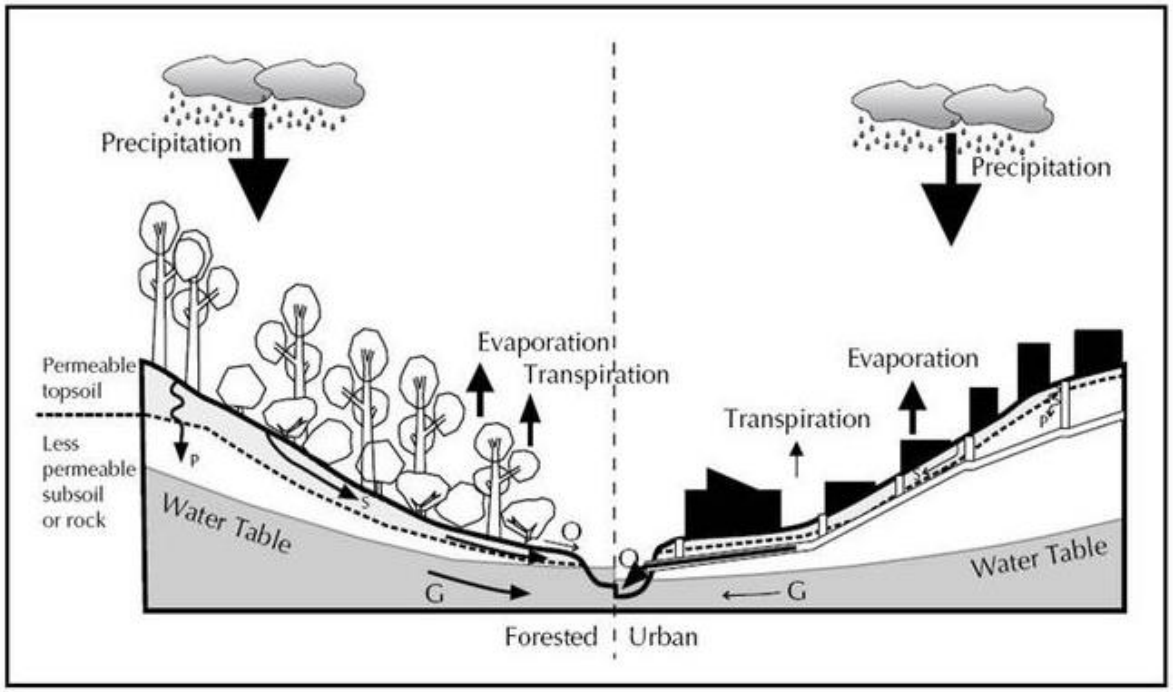
Why best practice is destroying our waterways

Presenter: Rod Wiese

31st August 2016

Bringing engineering to **life**



Change in stream behaviour

'urban stream syndrome'

Is current practice really effective for protecting our precious waterways?

Scope of presentation

1. How can we measure waterway protection?
2. How well does traditional practice or *business as usual* achieve waterway protection?
3. What are other options that could improve waterway protection?
4. How do these options compare to BAU?
5. What are the cost implications?
6. Is it worth it???

This is explored through a case study

Acknowledgments for Case Study

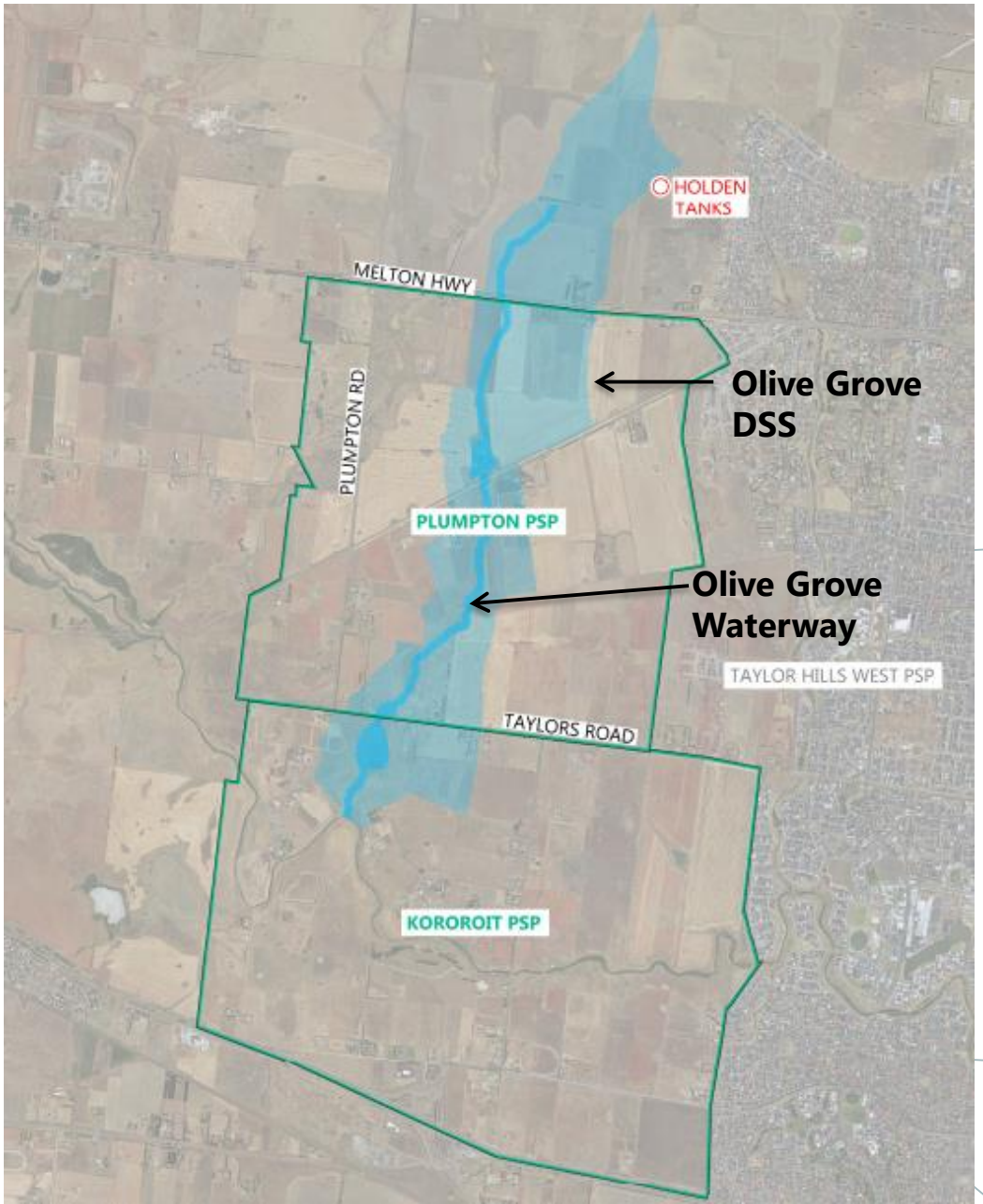
- MPA
  Development of WOWCA for Plumpton and Kororoit Precinct Structure Plans (PSP's)

- DELWP (initially OLV)
  Development of follow-up case studies on a specific DSS within the PSP's

Case Study – Plumpton and Kororoit

Case Study – Olive Grove DSS

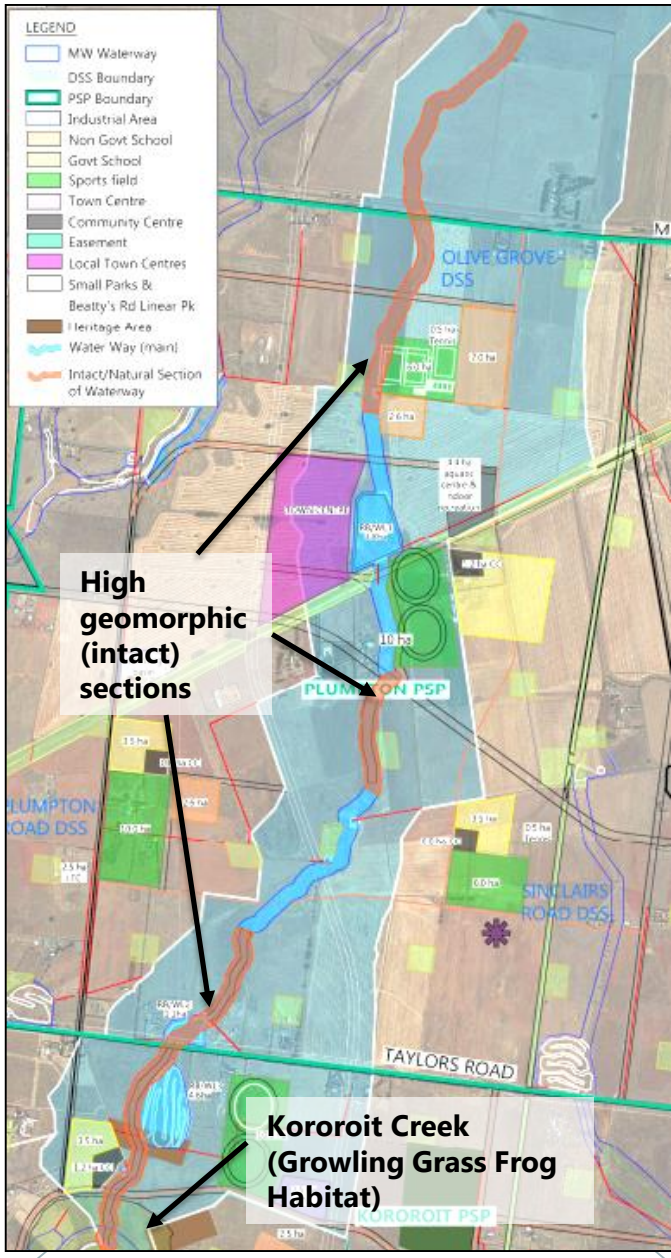
- Within the precincts, the Olive Grove DSS has been selected to compare options
- Catchment of 469 ha across the two precincts
- Comprises residential, commercial, school and parkland areas (no industrial)
- External agricultural catchment enters from the north
- Centralised assets in Base Case (BAU) case include 2 retarding basins and 3 wetlands



Olive Grove Waterway

- The Olive Grove Waterway is 4.3 km long and drains to Kororoit Creek
  - (a major creek in western Melbourne comprising protected Growling Grass Frog species).

- A geomorphological study of the Olive Grove Waterway indicates remnant sections exist of high geomorphic value

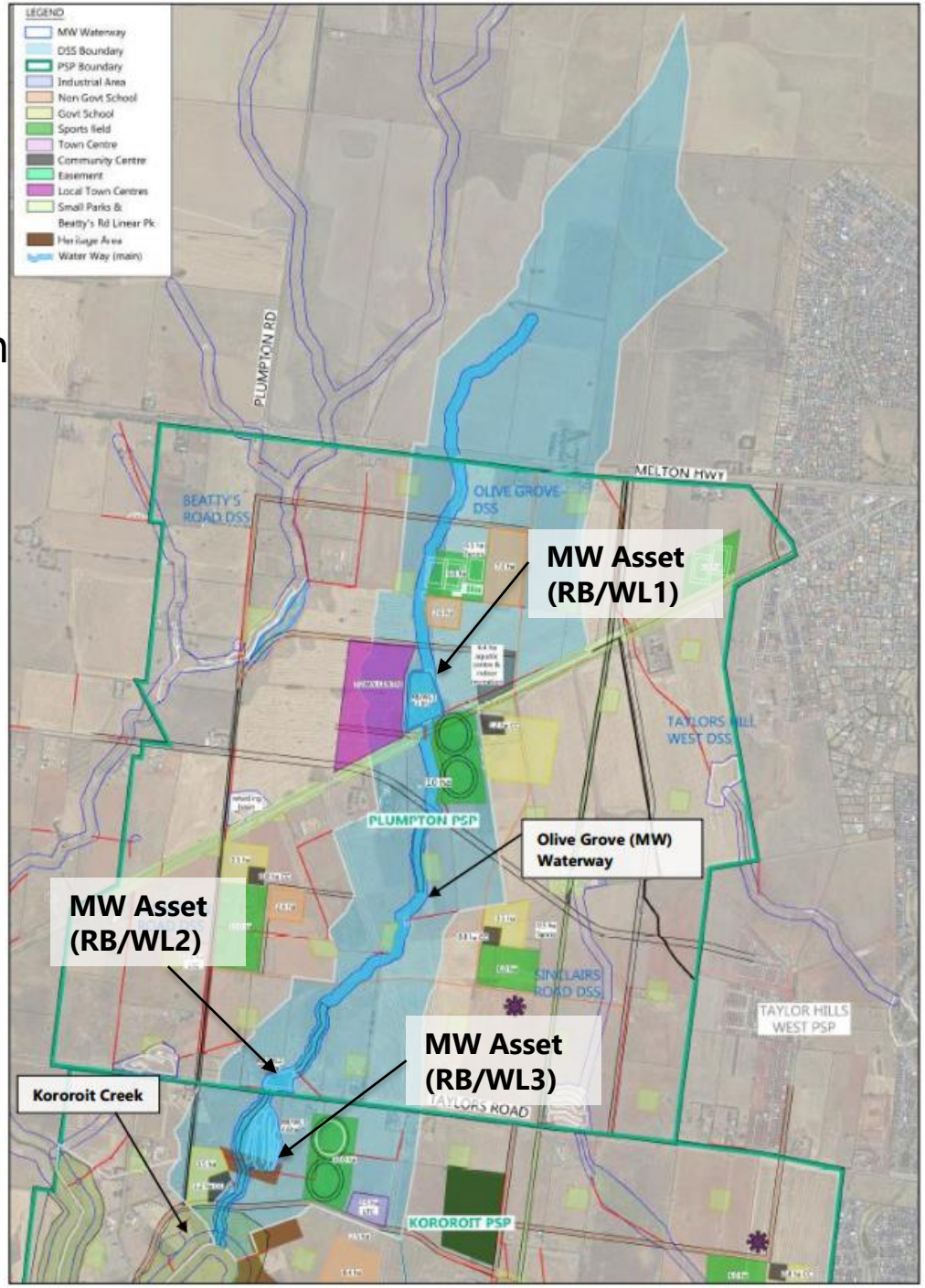


Case Study
Land Use Breakdown

The DSS (Base Case) requires approximately 9 ha of land through the two PSPs to be set aside for stormwater management and waterway protection

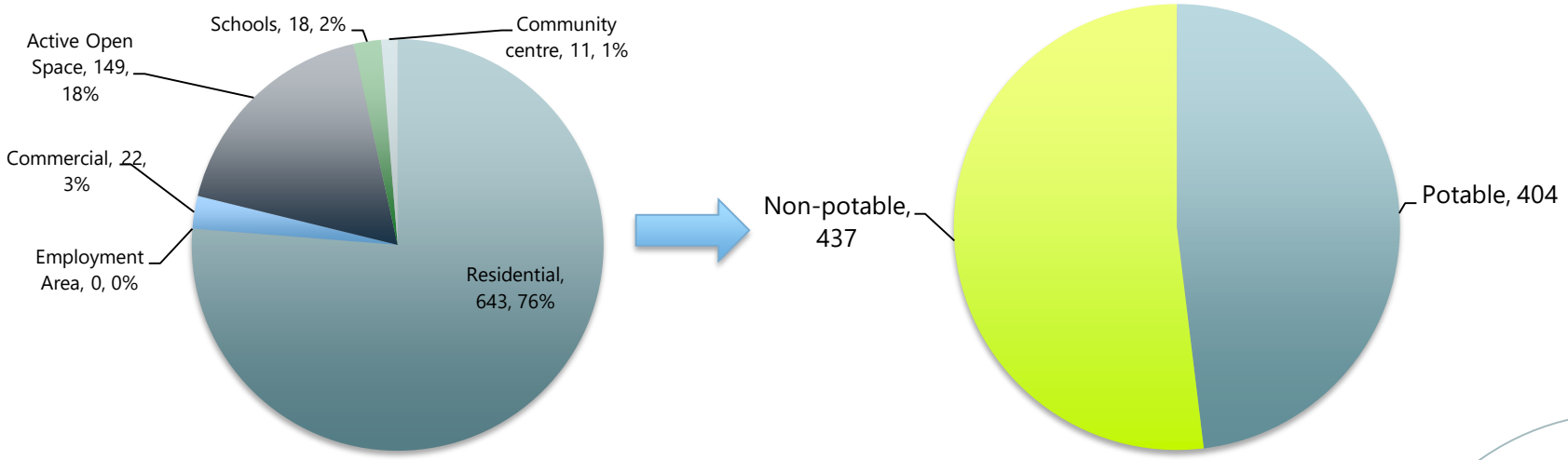
- Is this enough?

Surface Type	Catchment Area (Ha)
Town Centre	10.8
Parks and Tennis Courts	34.5
Beatty's Road Linear Park	3.0
Local Town Centre's	2.5
Schools and Community Centres	14.3
Indoor Rec	4.4
Melbourne Water Assets (Retarding Basins & Wetlands)	**9.0**
Agricultural	130
Remaining Urban (Residential & Roads)	260
Total	469



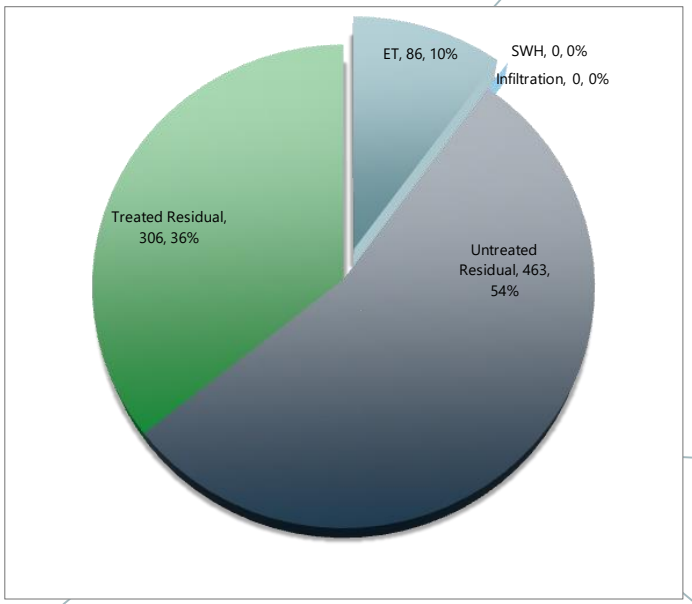
More Context – Whole of Water Cycle

Olive Grove Water supply requirements (total = 841 ML/yr):



Olive Grove Stormwater BAU Budget:

- Total stormwater = 855 ML/yr
- 86 ML/yr (10%) evaporation from Wetlands
- Outflow to Kororoit Creek = 769 ML/yr – 306 ML treated by wetlands (stormwater quality treatment)



Key Themes and Shared Values of Stakeholders for Olive Grove WWCM

- Liveability
- Co-location of assets is desirable
- Important to understand the economic costs and benefits of the WWCM options
- Commitment to maintaining affordability.

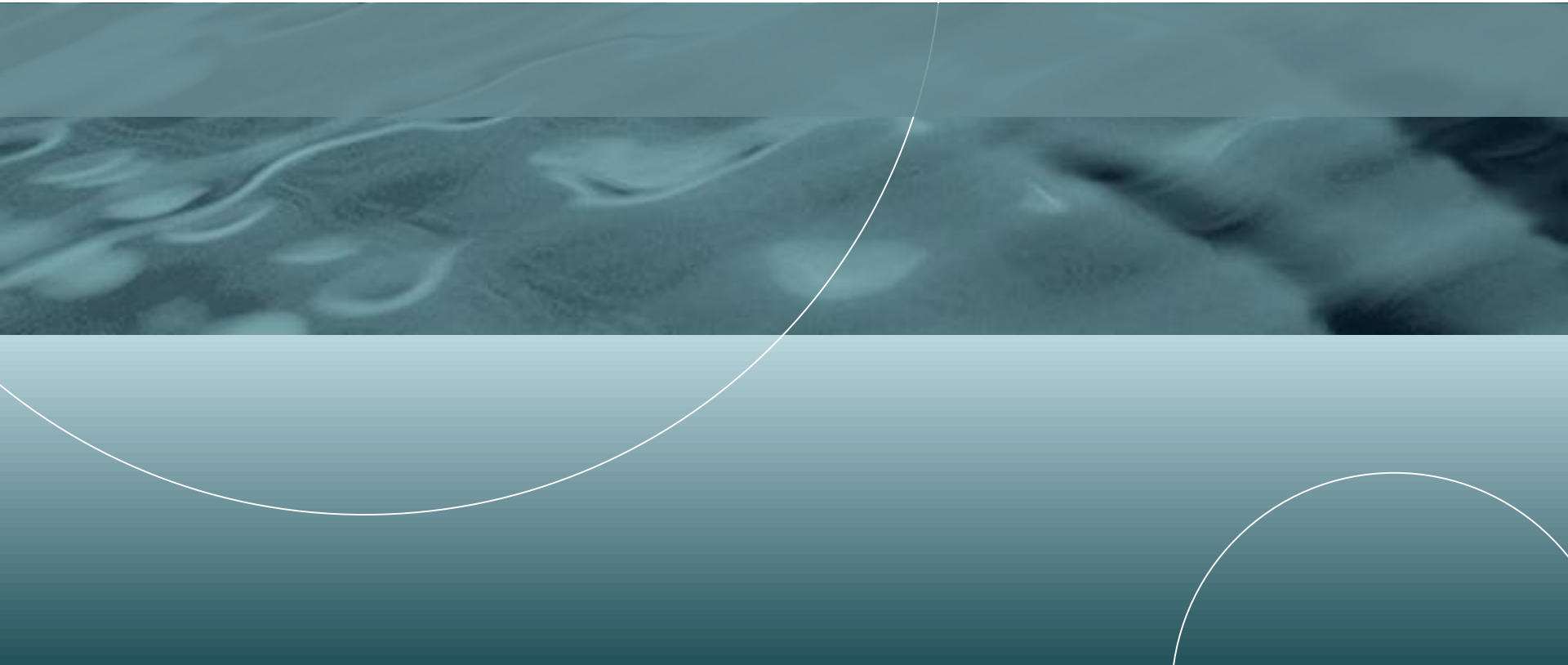
Stakeholder Values

Value	Relevant Agency	Objective and Benefit Measure
Water Supply	• CWW • Western Water • OLV	• Provision of reliable water supply (ML/yr) • Provision of alternative water supply (recycled water identified – ML/yr) • Stormwater and rainwater harvesting (impact on non-potable – ML/yr). • Public safety and climate resilience a key consideration of SWH and RWT.

