Flood purge and SWH at Lincoln Squares Project

Development of purging protocols

May 2017

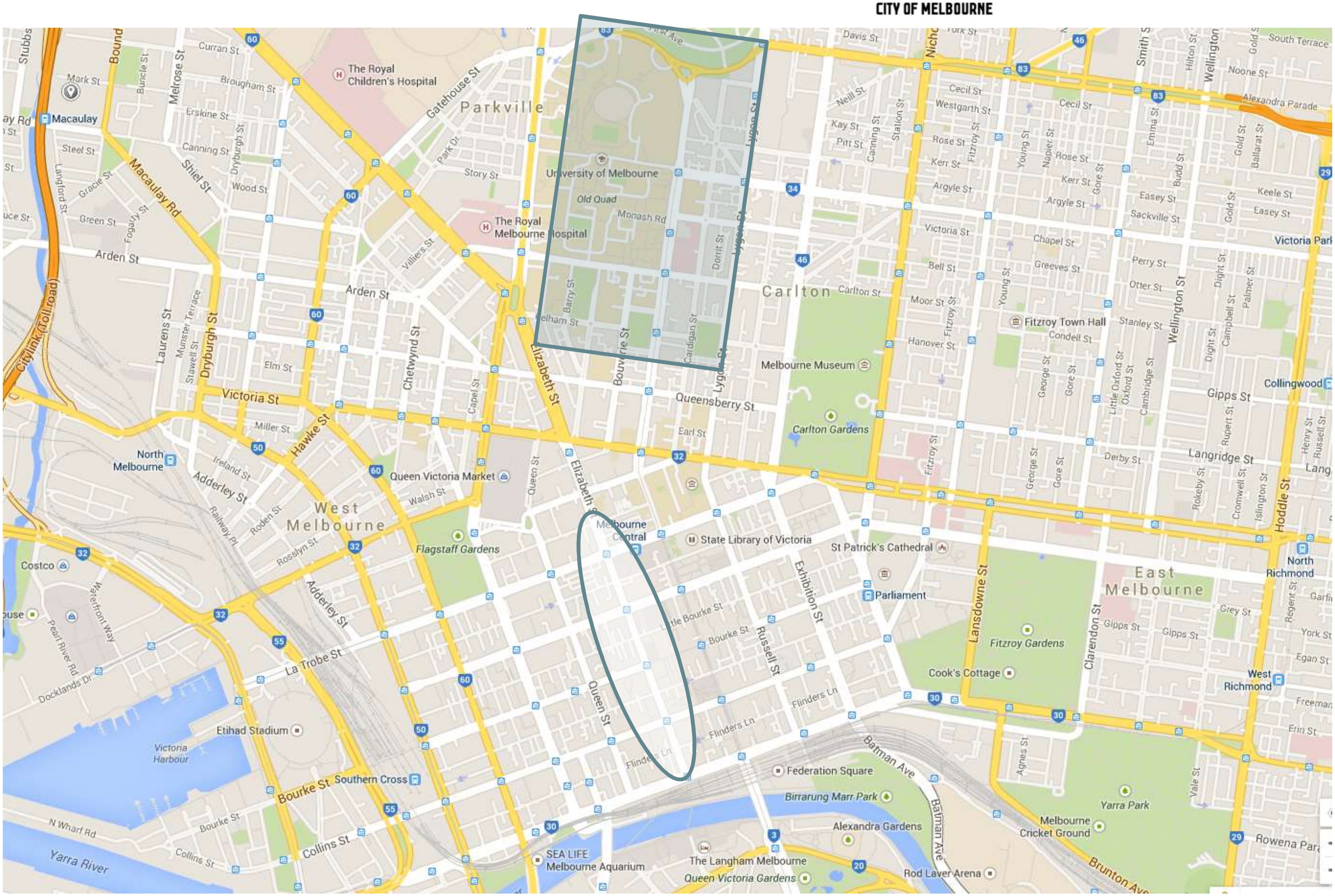
Bringing engineering to **life**

Presentation Outline

1. Introduction
2. Project objectives
3. Upstream catchment
4. System configuration
5. Performance results from previous studies
6. Development of purging protocols

CITY OF MELBOURNE

Storm

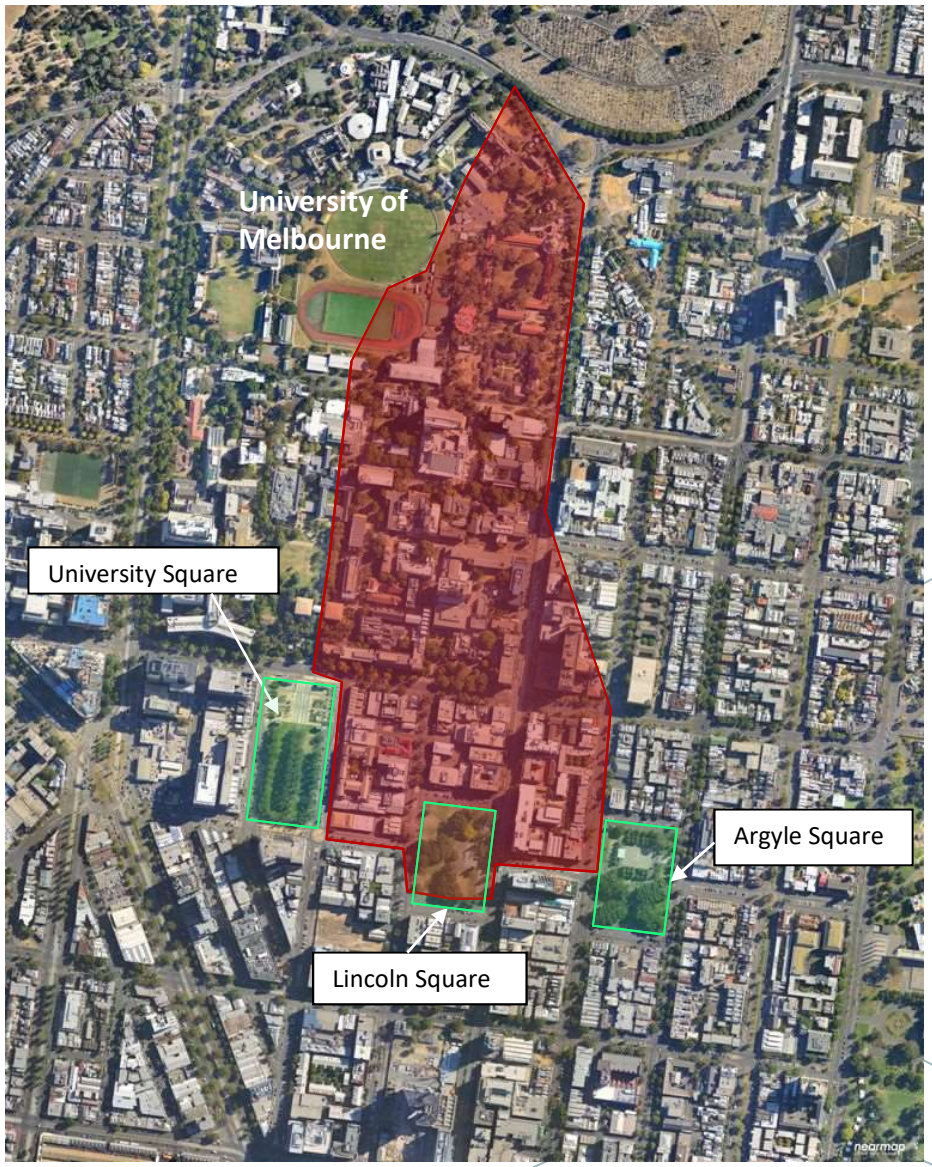


Project Objectives

- Flood Mitigation
  - Peak flow reduction for frequent events
  - Determine impact on flooding contributing to Elizabeth St for the 20 Year ARI event
- Stormwater Harvesting
  - Irrigation of Lincoln, Argyle and University Squares
  - Water balance optimisation to size storages and pumps to maintain reliability of irrigation supply

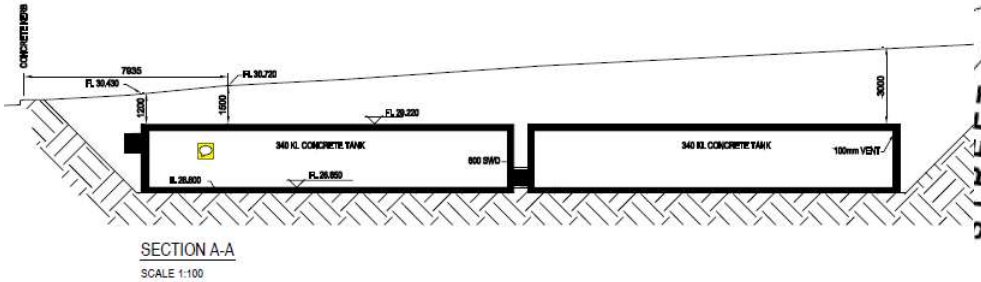
Upstream Catchment

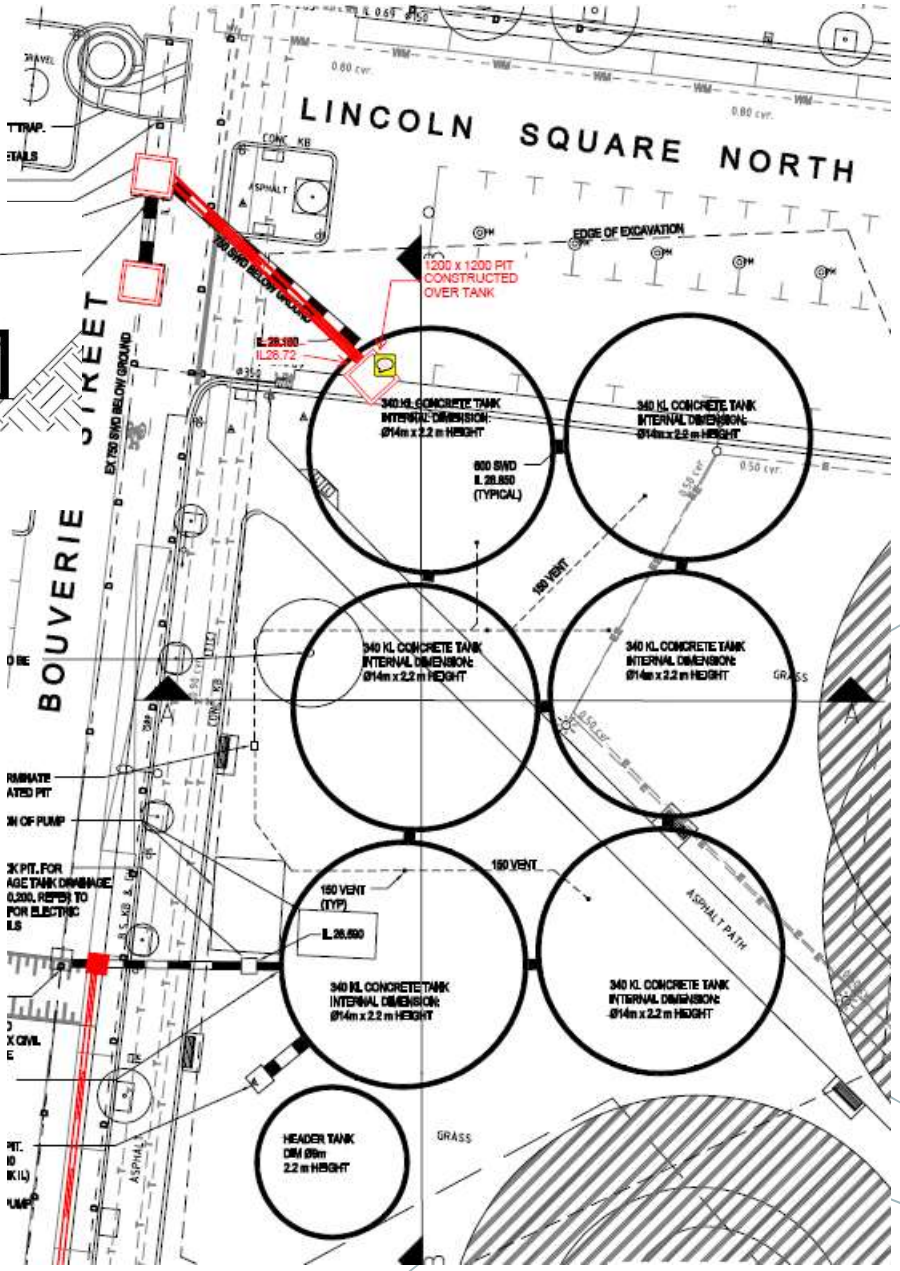
- Area to the north ~37ha
- Includes portion of the University of Melbourne and the tram line on Swanston St
- Meets at the 750mm pipe adjacent Lincoln Square (to the west)



