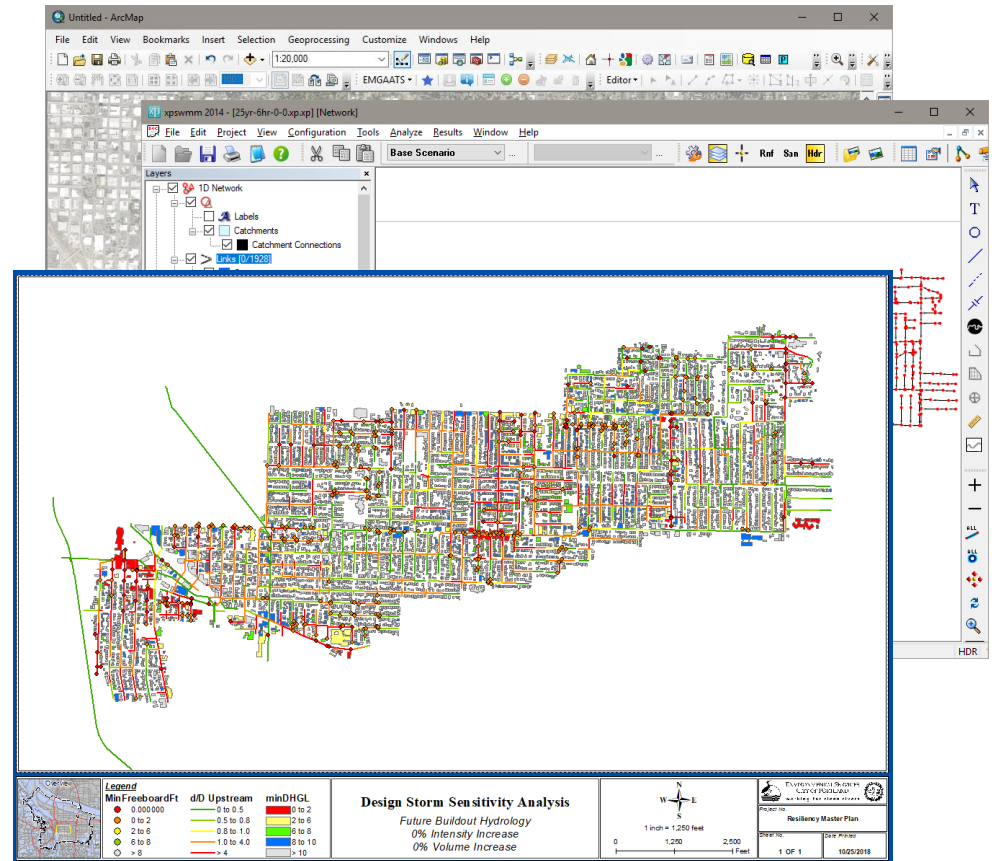
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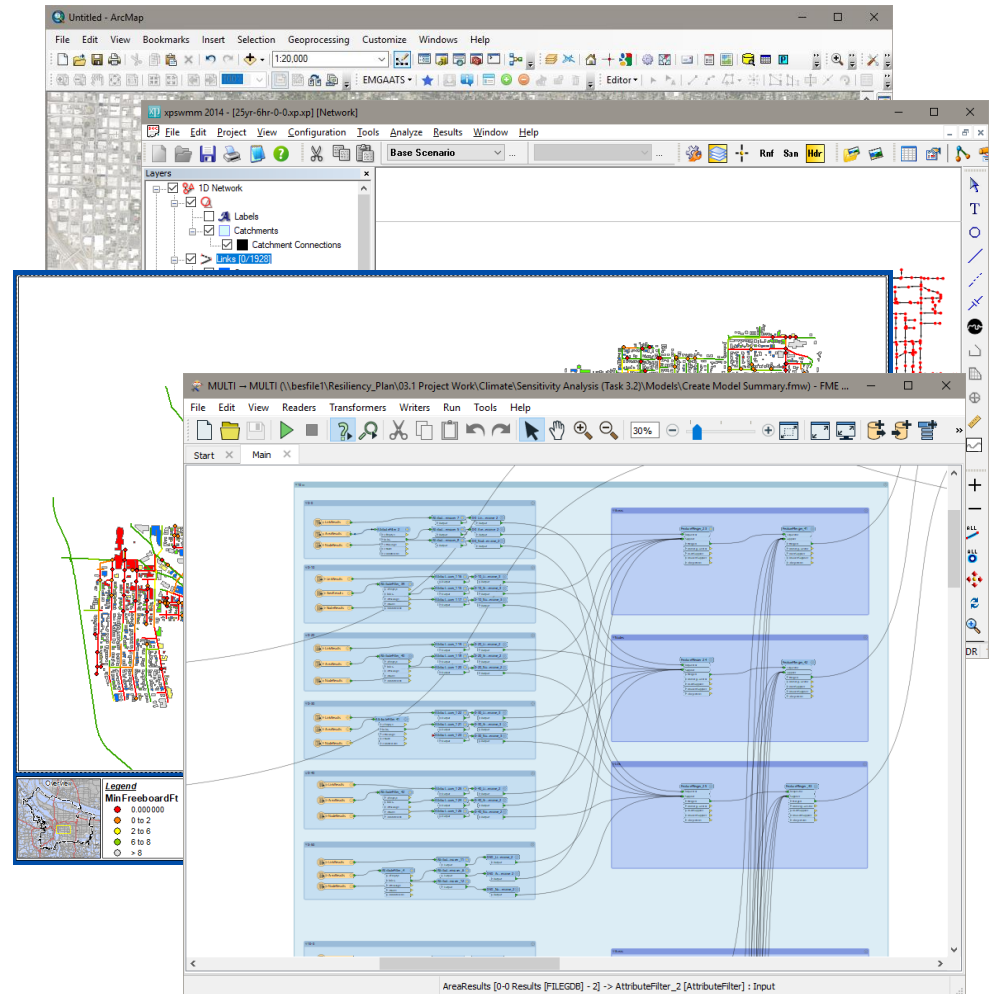