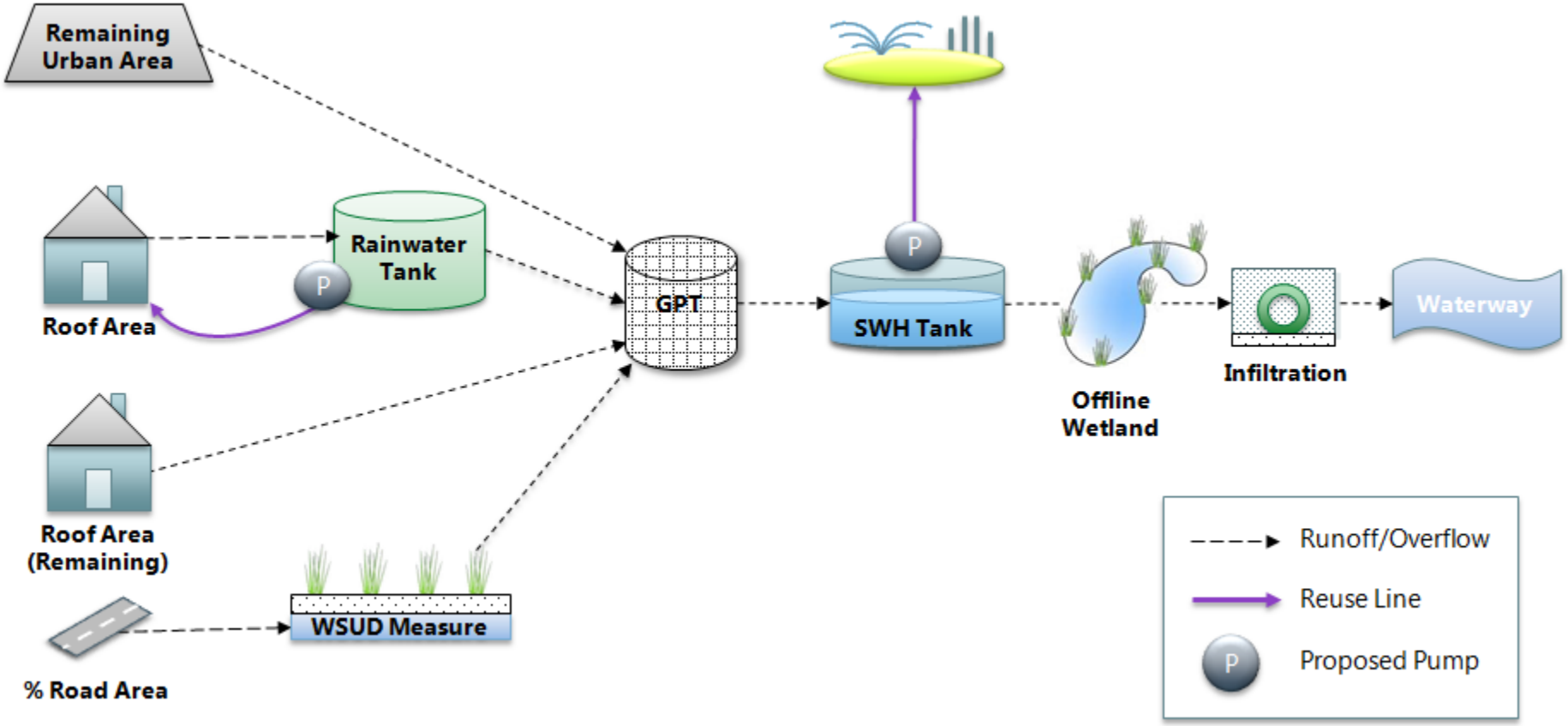
Waterways	• Melbourne Water
	• OLV
		• Protect and enhance health of waterway by meeting pre-development conditions
		  • Detention of Peak 1.5-yr ARI (m^3/s)
		  • Volume of runoff to stream (ML/yr)
		  • Volume of water to the environment (infiltration and ET - ML/yr)
		• Retain undisturbed (intact) portions of waterway identified as high value (protection of heritage, ecological and geomorph value)
		• Meet best practice (BPEM) stormwater quality objectives (TSS, TP and TN % reductions)

Drainage and flooding	• Melbourne Water • Council	• Protection from 100 yr peak flow (m^3/s) • Minor drainage capable of peak 5 Year ARI (m^3/s)
Liveability (including Environmental Amenity)	• Melbourne Water • OLV • MPA • Council	• Stream resilience and protection including vegetation (refer 'Waterways') • Resilience to climate change (green/open space provision, WSUD)
Community	• Developers • MPA • Council	• Affordable housing • Well being (refer 'Liveability')
Kororoit Creek Health	• DELWP	• Minimise impact on GGF (peak flow and volumes)

Case Study – WSUD Options Considered



Treatment Train Approach (Example)



Lot-Scale Residential

Rain tanks

- To supply non potable sources
  - Toilets, laundry, garden
- Decrease potable water demand
- Provides Creek protection through reduced runoff volume & frequency
- Provides detention reducing RB space
- Improves water quality decreasing streetscape and or centralised wetland size
- Reliability maintained with low flow top-up from recycled water
- Potentially decrease stormwater network pipe diameters

Porous pavement

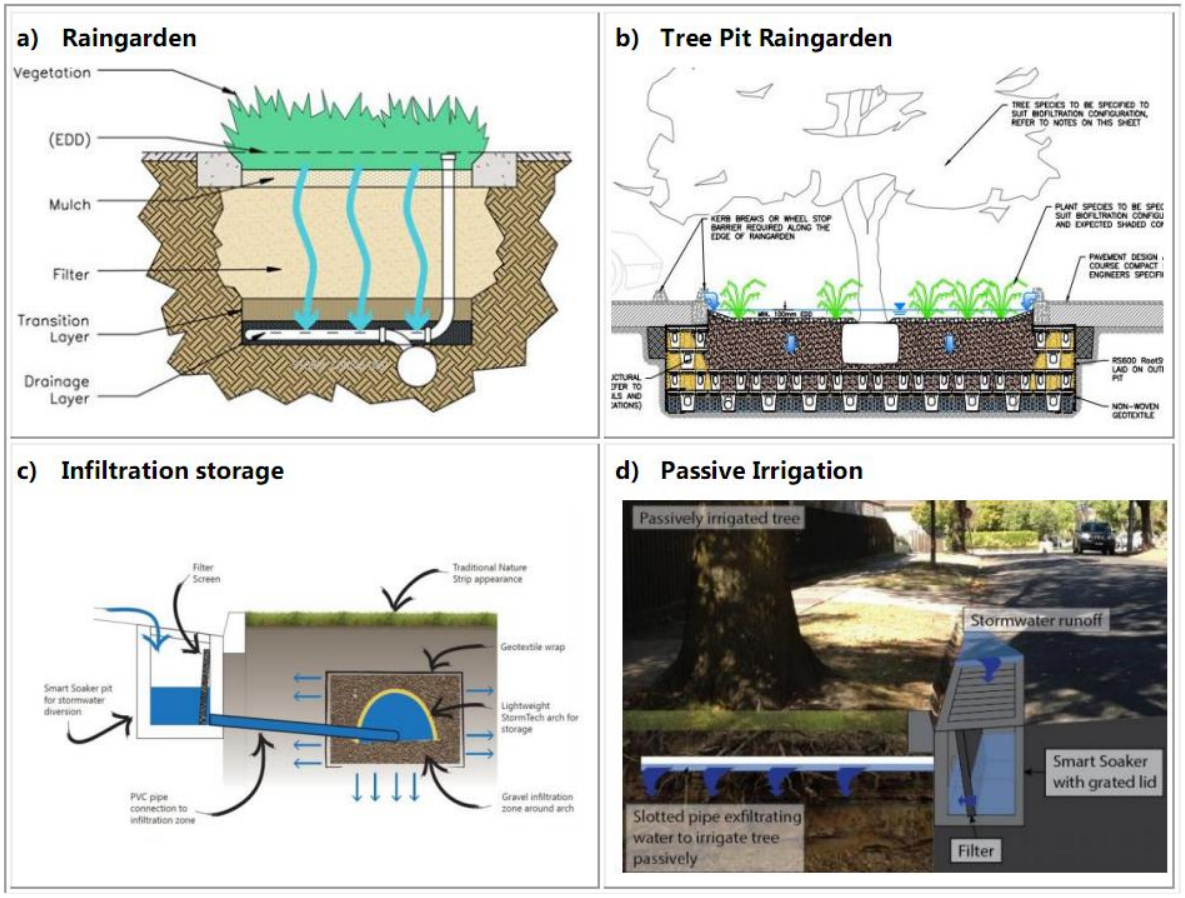
- Reduces impervious area
- Decreased Runoff
- Less treatment for water quality (streetscape WSUD or wetlands)
- Less volume & frequency to waterways
- Better waterway health

Street scale WSUD

- **Bio Retention / Passive Watering**
- **Swales (in Medians only)**
- **Detention (Limited)**
- **Porous Paving (Limited)**
- **Infiltration (Limited)**
- **Filter Strips**

- Improves water quality reducing need for constructed wetlands
- Protects waterway mainly for quality & some flow volumes/frequency
- Provides amenity
- WSUD area can be reduced by Lot-Scale WSUD

WSUD Street-scale Elements



Tandurrum Way

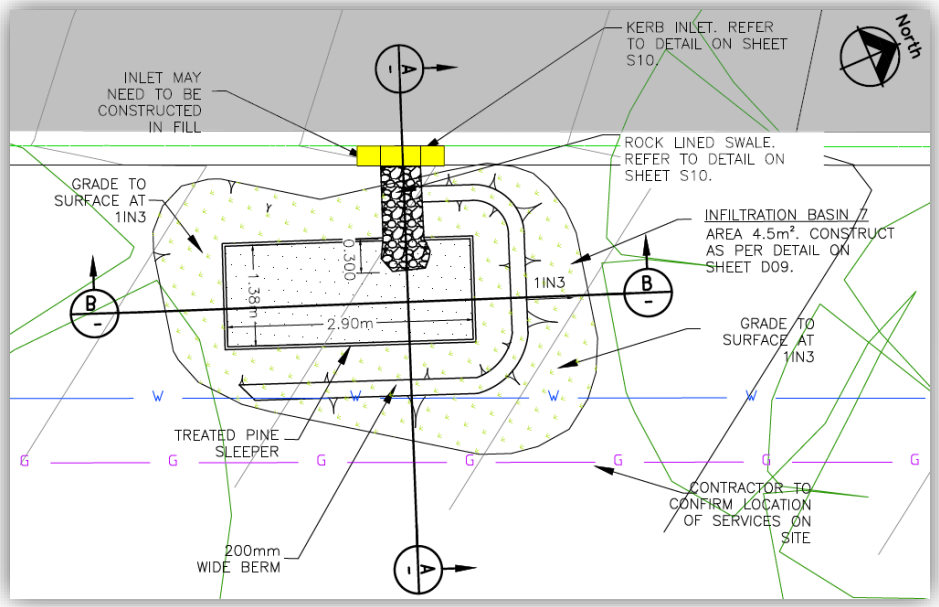
1. Vegetation
2. Concrete edge strip
3. Mulch layer
4. Sandy filter layer
5. Transition Layer
6. Drainage layer
7. Slotted PVC pipe
8. Geotextile wrap

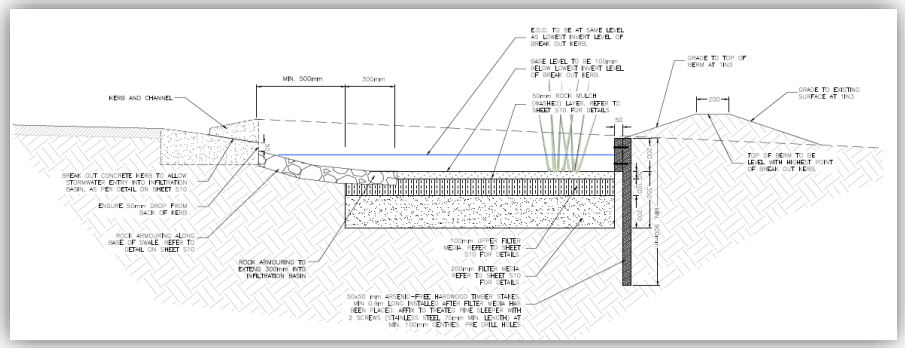
Carparks (Dorset Sq & Liechhardt)

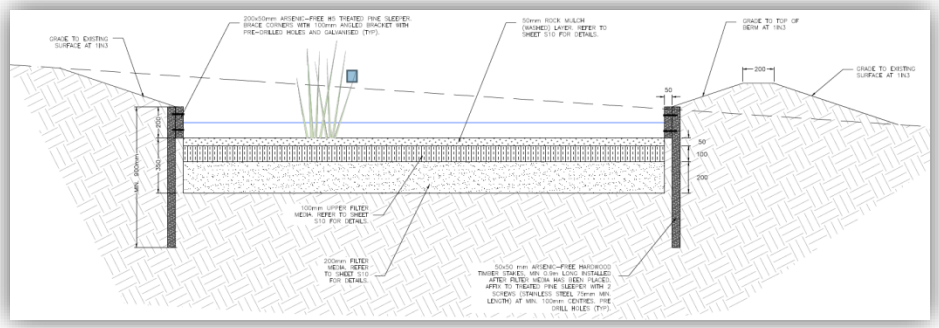
Example – Little Stringybark Creek

- Disconnection
- Harvesting and leaky tanks
- Infiltration/WSUD

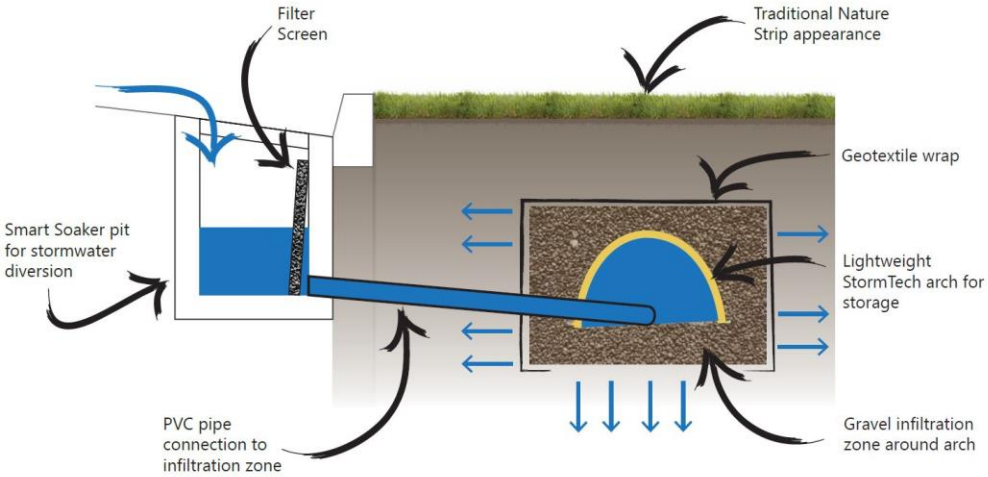
Little Stringybark Creek







Little Stringybark Creek



Storm
Bringing engineering to life

Little Stringybark Creek

Precinct Scale (End of Line)

Stormwater Harvesting for major parks & sports fields

- Reduces potable water demand
- Provides waterway protection by reducing runoff volume & frequency
- Provide amenity
- Reliability maintained by recycled top-up (? Rate)
- Opportunity to inject water into recycled network

Infiltration trenches in Riparian Zone (Encumbered Land)

- To make up shortfall in flow volume & frequency targets
- Depends on upstream measures adopted

Provides -

- Waterway Protection
- Passive Watering of Riparian Zone
- Amenity
- Opportunity to replicate base flows to waterways

GPT's, Filter strips, sand filters, Bioretention basins

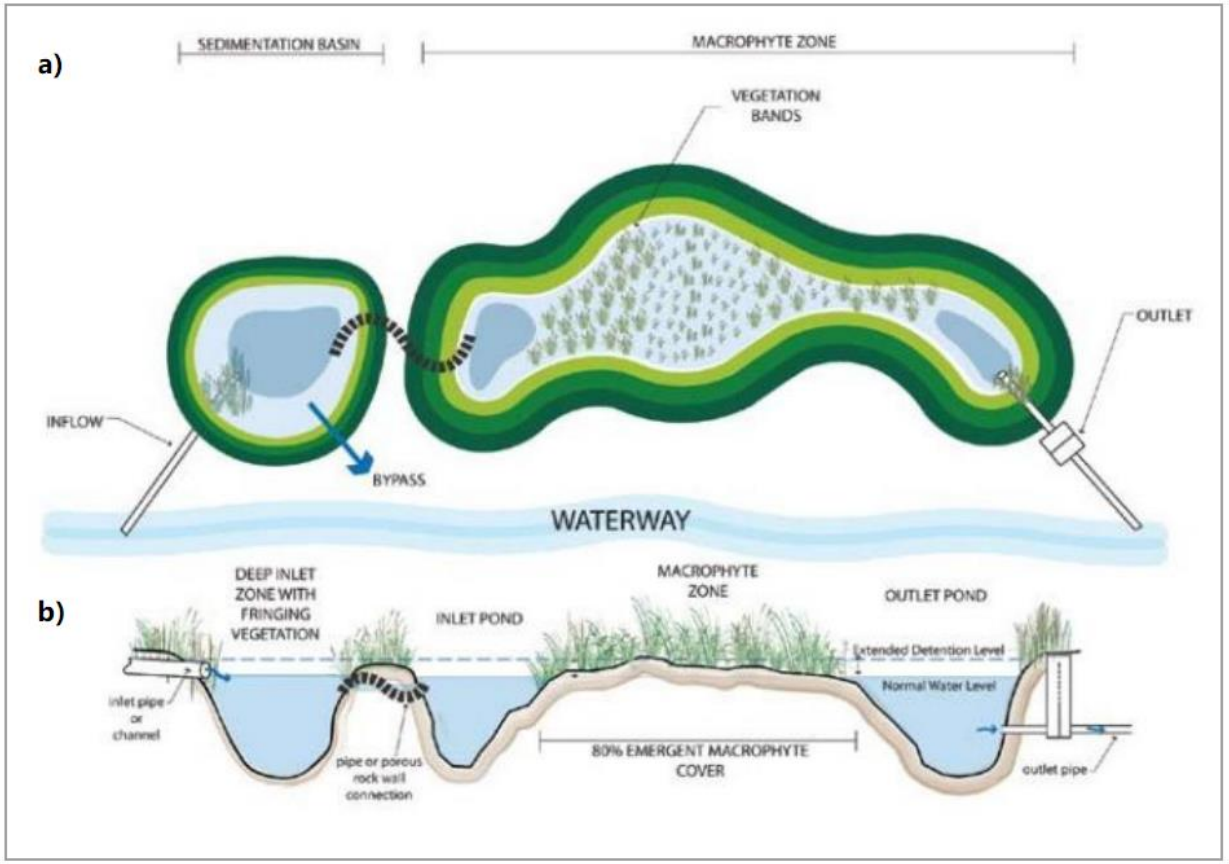
- - to make up shortfalls in lot/street scale WSUD

Detention tanks

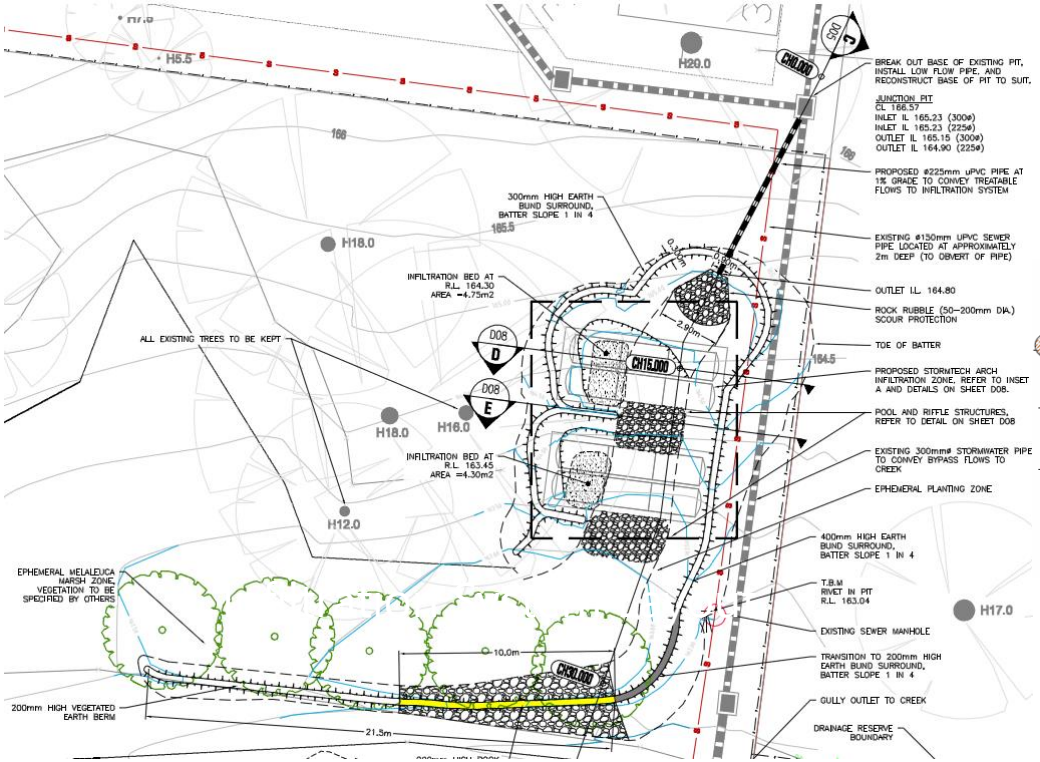
- Can be used to decrease RB size, however, not at expense of using unencumbered land
- Detention only will not protect waterway

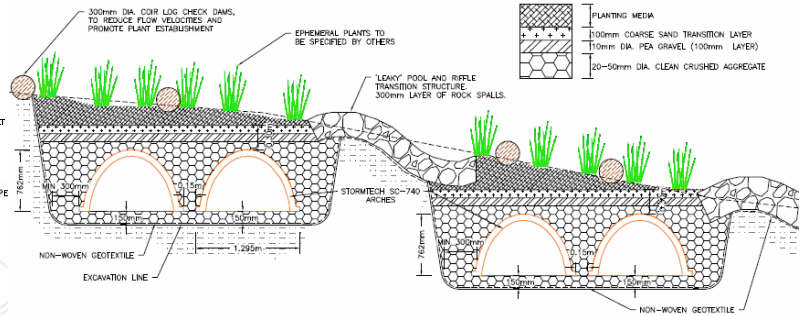
Outcomes sought for Water Future West		
1		**Supported liveable and sustainable communities**
	a)	Local agriculture and industry provides jobs and prosperity
✓	b)	Amenity in the West that creates community and pride of place
✓	c)	Improved flood protection is provided
✓	d)	Natural resources and built assets are valued, protected and used efficiently
✓	e)	Community is well informed, engaged and empowered with water cycle management
2		**Enhanced environmental health of waterways and bays**
✓	a)	The health of waterways and ecosystems are protected and enhanced
3		**Secure water supplies are efficiently provided**
✓	a)	Reliable fit for purpose water for optimal community outcomes is provided
✓	b)	Resilience and adaptability to shocks and trends including climate variability is provided
4		**Public health and well-being is improved**
✓	a)	Public health and safety for all in the community outcomes is provided
✓	b)	Climate resilient water and green space is provided in the urban environment to enhance community health and well-being and promote active lifestyles
5		**Affordable essential water services are delivered**
✓	a)	Efficient and affordable water solutions for brownfield and greenfield sites are provided
✓	b)	Existing water infrastructure for the region is optimised without restrictions of service boundaries