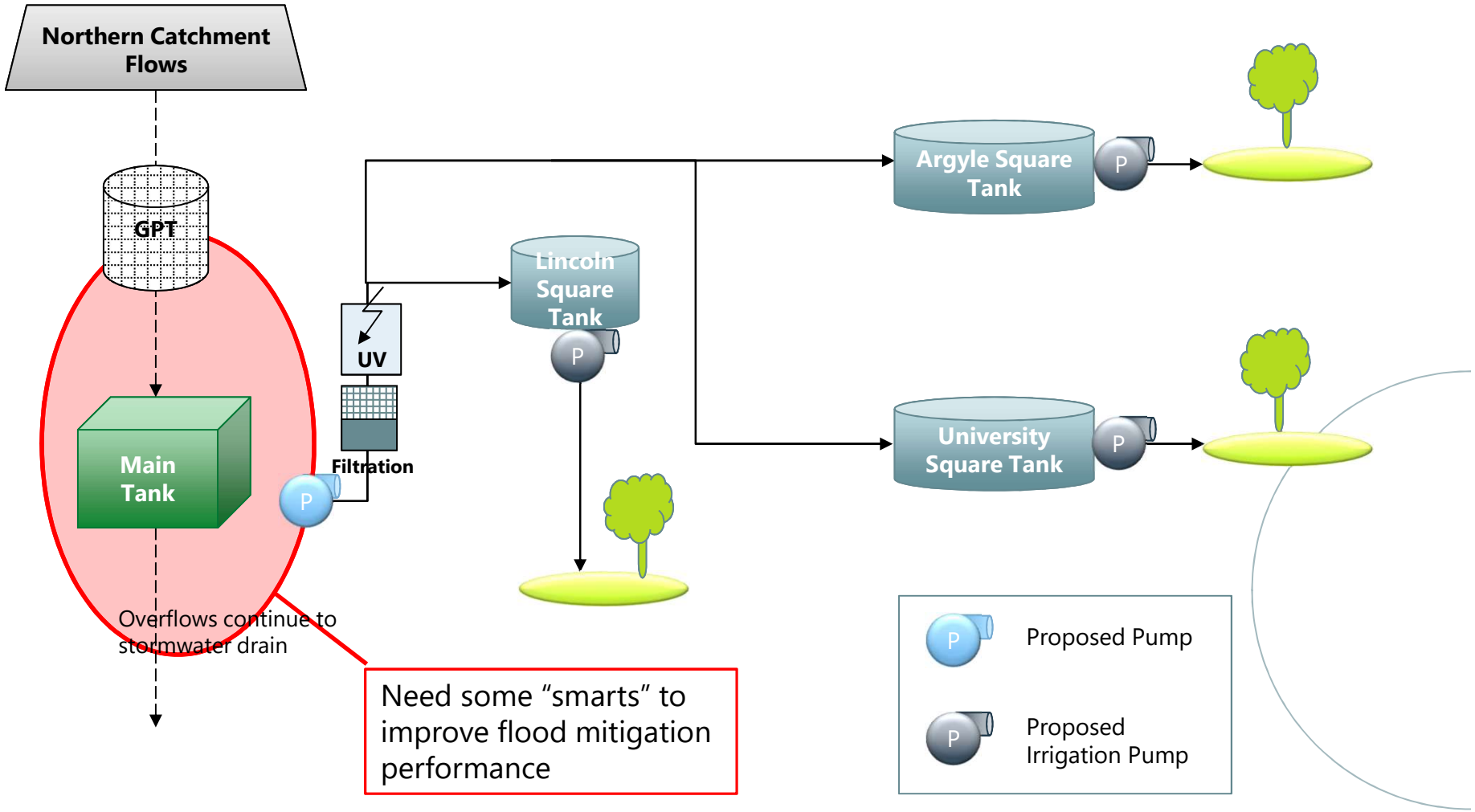
Project Layout

Design Drawing of tanks (by civil contractor)

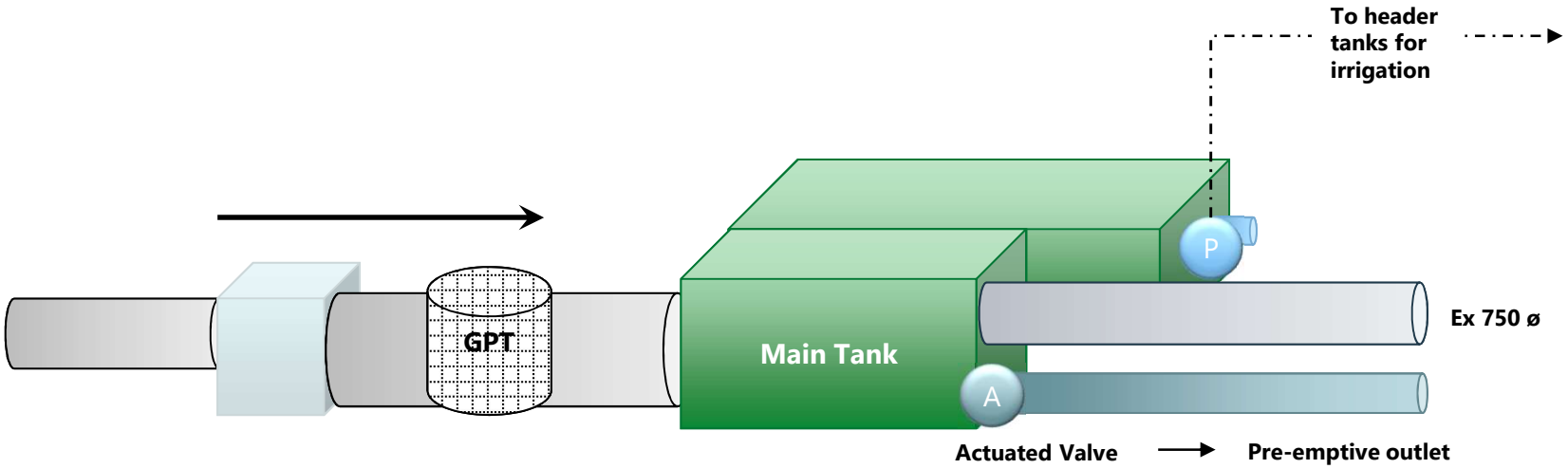




System Configuration Overview



Applying the smarts



Ex 750 ø → New JP → 1,200 ø → GPT → 1,200 ø → Main Tank → Irrigation systems Or Drainage system