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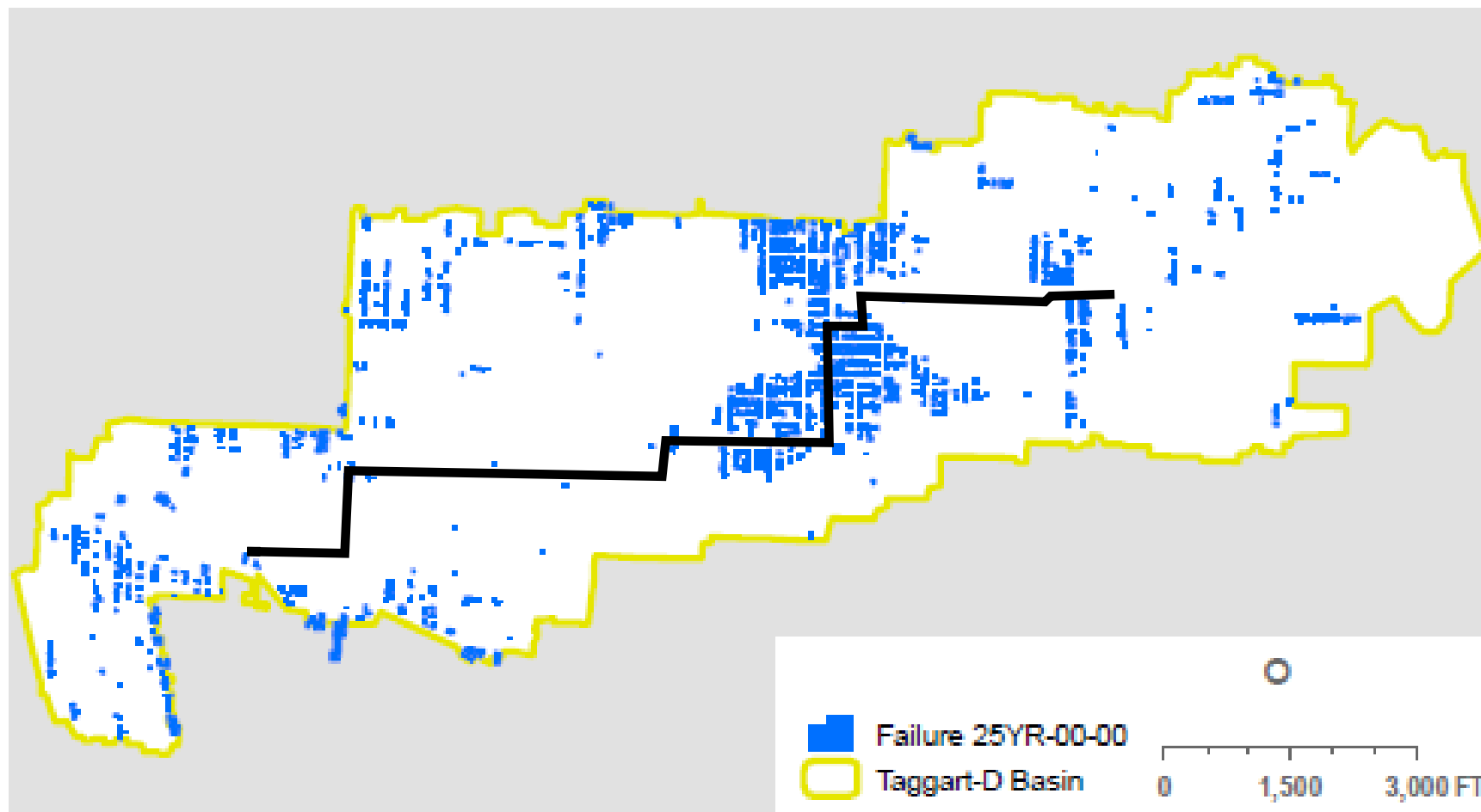