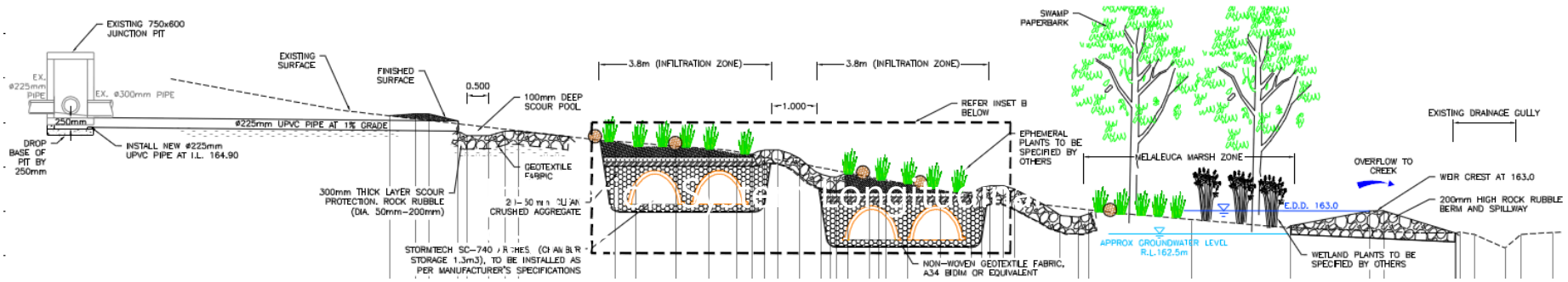
Wetlands (off-line)



Infiltration







Elambra Estate

Treatment Train Approach

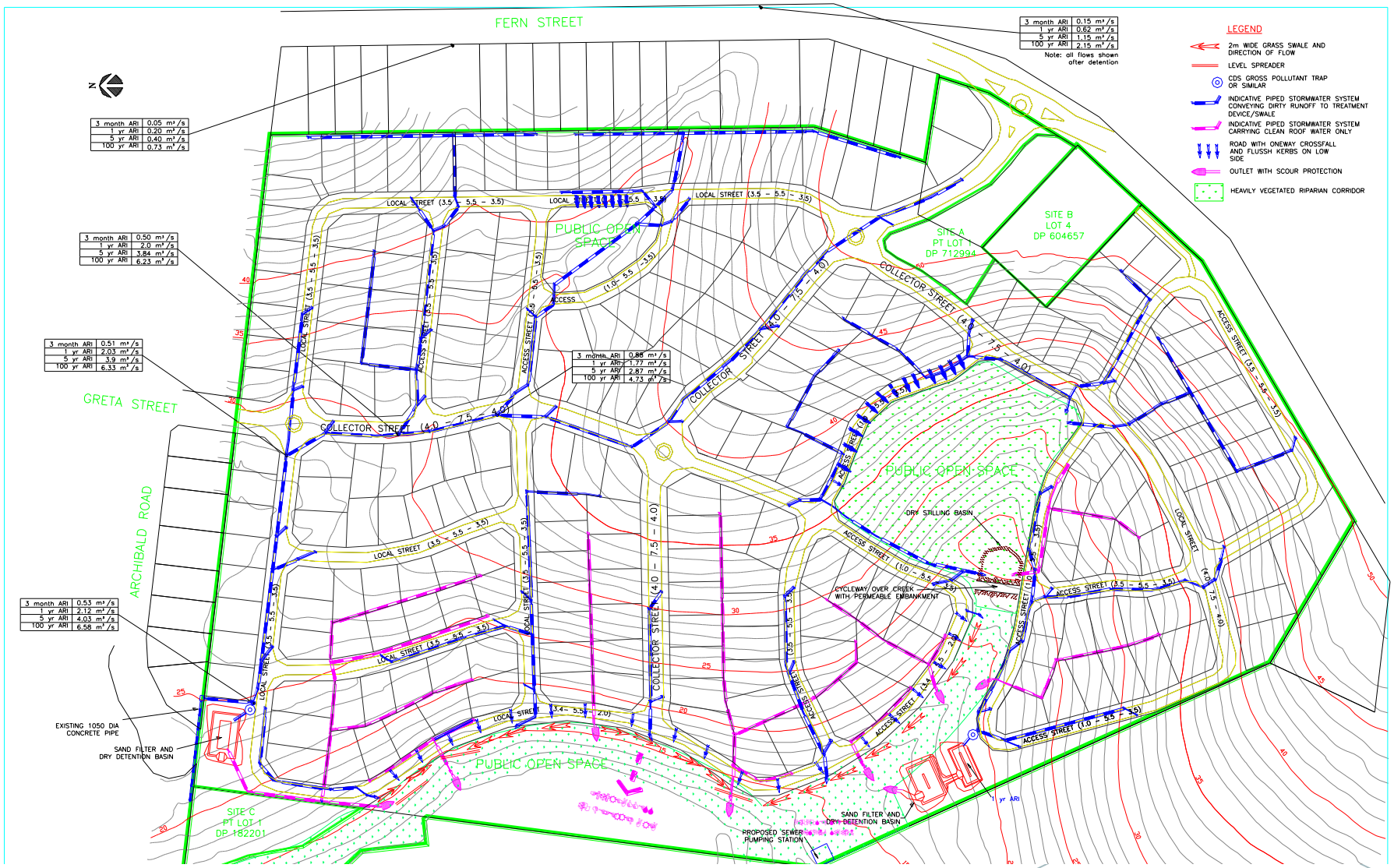
Source Controls - Rainwater Tanks, Litter baskets

Conveyance Controls – Dual Stormwater Systems

Grassed Swales, vegetated buffer strips, artificial creeks, pits and pipes

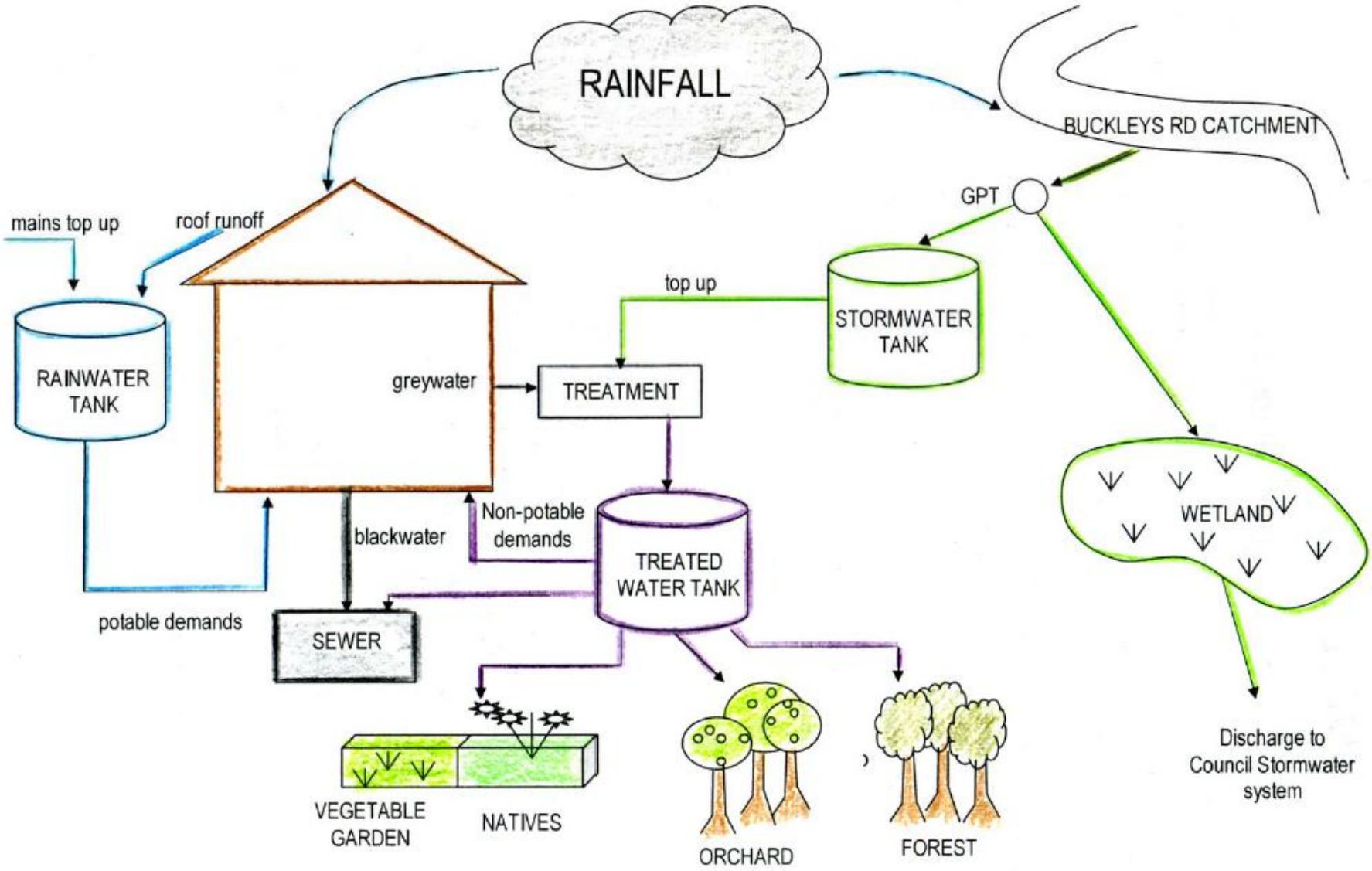
End of Pipe Controls – GPT/Sand Filter , Grassed swales and vegetative buffers

Elambra Estate



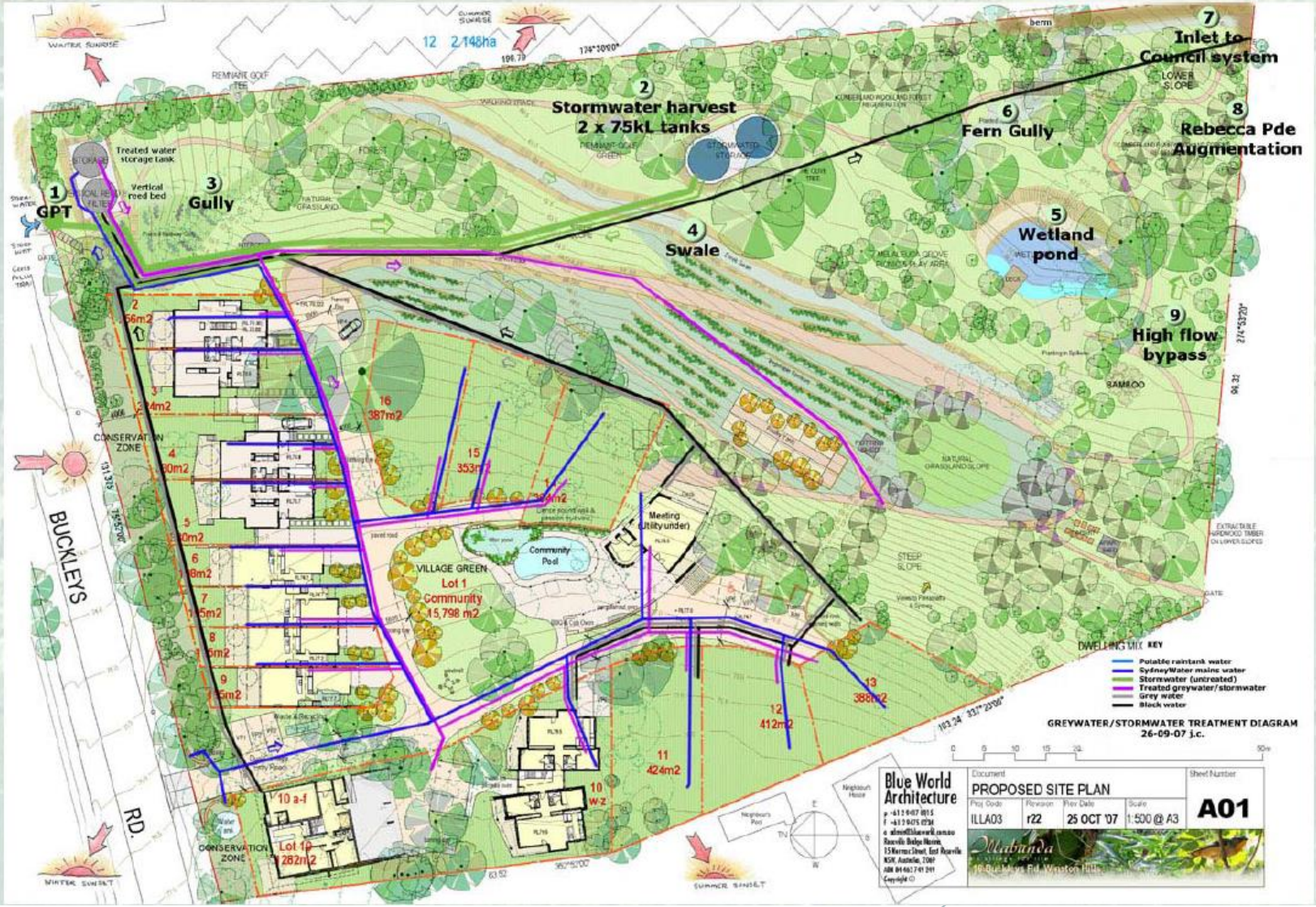
Illabunda ecovillage

Figure 2-1: IWCM Concept

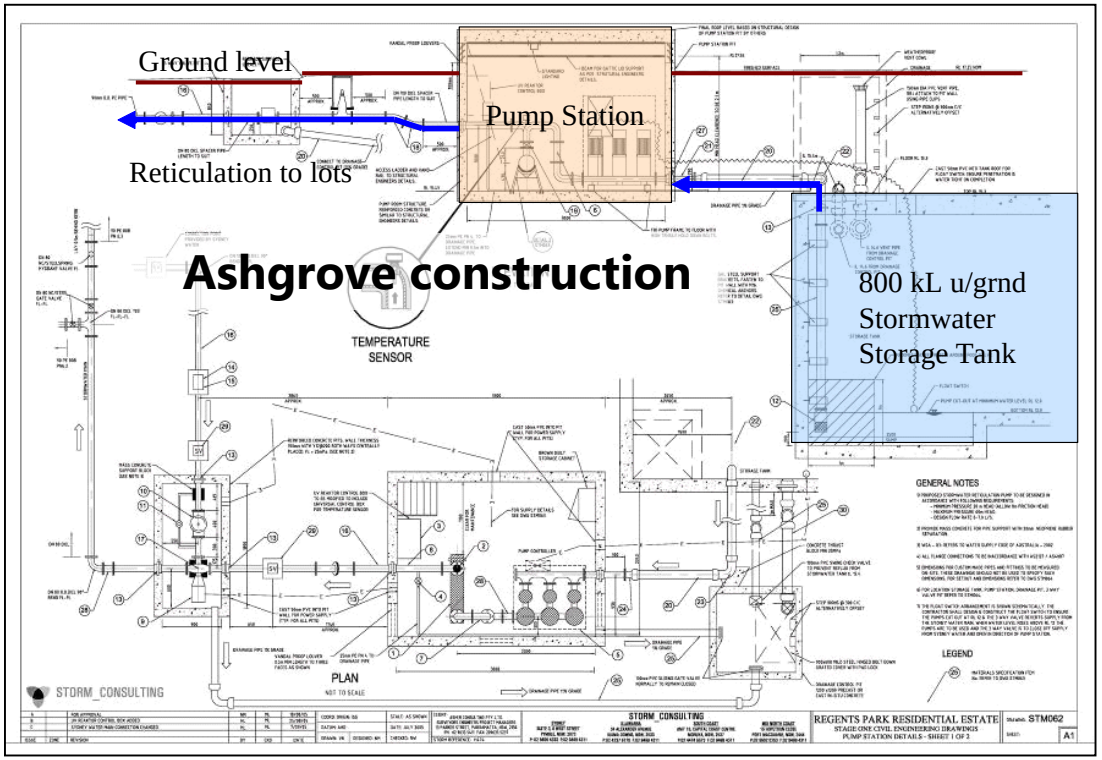


Illabunda

a village for life



Ashgrove Estate



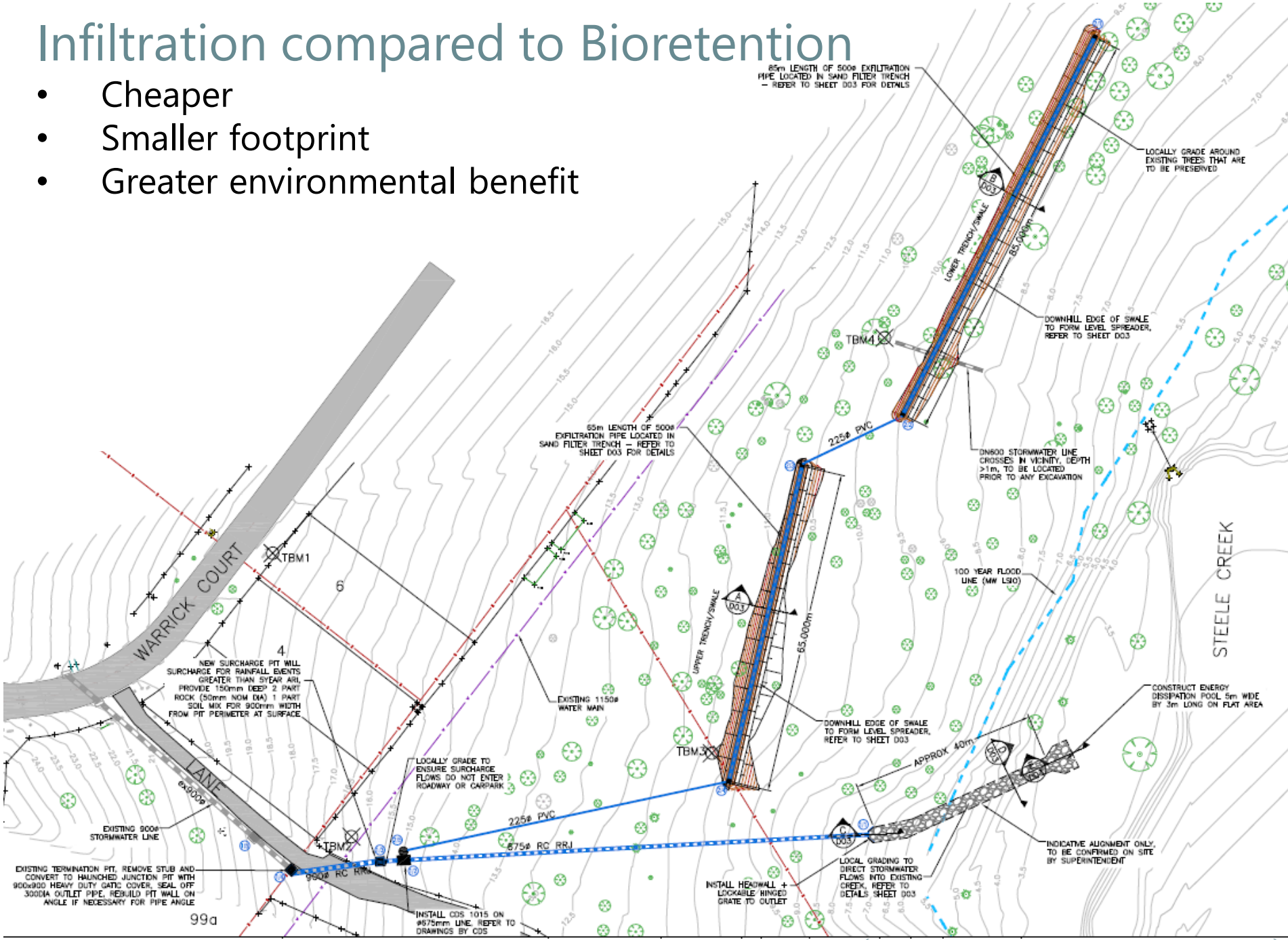
Ashgrove Basin A - constructed

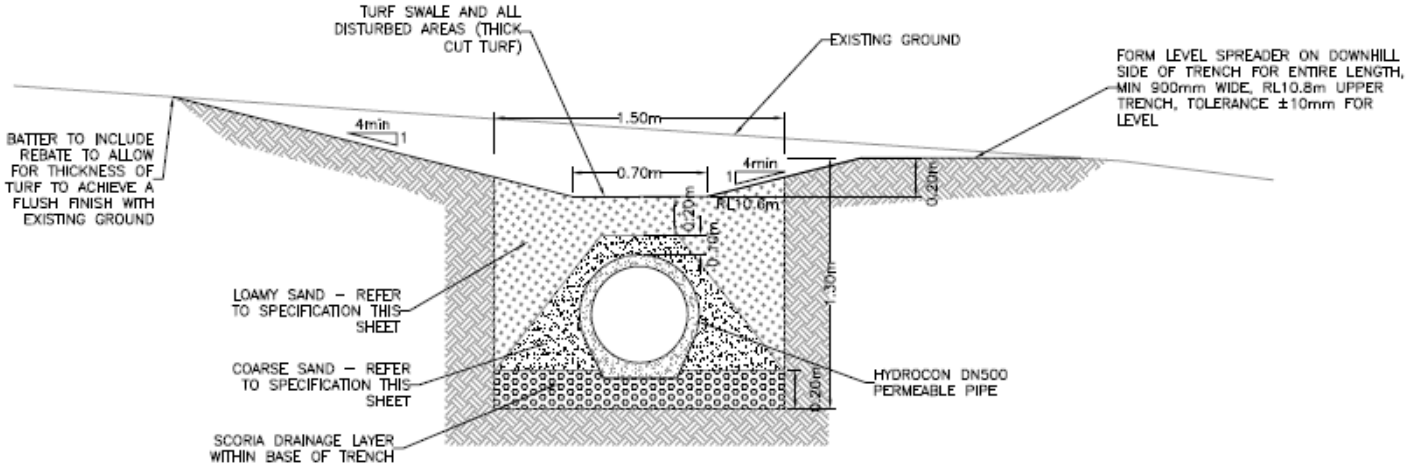
Warrick Court

Warrick Court

Infiltration compared to Bioretention

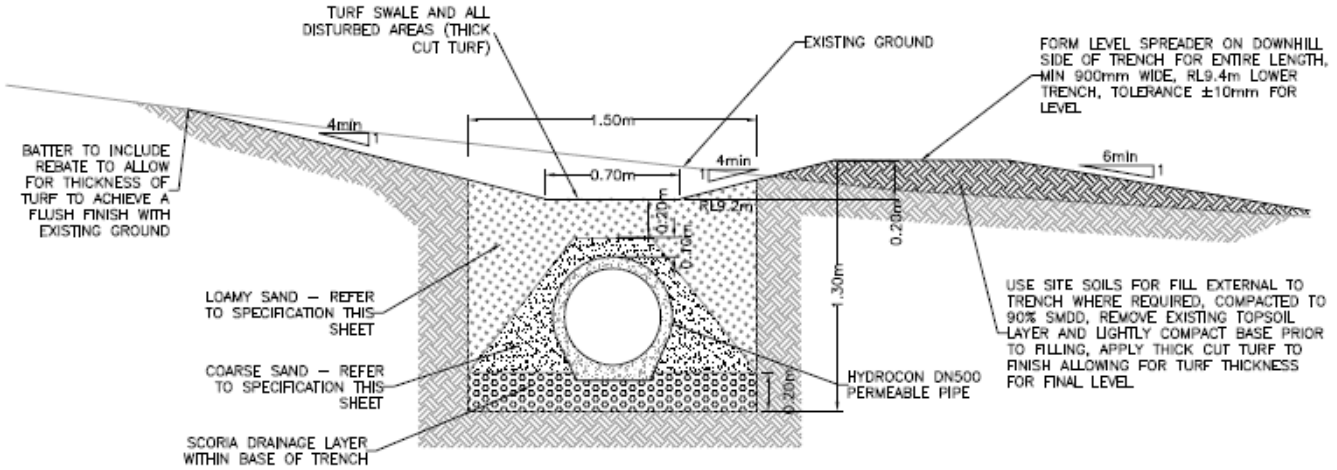
- Cheaper
- Smaller footprint
- Greater environmental benefit