P Proposed Pump

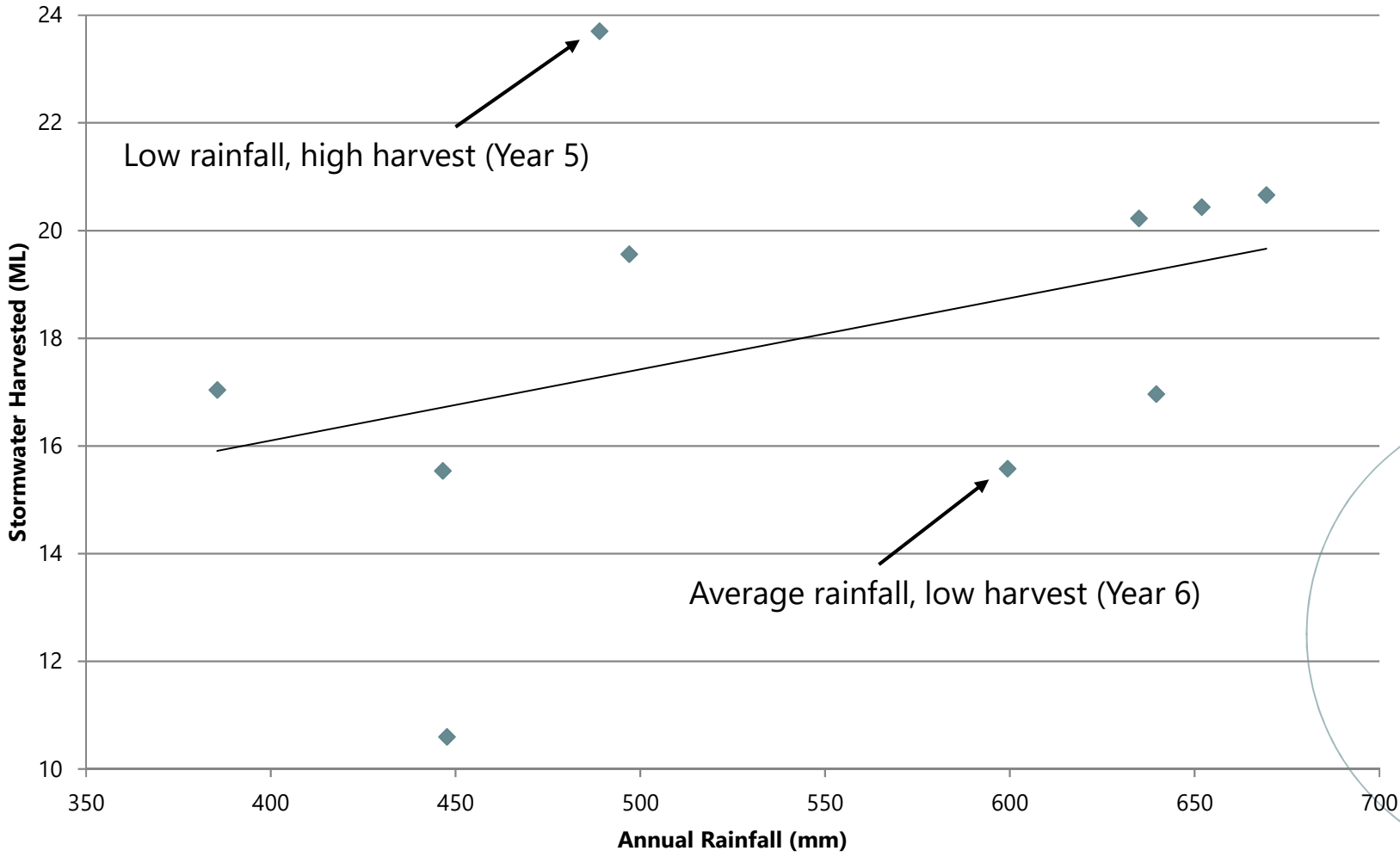
A Actuator

Council's irrigation demands

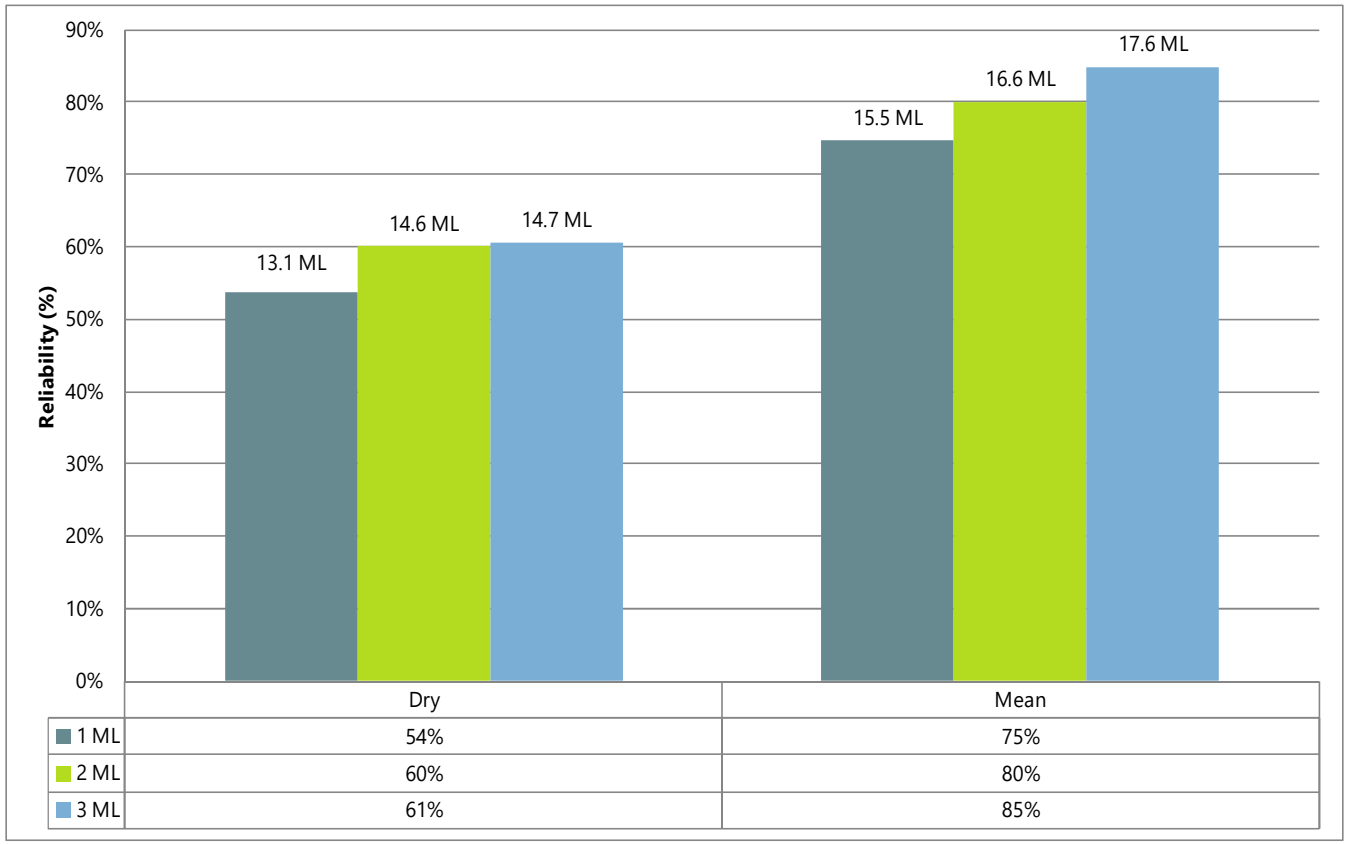
Period	Irrigation Area (m^2)	Irrigation Demand (Midway Efficient Use – ML pa)
Expanded Lincoln Square	12,897	6.97
Expanded University Square	13,500	7.25
Expanded Argyle Square	9,790	5.17
Pelham and Bouverie Street Trees	2,304	1.20
Total	**38,491**	**20.6**

The irrigation calibration produced a demand of 20.6 ML for a mean year, showing consistency with the data provided by Council.

Rainfall vs Yield

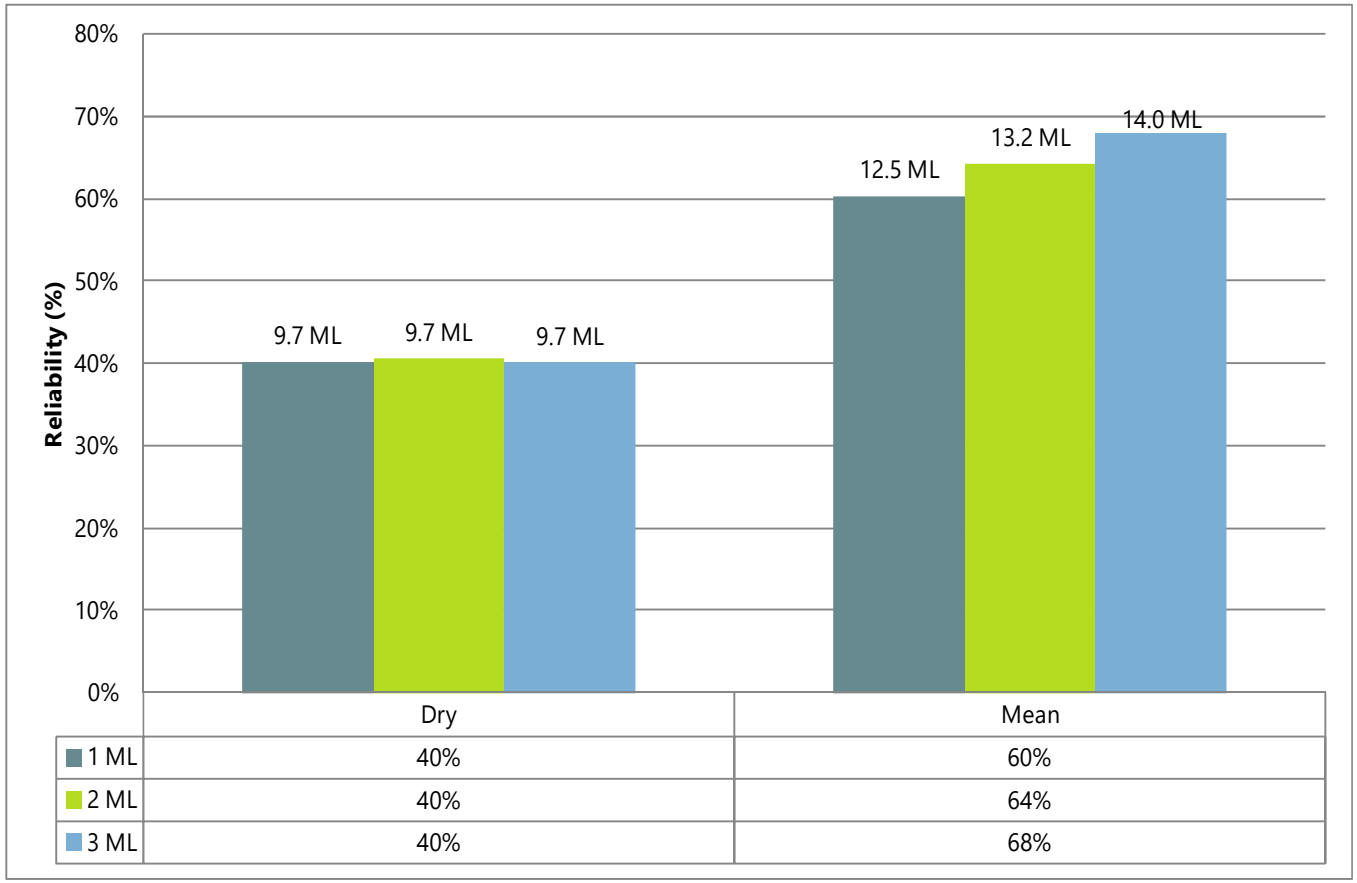


Main Tank Size Comparison – Optimal Operation



	Dry	Mean
1 ML	54%	75%
2 ML	60%	80%
3 ML	61%	85%

Main Tank Size Comparison – **Sub** Optimal Operation

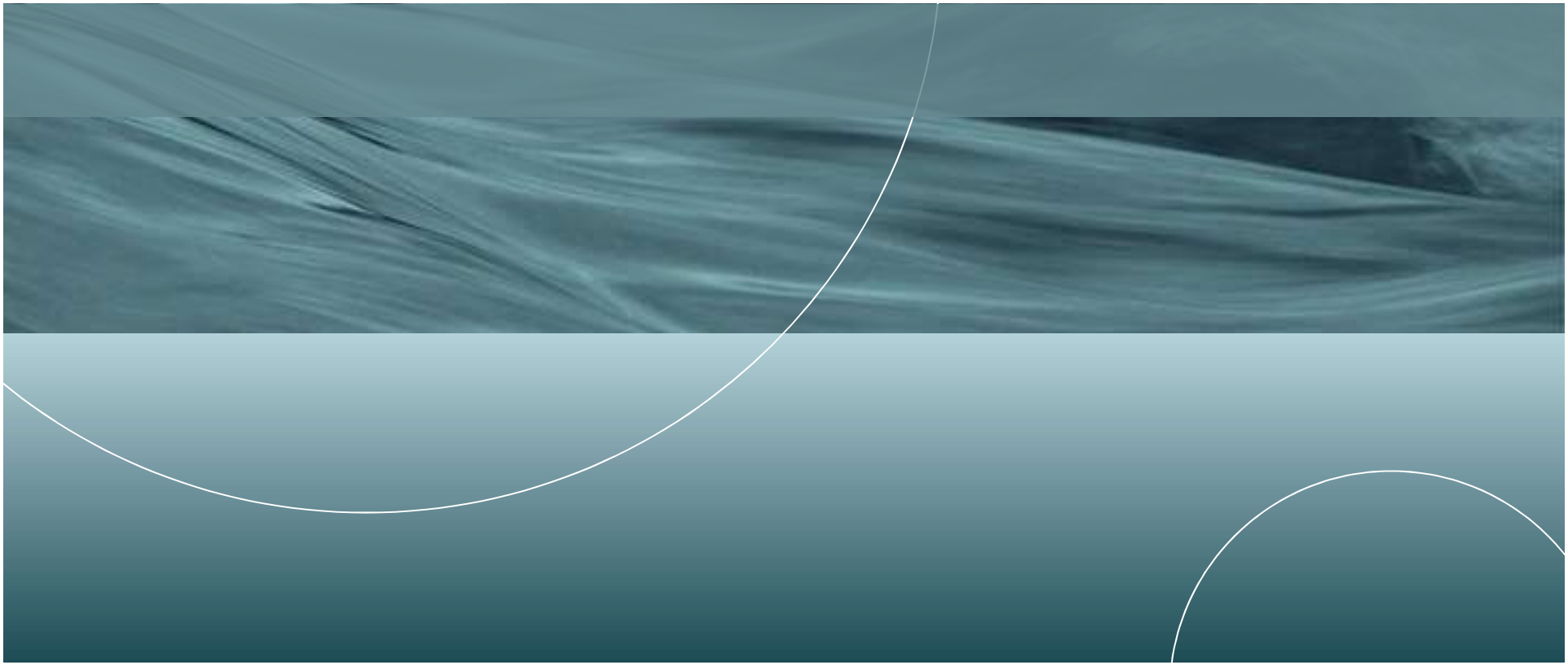


Peak Flow Analysis

Storm / flow type		Existing	2ML Tank	% Reduction	3ML Tank	% Reduction
5 Year, 20Min	Pipe	1.55	1.51	2.6%	1.48	4.5%
	Overland	1.83	0.362	80.2%	0.359	80.4%
	TOTAL	**3.38**	**1.872**	**44.6%**	**1.839**	**45.6%**
20 Year, 20Min	Pipe	1.76	1.66	5.7%	1.63	7.4%
	Overland	3.51	1.88	46.4%	1.87	46.7%
	TOTAL	**5.27**	**3.54**	**32.8%**	**3.5**	**33.6%**
50 Year, 20Min	Pipe	1.77	1.75	1.1%	1.72	2.8%
	Overland	4.88	3.31	32.2%	3.3	32.4%
	TOTAL	**6.65**	**5.06**	**23.9%**	**5.02**	**24.5%**