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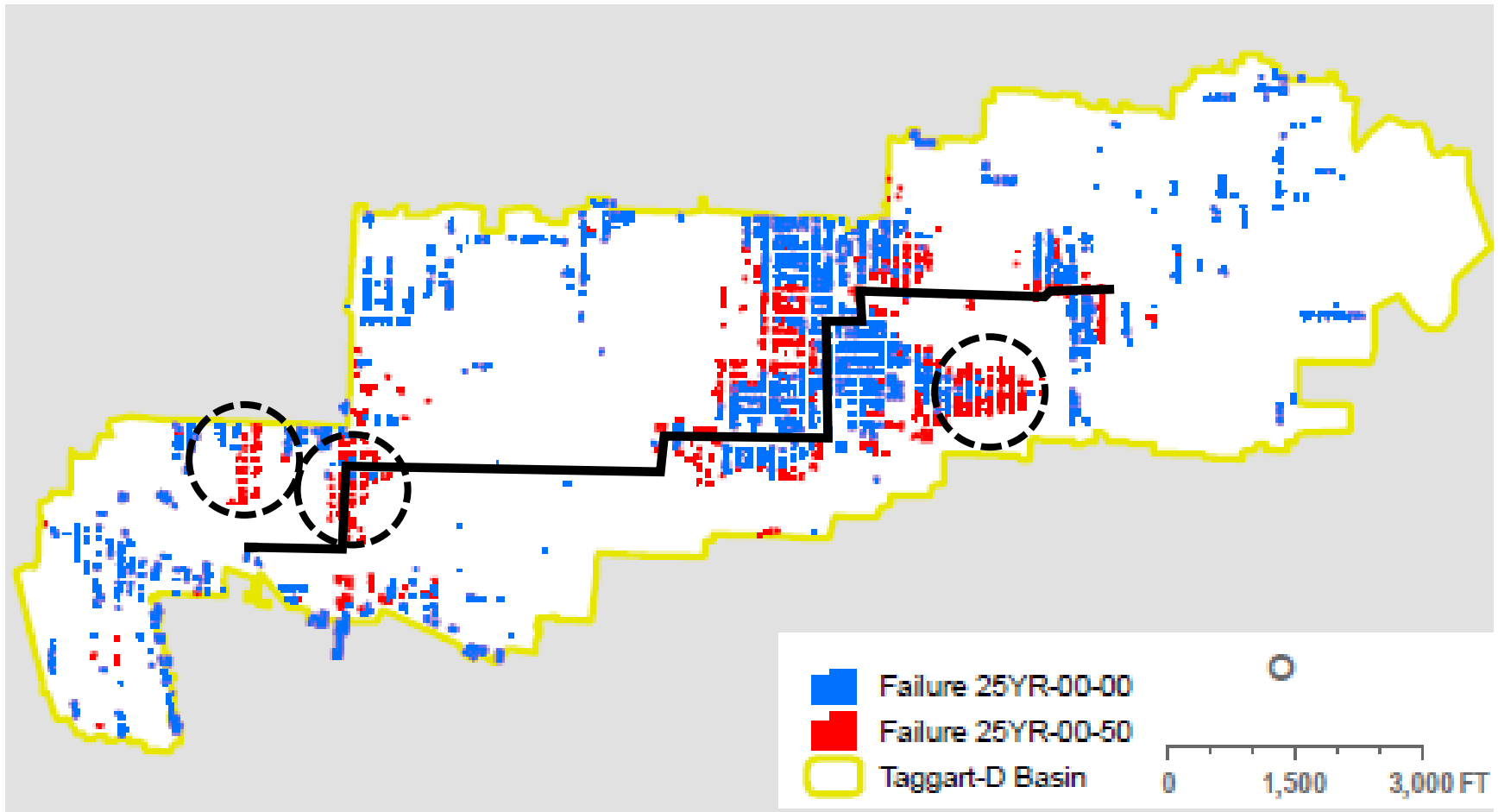
Mapping Results



