Shire of Serpentine Jarrahdale

Integrated Water Management Strategy

PRELIMINARY WATER SECURITY STUDY – SHORTLIST OF OPTIONS

Project No. 181592
Doc No. WGA181592-RP-CV-0002
Rev. A

31 July 2019

Revision History

Rev	Date	Issue	Originator	Checker	Approver
A	17/7/2019	Draft for Client Comment	D. Haworth	N. Silby	N. Silby

CONTENTS

Appendices

1 INTRODUCTION

1.1 BACKGROUND

The Shire of Serpentine Jarrahdale (SSJ) is situated on the fringe of Perth's urban development area and is reportedly one of the fastest growing communities in the country. It is predicted that Perth's population will grow by 1.5 million people by 2050 (Shire of Serpentine Jarrahdale, 2016).

In response, SSJ developed the SJ 2050 visioning document (2016) to help plan for the future and maintain the community liveability expectations whilst providing growth opportunities in housing and employment. The predicted increase in population will result in increasing pressure on water supply and wastewater management infrastructure in the region. As a result of climate change and overexploitation, Perth's water resources are under increasing pressure with the efficiency of use and reuse of alternative water supplies becoming increasingly important.

It has been recognised that a secure water supply and wastewater management infrastructure was required to meet the minimum community expectations. Both in the urban environment and agricultural precincts. Water security for the SSJ is of critical importance in a drying climate. This integrated water management strategy was commissioned to assist SSJ to understand the constraints and opportunities to water supplies in the project area and provide a platform for secure water management and planning into the future.

The project considers four main precincts within the SSJ governing boundary:

- Byford – Oakford
- Oldbury – Mundijong
- Hopeland – Serpentine-Keysbrook
- Jarrahdale Township

A site locality plan is presented in Figure 1.

Water demand for the SSJ managed infrastructure i.e. parks and reserves is considered the priority in the demand projections for this study. If surplus water is identified, consideration will be given to other local demands such as the proposed agricultural precinct, which intersects the SSJ's governing area.

This Integrated Water Management Strategy (IWMS) is being developed in a staged approach to ensure that all opportunities are appropriately considered, the stages include:

- Development of a preliminary long list of options, which included stakeholder consultation.
- Creation of a short list of up to three water supply concepts per precinct. The short list builds on the information presented in the long list and considers cost and risk implications of the selected concepts.

- The SSJ will implement a community consultation program based on the short list of options prior to finalising the IWMS.

The preliminary long list component has been completed and is presented in Haworth, 2019 with a synopsis presented in Section 1.3. This report presents the outcomes of the short list options assessment.

1.2 SCOPE OF SERVICES

The scope of services included in the development of the Short List of Options includes:

- Review SSJ comments and recommendations from the Long Options assessment.
- Consider strategic, legislative, policy and cost considerations for each option.
- Carry out a SWOT analysis and rank the overall options.
- Determine the priority / preferred options of up to three per precinct.
- Develop conceptual design and preliminary cost estimate for each option.
- Identify additional investigations required to determine the IWM opportunity feasibility.

1.3 SYNOPSIS OF LONG LIST OPTIONS ASSESSMENT

Further information pertaining to the long list options assessment can be found in Haworth, 2019 titled Integrated Water Management Strategy – Preliminary Water Security Study – Long List of Options. A summary of the options identified is provided in this section.

The long options assessment included a review of available background information to identify potential sources of water, current and future demands based on the SJ 2050 plan, a preliminary Managed Aquifer Recharge (MAR) feasibility assessment and stakeholder consultation. The water source options considered included groundwater, surface water, stormwater or urban runoff and wastewater (sewer mining or a decentralised wastewater system).

MAR is the purposeful recharge of water to an aquifer for storage and subsequent reuse, this can provide an alternative storage solution in place of above ground storages. There are different approaches for MAR, two techniques considered in this report include Aquifer Storage and Recovery (ASR) whereby water is recharged and extracted from the same recharge bore and infiltration to the unconfined Superficial Aquifer via galleries. A preliminary feasibility assessment in the project area identified that recharge to the Leederville, Yarragadee Formation and Cattamara Coal Measures is technically feasible. A number of unknowns or risks have been identified and a detailed MAR feasibility assessment would be required to determine if the concepts are viable, or design components such as treatment requirements, number of bores are appropriate etc. This is further discussed in Section 1.5. For the purpose of this assessment, the technique is deemed feasible.

Table 1 provides a summary of the current and predicted irrigation demand for the SSJ facilities. Estimates of agricultural or other local demands were not identified at this stage. Table 2 provides a summary of the options identified for each area with conceptual options presented in Figures 2 to 5.

Table 1: Current and Predicted Water Demand (rounded) for Irrigation of Public Open Space

Precinct	Current Demand (ML/a)	Future Demand (ML/a)	Current Groundwater Allocation (ML/a)	Deficit (ML/a)
Byford - Oakford	110	555	131	424
Oldbury-Mundijong	25	750	20*	730
Hopeland-Serpentine-Keysbrook	63	340	157	183
Jarrahdale	3	32	0	32
Total	201	1,677	308	1,369

Note:*Groundwater allocation requires confirmation.

Table 2: Summary of Long List of Options

Area	Future Demand / Deficit (ML/a)	#	Description	Potential Supply Volumes (ML/a) ±50%
Byford - Oakford	555 / 424	1	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter.	5,000-10,000
		2	Sewer mining from Water Corporation's sewer network or development of a decentralised wastewater treatment facility.	1,000-2,000
		3	Integrated approach for Opportunities 1 and 2 to increase security of supply.	6,000-12,000
		4	Orton Road District Sporting Facility – harvesting of surface runoff from Cardup Brook and urban runoff.	100-200
		5	Woodland Grove Sporting Facility – harvesting surface runoff from drainage line and urban runoff.	20-100
		6	Briggs Park Sporting Facility - harvesting of surface runoff.	10-50
		7	Austral Brick Quarry - Potential source of water from dewatering activities on site. There is the potential to integrate any supply with surface flows from Cardup Brook.	<20
Oldbury - Mundijong	750 / 730	8	Harvest of surface water flows from Manjedal Brook during winter.	3,000-5,000
		9	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter.	5,000-10,000
		10	Sewer mining from Water Corporation's sewer network or development of a decentralised wastewater treatment facility.	1,000-2,000
		11	Integrated approach for Opportunities 8 and 10 to increase security of supply.	3,000-6,000
		12	Keirnan District Sporting Facility - harvesting of surface runoff.	50-50
		13	Whitby and Mundijong District Sporting Facility – Potential to harvest surface runoff from the sporting facility and surrounding school buildings.	20-100
		14	Quarry - Potential source of water from dewatering activities on site.	<20
Hopeland Serpentine - Keysbrook	340 / 183	15	Harvest of surface water flows from Punrack Drain during winter.	5,000-10,000
		16	Harvesting of urban runoff through subsurface drainage network and a series of drainage basins.	<100
		17	Development of a decentralised wastewater treatment facility.	100-300
Jarrahdale	32 / 32	18	Harvest of surface water flows from Gooralong Brook during winter.	20-200
		19	Development of a decentralised wastewater treatment facility and retrofit the existing septic system.	20-50
		20	Development of a decentralised wastewater treatment facility for the proposed Tourist Park.	10
		21	Transfer of treated wastewater from Millbrook Winery via a piped network.	1

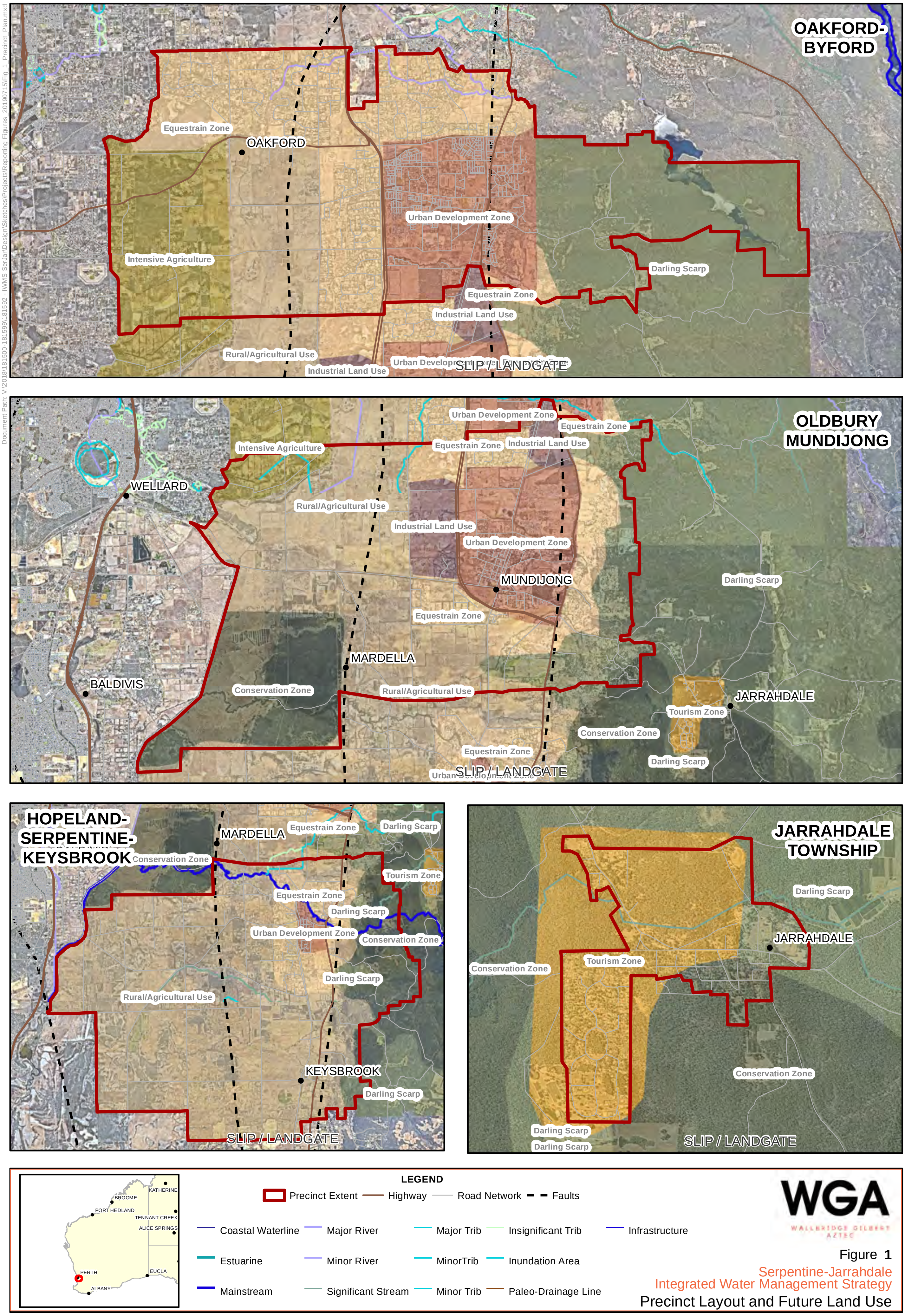
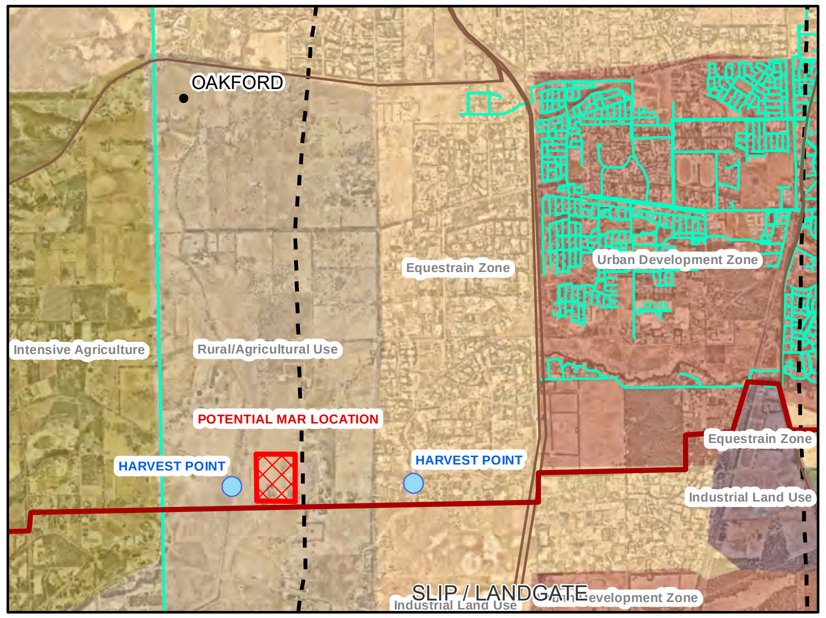
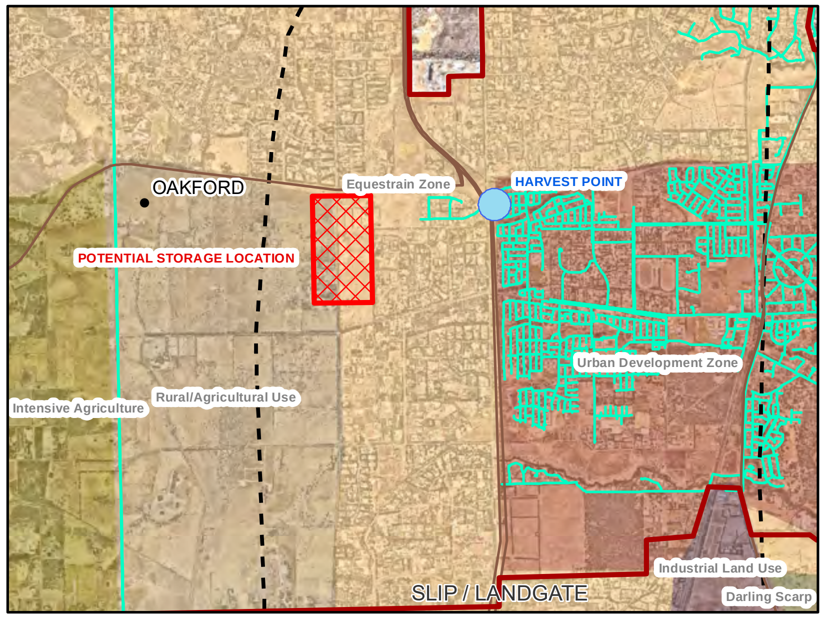