- Marginal (to no) benefit to increasing the tank size to 3ML

Purging Analysis



Purging Assessment Outline

1. Scope
2. Philosophy and Approach
3. Method
4. Protocol Development
5. Graphical Outputs
6. Key Storms
7. Sensitivity Analysis
8. Summary

1. Scope

Objective is to maximise **Flood Mitigation** without significantly compromising Stormwater Harvesting yield

- ✓ Flood Mitigation
  - Reduction of Overland Flow (to Elizabeth St)
  - Reduction of bypass discharge
- ✓ Stormwater Harvesting
  - Irrigation of Lincoln, Argyle and University Squares
  - Water balance optimisation to maximize Tank Water Level after each storm

2. Philosophy and Approach

Develop Purge protocols to address:

- Before Storm

✓ Purge Water to make Required Pre-Rain Air Space using Predicted Rainfall

- During Storm

✓ To maintain detention

✓ To ensure tank is close to full post rain event

3. Method

Key Variables:

- Before Storm

✓ Pre-Rains Air space: based on Predicted rainfall

✓ BOM 3-hour Rainfall Predictions

- During Storm

✓ Pre-peak Air Space

✓ Post-Peak Air Space

✓ Rainfall threshold for valve close

3. Method

Key Performance Indicators:

- Flood Mitigation Objective

✓ Overland Flow Reduction

✓ Percentage reduction in downstream overland flow

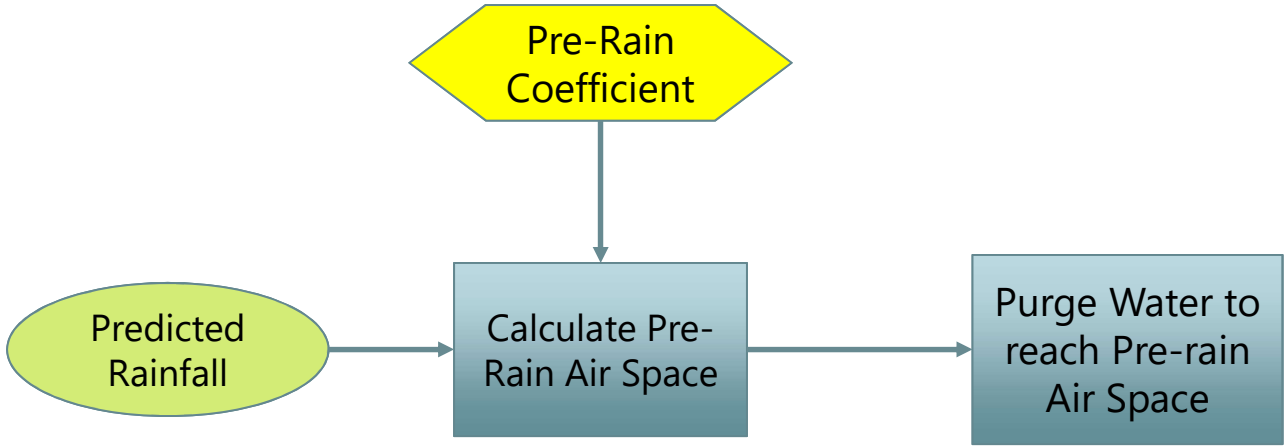
- Stormwater Harvesting Objective

✓ After Rain Tank Water Level

✓ Tank percentage full at the end of the storm

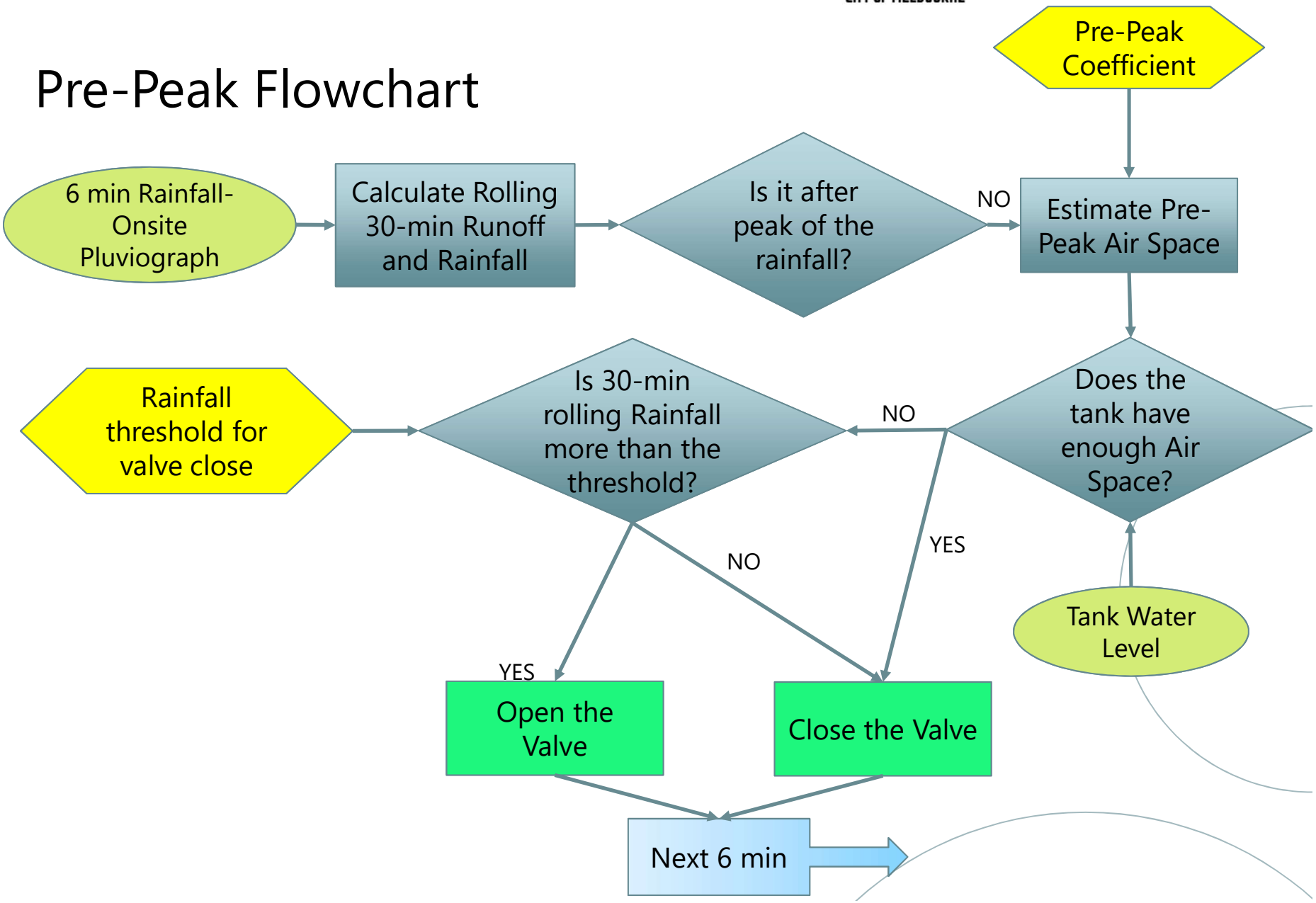
3. Method

Pre-Rain Flowchart



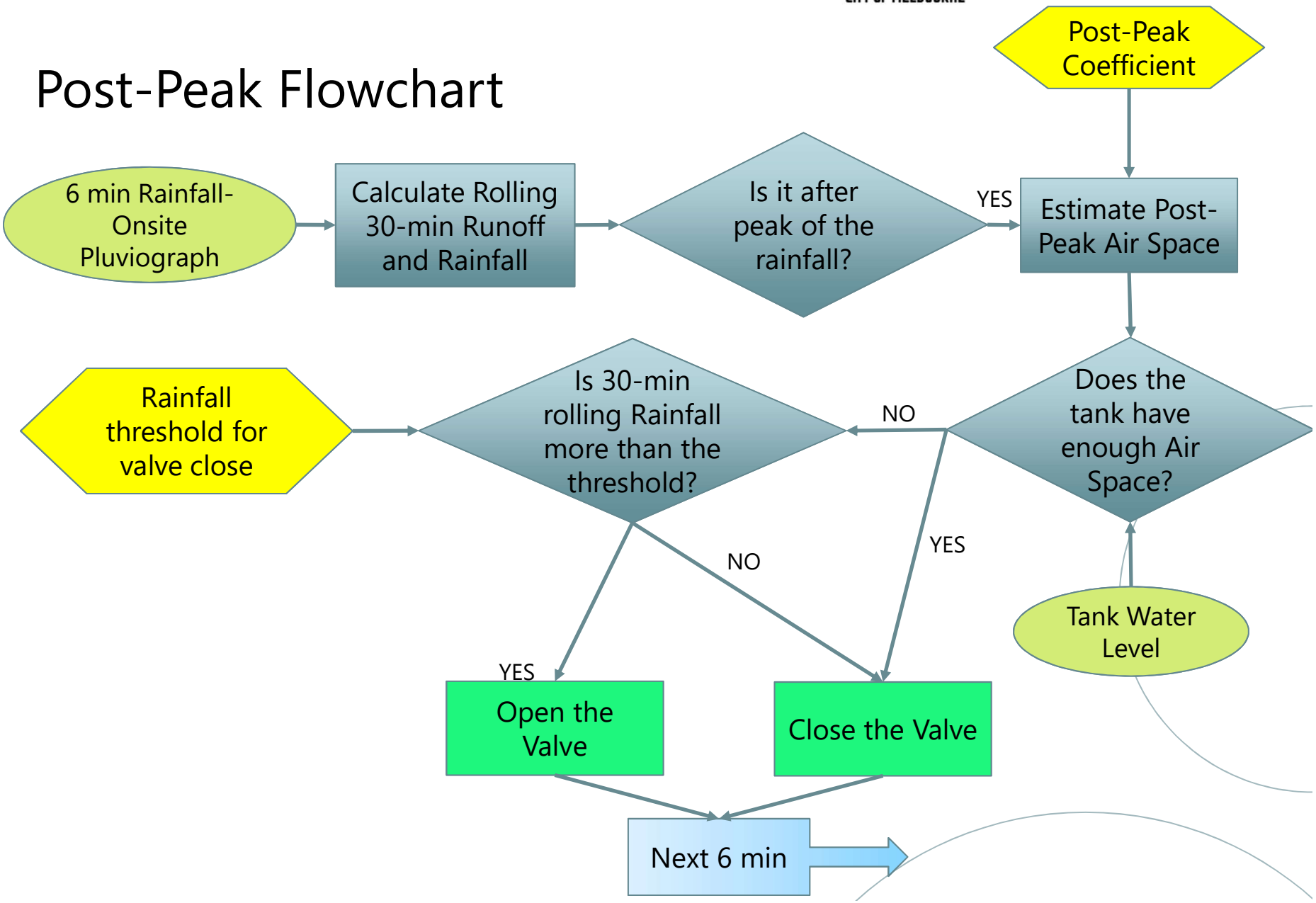
3. Method

Pre-Peak Flowchart



3. Method

Post-Peak Flowchart



3. Method

Selection of 50 storms

- Melbourne Regional Office Station # 086071
    1. 6-min Rainfall data between 1873-2010
    2. Maximum Daily Rainfall; 16 Storms
    3. Maximum Hourly Rainfall; 10 Storms
    4. Maximum 6-min Rainfall; 18 Storms
    5. Design Storms; 6 Storms