No increase



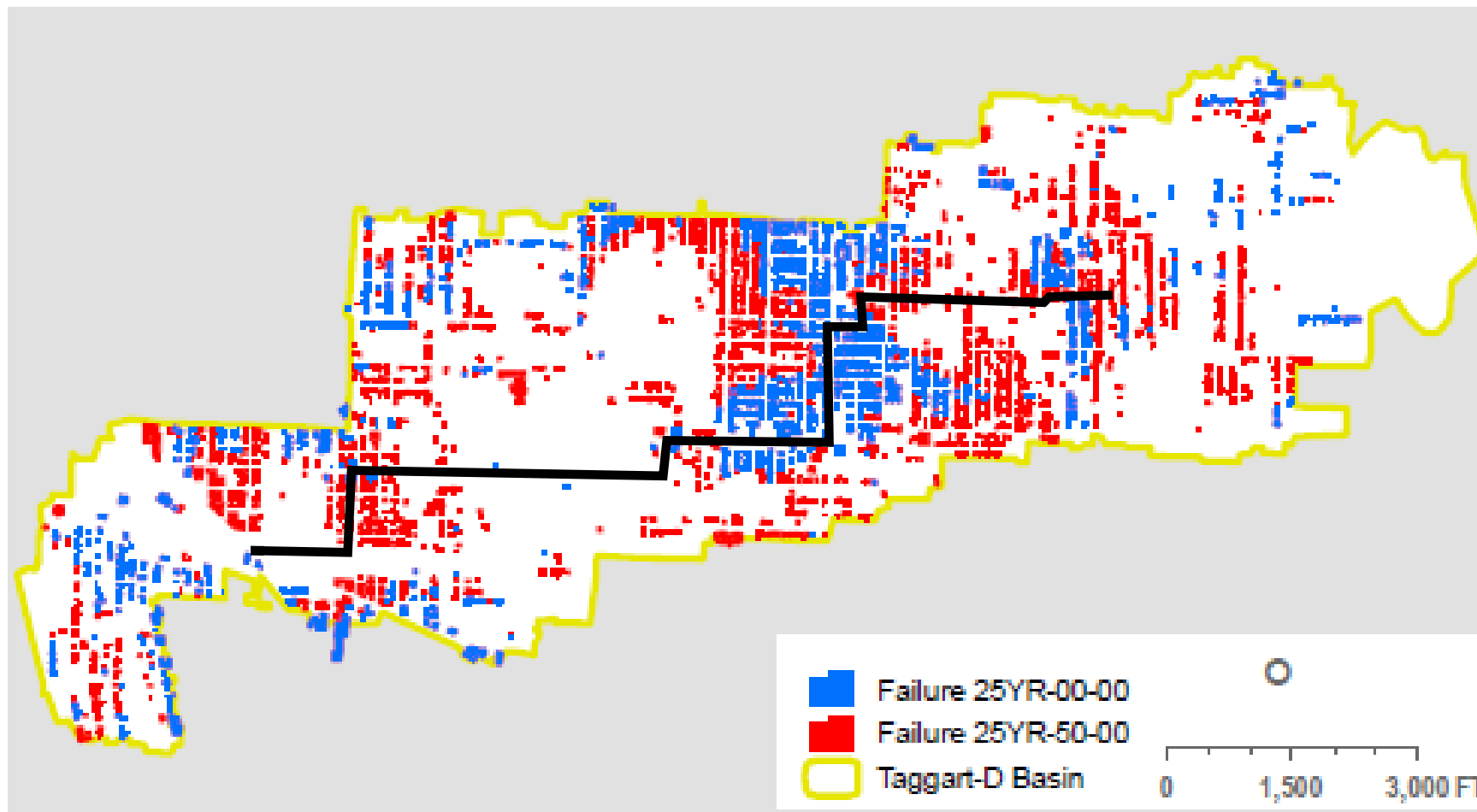
Mapping Results



Volume 50% increase



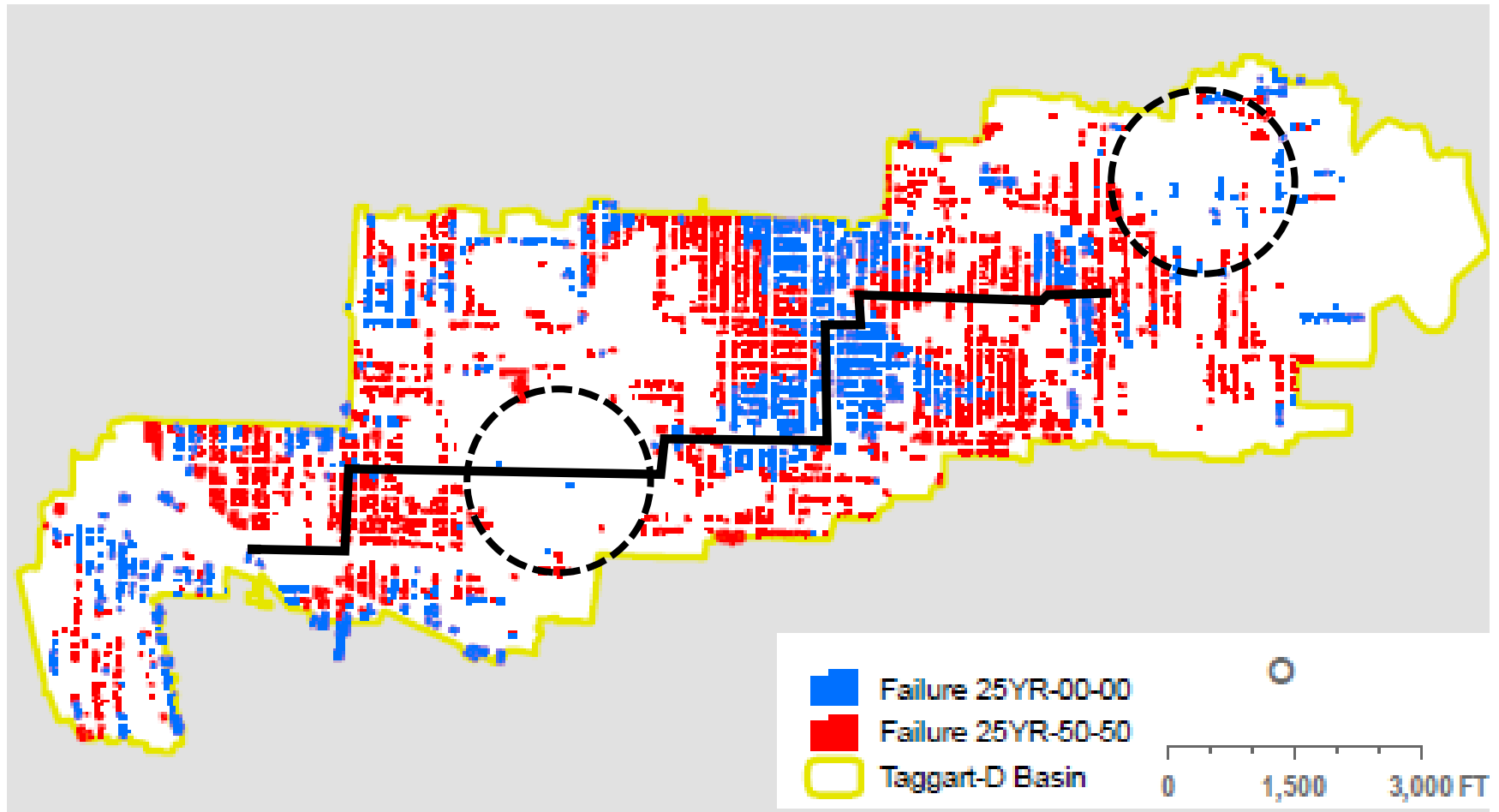
Mapping Results



Intensity 50% increase



Mapping Results