Figure 1
Serpentine-Jarrahdale
Integrated Water Management Strategy
Precinct Layout and Future Land Use

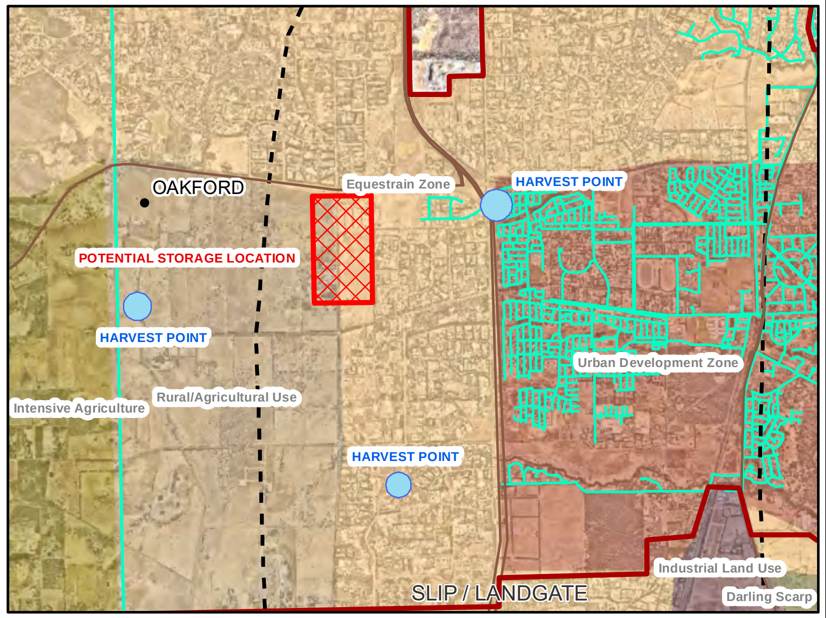
OPPORTUNITY 1



OPPORTUNITY 2



OPPORTUNITY 3

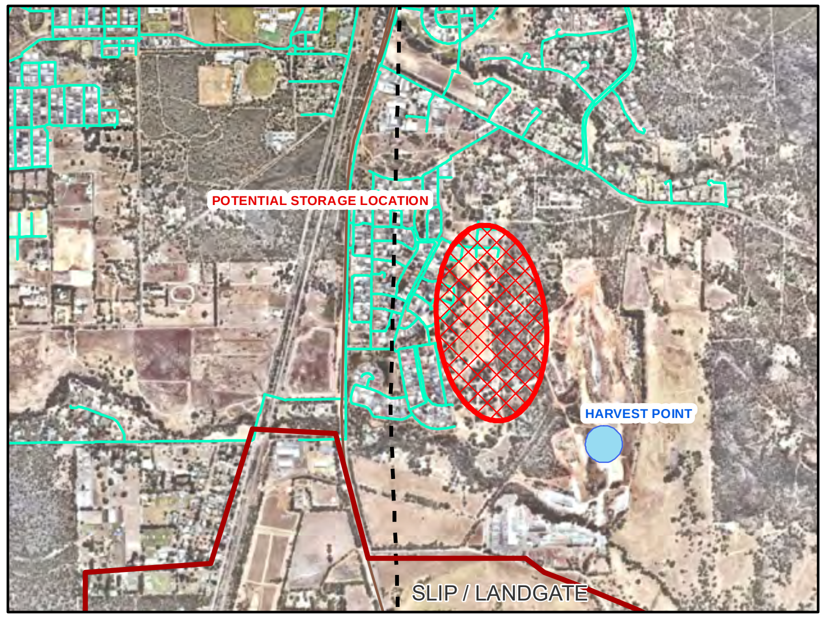


OPPORTUNITY 4

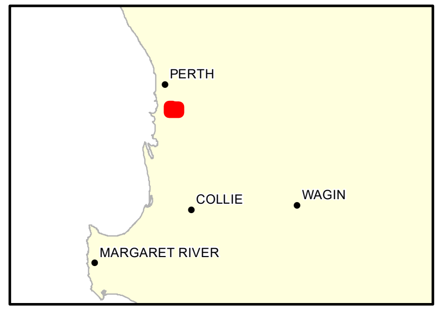
OPPORTUNITY 5

OPPORTUNITY 6

OPPORTUNITY 7



Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Byford - Oakford	555/424	1	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	5,000-10,000
		2	Sewer mining from Water Corporations sewer network or development of a decentralised wastewater treatment facility. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	1,000-2,000
		3	Integrated approach for Opportunities 1 and 2 to increase security of supply.	6,000-12,000
		4	Orton Road District Sporting Facility – harvesting of surface runoff, surface water from Cardup Brook and urban runoff captured in the drainage basin. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	100-+200
		5	Woodland Grove Sporting Facility – harvesting of surface runoff, surface water from drainage line and urban runoff captured in the drainage basin. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	20-+100
		6	Briggs Park Sporting Facility - harvesting of surface runoff. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	10-+50
		7	Austral Brick Quarry Potential source of water from dewatering activities on site. There is the potential to integrate any supply with surface flows from Cardup Brook.	<20



- Precinct Extent
- Potential Storage Location
- Harvest Point
- Highway
- Faults
- Water Delivery Pipe
- Coastal Waterline
- Estuarine
- Mainstream
- Major River
- Minor River
- Significant Stream
- Major Trib
- MinorTrib
- Minor Trib
- Insignificant Trib
- Inundation Area
- Paleo-Drainage Line
- Infrastructure

SJ2050 Proposed Landuse

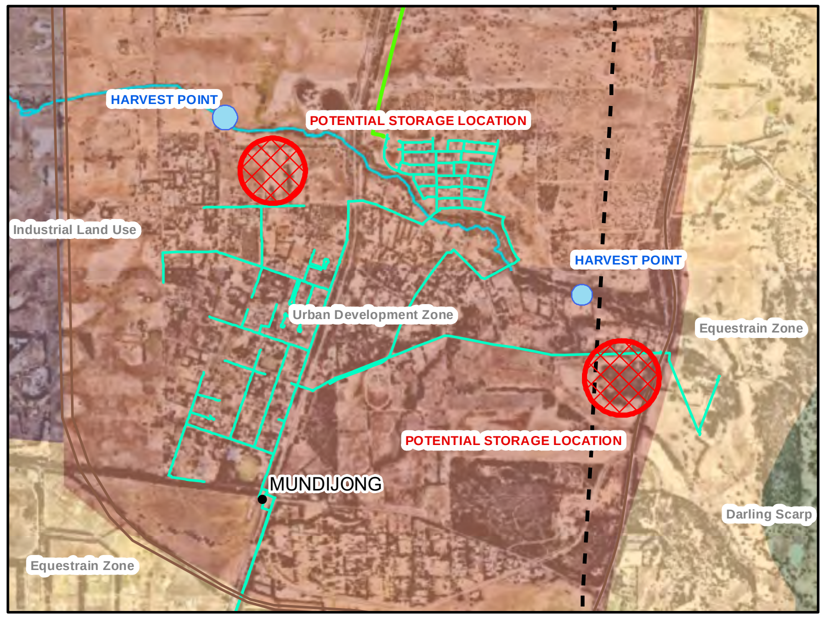
- Equestrain Zone
- Intensive Agriculture Zone
- Conservation Zone
- Darling Scarp
- Urban Development Zone
- Tourism Zone
- Rural/Agricultural Use
- Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