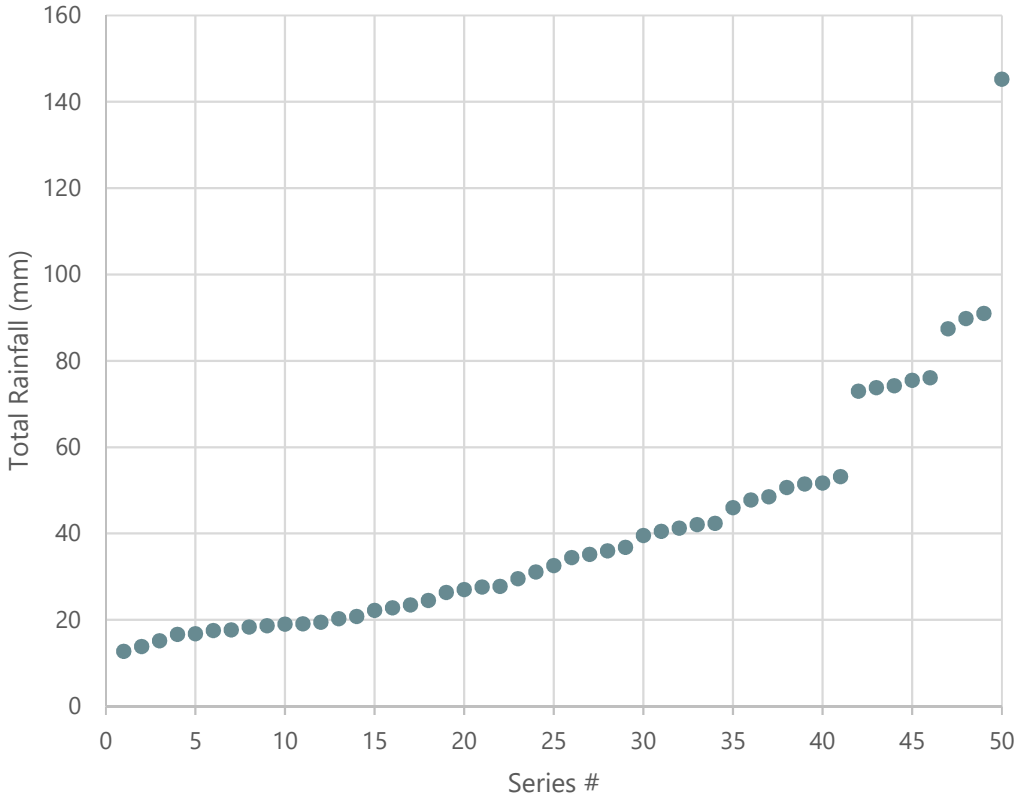
       1in 20 years: 30 min, 60 min and 90 min

       1 in 50 Years, 30 min, 60 min, 90 min

- Method

Selection of 50 storm

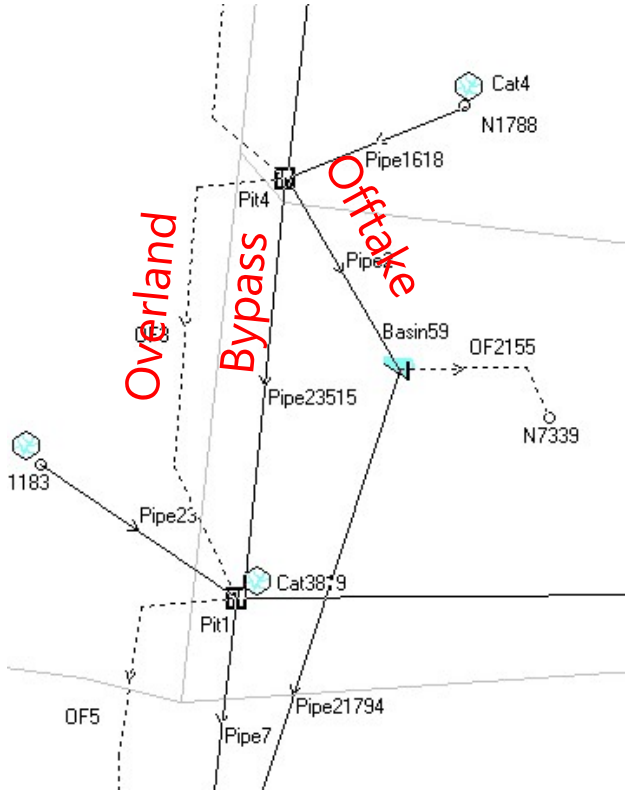
1in 20 Years, 30 min: 26.32 mm
1in 20 Years, 60 min: 34.42 mm
1in 20 Years, 90 min: 39.51 mm
1in 50 Years, 30 min: 32.57 mm
1in 50 Years, 60 min: 42.33 mm
1in 50 Years, 90 min: 48.47 mm

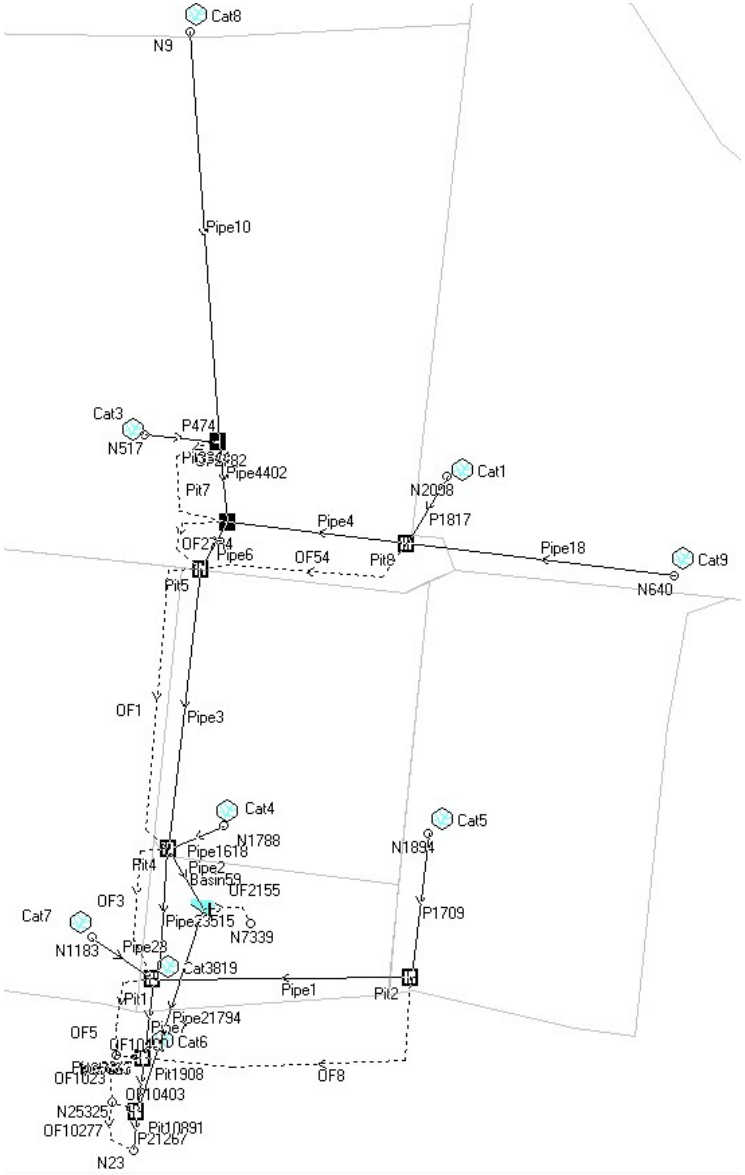


3. Method

Water Quantity Model:

- DRAINS
- ✓ ILSAX hydrologic model





3. Method

Water Balance Model

- Excel Spreadsheet based calculations
- Calculation time steps:

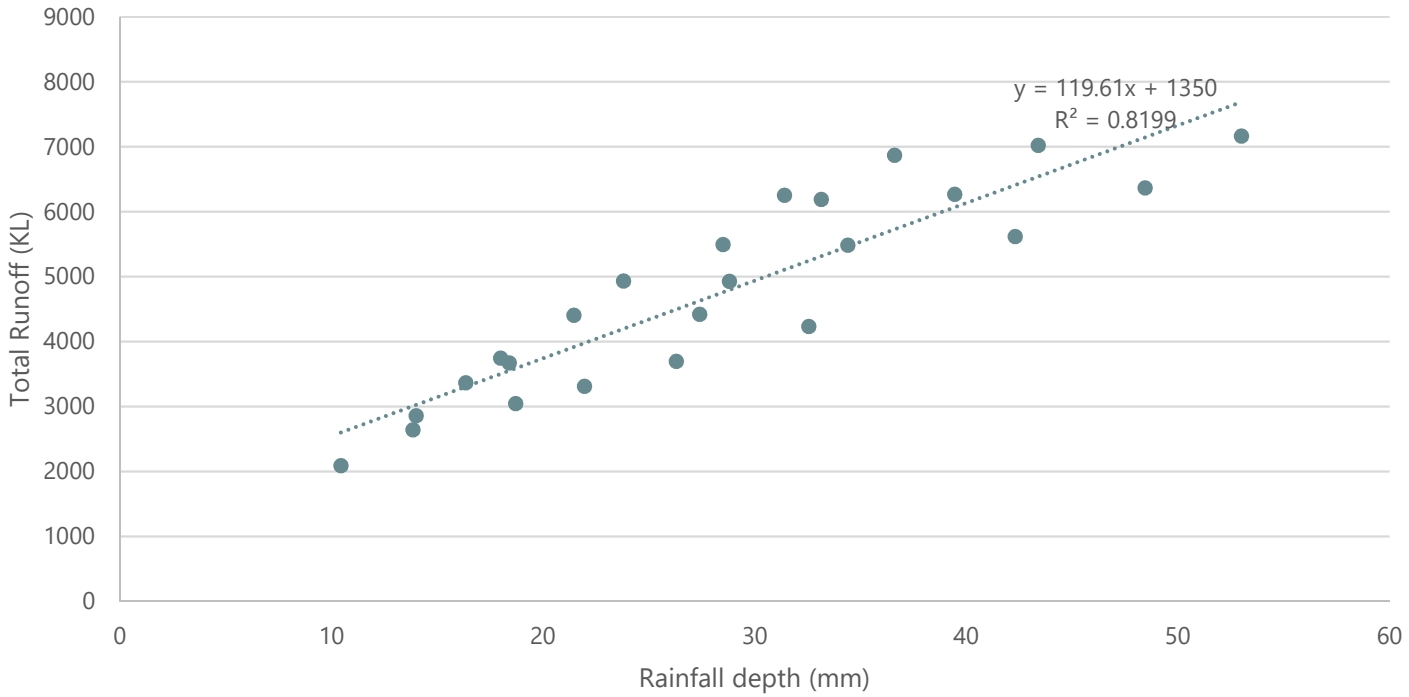
  5 min for Design Storms and 6 min for the others