Intensity and Volume 50% increase



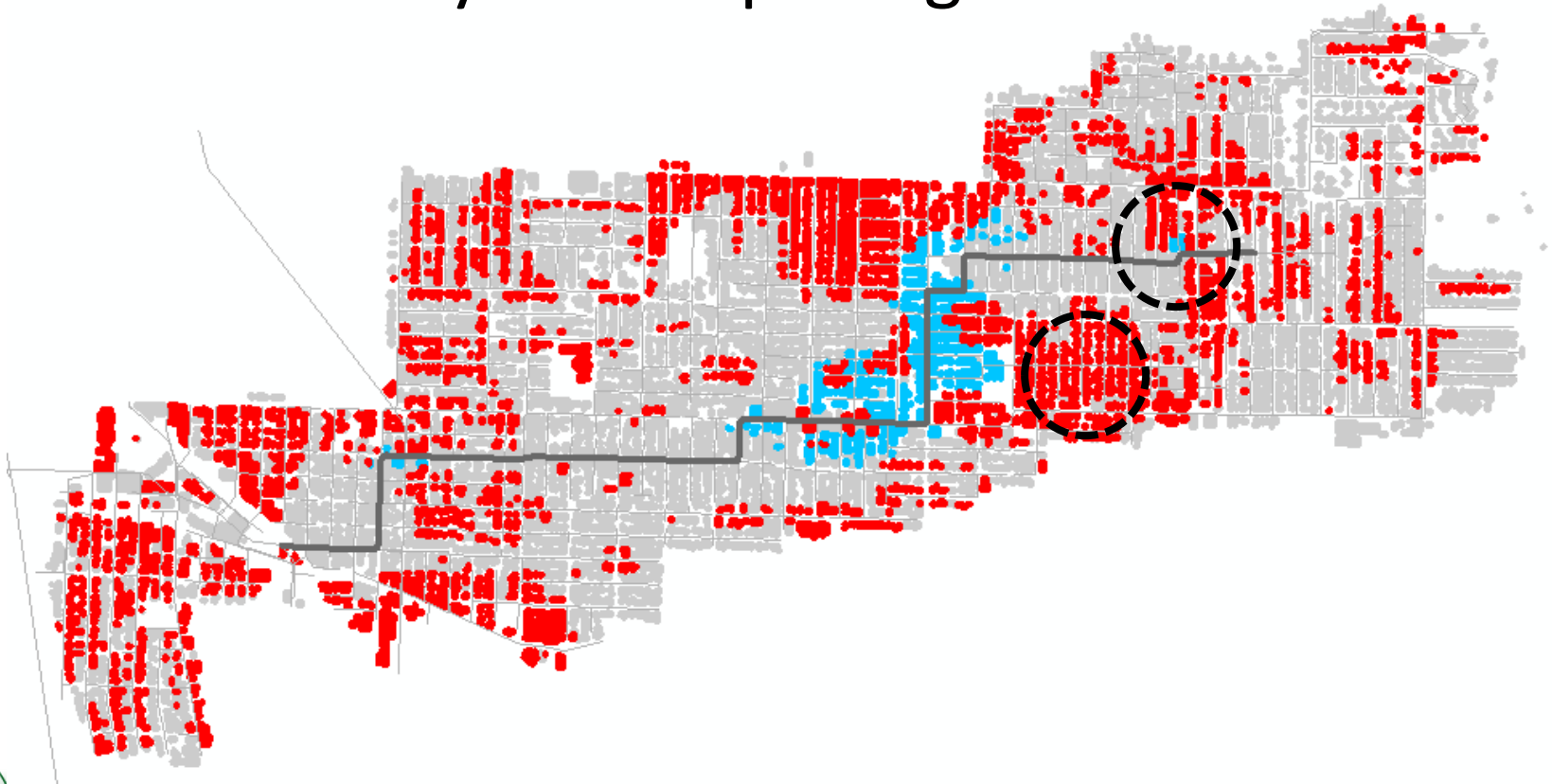
Trunk Upsizing Alternatives

- Increased volume risk
- Risk relieved by trunk upsizing

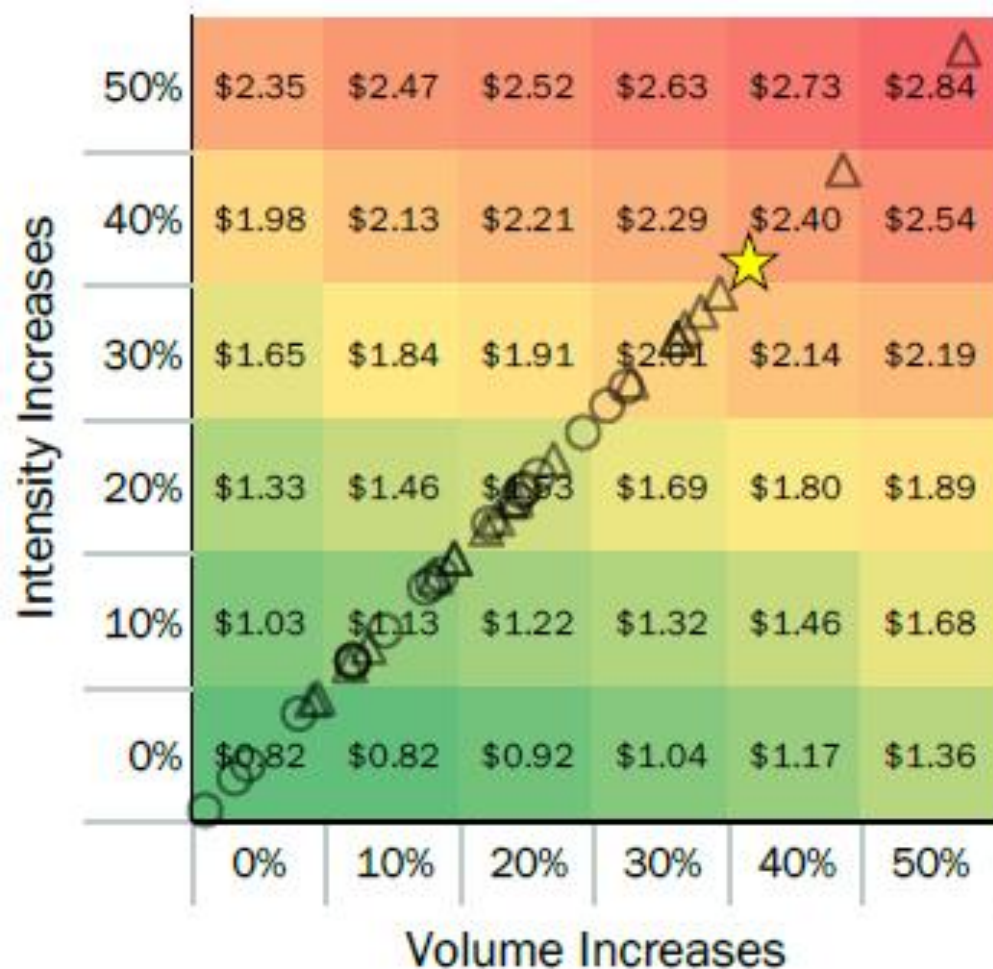