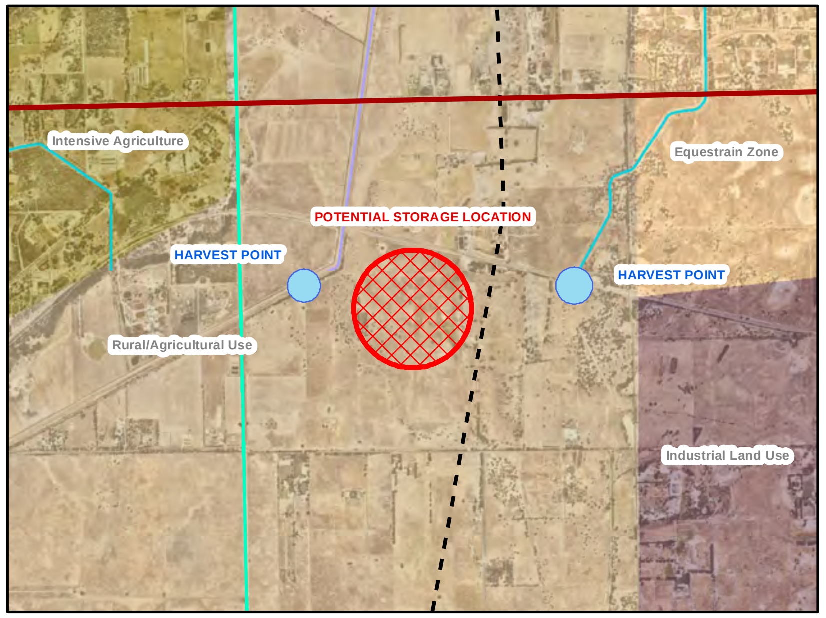
Figure 2

Summary of Long List of Opportunities – Byford-Oakford

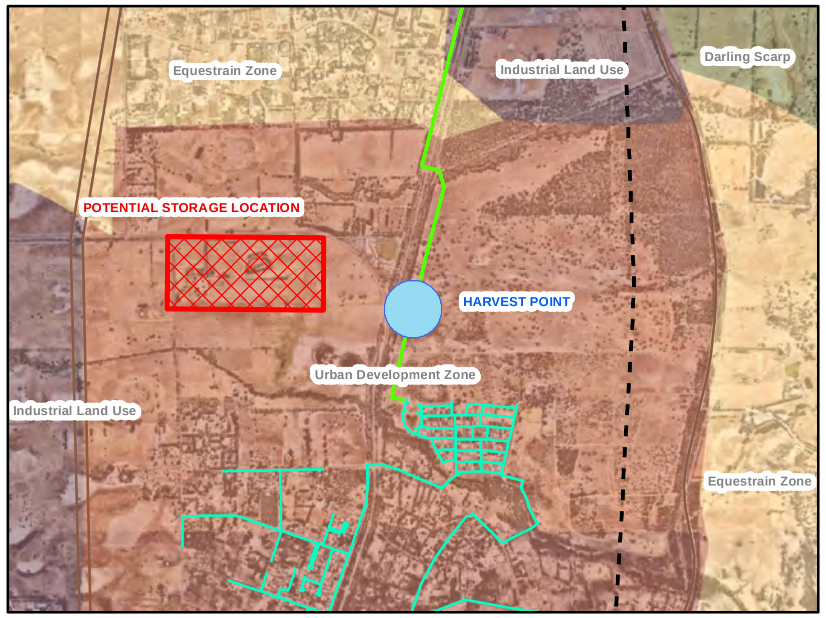
OPPORTUNITY 8



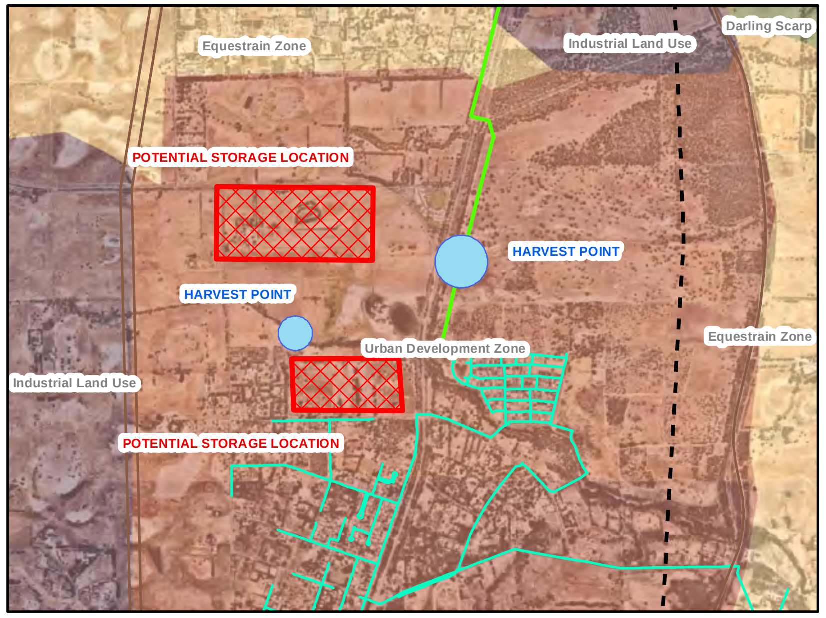
OPPORTUNITY 9



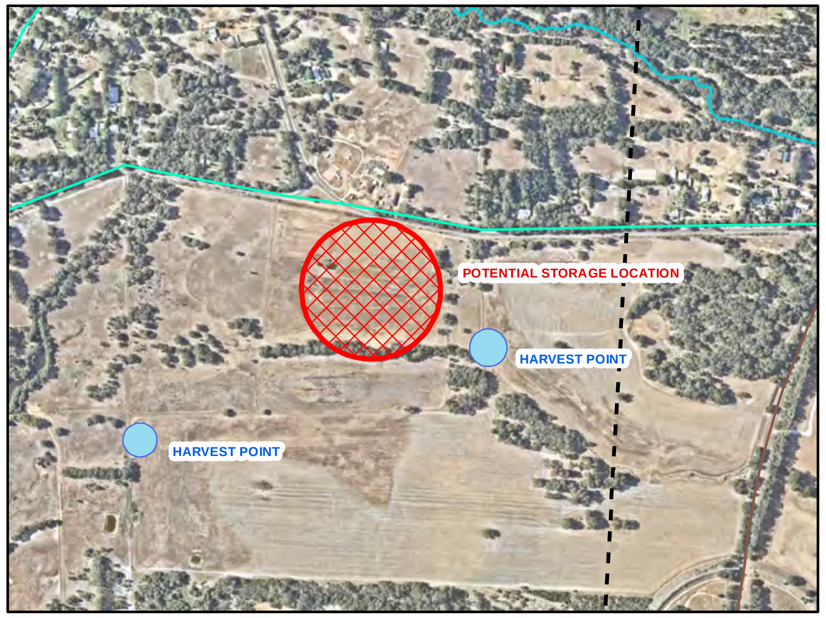
OPPORTUNITY 10



OPPORTUNITY 11

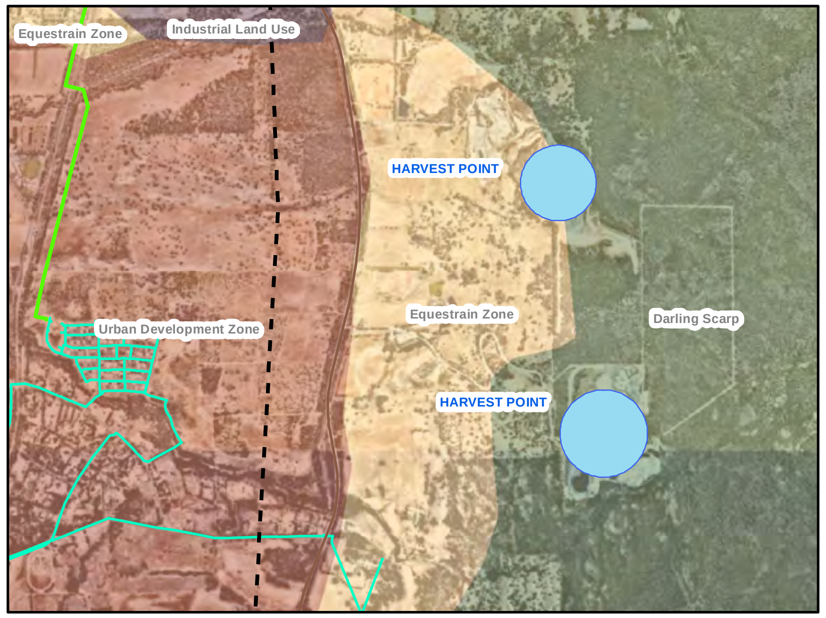


OPPORTUNITY 12

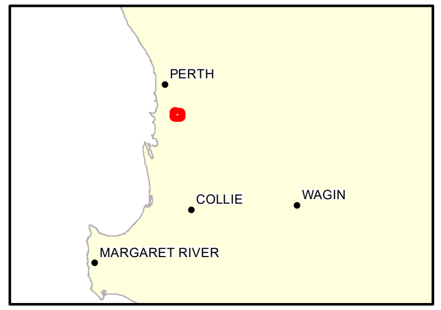


OPPORTUNITY 13

OPPORTUNITY 14



Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Oldbury - Mundijong	750/730	8	Harvest of surface water flows from Manjedal Brook during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	3,000-5,000
		9	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	5,000-10,000
		10	Sewer mining from Water Corporations sewer network or development of a decentralised wastewater treatment facility. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	1,000-2,000
		11	Integrated approach for Opportunities 8 and 9 to increase security of supply.	3,000-6,000
		12	Keirnan District Sporting Facility - harvesting of surface runoff. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	50-+50
		13	Whitby and Mundijong District Sporting Facility – Potential to harvest surface runoff from the sporting facility and surrounding school buildings. The facility is only in concept design therefore the integration of water sensitive urban design features is possible. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	20-+100
		14	Quarry Potential source of water from dewatering activities on site.	<20



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

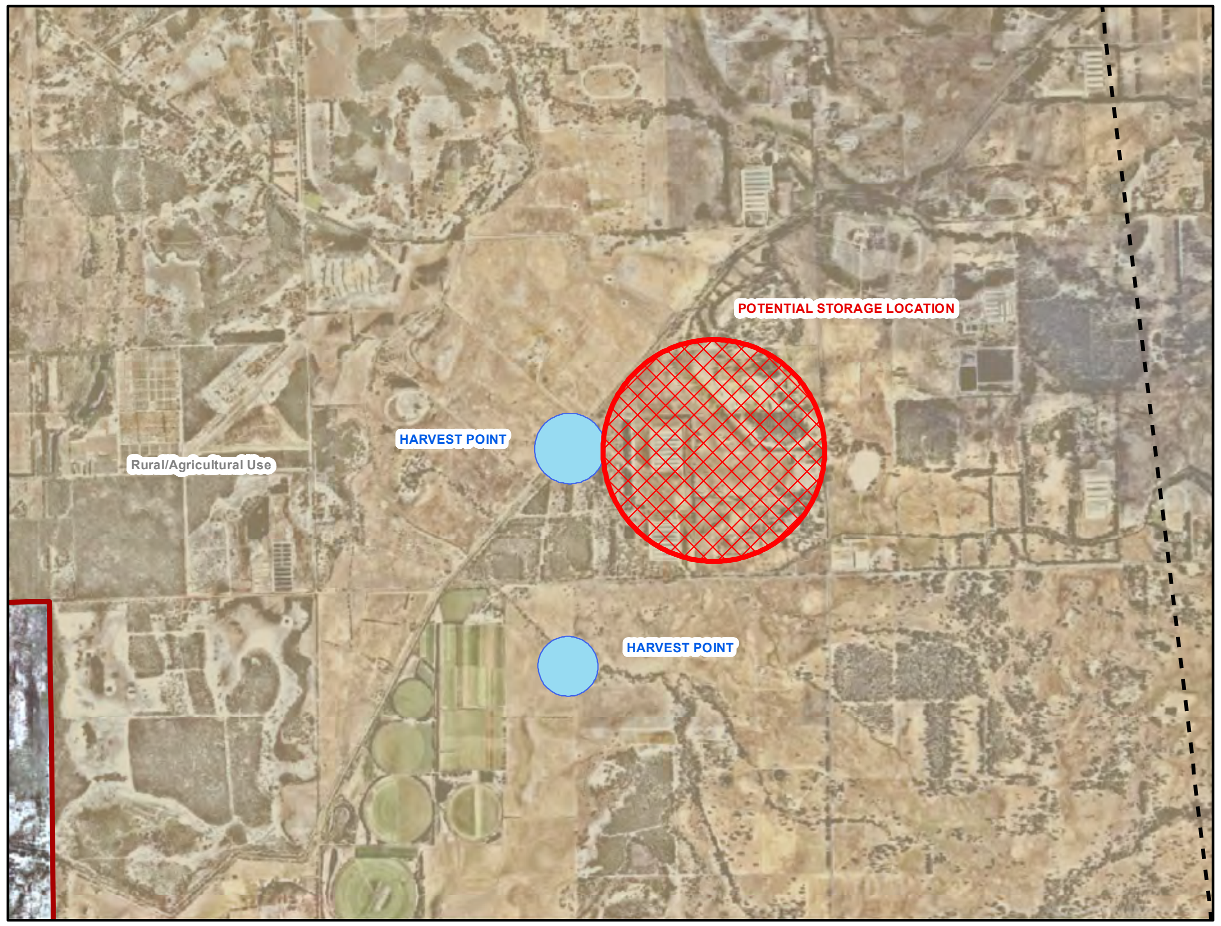
Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