- $\boldsymbol{Pre\ Rain}\ Air\ Space = Pre - Rain\ Coefficient \times Runoff\ Calculated\ based\ on\ Predicted\ Rainfall\ Depth$
- $\boldsymbol{Pre\ Peak}\ Air\ Space = Pre - Peak\ Coefficient \times Rolling\ 30\ \text{min}\ Runoff$
- $\boldsymbol{Post\ Peak}\ Air\ Space = Post - Peak\ Coefficient \times Rolling\ 30\ \text{min}\ Runoff$
- $Storage\ Volume = Initial\ Storage + Offtake\ - Tank\ Outflow$
- $DS\ Overland\ Flow = US\ Flow\ - Offtake\ - Bypass$

3. Method

Water Balance Model

- Rolling 30min Runoff calculation



4. Protocol Development

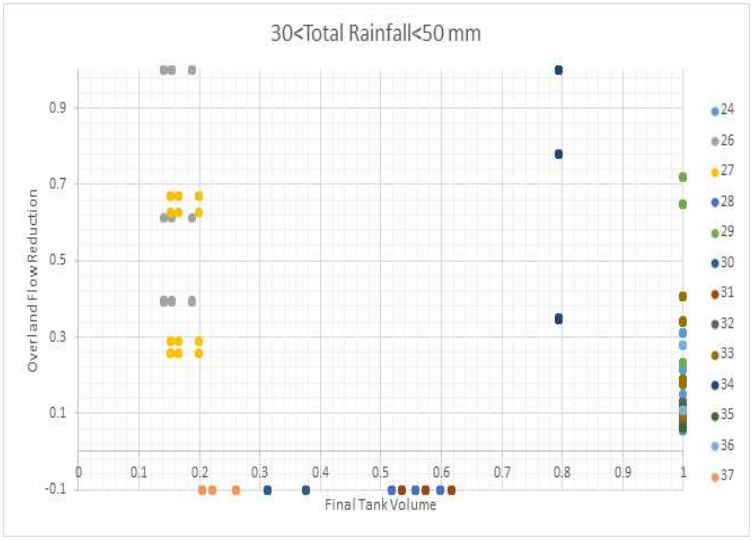
Phase 1:

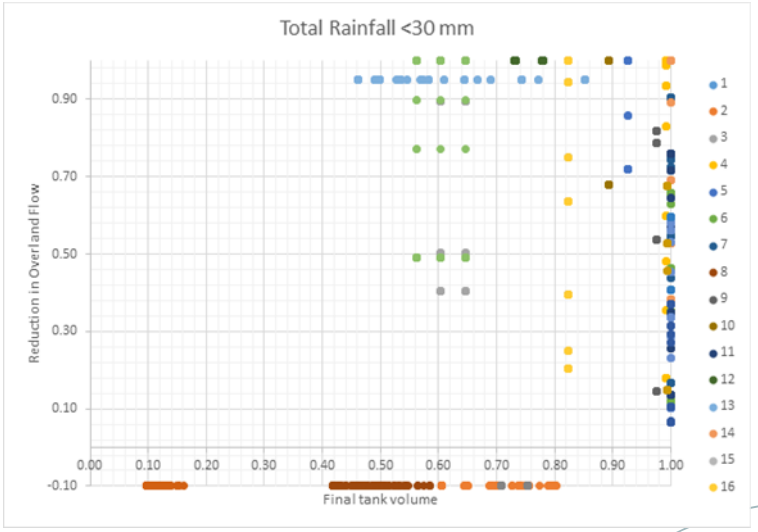
Pre-Rain Coefficient: **10%,20%,...,100%**

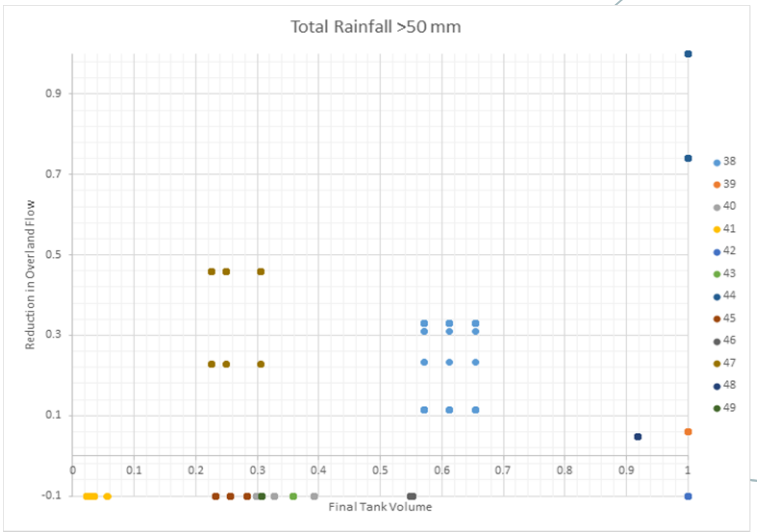
Pre-Peak Coefficient: **25%,50%,...,100%**

Post- Peak Coefficient: **25%,50%,...,100%**

No Rainfall Threshold for Valve Close







4. Protocol Development

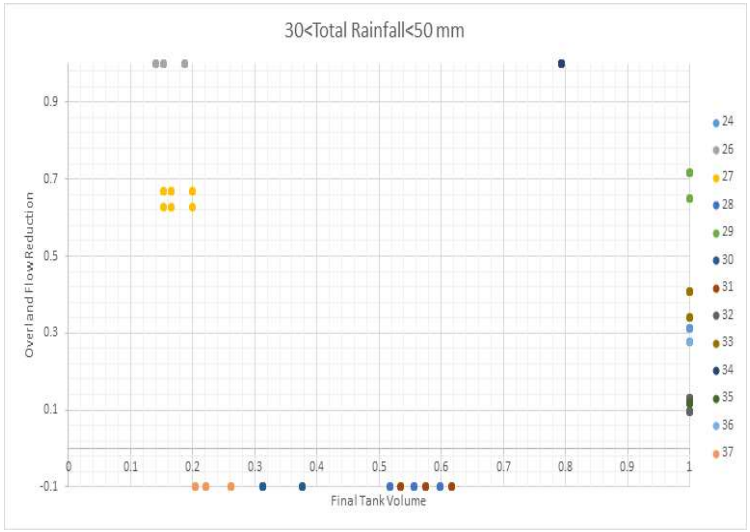
Phase 2:

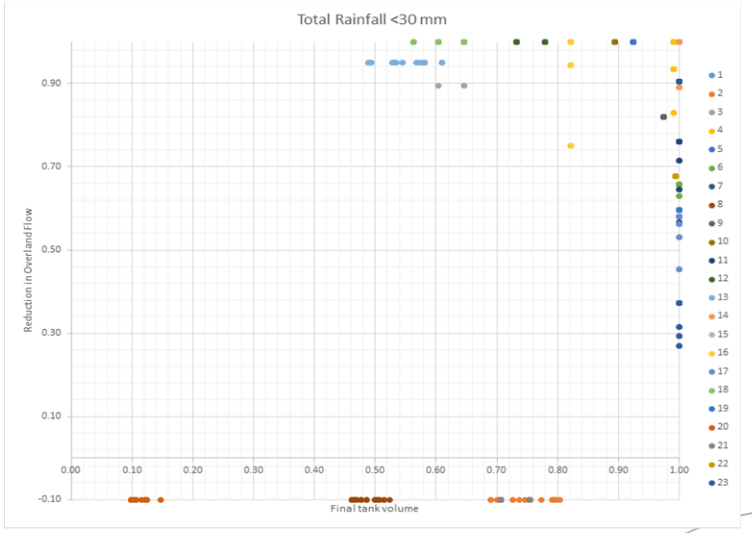
Pre-Rain Coefficient: **30%,40%,50%**

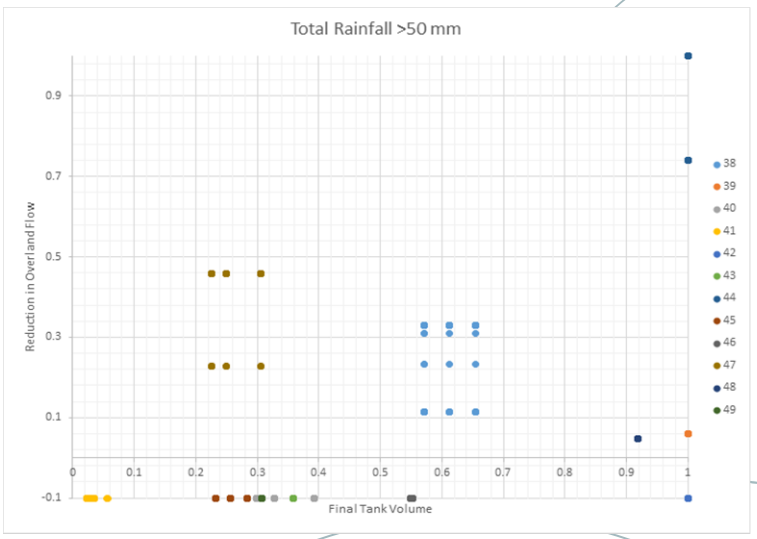
Pre-Peak Coefficient: **25%,50%,75%**

Post- Peak Coefficient: **25%,50%,75%**

No Rainfall Threshold for Valve Close





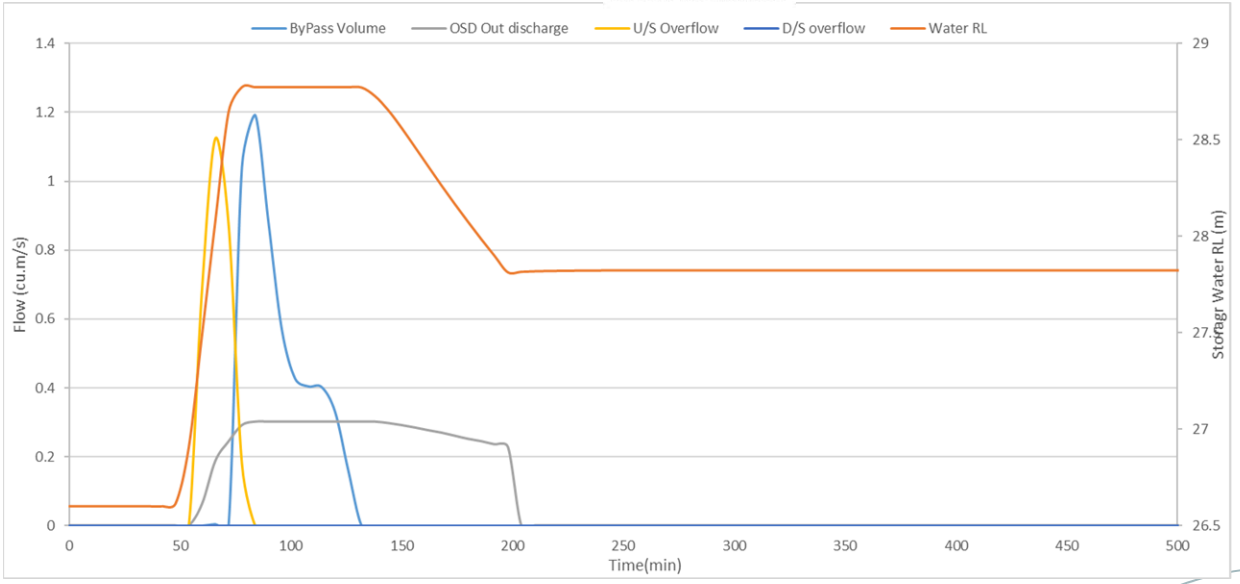


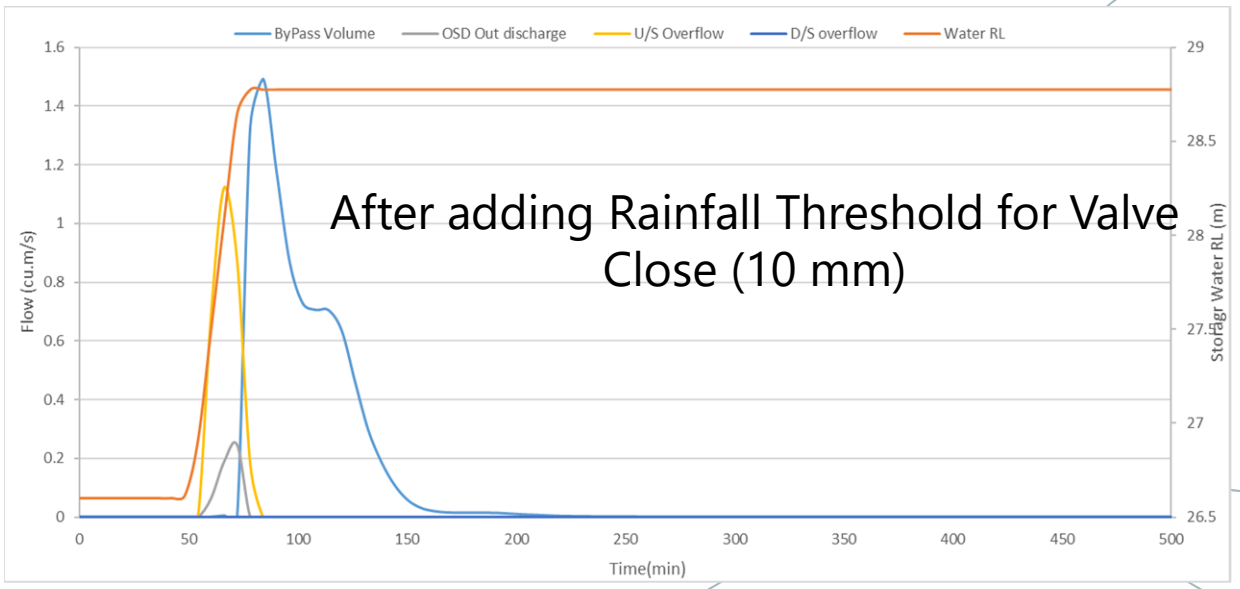
4. Protocol Development

Storm #49

Rainfall Summary	
Total rainfall (mm)	24.44
Duration (min)	180
Maximum Intensity (mm/hr)	84.9
Maximum Intensity (mm/6 min)	8.49
Estimated recurrance interval (1 in yr)	65

Protocols	
Pre- Rain Coefficient	50%
Pre-peak Coefficient	75%
Post-peak coefficient	25%
Rainfall threshold for valve close (mm/ 30 min)	10





After adding Rainfall Threshold for Valve Close (10 mm)

4. Protocol Development

Phase 3:

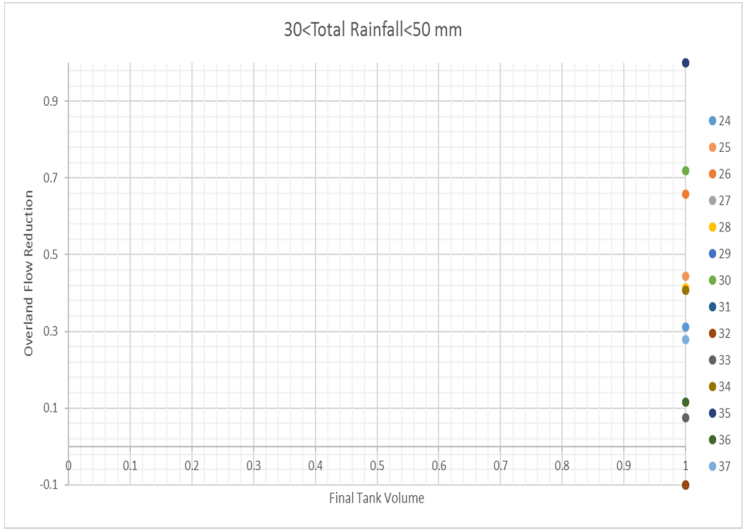
Pre-Rain Coefficient: **50%**

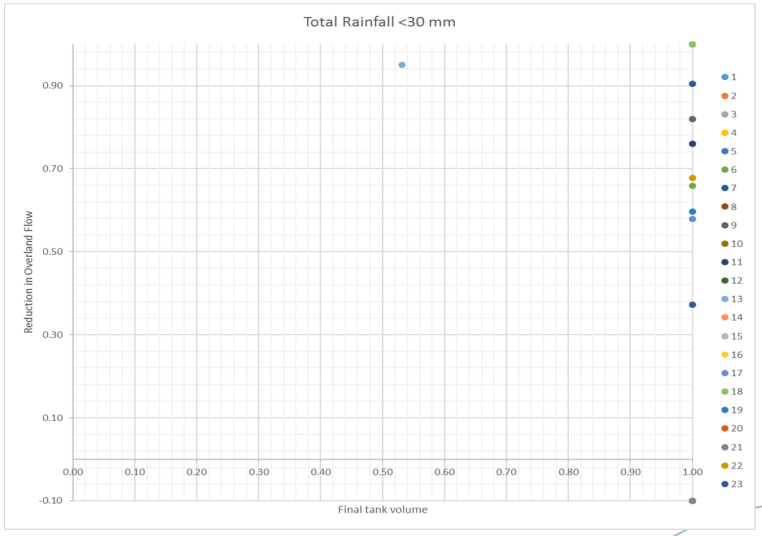
Pre-Peak Coefficient: **75%**

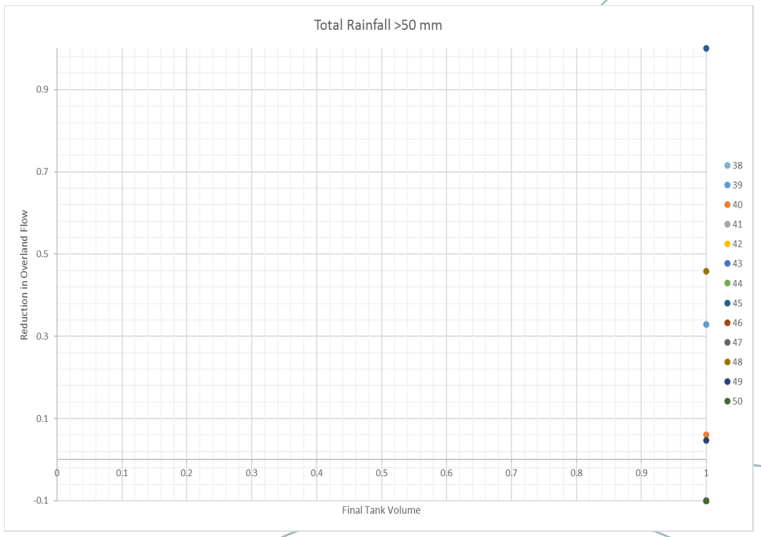
Post- Peak Coefficient: **25%**

Rainfall Threshold for Valve Close:

10 (mm/30min)







5. Graphical Outputs

- ✓ Demonstration "Presentation Sheet"

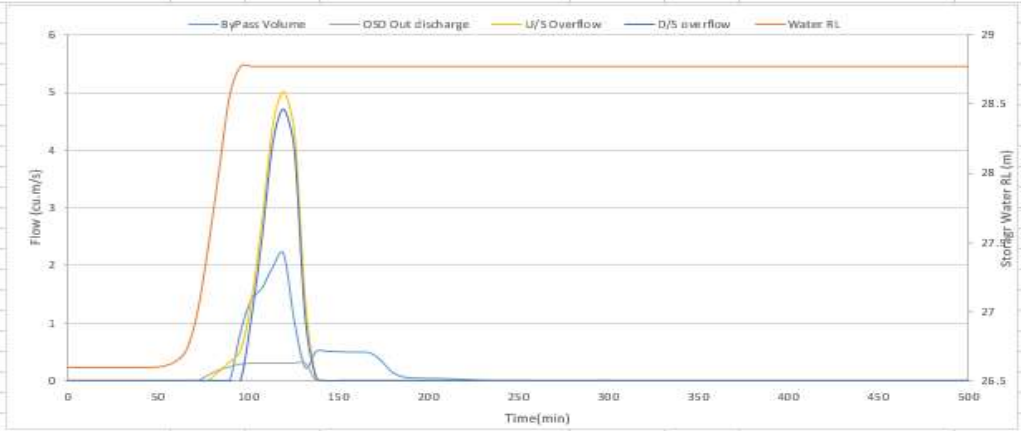
Storm #	34

Rainfall Summary	
Total rainfall (mm)	51.69
Duration (min)	144
Maximum Intensity (mm/hr)	101.2
Maximum Intensity (mm/6 min)	10.12
Estimated recurrance interval (1 in yr)	50

Protocols	
Pre- Rain Coefficient	50%
Pre-peak Coefficient	75%
Post-peak coefficient	25%
Rainfall threshold for valve close (mm/ 30 min)	10

Results	
Reduction in Overland Flow	6.01%
Final Tank Volume	100.00%
# Penstock open/close	4