SECTION A – UPPER TRENCH/SWALE

SCALE 1:20



SECTION B – LOWER TRENCH/SWALE

SCALE 1:20

Warrick Court

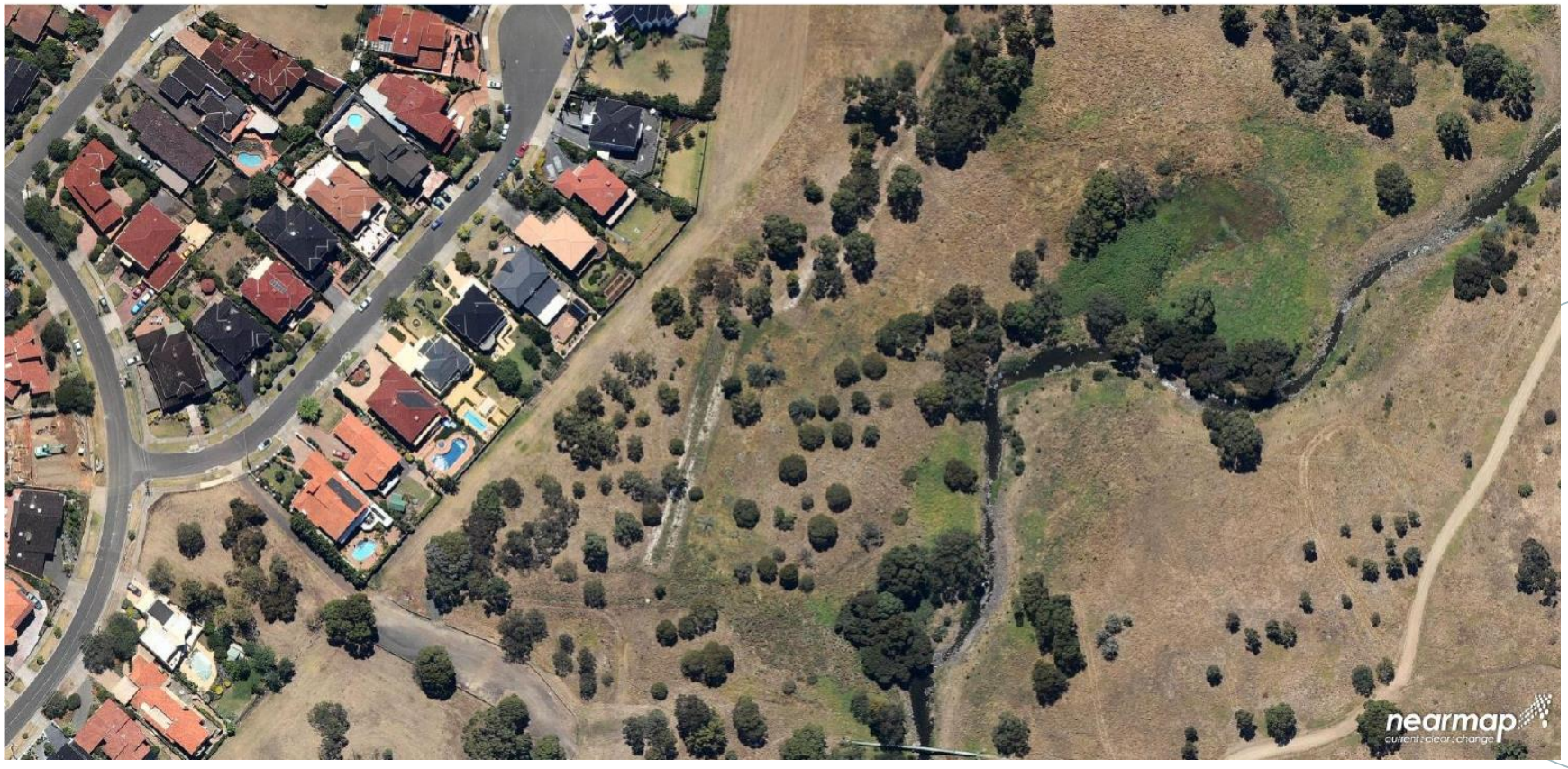
Date: Sat Aug 20 2011

Warrick Court

Date: Thu Nov 17 2011

Warrick Court

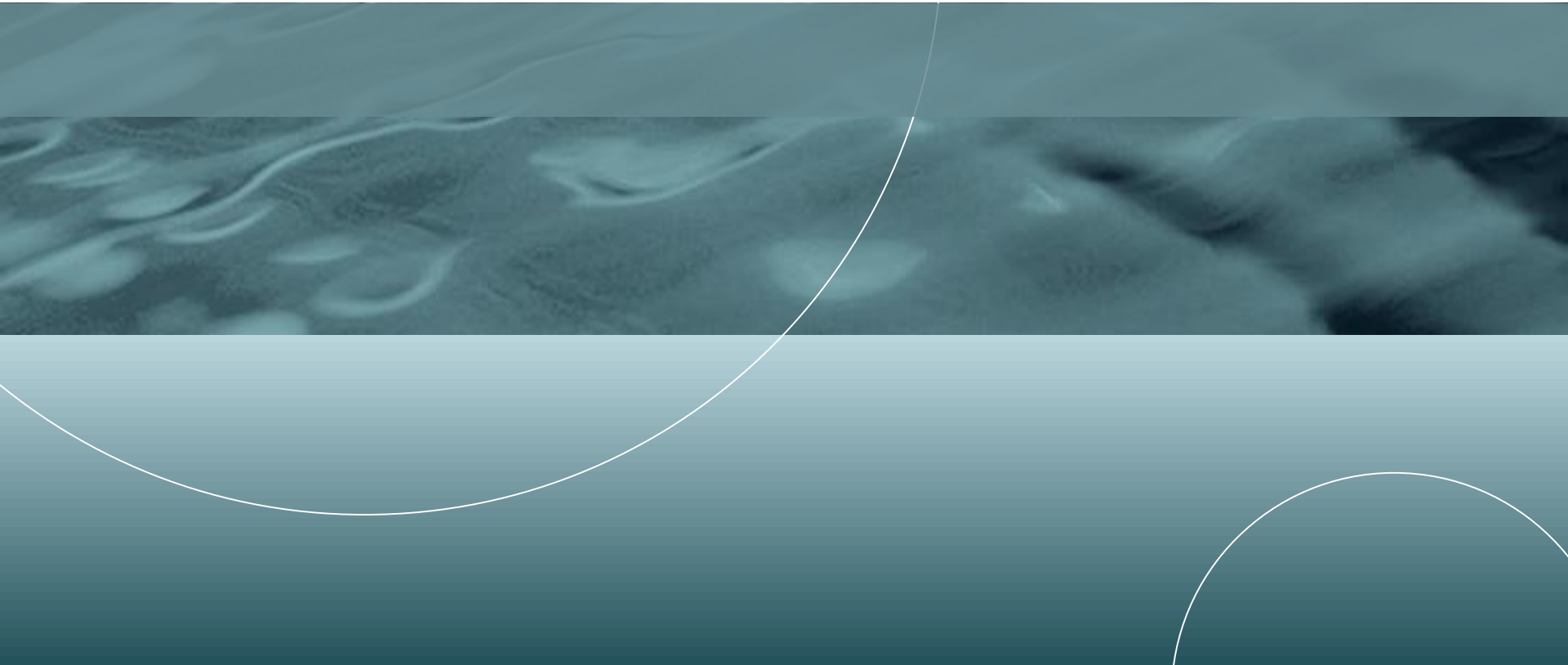
Date: Fri Jan 4 2013



Warrick Court
See the greening…

Date: Wed Mar 6 2013

Case Study Results



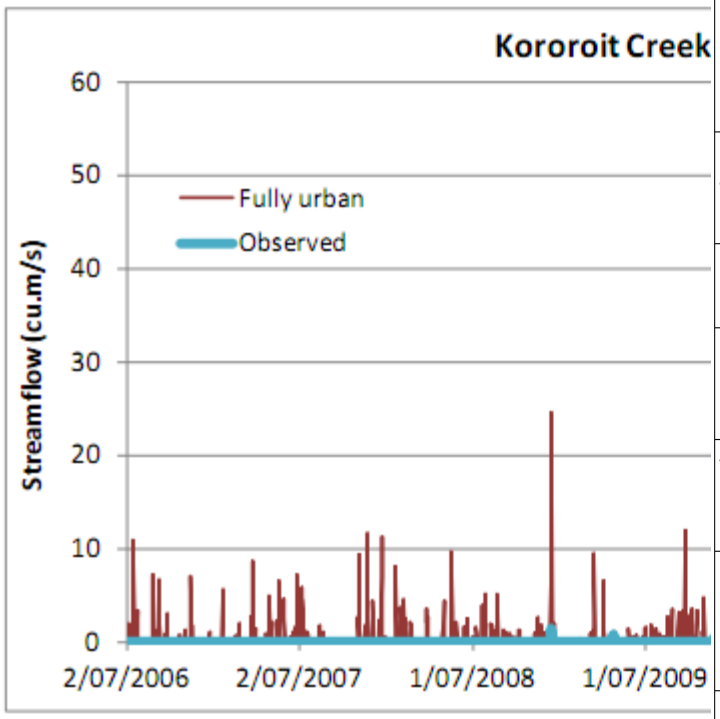
Targets: to protect the waterways

- UoM Study in the area shows 90 % of volume reduction is required to achieve waterway protection
- The targets or 'Levels of Service' to be achieved for this case study for waterway protection were:
  - BPEM (water quality only)
  - 60 % flow reduction
  - 90 % flow reduction

  – NB: The flow target refers to the reduction of total stormwater volume as a result of development

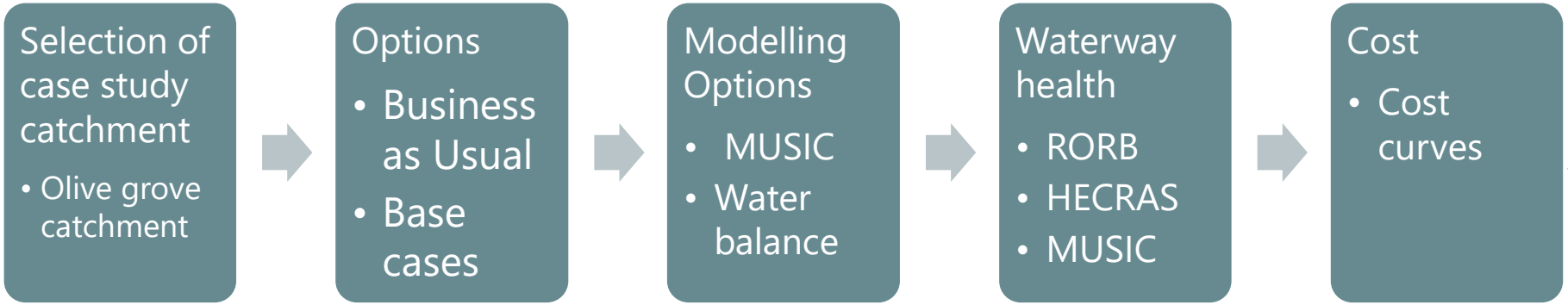
Flow Reduction (target 90%)

- Simplistic / easy measure of impact on waterway
- Based on 'waterway health metrics'
- Site specific



Flow aspect	Metric selected	Definition and comments on calculation	Ecological or geomorphic significance
Low flow duration	Days per year of zero flow. Mean duration of zero flow periods	Zero flow days in full record divided by number of years. Zero flow days in full record divided by zero flow periods in full record.	Low flow periods affect habitat availability, as well as facilitating presence of species adapted to ephemeral conditions.
Low flow frequency	*Not used for Kororoit Ck, due to ephemeral nature*	Published metrics are unsuitable for highly ephemeral stream. Geomorphic metrics (see below) cover this aspect better.	-
Duration	Tqmean	Fraction of days with daily mean flow greater than annual mean flow.	Duration of peak flows is an indicator of the duration of 'disturbance events' (both water quality and hydraulic)
Rate of change	R-B Index	Sum of the absolute values of change in mean daily flows divided by the sum of the mean daily flows.	Variability of flows is an indicator of the duration of 'disturbance events'
Timing	Month of minimum monthly flow	Take mean of all flows in period of record in Jan, Feb, etc., and find minimum of these mean monthly flows.	Seasonality of minimum flows important for alignment with seasonal biological events.
Bed mobilisation	Fraction of time > $Q_{1.5yrARI}/2$	Empirically derived based on analysis of sediments in study catchment and critical shear stress needed to mobilise them, combined with 1D hydraulic model.	Bed erosion influences habitat availability
Bank mobilisation	Fraction of time > $Q_{2yrARI}/2$	Based on commonly-used threshold for bank mobilisation	Bank mobilisation affects sediment transport, habitat availability, riparian vegetation, etc.

Assessment Approach



Base Case Options

Base Case 1: Business As Usual (BAU)
- stormwater quality focus
- downstream waterway impact only (ie immediately d/s wetlands)

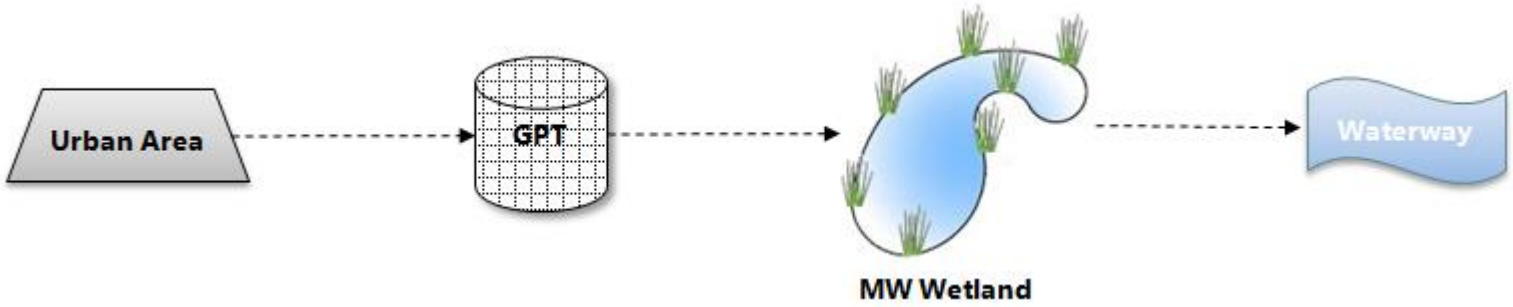
Base Case 2: introduces local stormwater harvesting

Base Case 3: regional stormwater harvesting (a large proportion of the developed catchment is directed to a large storage)

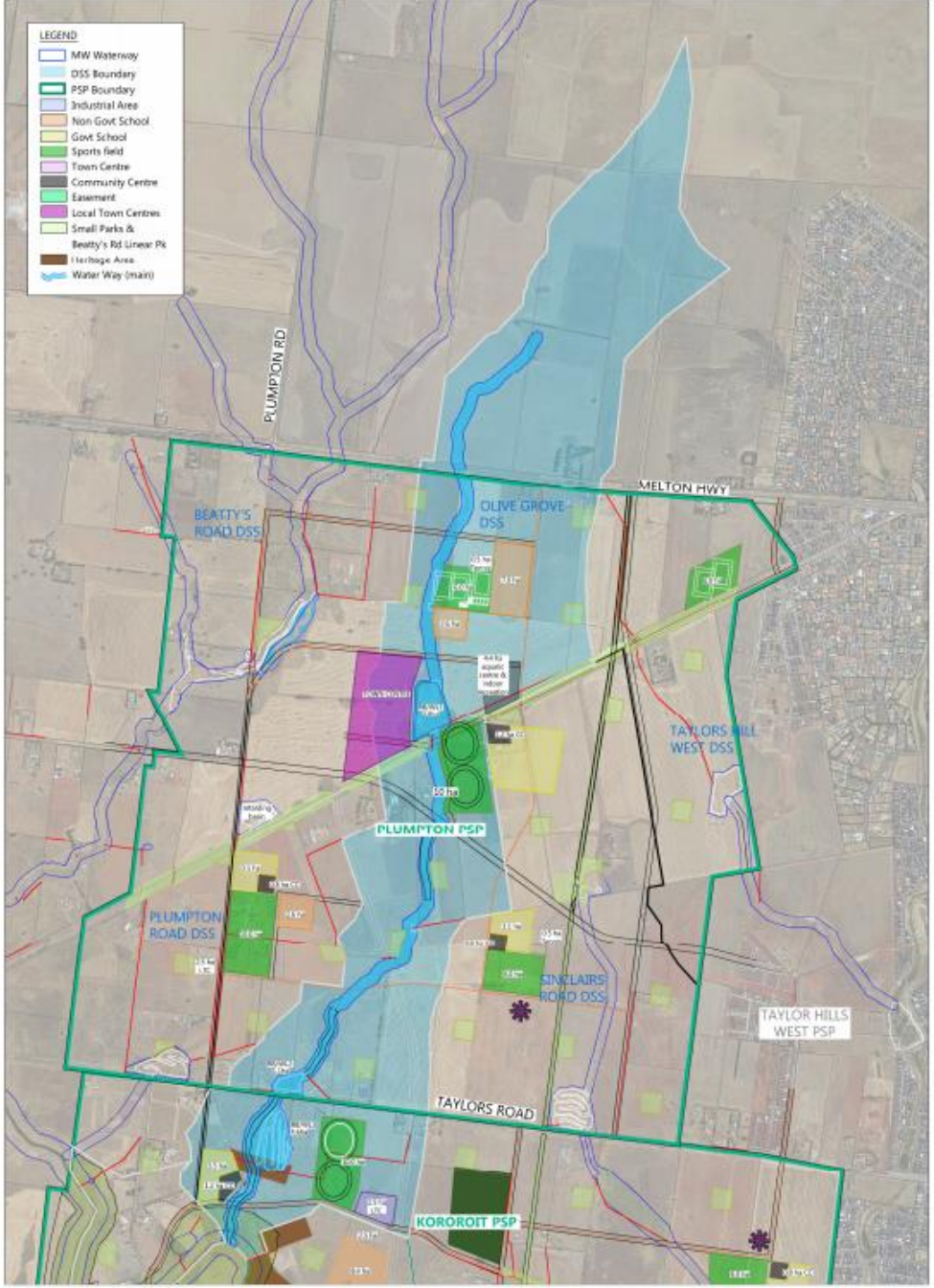
Base Case 1

Reflects the implementation of water management based on meeting current best practice

- Class A recycled water.
- Centralised water quality treatment and flood protection assets sized to meet regulatory requirements under Clause 56 (excluding the 1.5 year ARI discharge requirement).