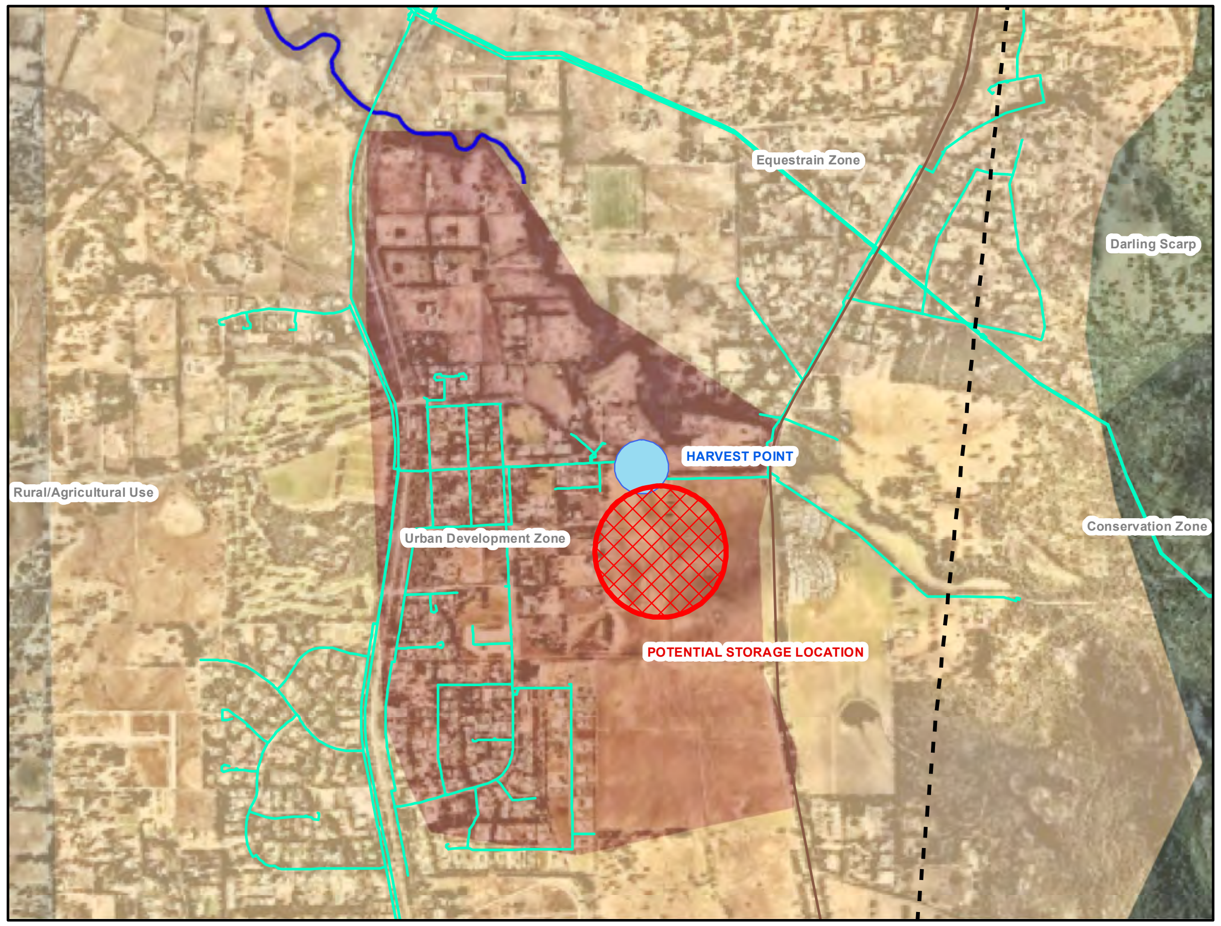
Figure 3

Summary of Long List of Opportunities – Oldbury-Mundijong

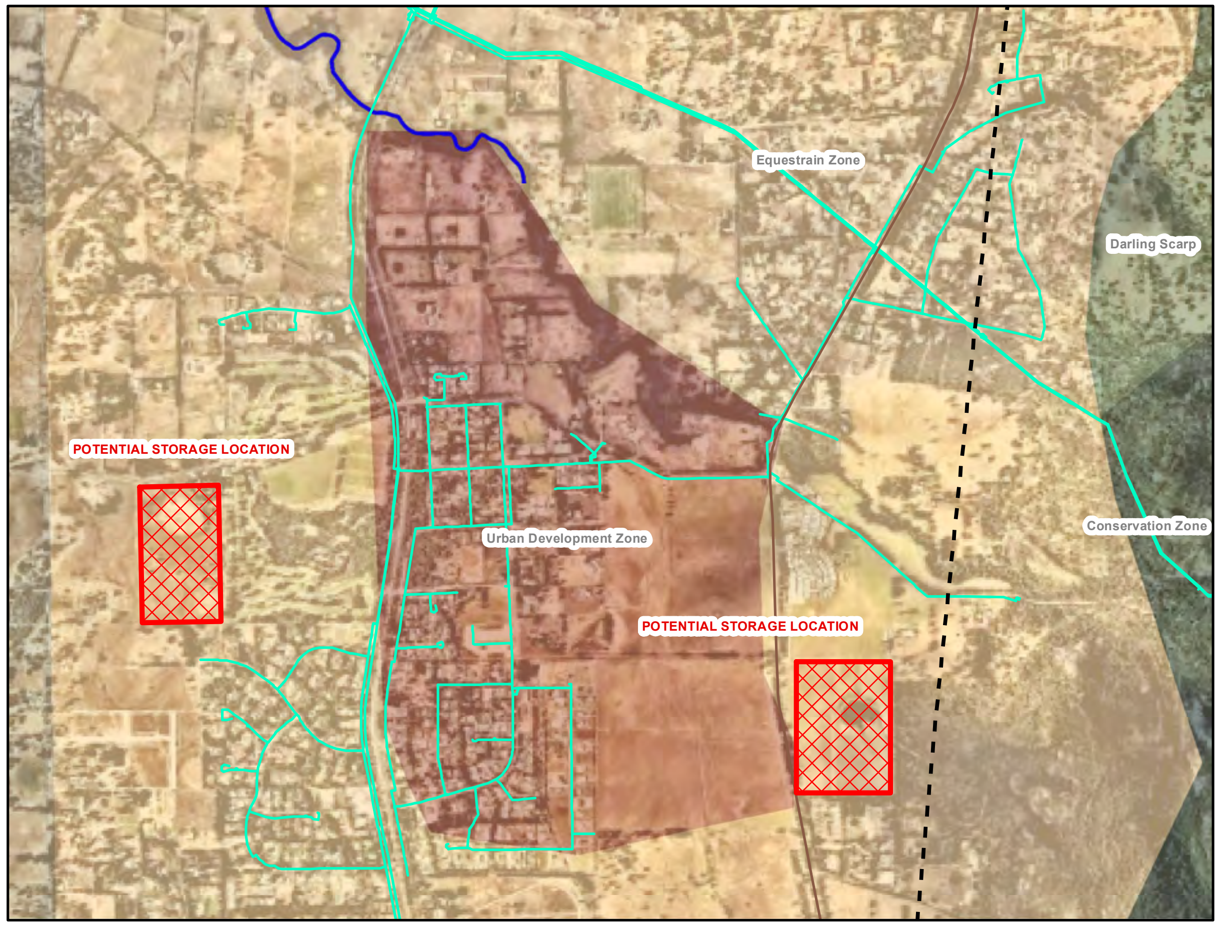
OPPORTUNITY 15



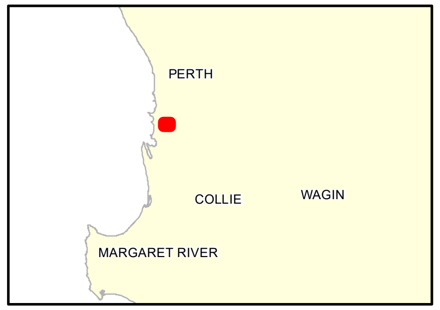
OPPORTUNITY 16



OPPORTUNITY 17



Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Hopeland – Serpentine - Keysbrook	340/183	15	Harvest of surface water flows from Punrack Drain during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	5,000-10,000
		16	Harvesting of urban runoff through subsurface drainage network and a series of drainage basins. Water to be harvested from the drainage basins and stored in above ground infrastructure or using MAR. Supply to be via a pipes distribution network or transfer of recharge credits.	<100
		17	Development of a decentralised wastewater treatment facility. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	100-300



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

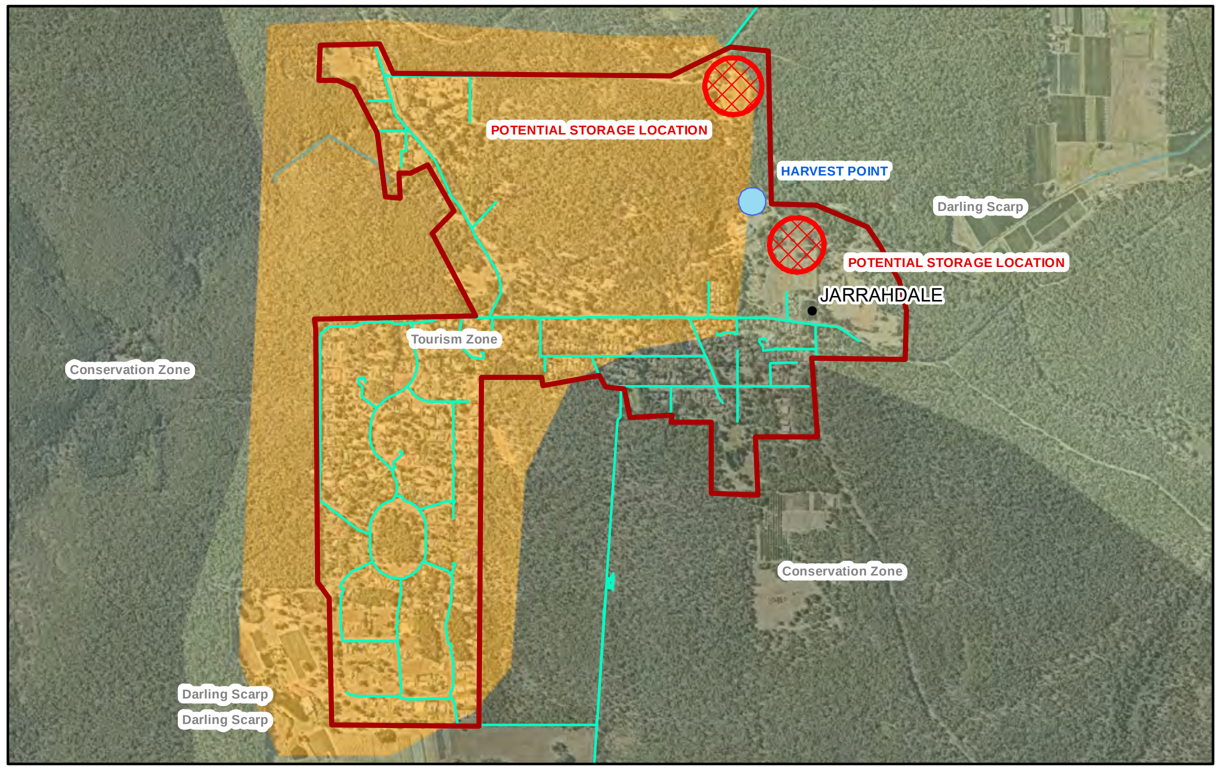
Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