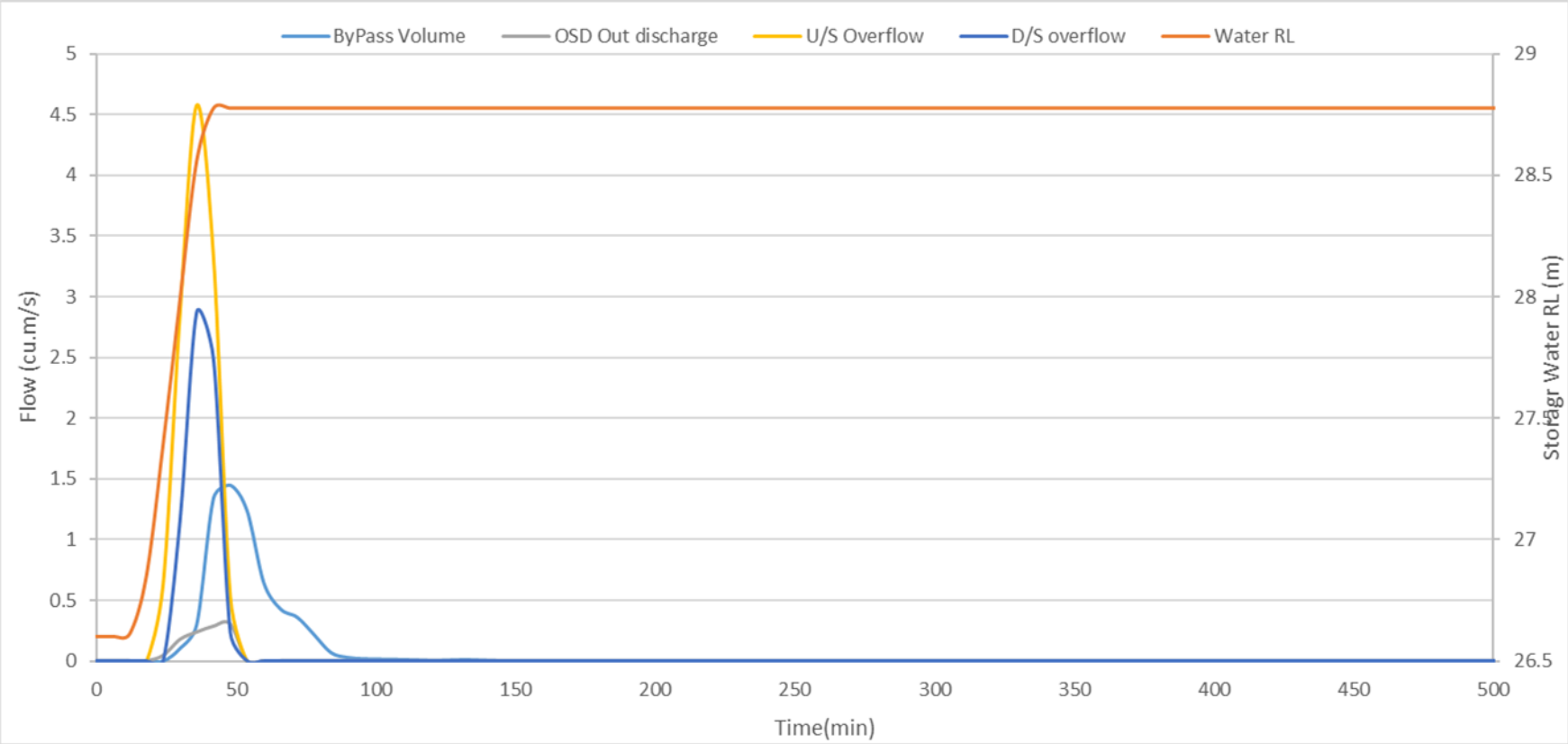
Flow parameters	
Bypass Capacity (cu.m/s)	1.7
Offtake pipe capacity (cu.r	1.7



Rainfall | Runoff | Inputs | Presentation | Target air space metho ...

6. Key Storms

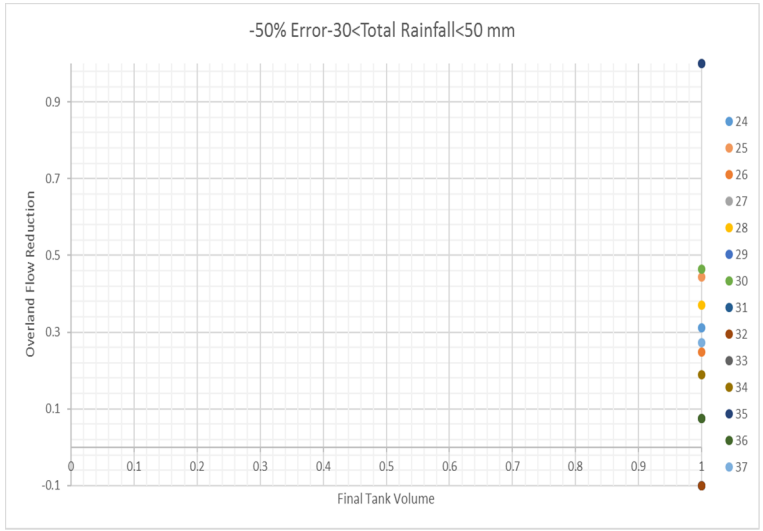
- ✓ Demonstration

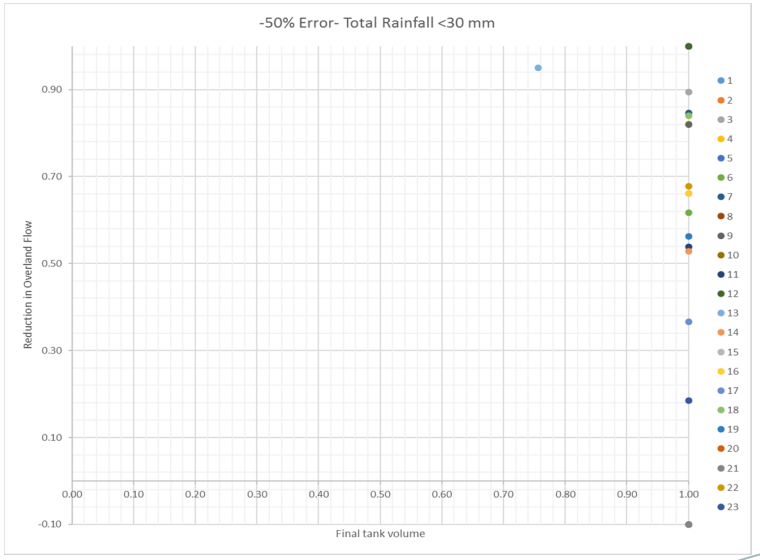


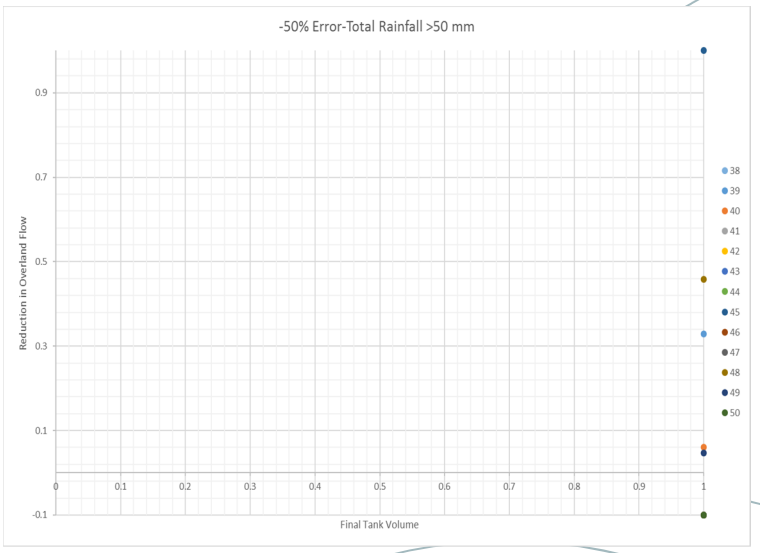
7. Sensitivity Analysis

Predicted rainfall is 50% less than the Actual one. (-50% Error)

Not Sensitive



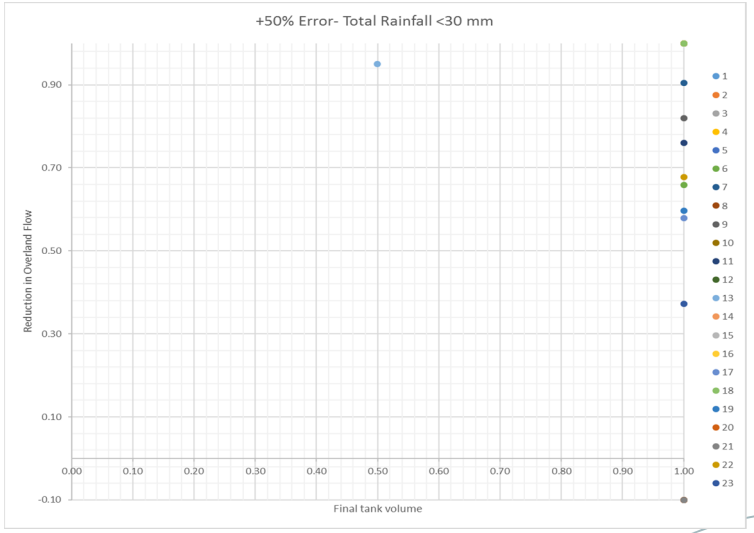


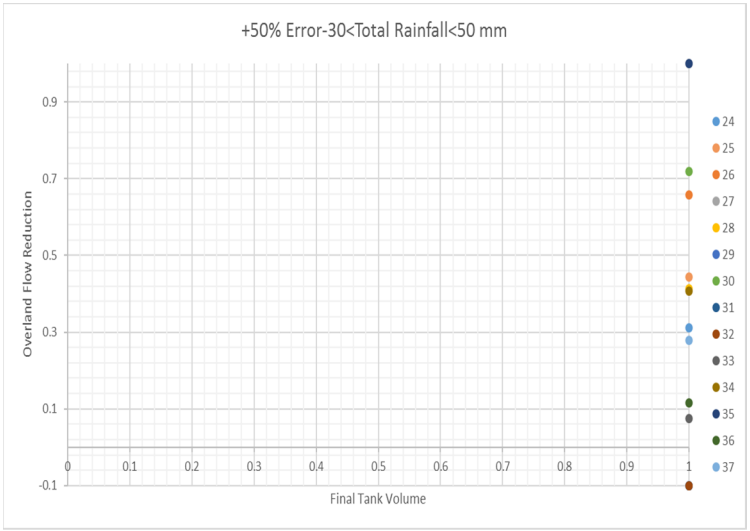


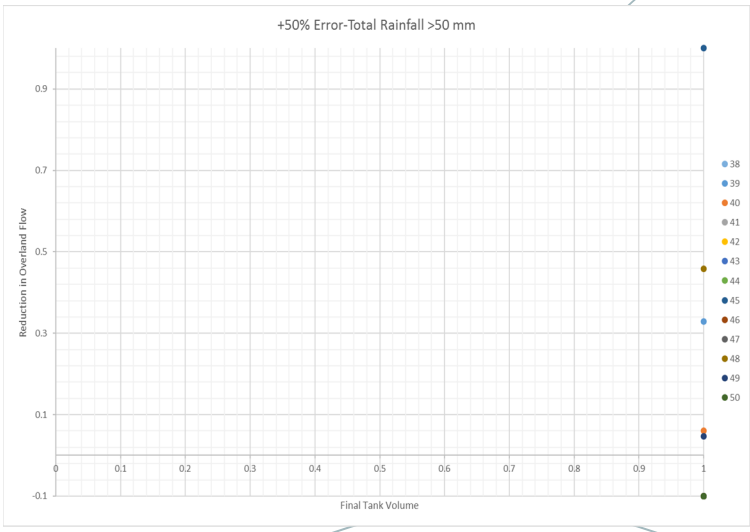
7. Sensitivity Analysis

Predicted rainfall is 50% more than the Actual one. (+50% Error)

Not sensitive







- Summary

- ✓ Protocols are developed for dual function of flood mitigation and stormwater harvesting.
- ✓ Pre-rain Air space is introduced based on the predicted rainfall – threshold is approximately 15mm with optimally 50% airspace coefficient.
- ✓ Pre peak airspace coefficient is optimally 75%
- ✓ Post peak airspace coefficient is optimally 25%
- ✓ Rainfall depth threshold for valve close in 30 min rolling period is 10mm.

- Summary

✓ The performance (final tank volume and reduction in overland flow) is more effective in storms with less than 50mm rainfall.

✓ Performance is not sensitive to up 50% error in rainfall prediction.

✓ Overland flow upstream generally occurs in events with intensity higher than 8 mm/6min (80 mm/hr).

Storm

Bringing engineering to **life**