BC1



Storm
Bringing engineering to life

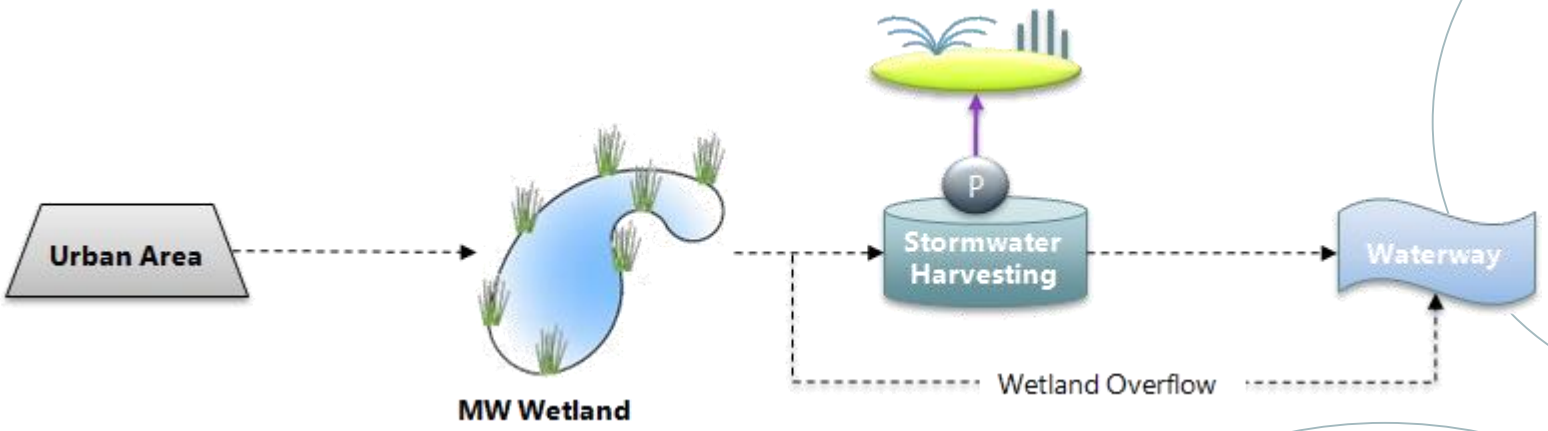
OLIVE GROVE WHOLE OF WATER CYCLE MANAGEMENT
FIGURE A2
BASE CASE 1 - BUSINESS AS USUAL

North
SCALE 1 : 25,000
500 250 0 500 1000
Original sheet size A4

Base Case 2

Builds on the BAU by introducing local stormwater diversion from wetlands to supply the irrigation needs of green and open space

- Class A recycled water.
- Centralised water quality treatment and flood protection assets sized to meet BPEM
- Stormwater diversion from online wetlands for storage and treatment (non-potable reuse, supplementing Class A water)

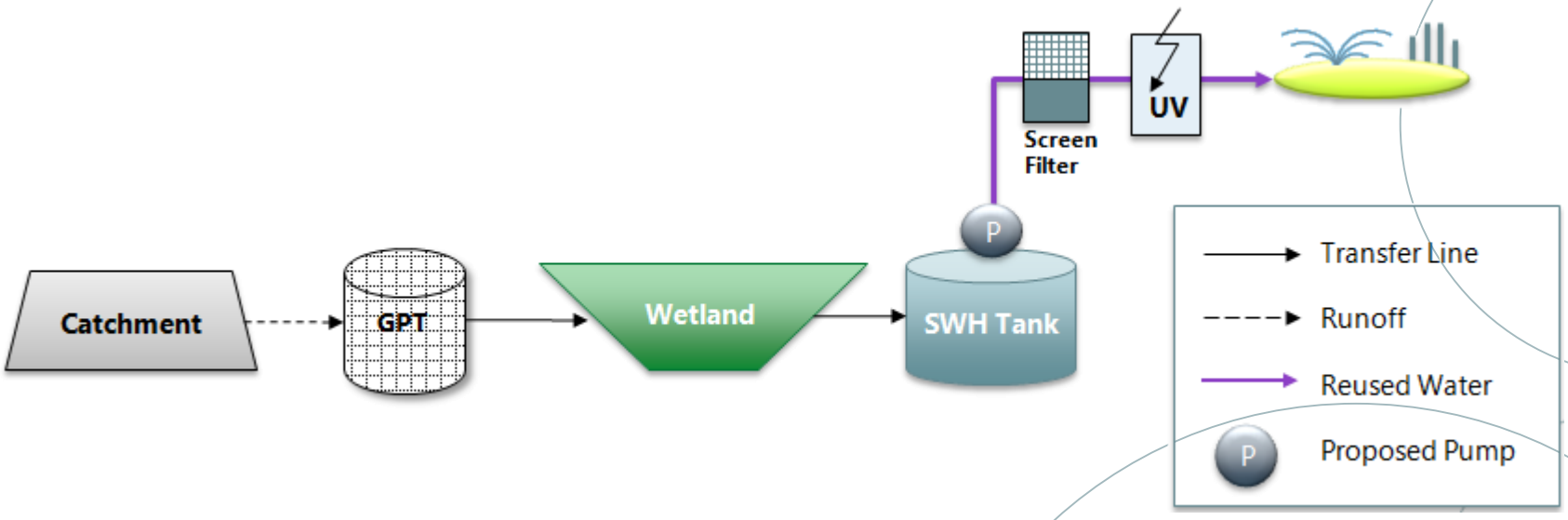


Base Case 2 Stormwater Harvesting

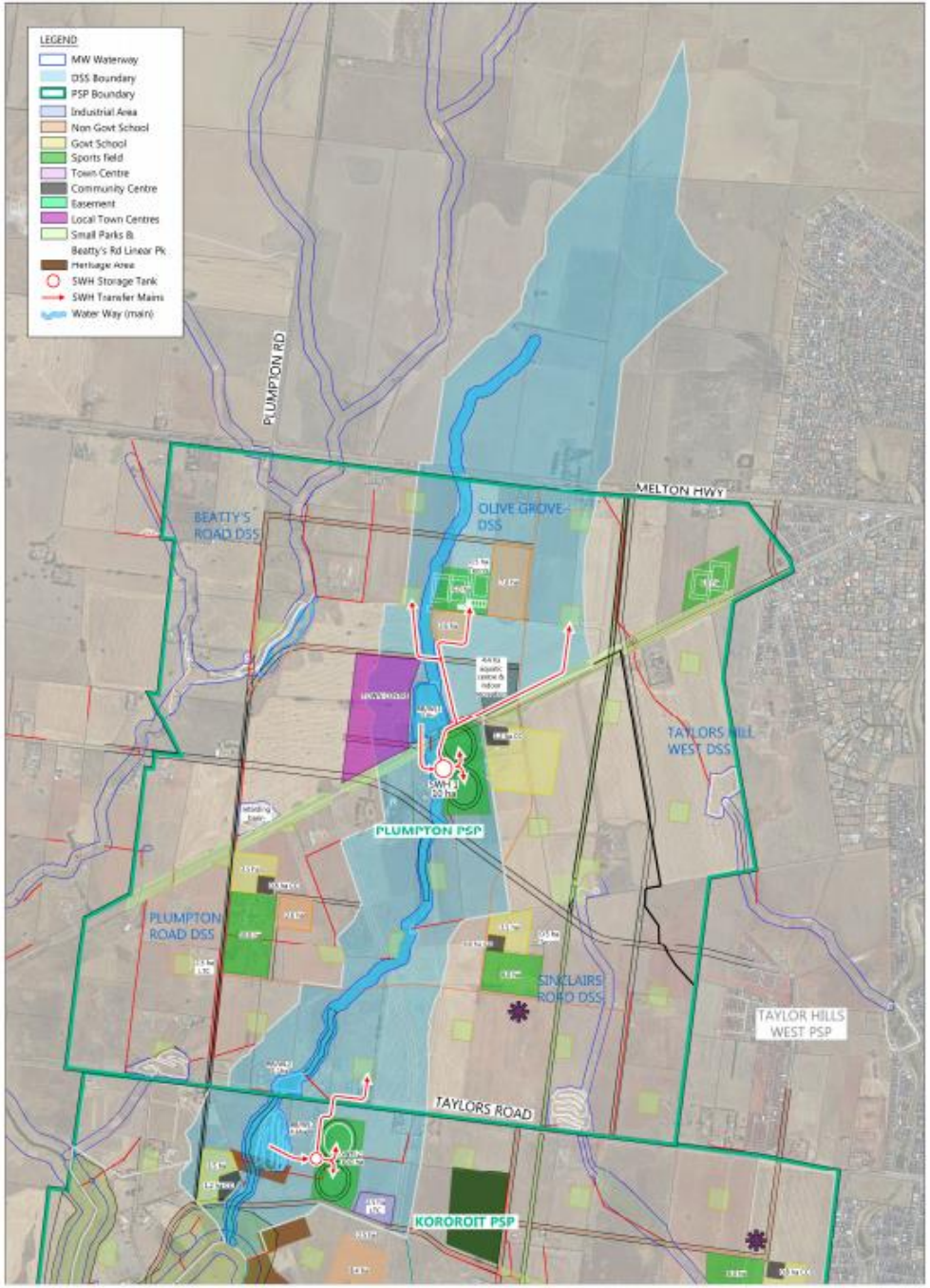
Sizing based on meeting 80 % demand reliability

SWH Sizing Parameters	SWH1	SWH2
Size (ML)	5.50	0.80
Demand (ML)	96.4 (20 Ha of green space)	53.2 (11 Ha green space)
Demand Met (%)	81 %	81 %
Re-use Supplied (ML)	78.1	43.1

Stormwater harvesting concept:



BC2



Storm
Bringing engineering to life

OLIVE GROVE WHOLE OF WATER CYCLE MANAGEMENT
FIGURE A3
BASE CASE 2 - LOCAL STORMWATER HARVESTING

North
SCALE 1:25,000
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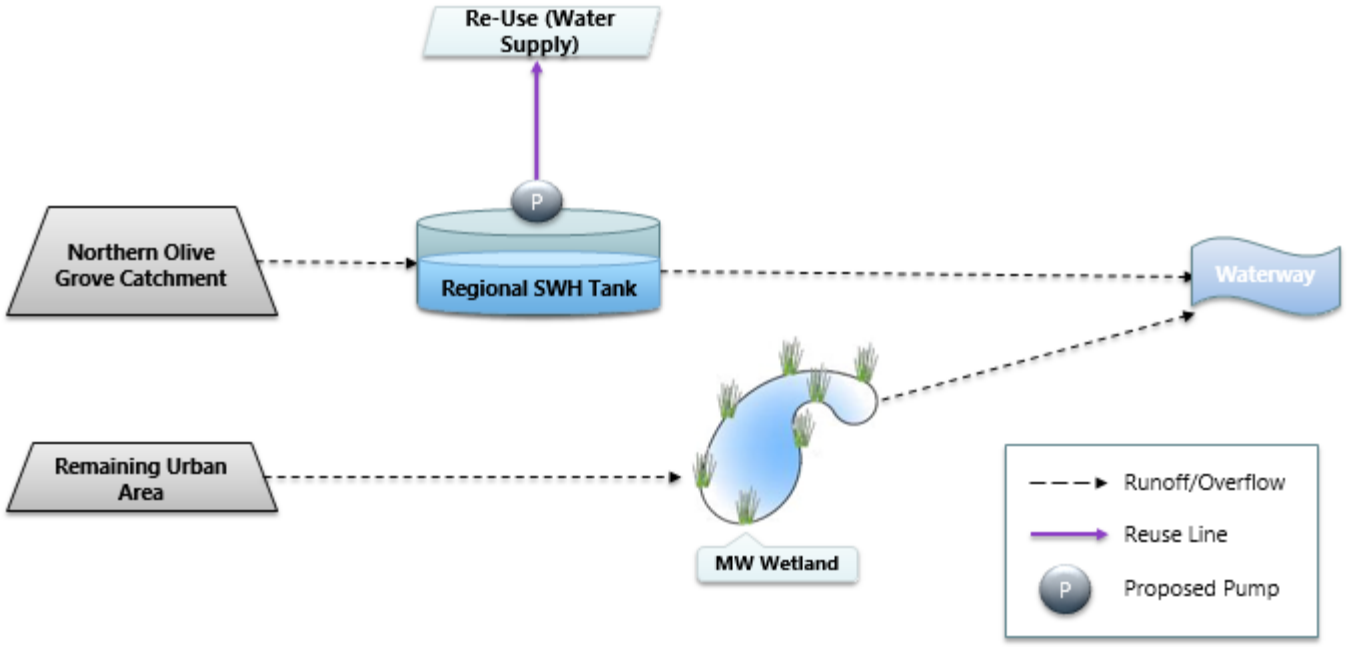
Original sheet size A4

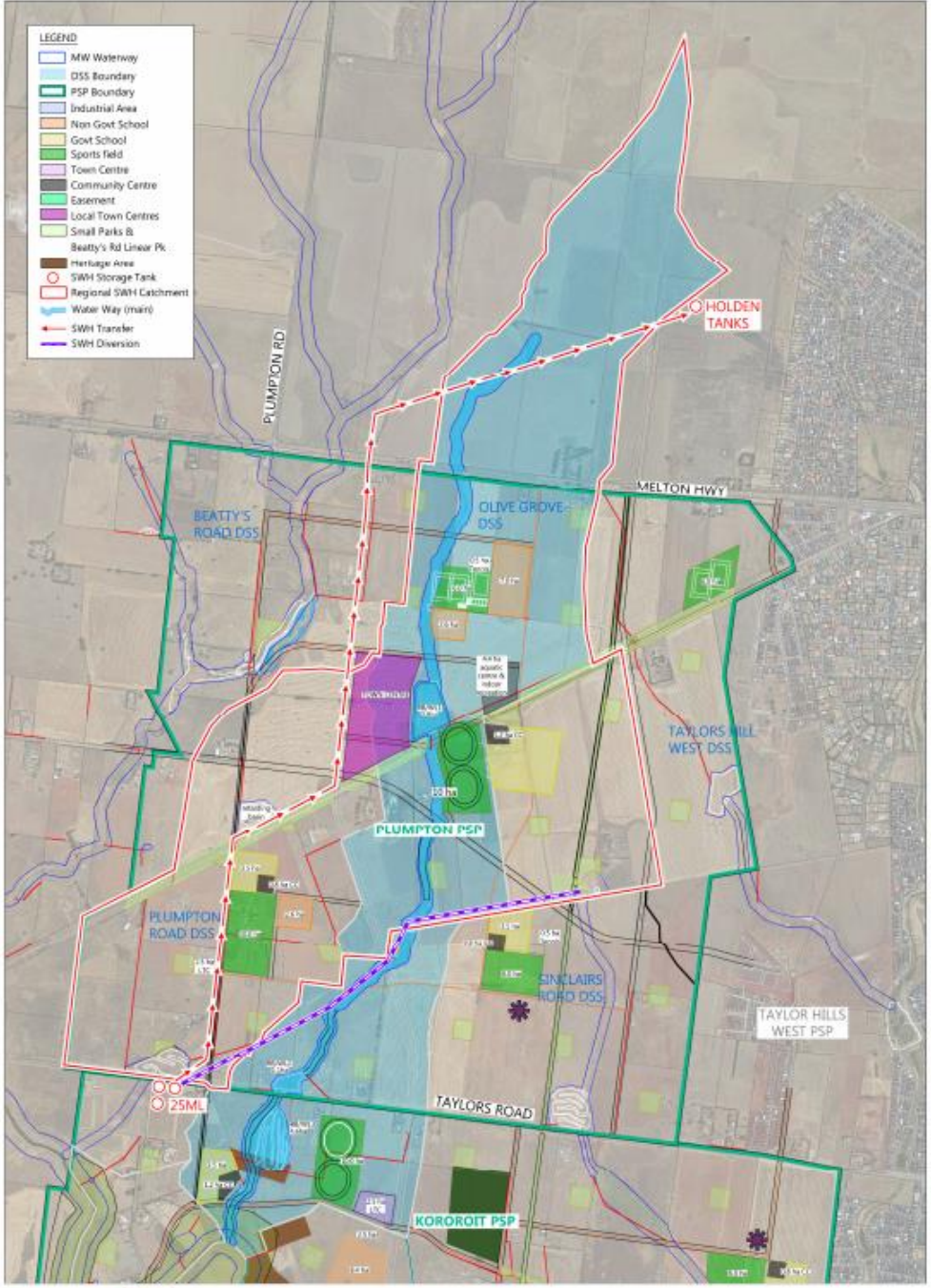
Base Case 3

Represents a focus on harvesting and using stormwater at a larger scale as an alternative supply option to the greater Melton area

- No Class A recycled water.
- Centralised water quality treatment and flood protection assets sized to meet BPEM
- Large scale stormwater diversion to be centrally treated and distributed via 3rd pipe for non potable supply



BC3



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OLIVE GROVE WHOLE OF WATER CYCLE MANAGEMENT
FIGURE A6
BASE CASE 3 - REGIONAL STORMWATER HARVESTING

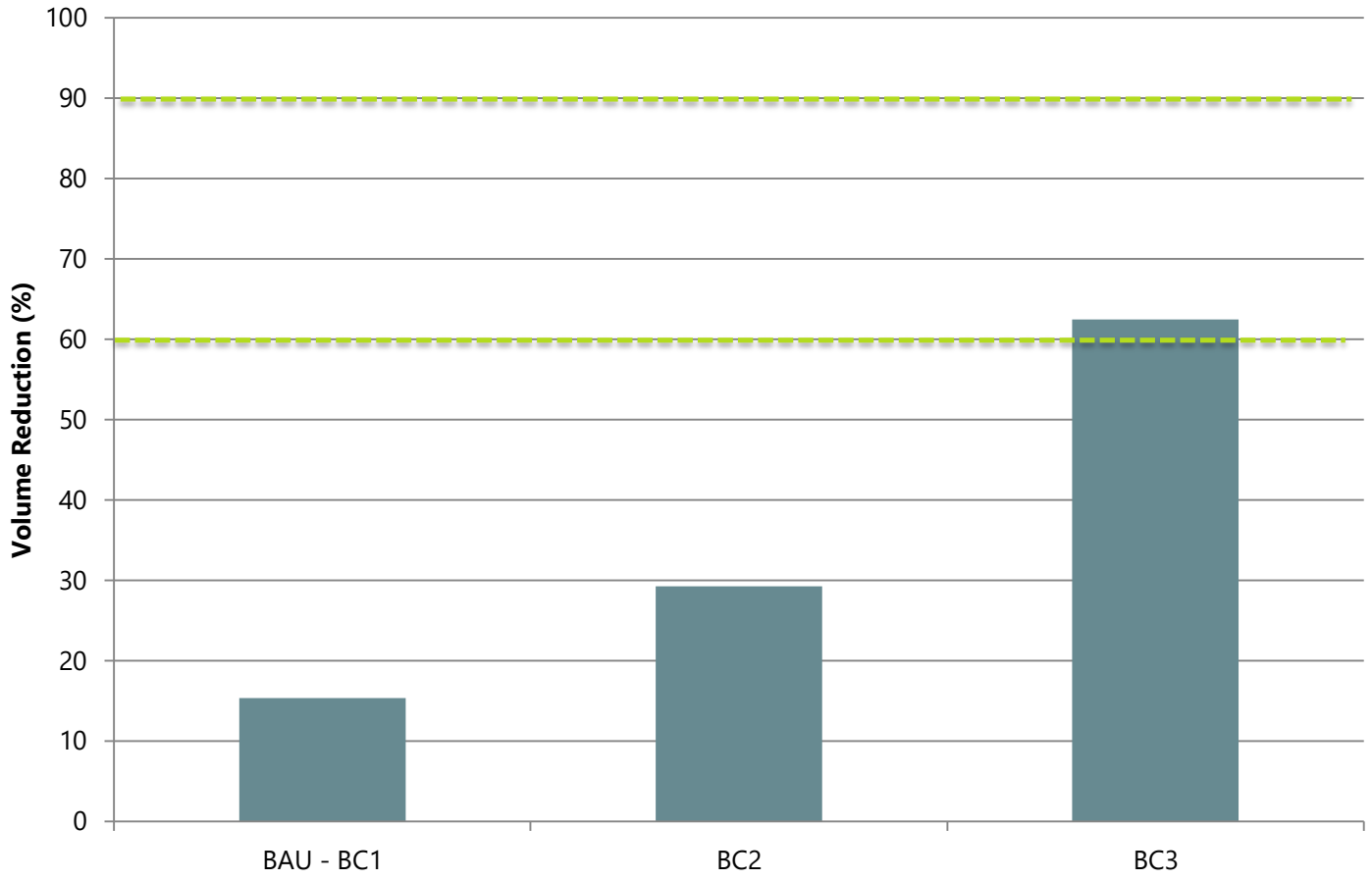
North
SCALE 1 : 25,000
500 250 0 500 1000
Original sheet size A4

Model Assumptions

- Volume reductions assessed using MUSIC
- Represents average climate conditions. Based on Melbourne Airport data (1996 average rainfall – 526 mm)
- Impervious fraction of surfaces based on MW MUSIC guidelines
- Soil Properties:
  - Shallow basalt bedrock, overlain by clay
  - Low relief
  - Calibrated soil parameters

Parameters	Typical MW	Calibrated
Soil Storage Capacity	30 mm	140 mm
Field Capacity	20 mm	115 mm
DRR	25 %	5 %
DBR	5 %	3 %

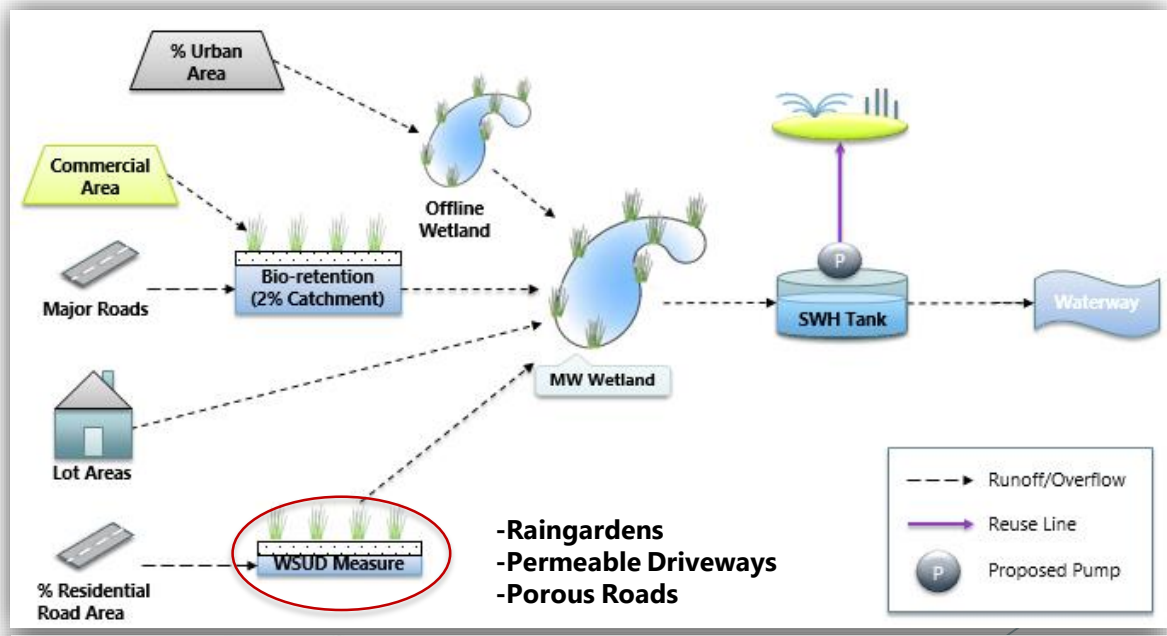
Base Case Model Results



Base Case 2 Options

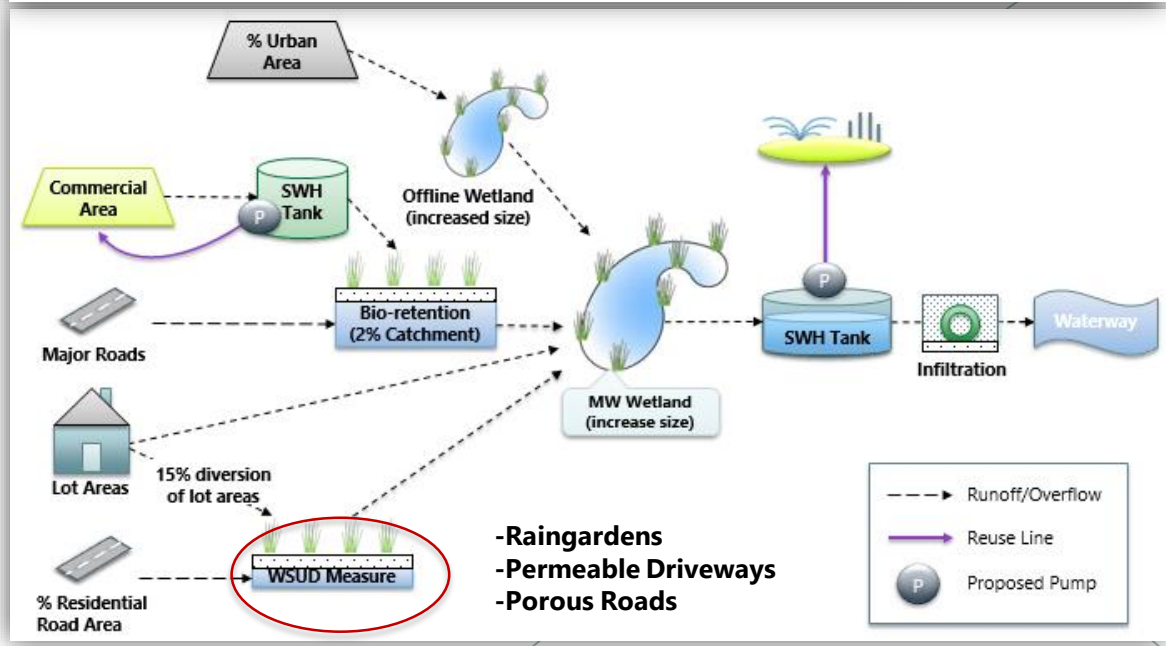
- Base Case 2

– 60 % reduction:



- Base Case 2

– 90% reduction:



BC2
Option 1

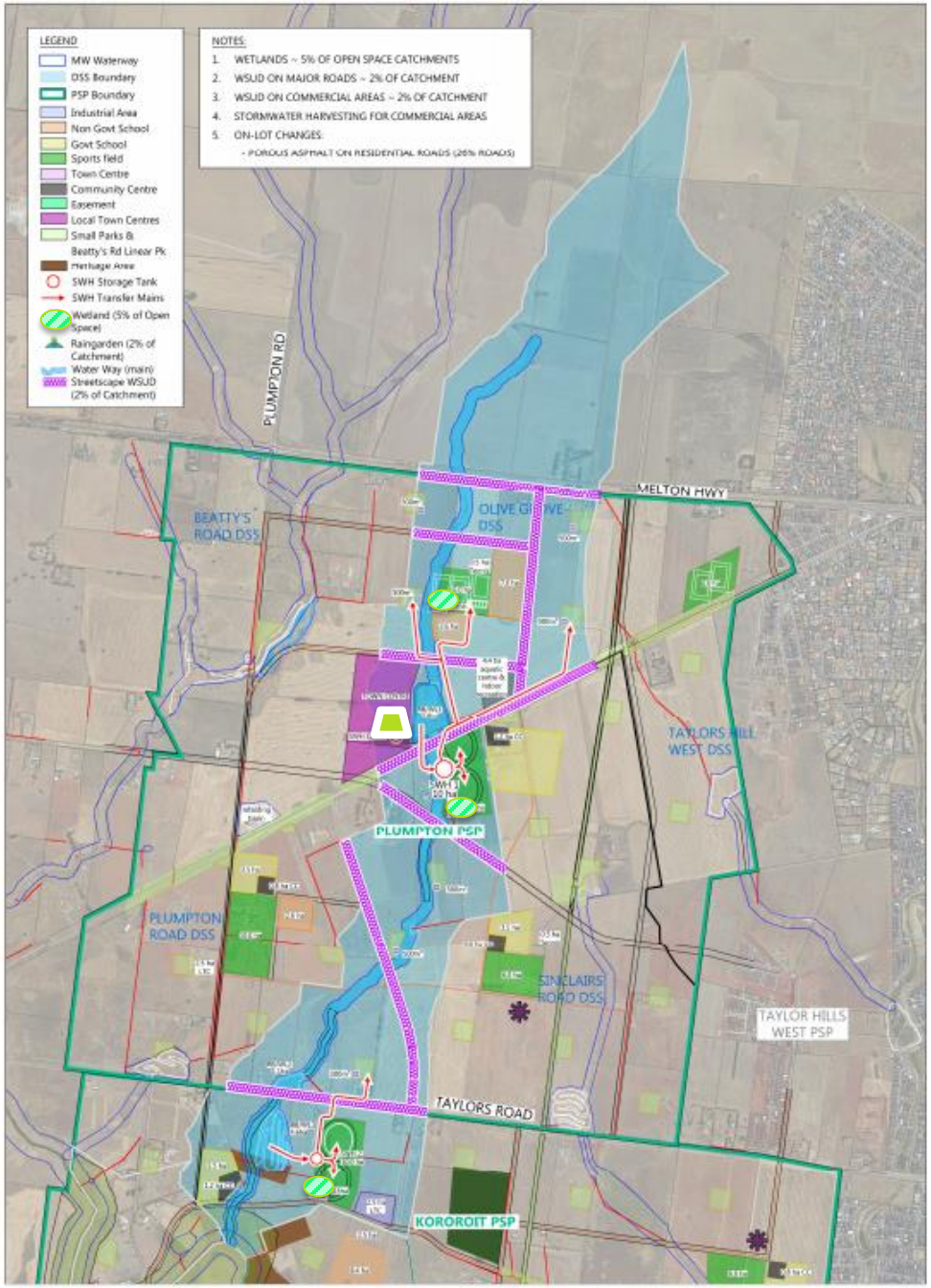

LEGEND
MW Waterway
DSS Boundary
PSP Boundary
Industrial Area
Non Govt School
Govt School
Sports field
Town Centre
Community Centre
Easement
Local Town Centres
Small Parks &
Beatty's Rd Linear Pk
Heritage Area
SWH Storage Tank
SWH Transfer Mains
Wetland (5% of Open Space)
Raingarden (2% of Catchment)
Water Way (main)
Streetscape WSUD (2% of Catchment)
NOTES:
1. WETLANDS ~ 5% OF OPEN SPACE CATCHMENTS
2. WSUD ON MAJOR ROADS ~ 2% OF CATCHMENT
3. WSUD ON COMMERCIAL AREAS ~ 2% OF CATCHMENT
4. STORMWATER HARVESTING FOR COMMERCIAL AREAS
5. ON-LOT CHANGES:
- POROUS ASPHALT ON RESIDENTIAL ROADS (26% ROADS)
PLUMPTON RD
MELTON HWY
BEATTY'S ROAD DSS
OLIVE GROVE DSS
TAYLORS HILL WEST DSS
PLUMPTON PSP
PLUMPTON ROAD DSS
SINCLAIRS ROAD DSS
TAYLOR HILLS WEST PSP
TAYLORS ROAD
KOROROIT PSP
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FIGURE A4
BASE CASE 2 - LOCAL STORMWATER HARVESTING
OPTION 1 - 60% FLOW REDUCTION
North
SCALE 1 : 25,000
500 250 0 500 1000
Original sheet size A4

BC2
Option 2

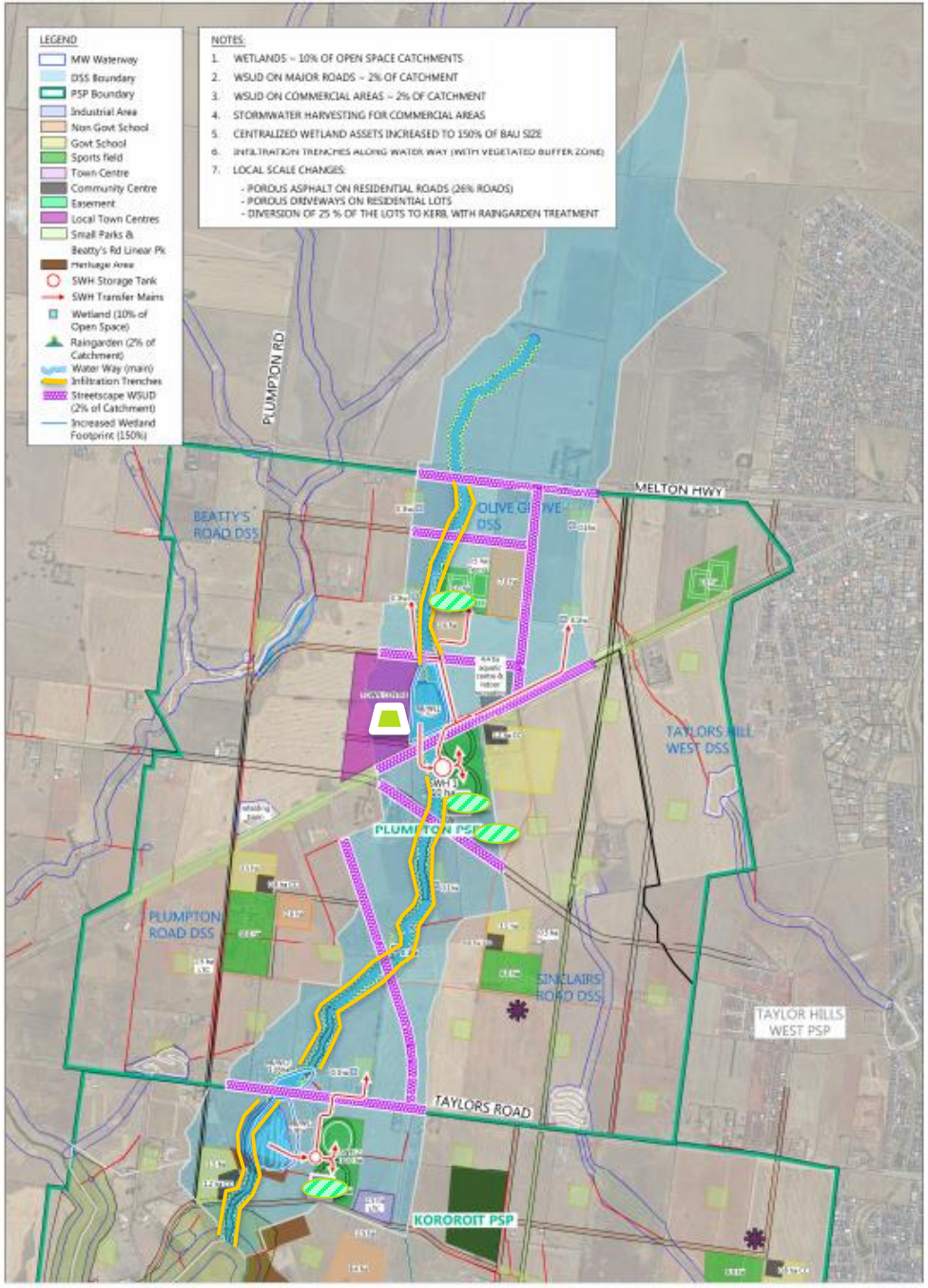
LEGEND
MW Waterway
DSS Boundary
PSP Boundary
Industrial Area
Non Govt School
Govt School
Sports field
Town Centre
Community Centre
Easement
Local Town Centres
Small Parks &
Beatty's Rd Linear Pk
Heritage Area
SWH Storage Tank
SWH Transfer Mains
Wetland (10% of Open Space)
Raingarden (2% of Catchment)
Water Way (main)
Infiltration Trenches
Streetscape WSUD (2% of Catchment)
Increased Wetland Footprint (150%)
NOTES:
1. WETLANDS ~ 10% OF OPEN SPACE CATCHMENTS
2. WSUD ON MAJOR ROADS ~ 2% OF CATCHMENT
3. WSUD ON COMMERCIAL AREAS ~ 2% OF CATCHMENT
4. STORMWATER HARVESTING FOR COMMERCIAL AREAS
5. CENTRALIZED WETLAND ASSETS INCREASED TO 150% OF BAU SIZE
6. INFILTRATION TRENCHES ALONG WATER WAY (WITH VEGETATED BUFFER ZONE)
7. LOCAL SCALE CHANGES:
- POROUS ASPHALT ON RESIDENTIAL ROADS (26% ROADS)
- POROUS DRIVEWAYS ON RESIDENTIAL LOTS
- DIVERSION OF 25 % OF THE LOTS TO KERB, WITH RAINGARDEN TREATMENT
PLUMPTON RD
MELTON HWY
BEATTY'S ROAD DSS
OLIVE GROVE DSS
TAYLORS HILL WEST DSS
PLUMPTON PSP
PLUMPTON ROAD DSS
SINCLAIRS ROAD DSS
TAYLOR HILLS WEST PSP
TAYLORS ROAD
KOROROIT PSP
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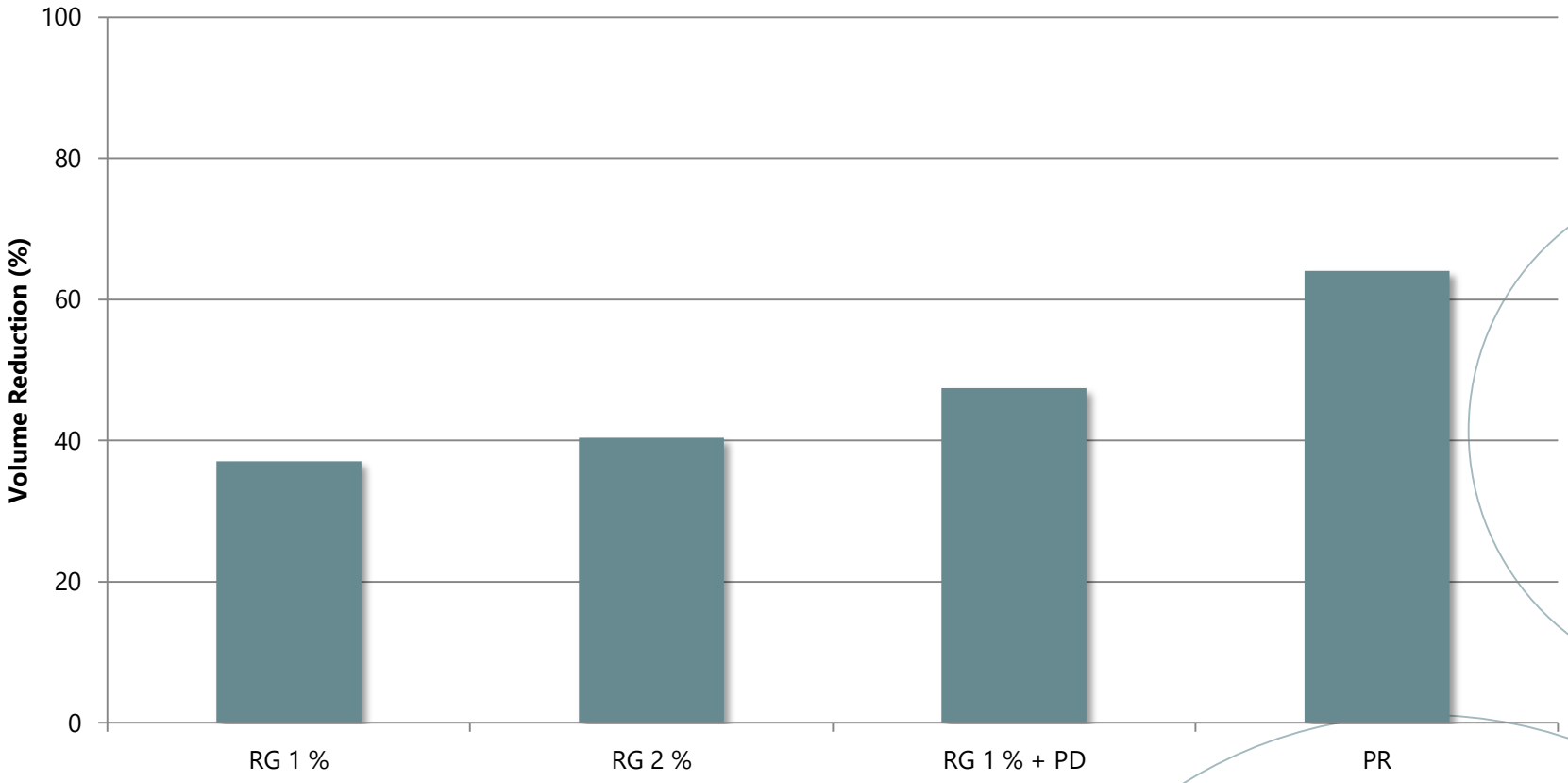
FIGURE A5
BASE CASE 2 - LOCAL STORMWATER HARVESTING
OPTION 2 - 90% FLOW REDUCTION
North
SCALE 1 : 25,000
500 250 0 500 1000
Original sheet size A4

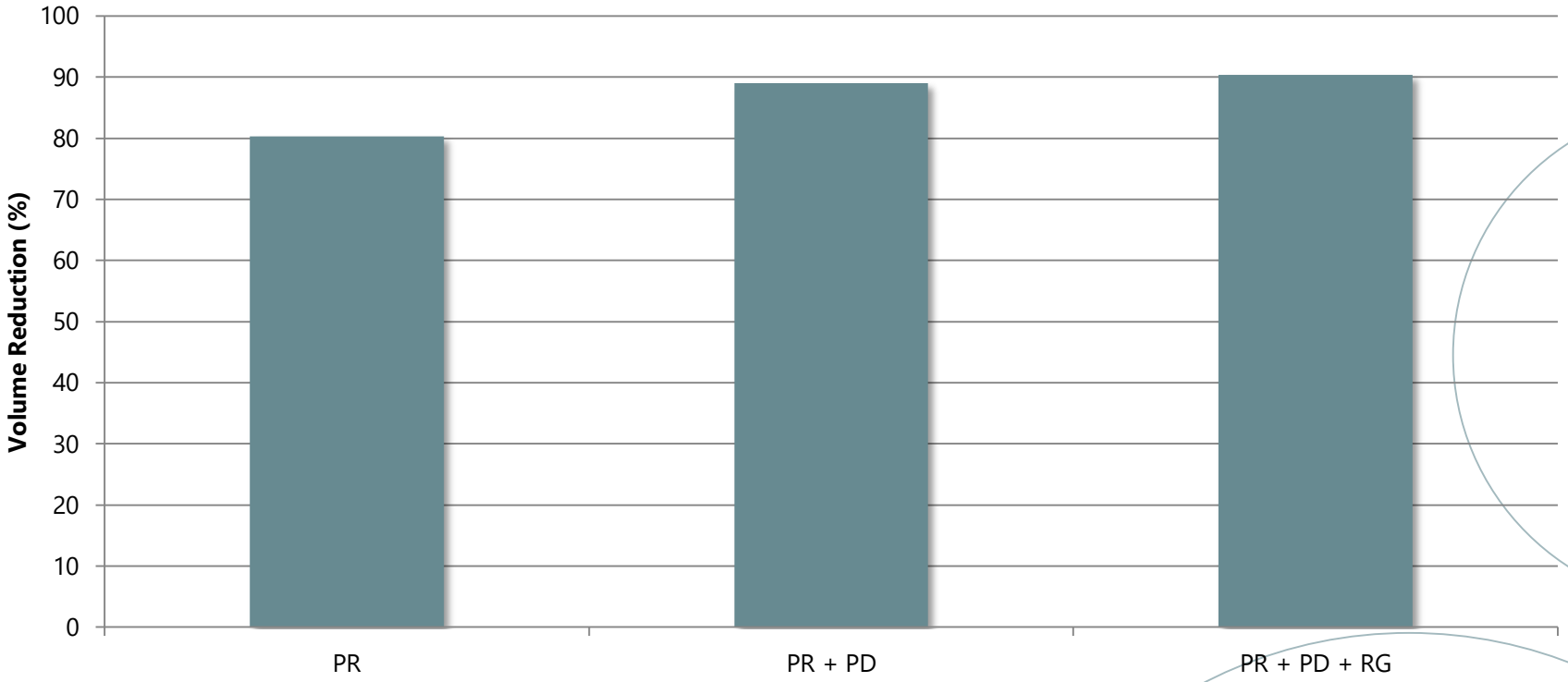
Base Case 2 – 60% reduction

- Major changes (achieved only 35 % reduction)
  - Distributed offline wetlands located at parks - 5 % of park area
  - WSUD applied to commercial area at 2 %
  - WSUD and infiltration on the main roads 2 %
- Then introduce residential changes:



Base Case 2 – 90% reduction

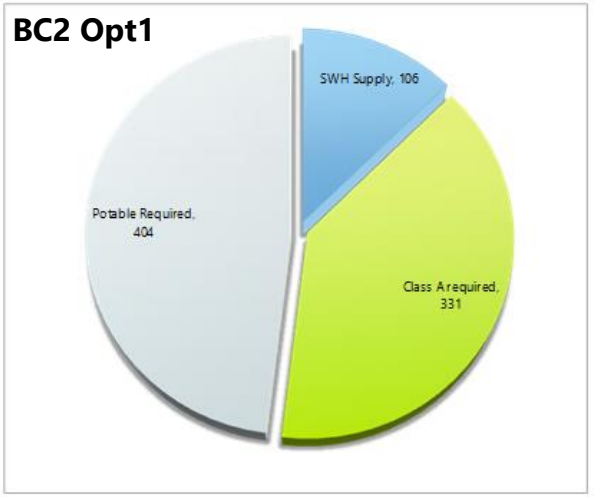
- Major changes
  - Distributed offline wetlands located at parks - 10 % of park area
  - Increased online wetlands 150 %
  - Commercial area stormwater harvesting
  - Infiltration trenches
- Then introduce residential changes:



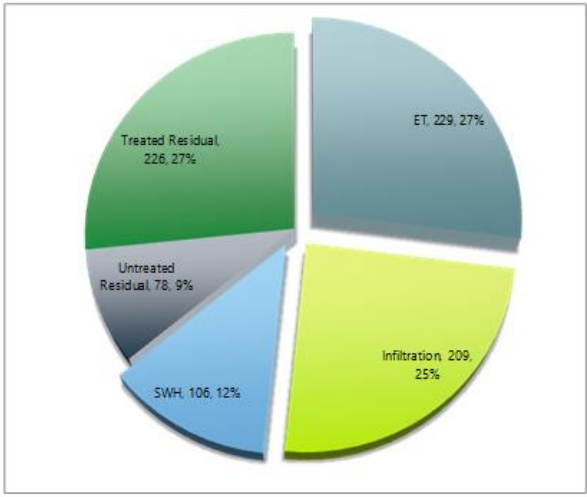
Base Case 2 Options (WWCM)

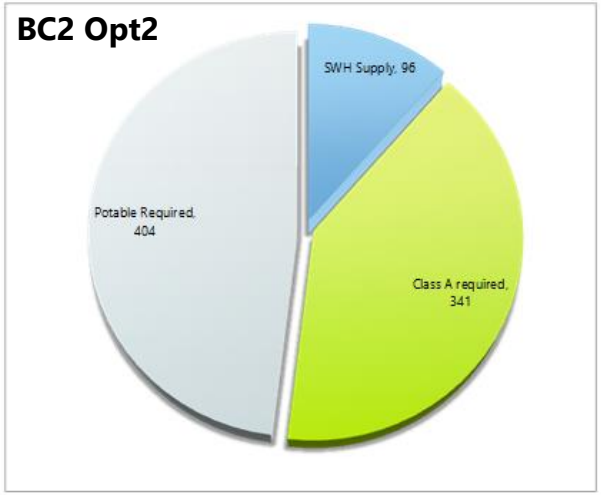
- Increasing ET and infiltration with increasing measures
- BC2 Option 2 supplies less stormwater due to less water coming from the catchment