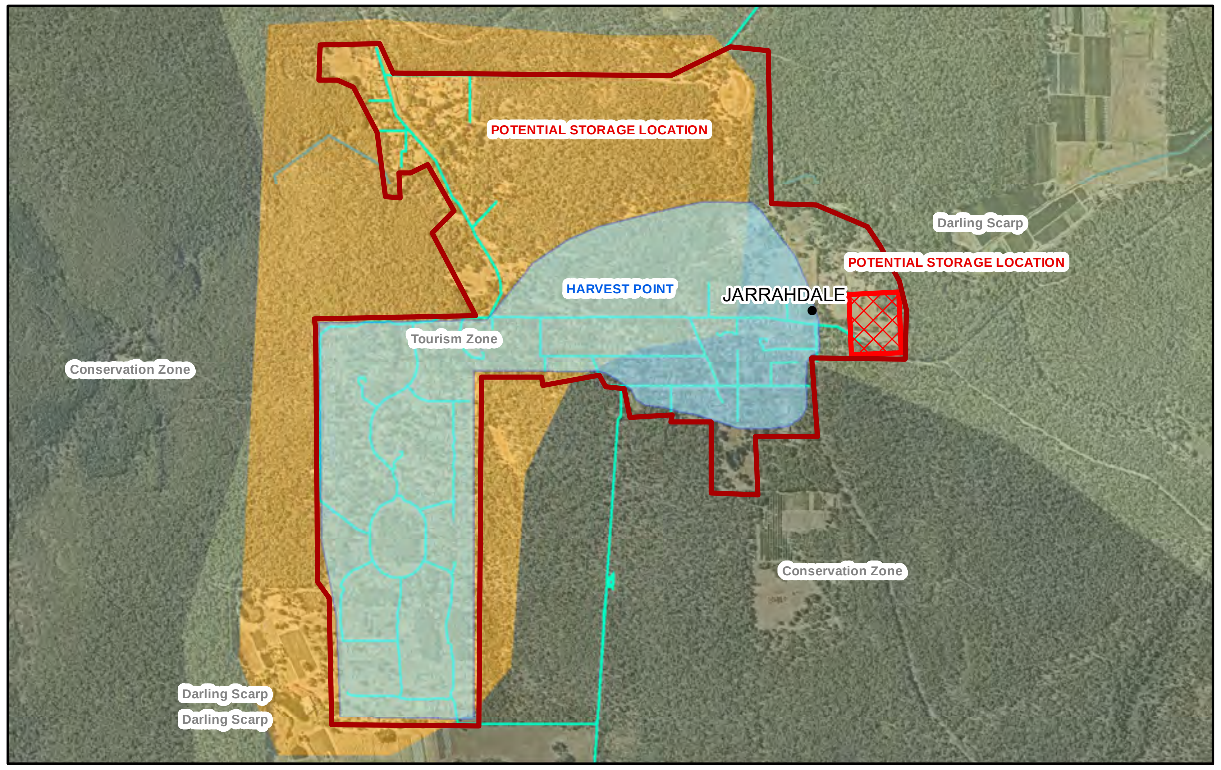
Figure 4

Summary of Long List of Opportunities – Hopeland – Serpentine – Keysbrook

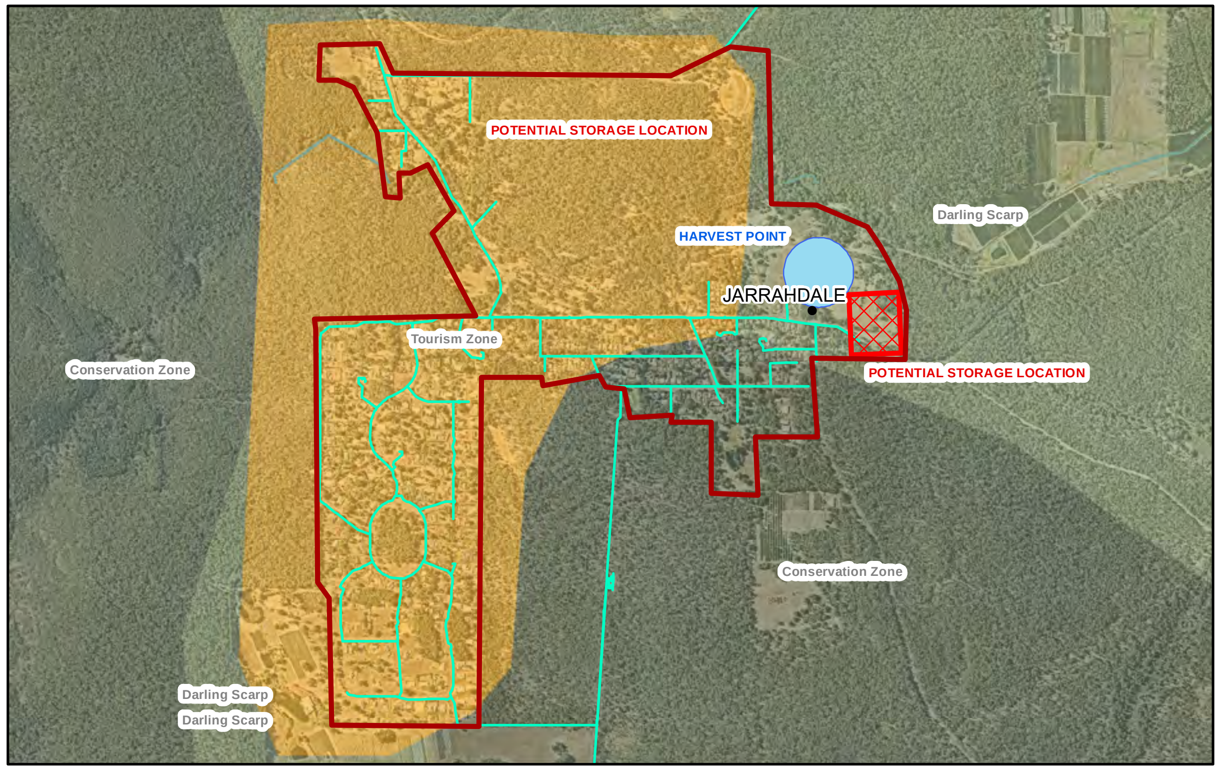
OPPORTUNITY 18



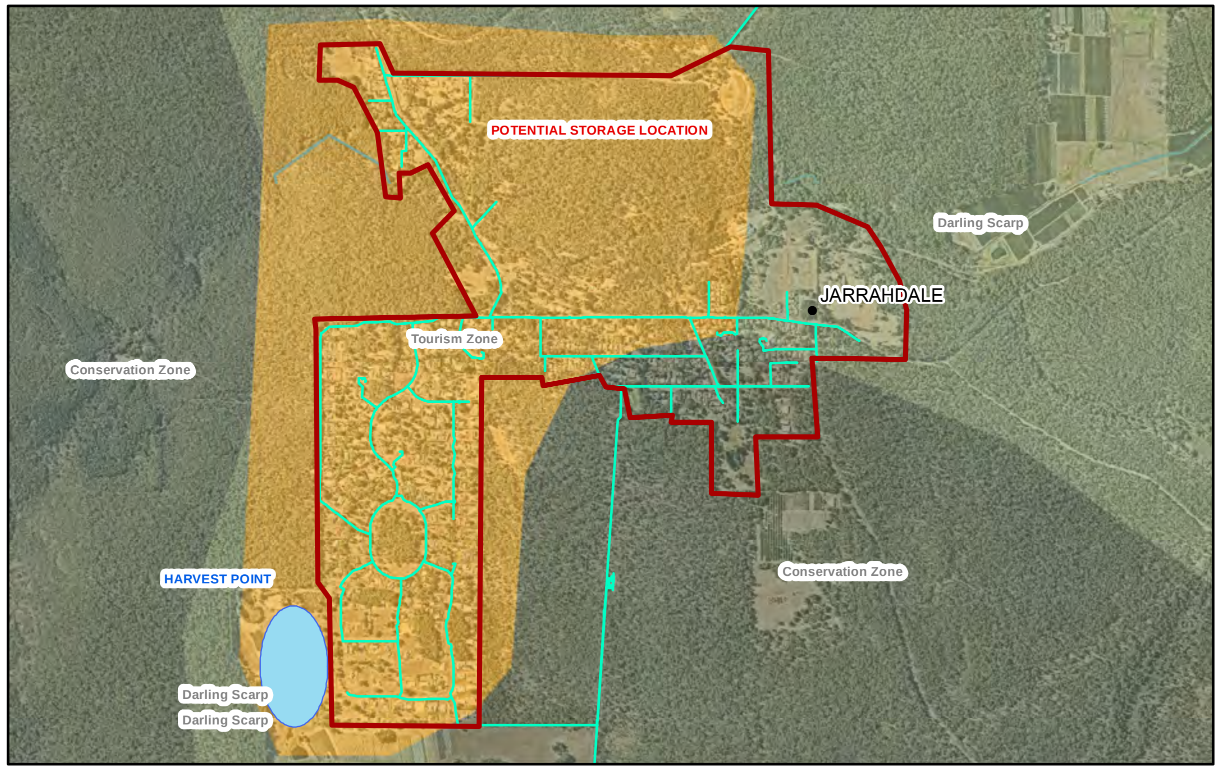
OPPORTUNITY 19



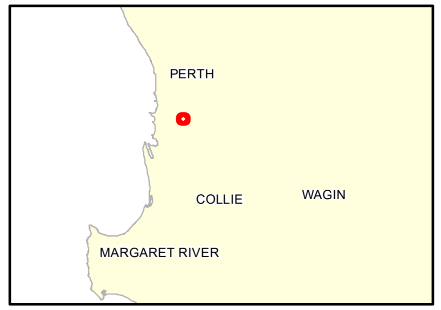
OPPORTUNITY 20



OPPORTUNITY 21



Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Jarrahdale	32/32	18	Harvest of surface water flows from Gooralong Brook during winter. Storage using above ground structures and distribution using a pipe network.	20-200
		19	Development of a decentralised wastewater treatment facility and retrofit the existing septic system. Storage using above ground structures and distribution using pipe network.	20-50
		20	Development of a decentralised wastewater treatment facility for the proposed Tourist Park. Storage using above ground structures and distribution using pipe network.	10
		21	Transfer of treated wastewater from Millbrook Winery via a piped network.	1



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

Figure 5

Summary of Long List of Opportunities – Jarrahdale

1.4 SUMMARY OF SHORT LIST OF OPTIONS

The preliminary long options were review by SSJ to determine which water supply options meet their requirements and should progress to the short list assessment stage. Table 3 presents the water supply concepts, which have progressed to the Short List stage, the numbering presented in Table 3 is consistent with the Preliminary Long Options Assessment, however, concepts will be renumbered in this assessment to avoidlater confusion with option numbers.

The concepts have been developed based on the assumption that the end use is restricted irrigation if unrestricted irrigation is required then additional treatment may be required in some circumstances.

During review discussions of the long options, an additional opportunity whereby water could be recharged to a decommissioned open pit sand mine was identified. This option has now been included in the short options assessment. A map identifying the locations of the short list options is provided in Appendix A.

Table 3: Short List of Water Supply Concepts

Area	#	Description	Potential Supply Volumes (ML/a) ±50%
Byford - Oakford	1	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter.	5,000-10,000
	3	Integrated approach for Opportunities 1 and 2 to increase security of supply.	6,000-12,000
	5	Woodland Grove Sporting Facility – harvesting of surface runoff, surface water from drainage line and urban runoff.	20-100
Oldbury - Mundijong	9	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter.	5,000-10,000
	10	Sewer mining from Water Corporations sewer network or development of a decentralised wastewater treatment facility.	1,000-2,000
	11	Integrated approach for Opportunities 8 (surface water harvesting from Manjedal Brook) and 10 to increase security of supply.	3,000-6,000
	13	Whitby and Mundijong District Sporting Facility – Potential to harvest surface runoff from the sporting facility and surrounding school buildings.	20-100
Hopeland Serpentine - Keysbrook	15	Harvest of surface water flows from Punrack Drain during winter.	5,000-10,000
	17	Development of a decentralised wastewater treatment facility.	100-300
	* Additional	Recharge of surface water flows into decommissioned open sand mines using a gallery infiltration approach.	Up to 50
Jarrahdale	18	Harvest of surface water flows from Gooralong Brook during winter.	20-200
	20	Development of a decentralised wastewater treatment facility for the proposed Tourist Park.	10

1.5 CONCEPT VIABILITY

SSJ are strategically considering their water supply options and security now and into the future. The primary aim is to identify a fit-for-purpose water supply for irrigation of public open space and reduce their current and future reliance on scheme water. It is currently unclear if Water Corporation's current infrastructure could manage such an increase in demand if a fit-for-purpose water supply is not developed.

For comparative purposes, the cost to supply fit-for-purpose water would traditionally be compared to the cost of scheme water. This is relevant if scheme water is available for this purpose, if Water Corporation's system cannot meet the demand then the cost comparison should be against the various alternative water supply options.

A significant risk to the viability of the identified concepts is the water quality treatment requirements associated with Managed Aquifer Recharge. The target aquifers are typically fresh (less than 500 mg/L), therefore, the source water may need to be treated to near potable standards prior to recharge as not to reduce the overall quality or beneficial end use of the aquifer system. Discussions have been held with DWER regarding the requirements and it has been indicated that the treatment requirement will be based on a risk management approach. As this study is high-level, the detailed assessments required to determine the risk and therefore the appropriate level of treatment have not been completed. The risk level will also likely vary in different locations.

For the purpose of this assessment, a high level of treatment, including membrane filtration, has been adopted in systems where a large volume is being recharged to the aquifer. The cost of such a system is significant and could be the difference between the concept being viable. For example, for Option 1, the cost per kL price is $2.15 to $2.60 (4-7% RDR) with the membrane but reduces to $1.50 to $1.85 (4-7% RDR) if a lower standard of treatment is acceptable.