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Tabulating Results

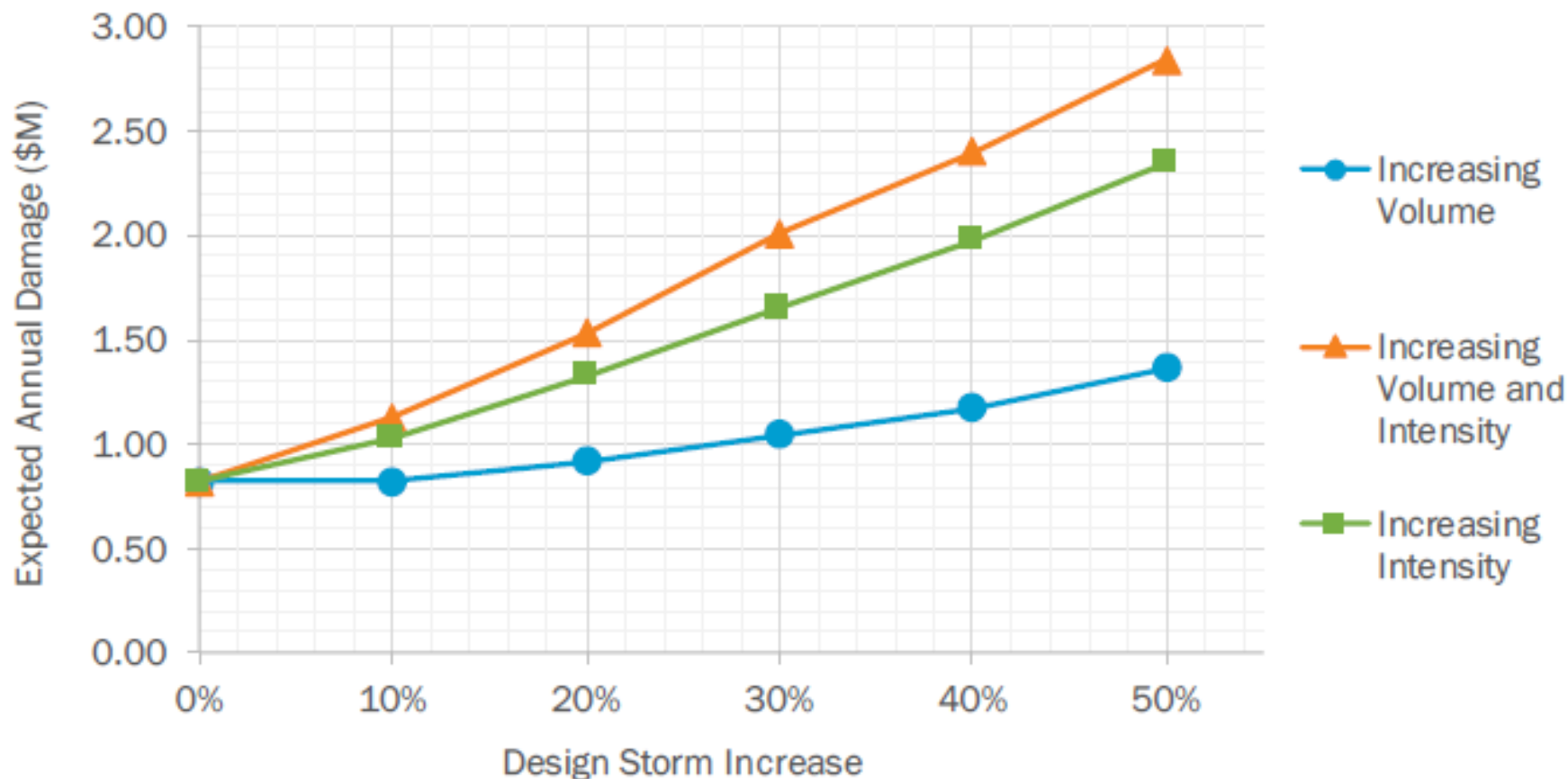


Expect annual damage due to failures in \$M.

Key: ▲ GCM RCP 8.5 ● GCM RCP 4.5 ★ Centered Storm



Graphing Results



Value of Pilot Study

- More sensitive to intensity than volume
- Some local capacity risk depends on scenario
- Suggests alternatives to test
- Shows first/last areas to be affected
- Puts rough dollar values on range of GCMs
- Basis for very rough cost benefit analysis
- Can apply design storms to other basins



Lessons Learned

- Major direction change in project
- Shape of design storm is significant
- Data management and automation