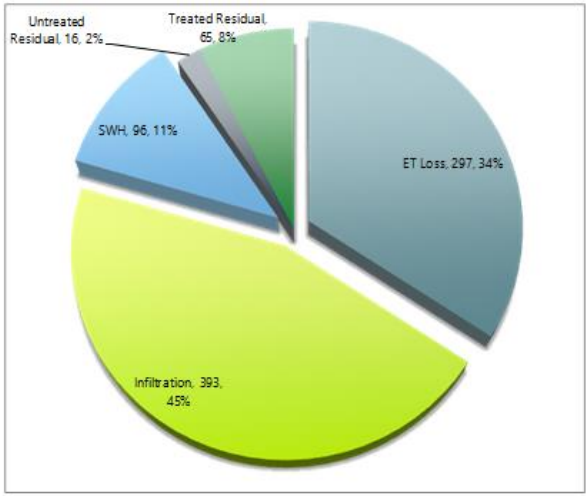
a) Water Supply Budget (ML/yr)



b) Stormwater Volume Breakdown (ML/yr)

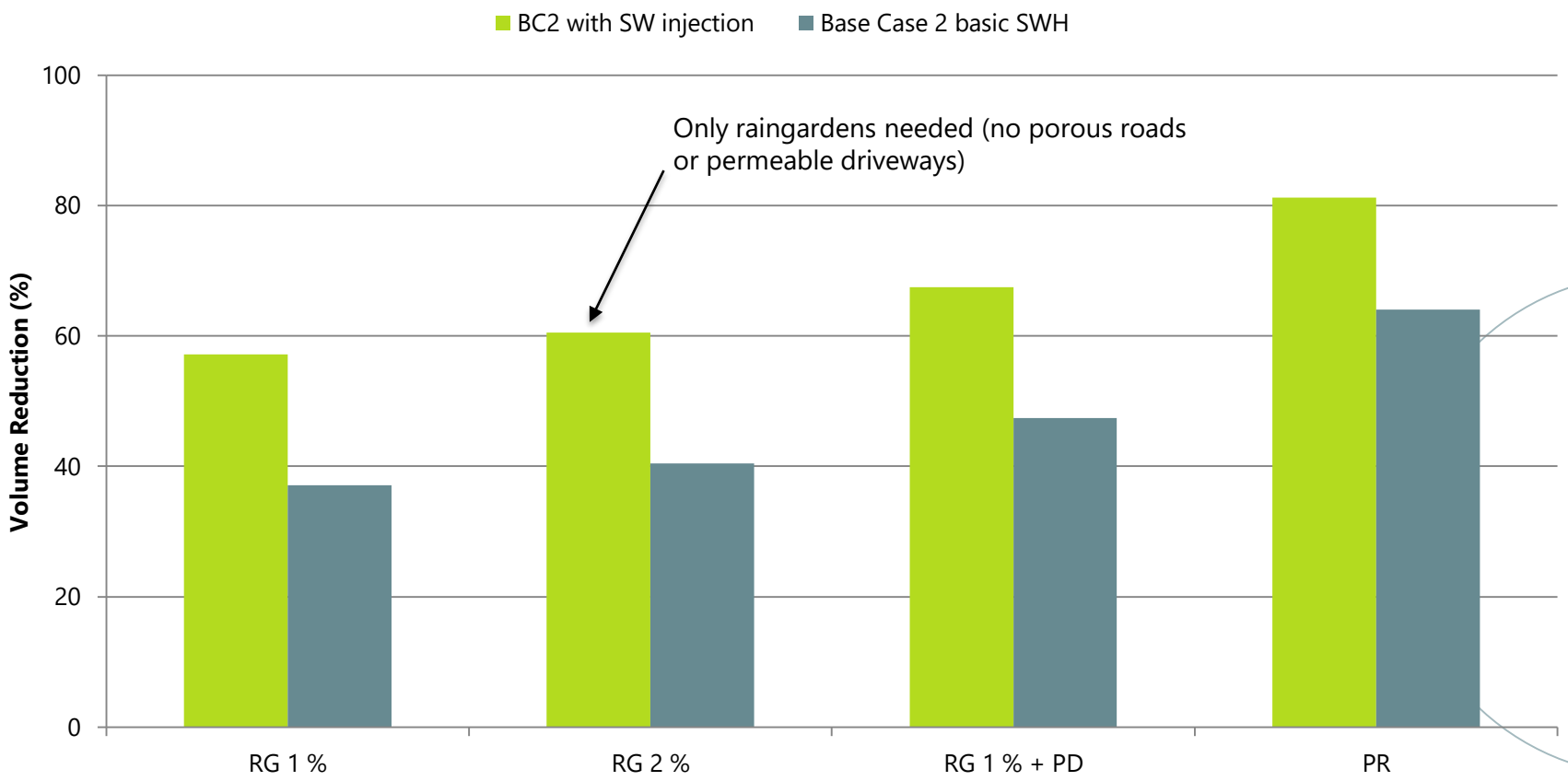






Base Case 2 – Alternatives (60% reduction)

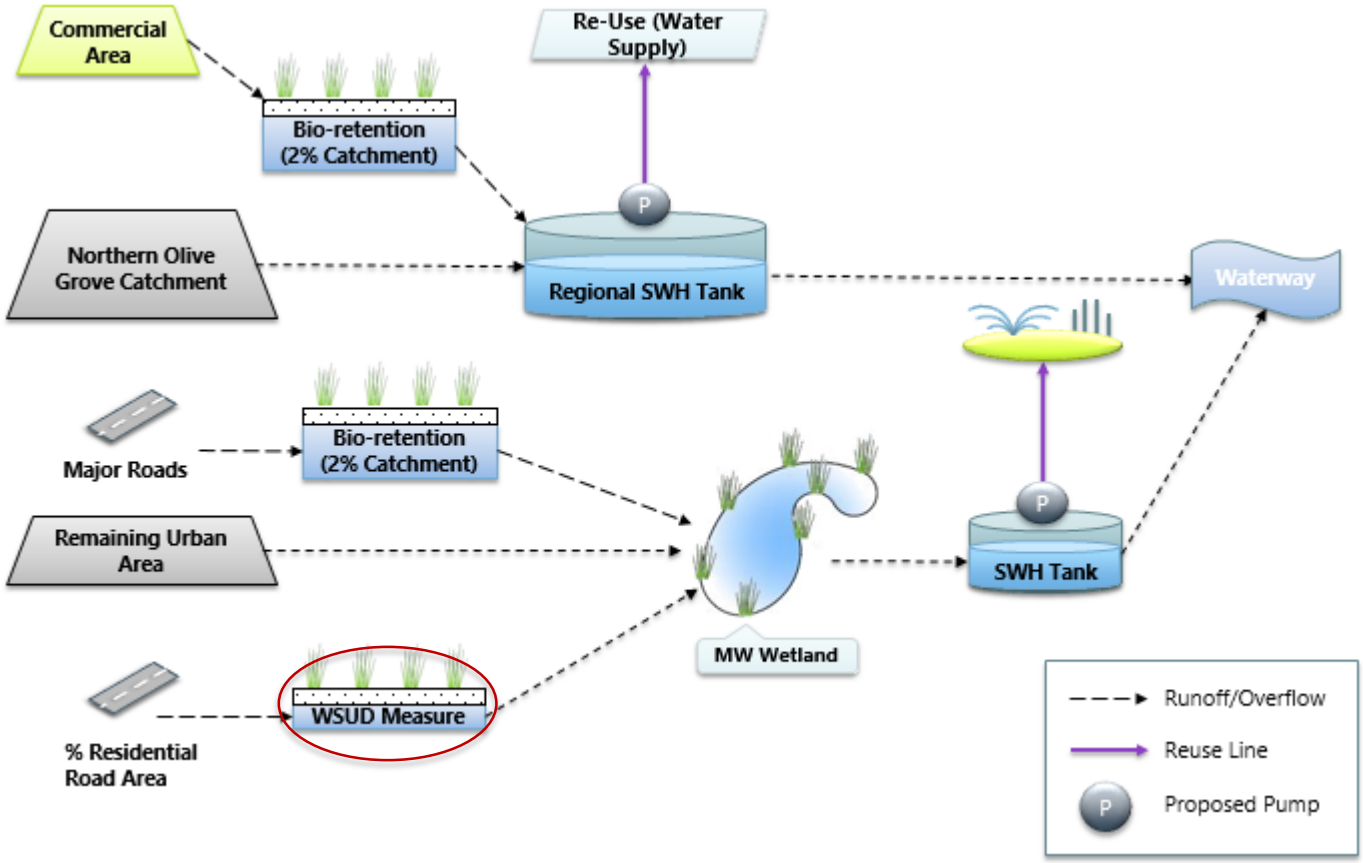
- Stormwater harvesting (for fields) vs stormwater injection (for water supply – Class A substitute)



- Also: Also neighbourhood rainwater harvesting (>60%)

Base Case 3 Option

- Initial Base Case 3 achieves 60 % reduction Level of Service.
- To achieve 90 %:



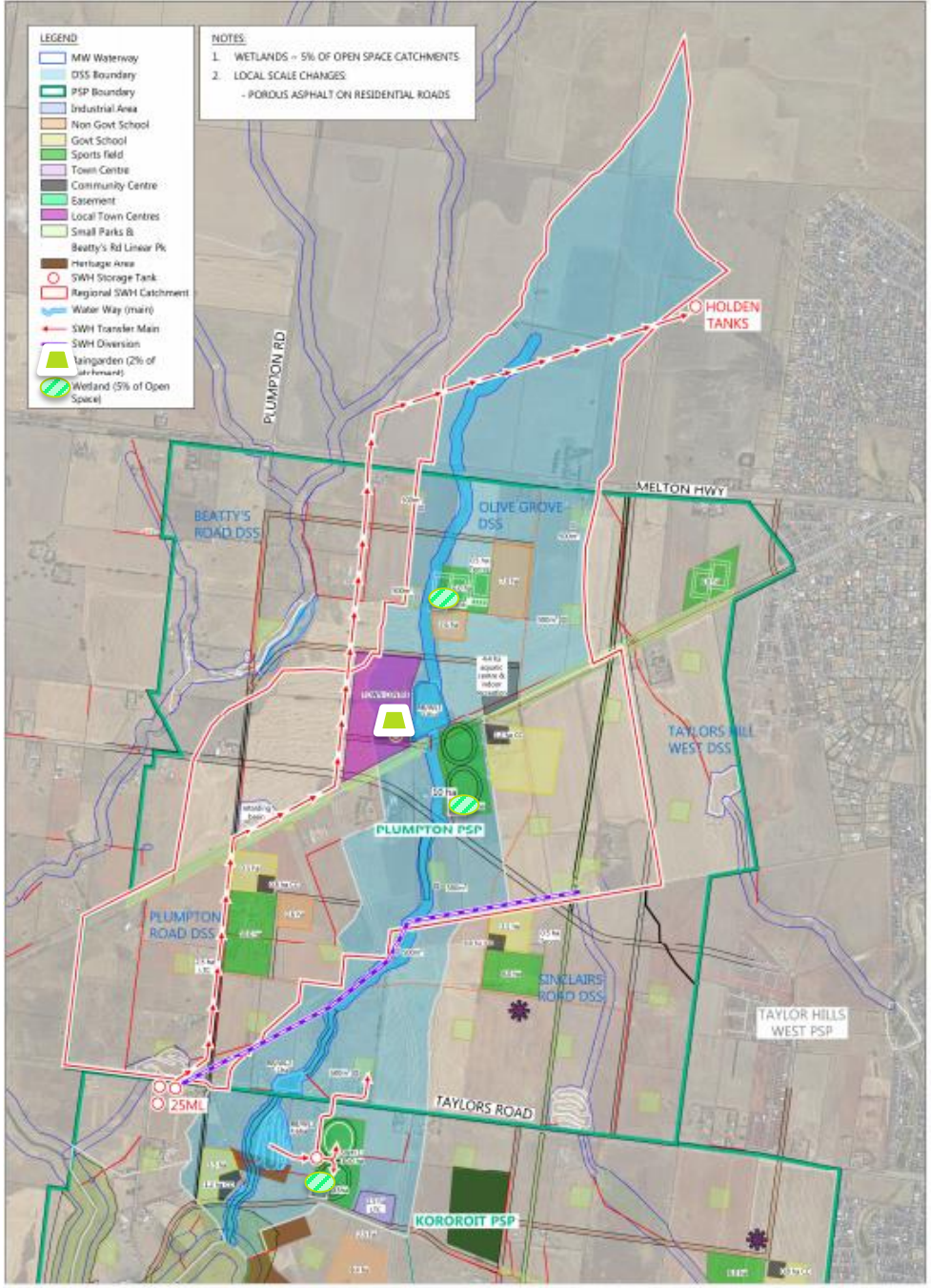


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FIGURE A7

BASE CASE 3 - REGIONAL STORMWATER HARVESTING
OPTION 1 - 90% FLOW REDUCTION

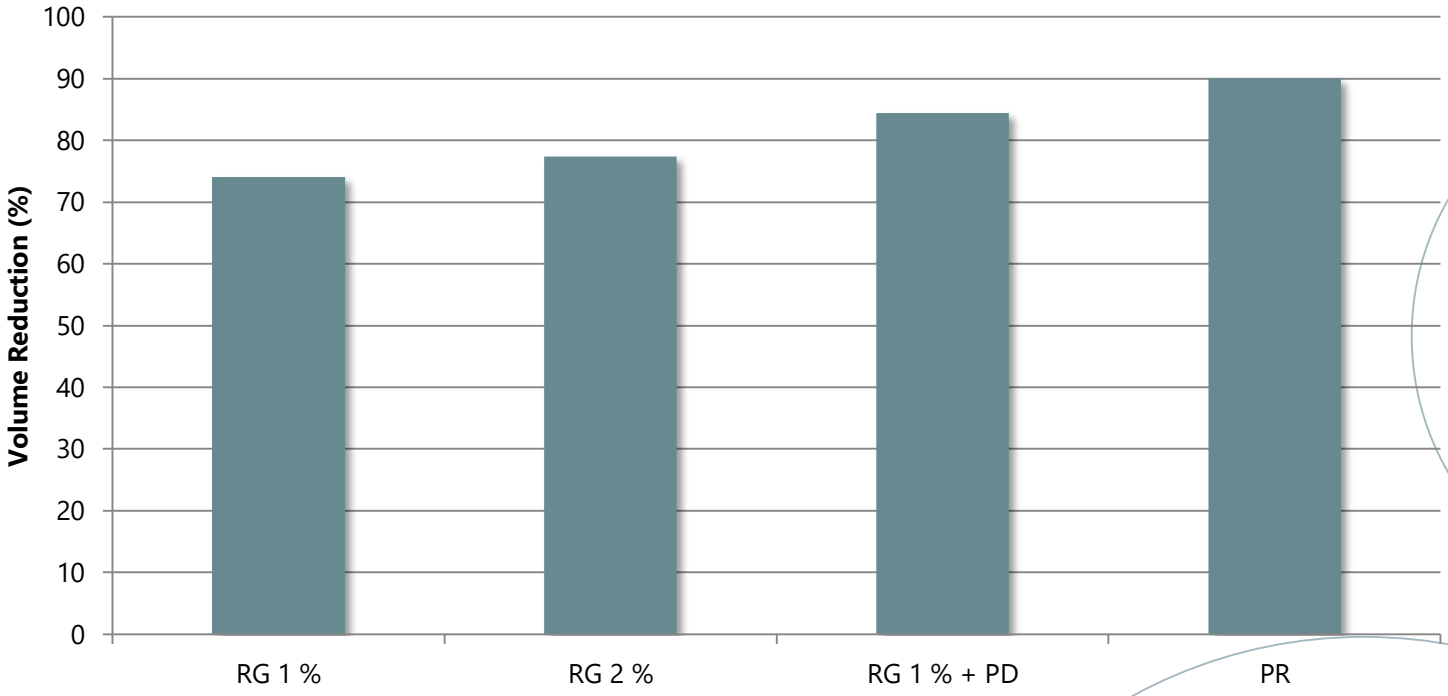
North

SCALE 1 : 25,000
500 250 0 500 1000

Original sheet size A4

Base Case 3 – 90 % reduction

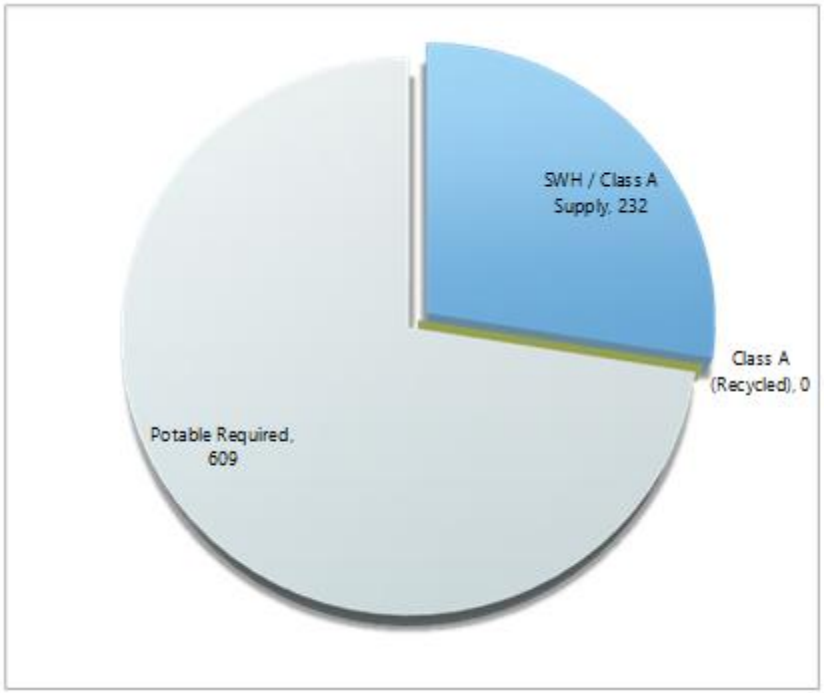
- Major changes (70 % reduction)
  - Distributed offline wetlands located at parks - 5 % of park area
  - Local stormwater harvesting (set at 3 ML to achieve 80% reliability)
  - WSUD applied to commercial area at 2 %
  - WSUD and infiltration on the main roads 2 %
- Then introduce residential changes:



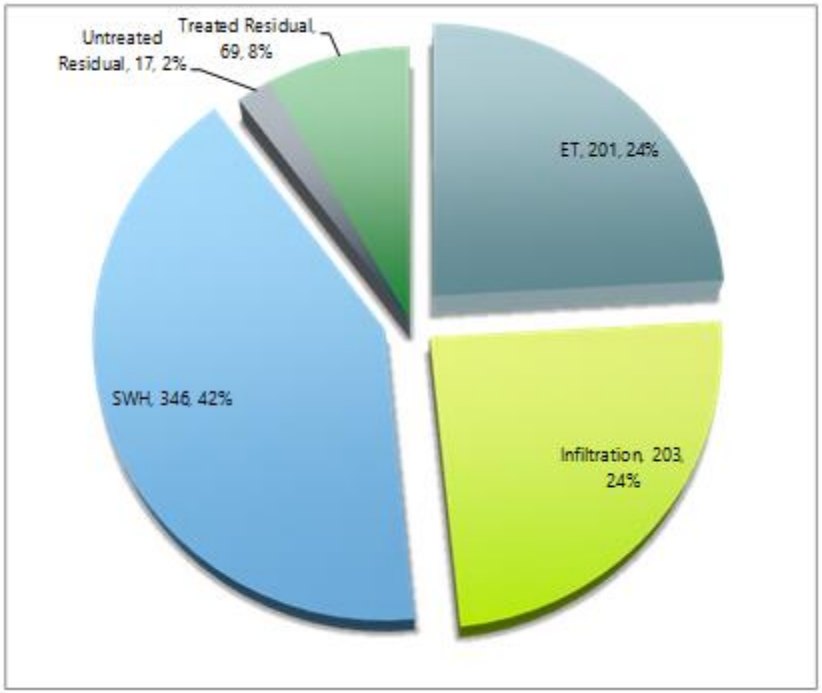
Base Case 3 – 90% reduction

Supplies the largest amount of stormwater to supplement traditional sources

Water supply budget

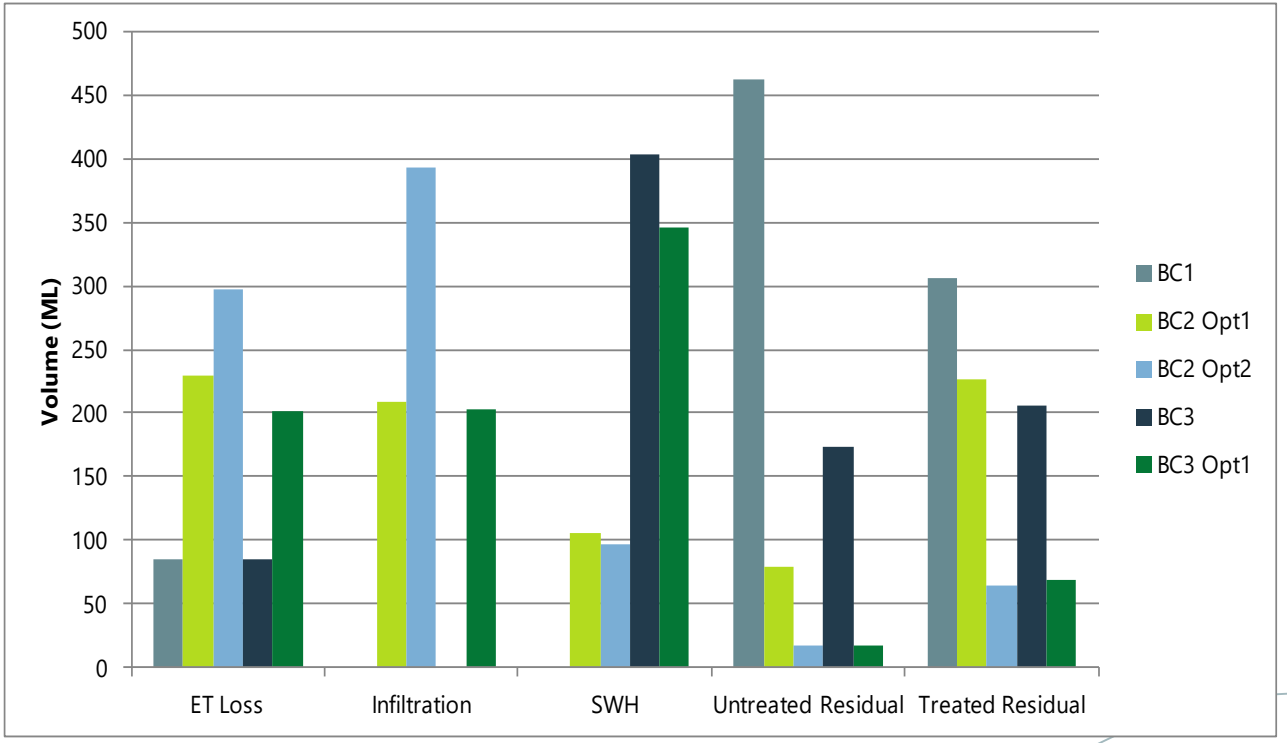


Stormwater volume breakdown



Summary of Options

- Base Case 2 Option 2 and Base Case 3 Option 1 produce the least residual flow and the highest ET, infiltration and re-use losses.
- BC3 shows the highest water supply potential