The aquifer geometry in the region is such that recharge transfer credits may be available reducing the requirement to construct a distribution network. Recharge credits allow water to be recharged in one location and be withdrawn from the same aquifer in a different location(s). For the purpose of this study, where MAR has been adopted so has a distribution system until the viability of a credit transfer scheme can be confirmed.

Another opportunity for cost management is the use of existing infrastructure, the concepts do not consider using existing bores to recharge the target aquifer. If suitable bores are identified, then this presents a cost saving to the project.

Further investigations into the feasibility of MAR and risks is strongly recommended to further understand and develop these concepts prior to progressing to a concept design stage.

Funding to support the development of alternative water supplies may also be available from state and federal government bodies. If funding can be sought for all or a portion of the capital construction costs of a system, this could make a system financially viable for the scheme owner. For example, Option 1 (with membrane) cost per kL price is $2.15 to $2.60 (4-7% RDR), however, if 50% of the capital costs are funded through a government scheme then the cost per kL price reduces to $1.70 to $1.90 (4-7% RDR).

The larger water supply concepts, which supply gigalitres of water per annum, are scalable depending on the available capital, risk appetite and demand requirements. This will allow SSJ to manage their risk and build their knowledge of the system operation over time.

The impact of funding opportunities or treatment level requirements have not been considered in each scheme. The worst case or highest cost option has been adopted to inform SSJ, however, the scalability of each scheme (i.e. opportunities to stage the development), risks and opportunities should be considered for all concepts.

2 BYFORD - OAKFORD PRECINCT

2.1 WATER SUPPLY OPTION 1 – SURFACE WATER FLOWS FROM OAKLAND / BARRIGA MAIN DRAIN

2.1.1 Overview

This water supply concept considers harvesting surface water flows from the Oakland and / or Barriga Main Drain, following treatment the water will be transferred to either an above ground storage or underground using MAR for storage. The water will be subsequently recovered and transferred for irrigation of SSJ land or for agriculture / industry. Figure 6 presents the process flow diagram for Concept 1 whilst Figure 2 provides a spatial representation. Table 4 presents the water balance for the system and Table 5 presents the water supply concept components. This concept assumes a harvest volume of up to 5,000 ML/a to ultimately supply 4,000 ML/a following losses through the system.

Preliminary square modelling has been carried out by DoW (2012) which reported average annual flows of 33.8 GL/a in the Barriga Main Drain. There are no estimates of flows within the Oakland Drain. This flow is expected to increase due to an increase in runoff from the urban development. A target harvest volume of between 5 and 10 GL/a has been estimated based on the available information, however, this may be impacted by climate variability, monitoring of the flows and water quality. Further investigations are required to more accurately predict a reliable harvest volume.

Water quality variability (e.g. suspended solids or salinity) is currently unknown, water quality monitoring in the form of grab samples for a broad range of contaminants and inline monitoring of salinity, turbidity and pH is recommended to refine the treatment process required to achieve the reliable harvest volume. This concept considers a high level of treatment and hence cost allowance due to the data gaps and risk around source water quality and the receiving aquifer risk profile. Additional assessments will assist in determining the level of treatment required. The treatment level required for above ground storage is likely to be less than aquifer storage unless the necessary risks can be managed to ultimately recharge non-potable standard water.

The drains are managed by Water Corporation and approval to access the infrastructure would be required. The take of water from the drain is not currently prescribed.

The water supply concept has the opportunity to be implemented in a staged approach to meet demand requirements or budget expenditure. The timing of the development of the Byford area and the agri-precinct are unknown, therefore a staged approach assists the SSJ to manage their risk. The concept adopts an above ground balancing storage dam, this facility could be constructed in a way to provide public amenity and provide recreational facilities.

Table 4: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Oakland / Barriga Main Drain	5,000 ML/a total assumed to be 2,500 ML/a per drain	Flow monitoring data is not available from the Oakland and Barriga Main Drains, therefore harvest volumes have been based on 50% per drain. Based on rainfall and a 153 days of available harvest, an extraction rate of 285 L/s is required from each drain based on 16 hours of operation per day. Depending on the outcomes of the monitoring program this may be in the form of one or multiple pumping locations.
Balancing Storage / Capture Storage	100 ML	Capture storage provides flexibility in the operation of the system to manage injection and extraction rates, provide treatment or holding times. The flow in the drains may be such that a high extraction rate is required to capture the higher rainfall events, having a capture storage allows for continual injection (not just limited to rainfall periods) which may reduce the number of bores required. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Water Treatment and Aquifer Replenishment	Injection rate of 25 L/s / bore Number of bores 23 Treatment Rate 570 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores may be able to be reduced. The number of bores is based on the injection rate of 25 L/s, 16 hours a day over 153 days of operation and a target daily recharge rate of 33 ML/d.
Irrigation Supply	4,000 ML/a	Assuming losses through the system from evaporation, backwash, scour and for the environmental benefit, the losses are assumed to be 20%.

Table 5: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Surface water from Oakland and Barriga Main Drains. Pumps to harvest water from each location and transfer water to a centralised balancing storage.	No significant variation to the drain has been proposed other than the installation of the harvest offtakes. To manage the level in the drain multiple harvest locations have been proposed, based on a flow rate of 285 L/s total for each drain. Transfer infrastructure from each harvest location will be required to transfer water to the capture storage. A nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted	A 100 ML storage has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated in to the cost analysis component. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water). Transfer infrastructure from the capture storage to the treatment facility and to the 23 production bores has been assumed to be 5 km of pipe. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter, membrane filter, UV treatment and chlorination system. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration may not be required.
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however this approach may vary depending on future rainfall patterns.	Based on a volume of 5,000 ML/a, an injection rate of 25 L/s, 153 recharge days and 16 hours a day operation. 23 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on yield,	Installation of 23 production bores assuming not suitable bores exist. Installation of five monitoring bores. Headworks infrastructure, pump infrastructure and monitoring infrastructure. SCADA system allowance and inline water quality and pressure monitoring.

Parameter	Discussion	Allowance
	location, risks and surrounding users. The depth to aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallower systems are likely to be required. Five monitoring bores have been adopted.	Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site - specific irrigation infrastructure has not been considered. If transfer infrastructure is required a transfer pump and 10 km of pipe to the agricultural precinct and 10 km to the central Byford area would be required. Ultimately, the use of transfer credits in the aquifer so users can extract water from an onsite bore is the priority approach. This assumes that the groundwater at the end user location can be taken (i.e. is of suitable quality, there is no risk to the environment or human health).	Final design would need to consider onsite irrigation infrastructure. Assumes 20 km of transfer pipework. If credit transfers are viable, the cost for the installation of additional bores has not been incorporated.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

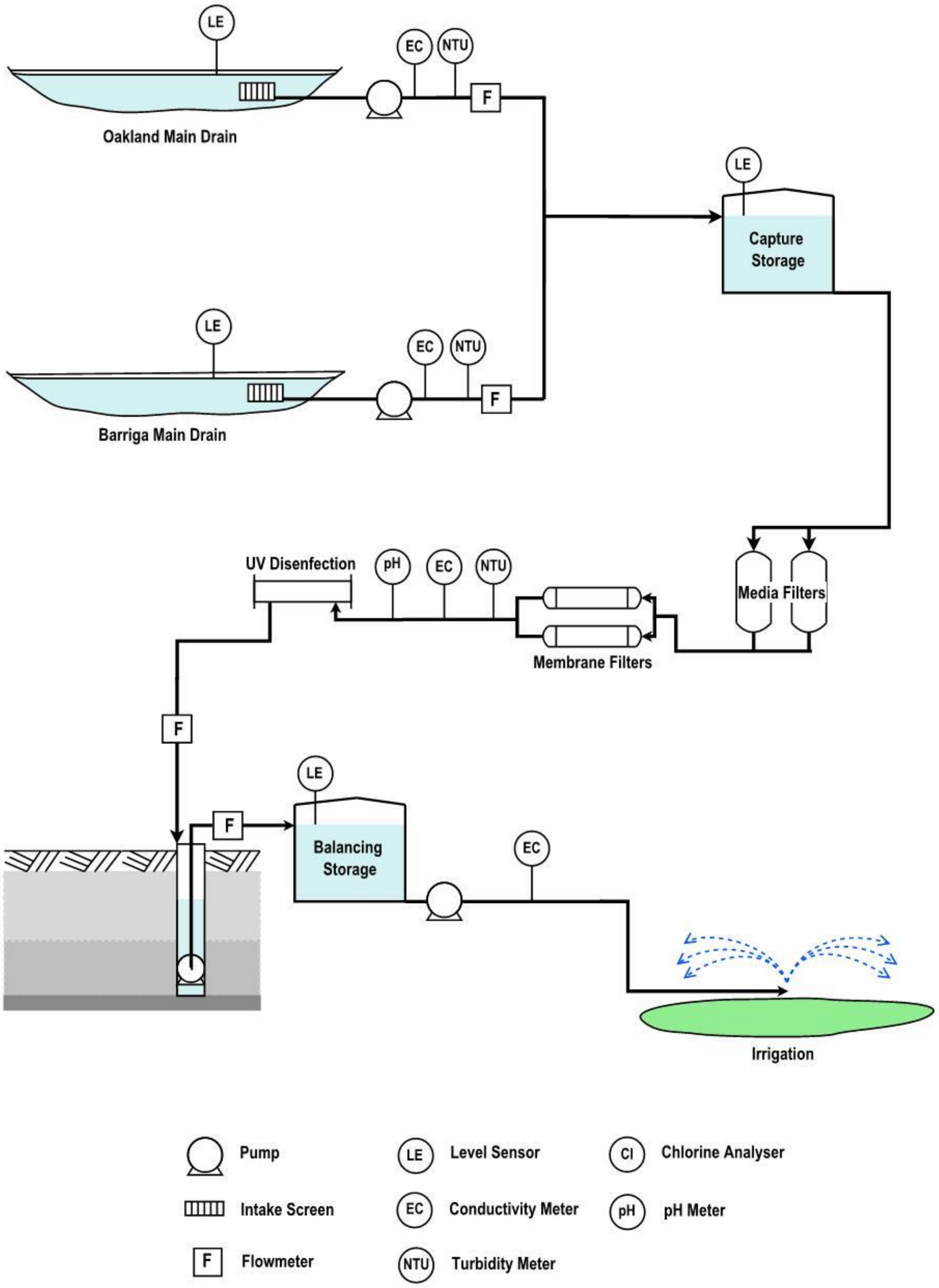


Figure 6: Operational Process Chart – Option 1

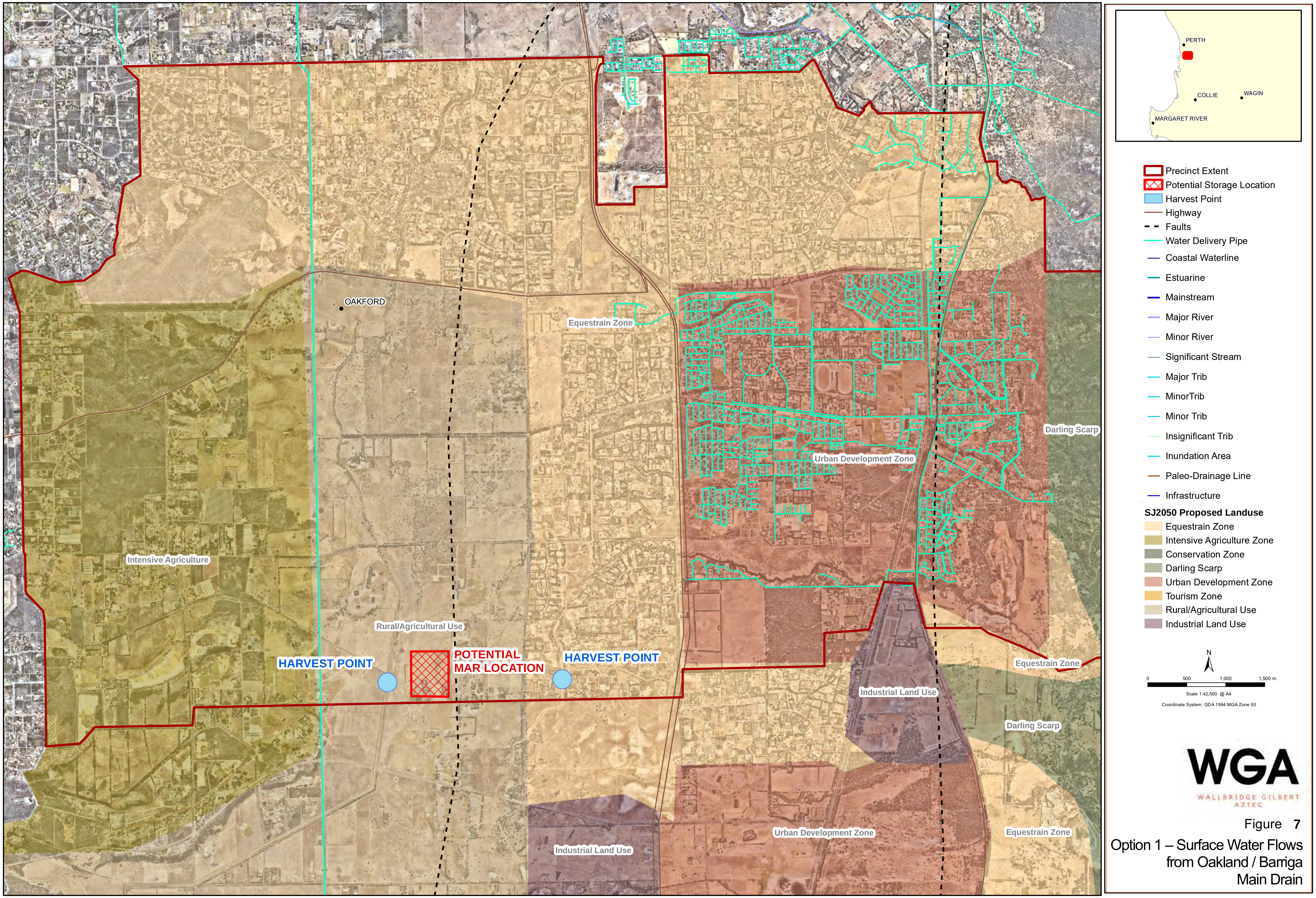


Figure 7
Option 1 – Surface Water Flows from Oakland / Barriga Main Drain

2.1.2 Above Ground Storage Opportunity

MAR is commonly adopted to reduce the requirement for above ground storage which is typically costly, or land acquisition is complicated. The land use in the proposed area is rural agriculture and land may be available for acquisition. In addition, the SSJ has expressed an interest in a water recreation facility. If the above ground storage option is adopted then this could be integrated with recreational facilities, the type of facilities, land acquisition costs and the associated cost have not been incorporated into this opportunity.

All remaining components, with the exception of the aquifer replenishment, outlined in 2.2.1 are identical. In place of the MAR storage component, a 5 GL above ground storage has been adopted. If recreation is a key driver then additional harvest volume or a reduced supply volume would be required to maintain an acceptable water level in the facility to enable use for recreation. Based on a 6 m deep facility, an area of approximately 83 Ha would be required. An example of this area is presented on Figure 8. There is also the opportunity to have a combination of both MAR and above ground storage of various magnitudes, this has not been explored here due to the number of iterations.

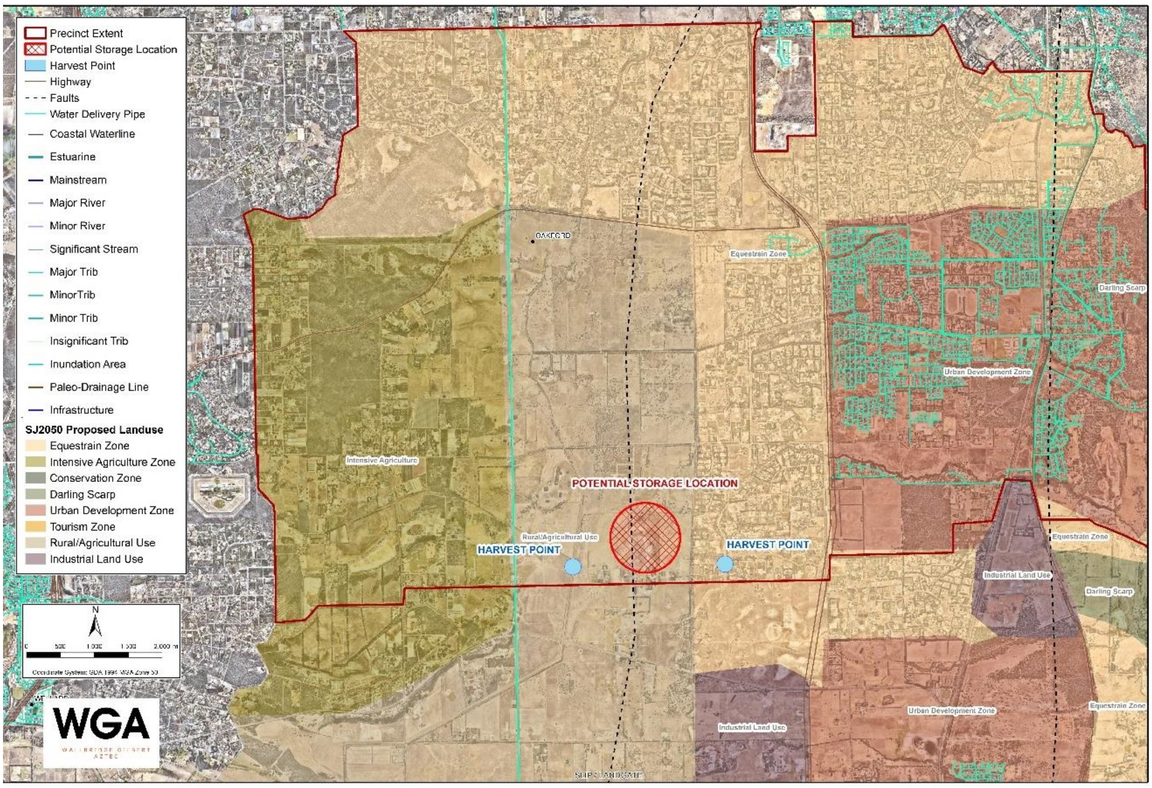


Figure 8: Option 1- Surface Water Flows from Oakland / Barriga Main Drain with Above Ground Storage

2.1.3 Cost Estimate

Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 6 with a summary breakdown and assumptions are presented in Appendix B.

Table 6: Summary of Cost Estimate – Option 1

CAPEX	$74,598,000
OPEX (annual)	$3,112,500
NPV (4-7% Real Discount Rate)	$2.15-2.60 / kL

The treatment level adopted in this scenario is near potable standards and includes membrane filtration, this is due to the water being recharged to an aquifer that is fresh. If the risk profile and DWER agree, the water quality standards could be reduced. If membrane treatment is not required, the NPV is $1.50 / kL (4% RDR) to $1.85 / kL (7% RDR).

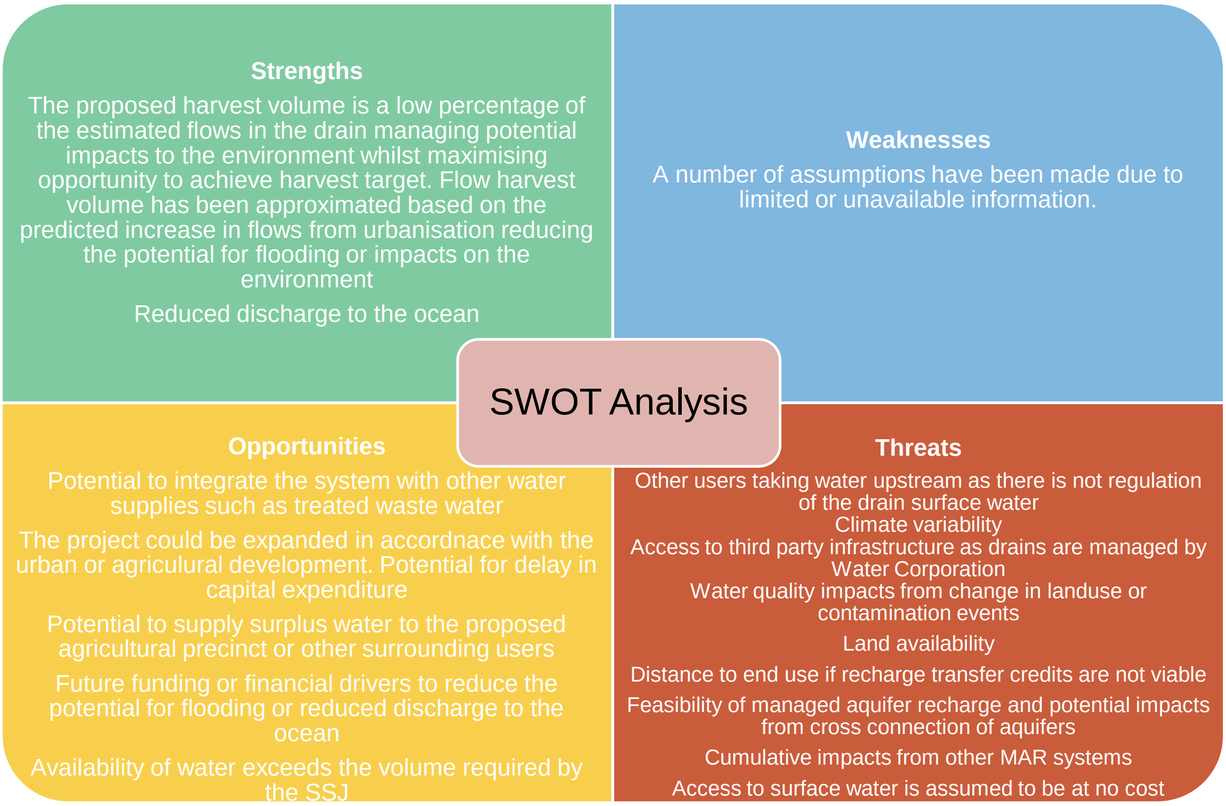
Table 7 presents the scheme costs where above ground storage is adopted instead of MAR. The costs do not include land acquisition costs, or any recreational facilities associated with the area.

Table 7: Summary of Cost Estimate – Option 1 with Above Ground Storage

CAPEX	$133,664,020
OPEX (annual)	$2,052,500
NPV (4-7% Real Discount Rate)	$2.10 – 2.95 k/L

2.1.4 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the agricultural precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



2.1.5 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 8 provides a recommended forward program of works for this conceptual design.

Table 8: Forward Program of Works – Option 1

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of both the Oakland and Barriga Drains. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Survey of both drains to identify ideal harvest locations and system location.
	The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Seek confirmation from Water Corporation regarding access entitlements.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study. Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Demand Forecast	The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participant in industry forums or engage with industry to understand the demand and willingness / capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

2.2 WATER SUPPLY OPTION 2 – INTEGRATION OF SURFACE WATER FLOWS FROM OAKLAND / BARRIGA MAIN DRAIN AND SEWER MINING

2.2.1 Overview

This water supply concept considers harvesting surface water flows from Oakland and / or Barriga Main Drain as described in Concept 1 and integrating the system with treated wastewater from the Water Corporation's pressure sewer main. This section described the components of the sewer mining only, a description of the process of the surface water harvesting is presented in Section 2.1.

Sewage from the existing Water Corporation pressure main would be harvested to a dedicated treatment facility. Once treated, the wastewater will be transferred to the lined above ground balancing storage and mixed with harvested surface water. The water will then be further treated and recharged into the underlying aquifer for storage using MAR and subsequently recovered and transferred for irrigation of SSJ land or for agriculture / industry. Figure 9 presents the process flow diagram for Concept 2 whilst Figure 10 provides a spatial representation.

Table 9 presents the water balance for the system and Table 10 presents the water supply concept components. This concept assumes a harvest volume of 6,000 ML to ultimately supply 4,800 ML following losses through the system, the wastewater component of this system aims to deliver an addition 800 ML of water for supply.