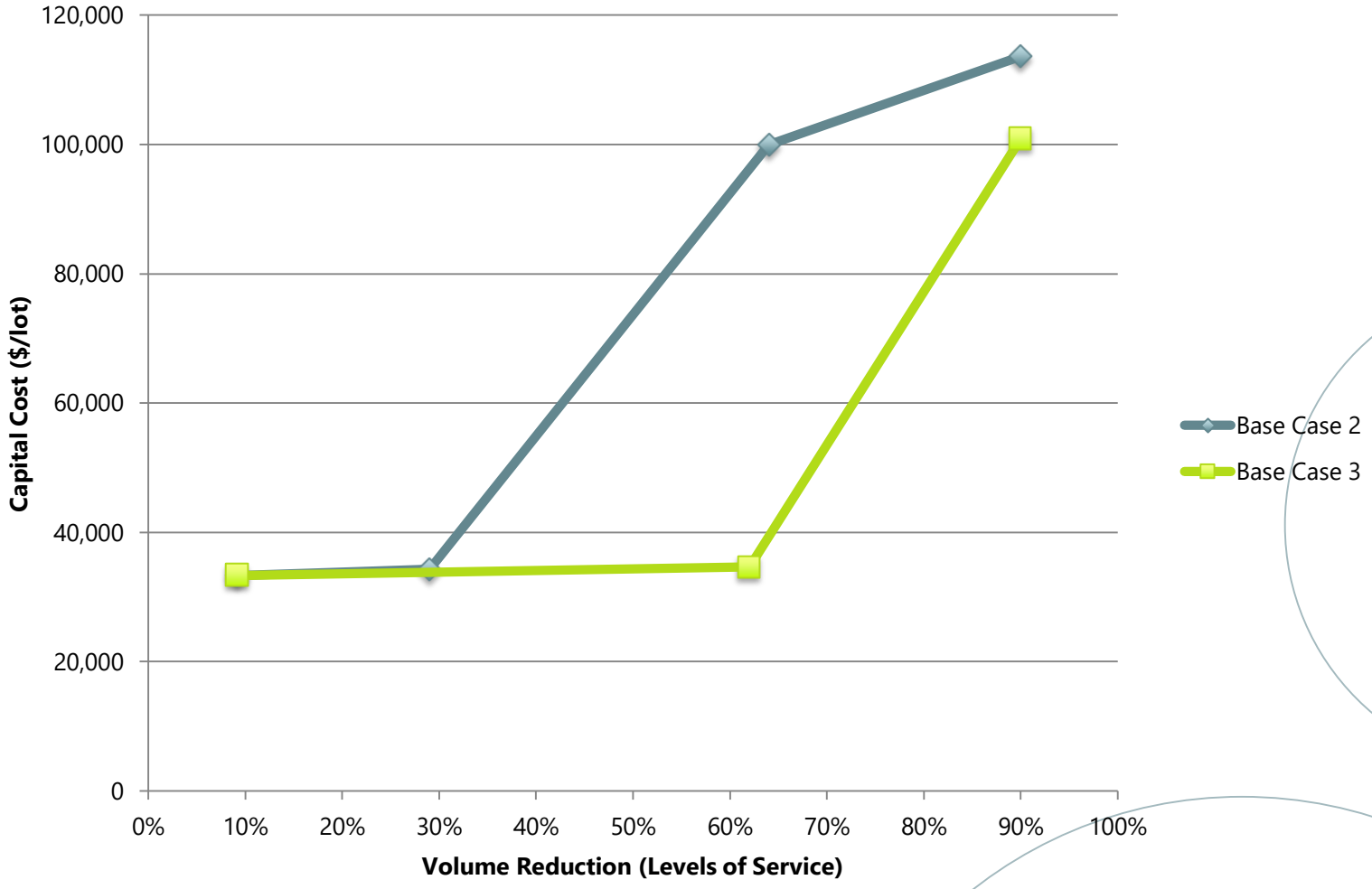
Summary of Options - Footprint

- Largest required treatment is for BC2 Opt2 due to permeable driveways and increased asset sizes (on and offline wetlands)
  - Treatment area required excludes the 83 Ha of Porous Road for BC2 Opt1, BC2 Opt2 and BC3 Opt1 as these are encumbered by residential roads.
  - BC2 Opt 2 also includes ~5.5 km of infiltration trenches, however, not been included in the treatment area required as it is assumed to be installed in the encumbered waterway buffer.

Option	Retarding Basins (Ha)	Centralised Wetlands (Ha)	Offline Wetlands (Ha)	Residential Measures (Ha)	Street scale (Ha)	SWH (ML)	Treatment Area Required (Ha)[1]
BC1	6	9.5					9.5
BC2	6	9.5				6.3	9.5
BC2 Opt1	6	9.5	3.85	83	0.39	6.3	14
BC2 Opt2[†]	6	14.3	7.7	106	0.39	6.3	46
BC3	6	9.5				25	9.5
BC3 Opt1	6	9.5	3.85	83	0.39	28	14

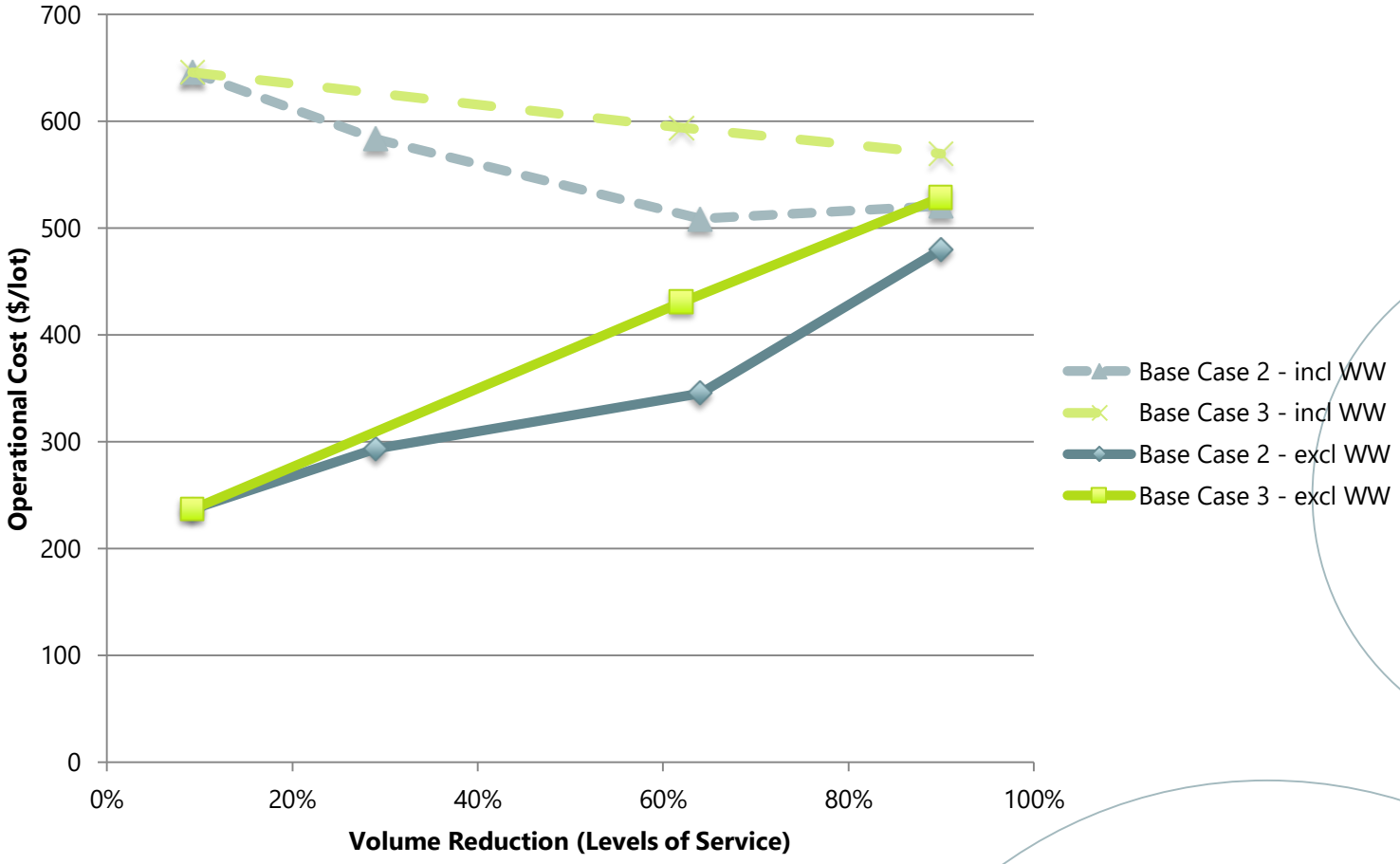
Capital Cost

- Current porous pavements for roads are expensive
- Technology (eg New Orleans) arriving in Aus may drive this down



Operating Cost

- Net operating cost shows benefit due to the avoided cost of waterway works.
  - Waterway maintenance cost decreases with increases Levels of Service (approximately correlated eg 60 % volume reduction equates to 60 % lower cost).



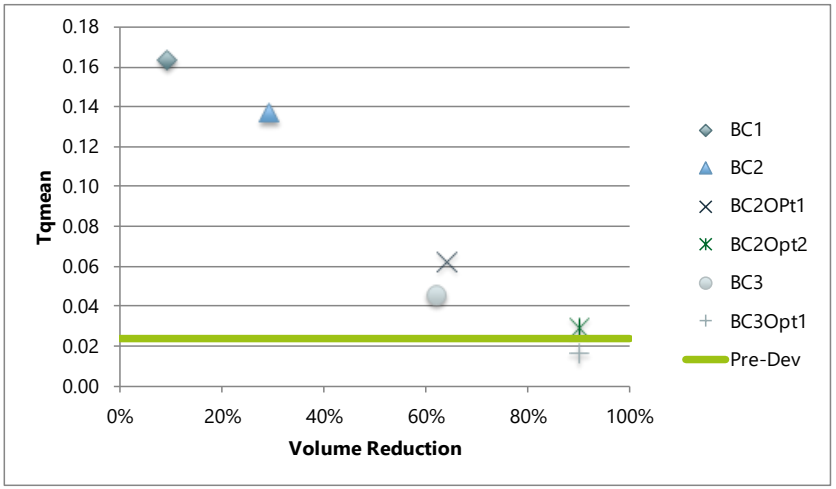
Waterway health assessment

Extended the rainfall period to 5 year mean in MUSIC

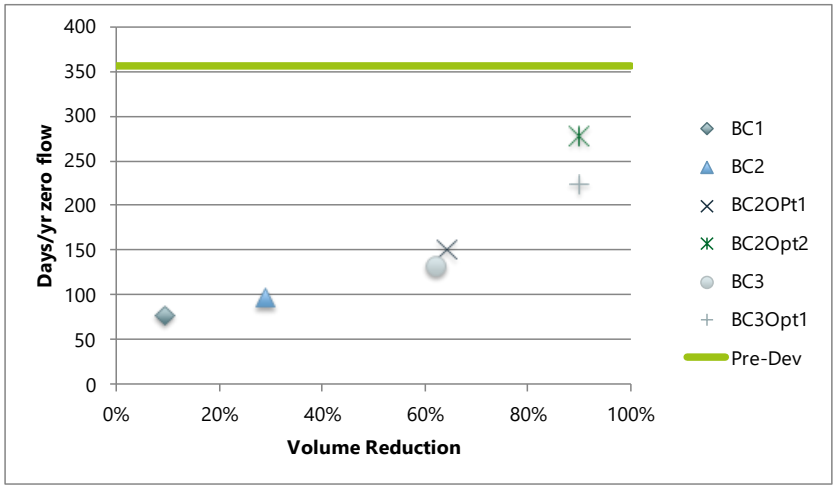
Metric	Impact	Approach
Low flow duration (days = zero flow & mean duration of zero flow	Low flow affects habitat availability & affects species adapted to ephemeral	MUSIC - daily
Duration (Tqmean) = mean days > annual mean	Affects water quality & hydraulics – indicates 'peakiness'	MUSIC - daily
Rate of Change (R-B index) = sum daily change / mean daily flow	Affects water quality & hydraulics - duration of disturbance events	MUSIC - daily
Bed mobilisation (time > Q1.5 / 2)	Bed erosion - Habitat availability	RORB (Q – convert to 6 min) HECRAS – shear stress (>2 N/m^2) MUSIC – 6 min
Bank mobilisation (time > Q2 / 2)	Sediment transport, habitat, riparian vegetation	RORB (Q – convert to 6 min) MUSIC – 6 min

Results – daily metrics

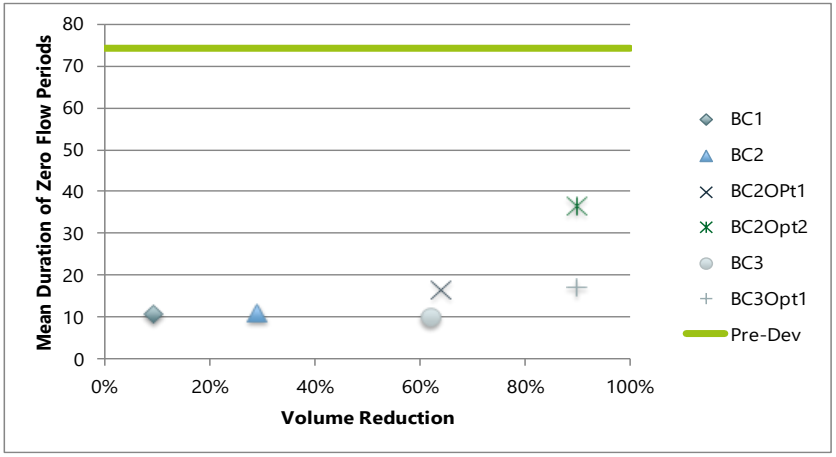
TQmean



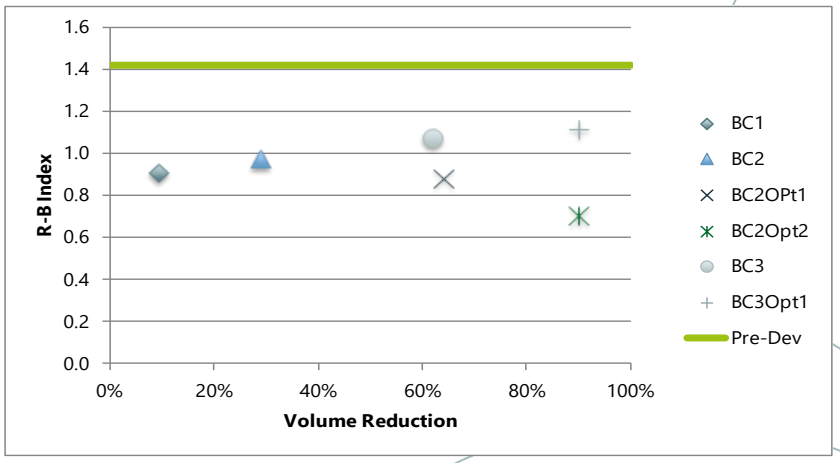
Mean days = zero flow



Mean duration of zero flow



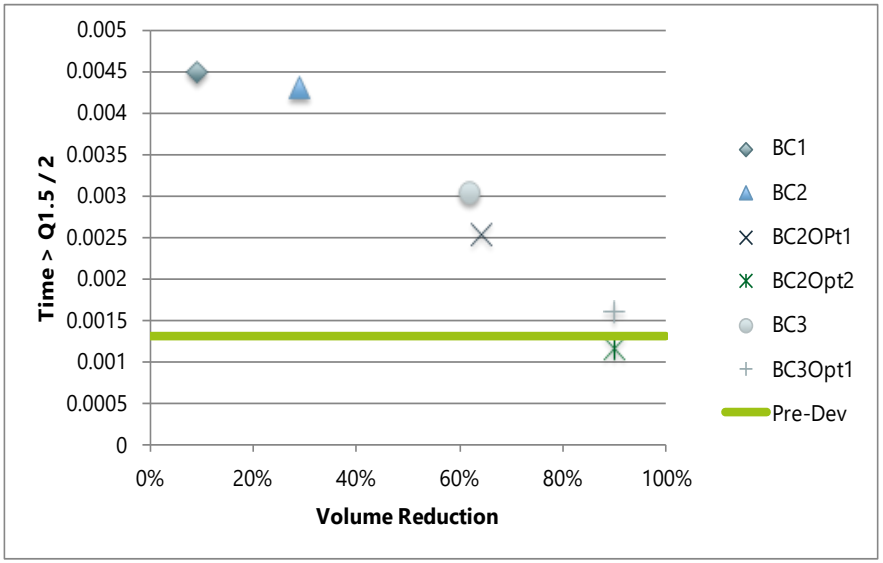
Rate of Change

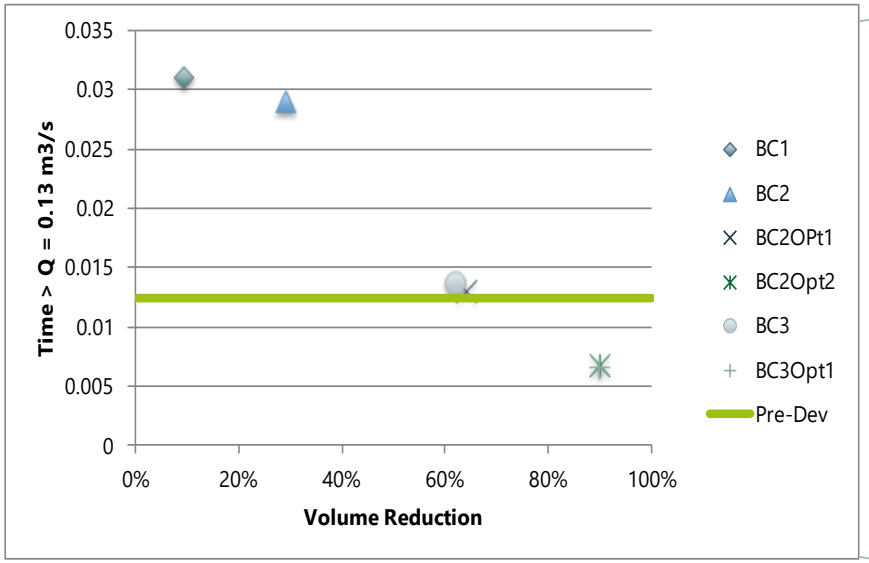


Results – bed mobilisation

Event	RORB Output	Pre-development Thresholds
Q1.5	1.51 m^3/s	271.8 m^3 / 6 mins
Q2.0	1.75 m^3/s	315.0 m^3 / 6 mins

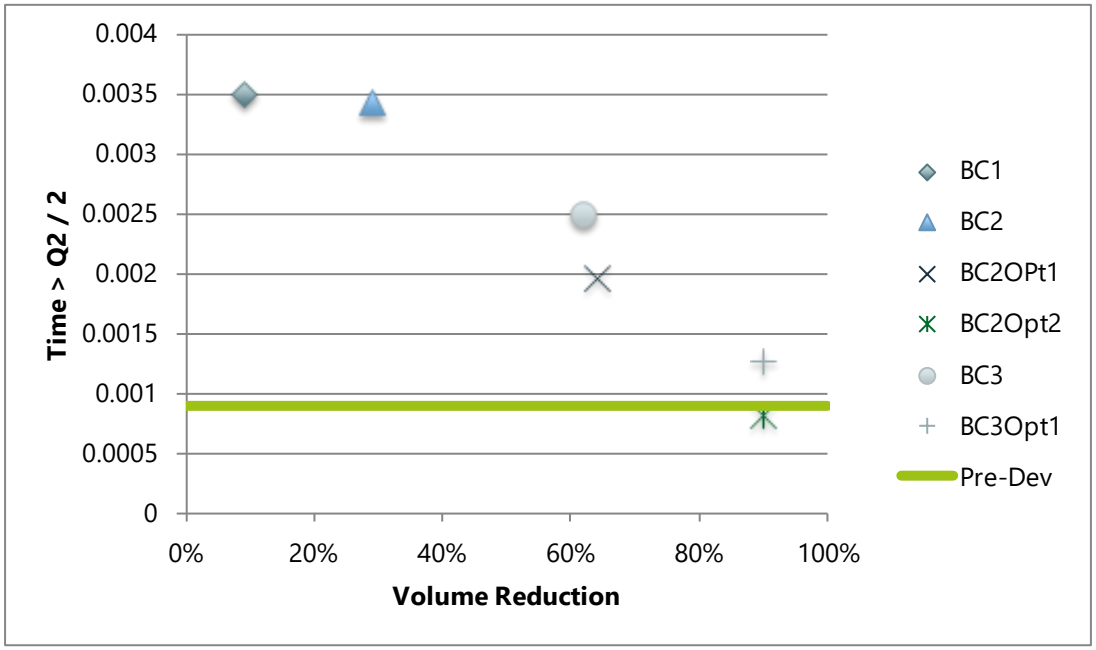
- Q1.5 flow in HECRAS > 2 N/m^2
  - Q = 0.13 m^3 /s -> assess both





Bed Mobilisation

Increasing benefits to increasing stormwater treatment



- Concern: comparing the coarse (average) 6 min output of MUSIC to instantaneous peak flow from RORB

Key Outcomes

- Large assets alone can not achieve high Levels of Service;
- The 90 % volume reduction Level of Service generally achieves waterway health metrics;
- Technology should be encouraged to drive prices down;
  - An alternative scenario for effective volume reduction could be SW injection (cost effective).
- The LoS & health metrics do not discriminate effectively between options that protect the 'whole' creek.
  - End of line treatments, involve deterioration of some sections of the creek. The % volume reduction and waterway metrics only assess the discharge downstream of these systems.
  - In this study distributed catchment measures have been valued higher for protection of waterways

Key Concerns

- Interpretation of indicators / LoS: These are designed to be simplistic, to enable easy and relative assessment of options.
  - Volume reduction alone may not be a good indicator
- Misrepresentation of indicators / LoS: The temptation exists to use these indicators in other zones, providing an inappropriate result.
  - Other zones outside Melton, require specific studies to assess the suitable LoS required as these have differing soil properties and catchment characteristics
- Cost – pieces of the stakeholder pie – who pays?

Developer Issues

- Costs, time and land take are the main issues
- Space constraints due to higher density areas would limit the acceptance of tanks on private land
- Avoiding land take is desirable with co-locating assets and centralised systems preferred
- Extra costs for options may be accommodated, however, the key concern is the additional time taken to approve 'non-standard solutions'. An incentive would be to speed up the approval process for these solutions
- Government commitment is paramount to getting buy in from developers (and the community) with respect to options.
- Developers believe the community values easy access to green space (including aesthetics of theses spaces) and connectivity corridors are important.

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