The availability of sewage from the system is unknown as this will be governed by Water Corporation and will likely be based on the flows at the time, this aspect requires clarification from Water Corporation. For the purpose of this concept, it has been assumed that take is evenly distributed over the year. The opportunity to only take water during peak demand months should be investigated with Water Corporation. The availability will be based on the urban development rate, the volume has been based on 50% of the predicted population growth for the Byford Region. There may be a supply cost of wastewater from Water Corporation, as this cost is not available a supply rate has not been adopted and would be in addition to the cost presented here.

Similar to Option 1, the wastewater component can be staged to ensure timing is appropriate to meet demand and supply and an above ground storage option could be adopted.

Depending on the treatment level at the offtake location, there is the opportunity to supply directly to irrigation sites.

Table 9: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Oakland / Barriga Main Drain	5,000 ML/a total assumed to be 2,500 ML/a per drain	Flow monitoring data is not available from the Oakland and Barriga Main Drains, therefore harvest volumes have been based harvesting equally from both drains. Based on rainfall and a 150 days of available harvest, an extraction rate of 285 L/s is required from each drain based on 16 hours of operation per day. Depending on the outcomes of the monitoring program this may be in the form of one or multiple pumping locations.
Wastewater	1,000 ML/a, assumed to be equal over 365 days a year, however, this may vary.	The availability and timing of water will need to be determined in conjunction with Water Corporation, for the purpose of this assessment a flow rate of 48 L/s assuming a 16 hour a day operational period has been adopted.
Capture / Balancing Storage	100 ML	Balancing storage provides flexibility in the operation of the system to manage injection and extraction rates, provide treatment or holding times. The flow in the drains may be such that a high extraction rate is required to capture the higher rainfall events, having a balancing storage allows for continual injection (not just limited to rainfall periods) which reduces the number of bores required. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Water Treatment and Aquifer Replenishment	Injection rate of 25 L/s/ bore Number of bores 25 Treatment Rate 620 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 L/s and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores can be reduced. The number of bores is based on the injection rate of 25 L/s, 16 hours a day over 150 days of operation and a target daily recharge rate of 35 ML/d. Depending on the demand and supply profile, due to the supply of wastewater being all year round additional injection or treatment capacity may not be required. As these components are not know at this stage an increased injection capacity has been conservatively adopted.
Irrigation Supply	4,800 ML/a	Assuming losses through the system from evaporation, backwash, scour and for environmental benefit the losses are assumed to be 20%.

Table 10: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Surface water from Oakland and Barriga Main Drains is pumped to a centralised balancing storage.	No significant variation to the drain has been proposed other than the installation of the harvest offtakes. To manage the level in the drain multiple harvest locations have been proposed, based on a flow rate of 285 L/s at each drain. Transfer infrastructure from each harvest location will be required to transfer water to the balancing storage. A nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Sewer Mining – Pump Station, Treatment and Transfer Line	Harvest from the Water Corporation pressure main, transfer to a treatment facility and then transferred to the balancing storage.	Pump station with the capacity to harvest 48 L/s. Allowance has been made for primary and secondary treatment. Valves, gauges and non-return valves included. 5 km of transfer pipework has been adopted.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted	A 100 ML dam has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated in to the cost analysis component. Transfer infrastructure from the balancing storage to the treatment facility and to the 25 production wells has been assumed to be 5 km of pipe. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter, membrane filter, UV treatment and chlorination system. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration and UV treatment may not be required for restricted irrigation.
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however, this	Based on a volume of 6,000 ML/a, an injection rate of 25 L/s, 153 recharge days and 16 hours a day operation. 25 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on yield, location, risks and surrounding users. The depth to	Installation of 25 production bores assuming no suitable bores exist. Installation of five monitoring bores. Headworks infrastructure, pump infrastructure and monitoring infrastructure.

Parameter	Discussion	Allowance
approach may vary depending on future rainfall patterns.	aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallow systems are likely to be required. Five monitoring bores have been adopted.	SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site - specific irrigation infrastructure has not been considered. If transfer infrastructure is required a transfer pump and 10 km of pipe to the agricultural precinct and 10 km to the central Byford area would be required. Ultimately, the use of transfer credits in the aquifer so users can extract water from an onsite bore is the preferred approach. This assumes that the groundwater at the end user location can be taken (i.e. is of suitable quality, there is no risk to the environment or human health).	Final design would need to consider onsite irrigation infrastructure. Assumes 20 km of transfer pipework. If credit transfers are viable, the cost for the installation of additional bores has not been incorporated, however, the 20 km of pipework could be removed.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

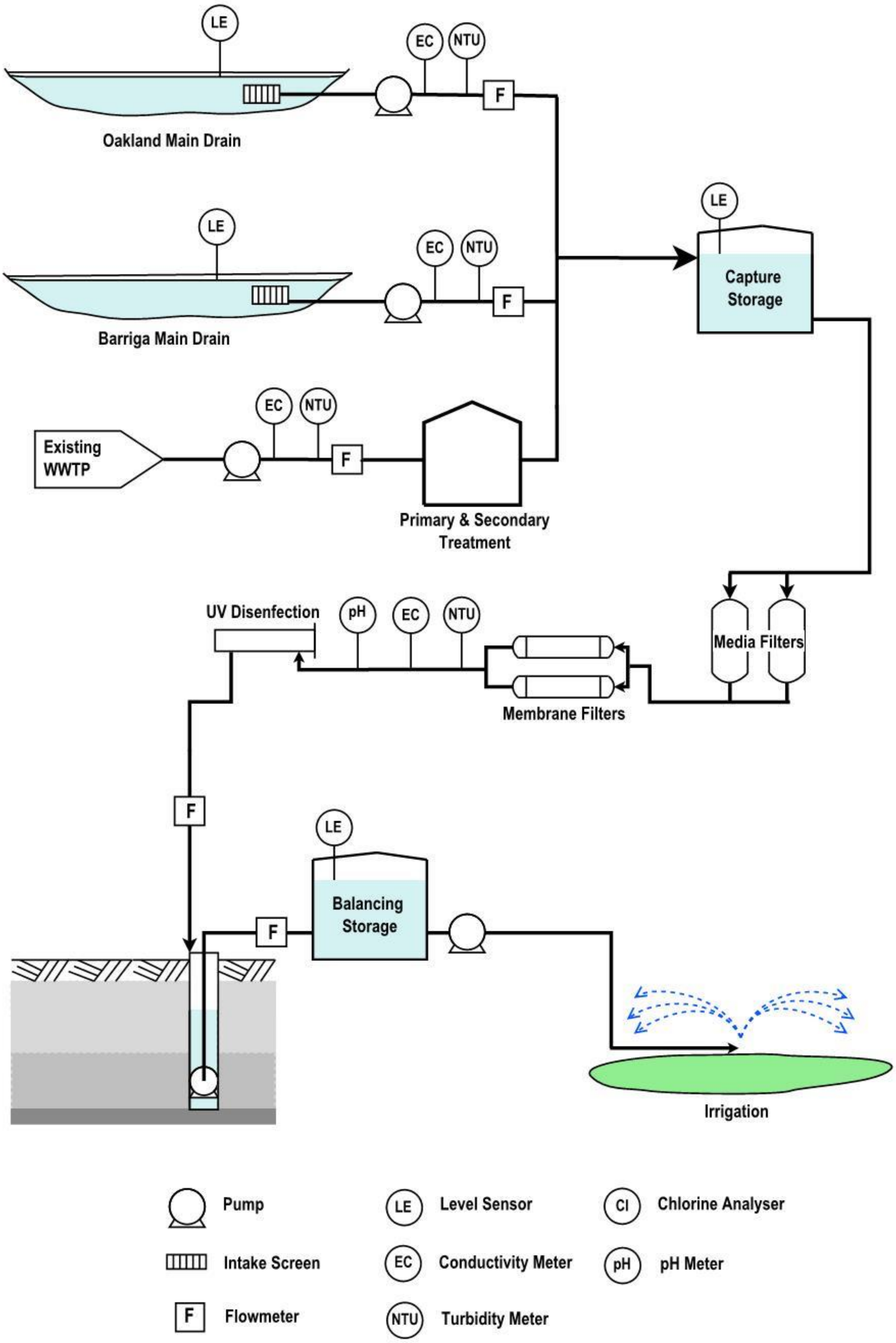
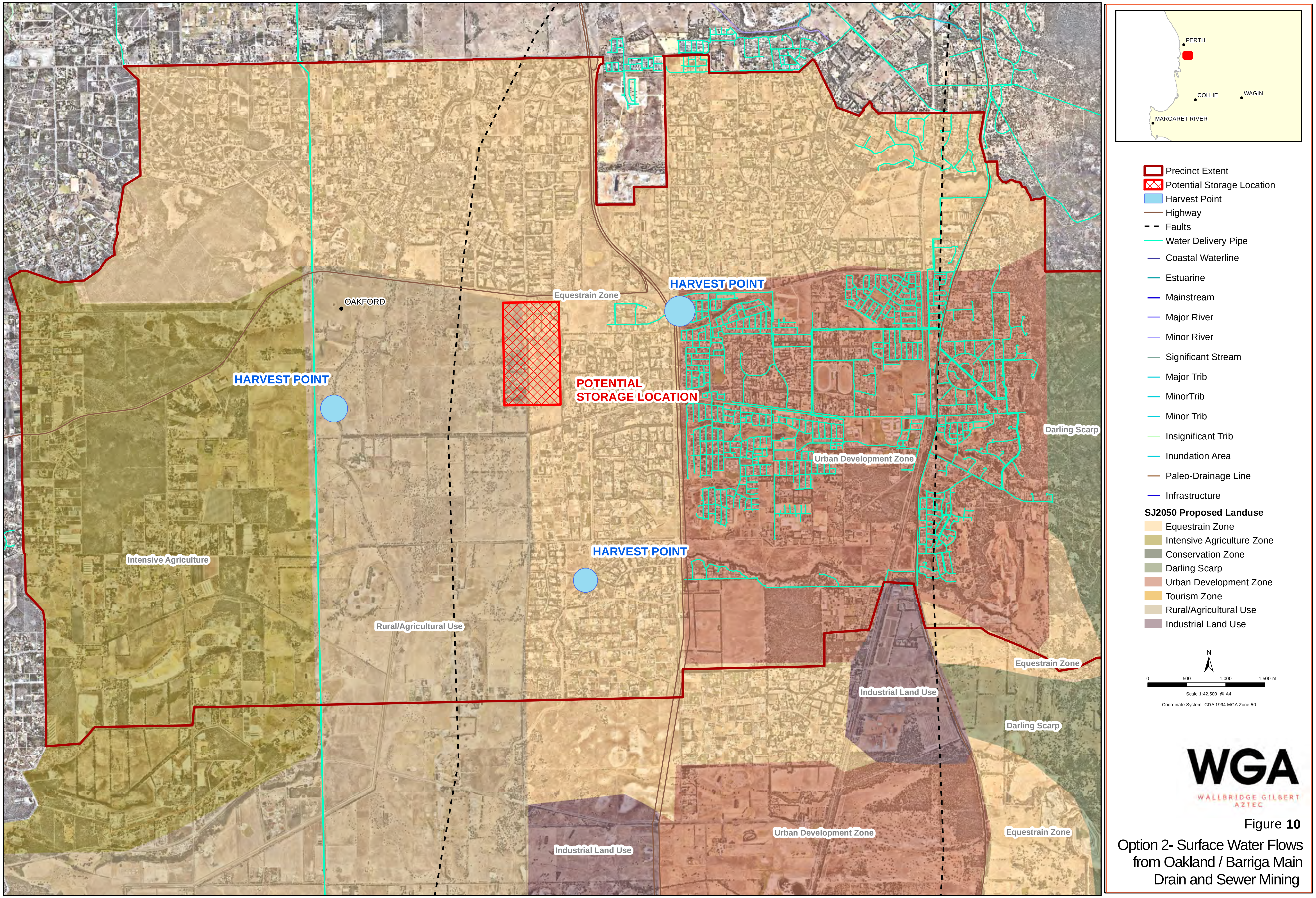


Figure 9: Operational Process Chart – Option 2



WGA
WALLBRIDGE GILBERT AZTEC

Figure 10
Option 2- Surface Water Flows from Oakland / Barriga Main Drain and Sewer Mining

2.2.2 Cost Estimate

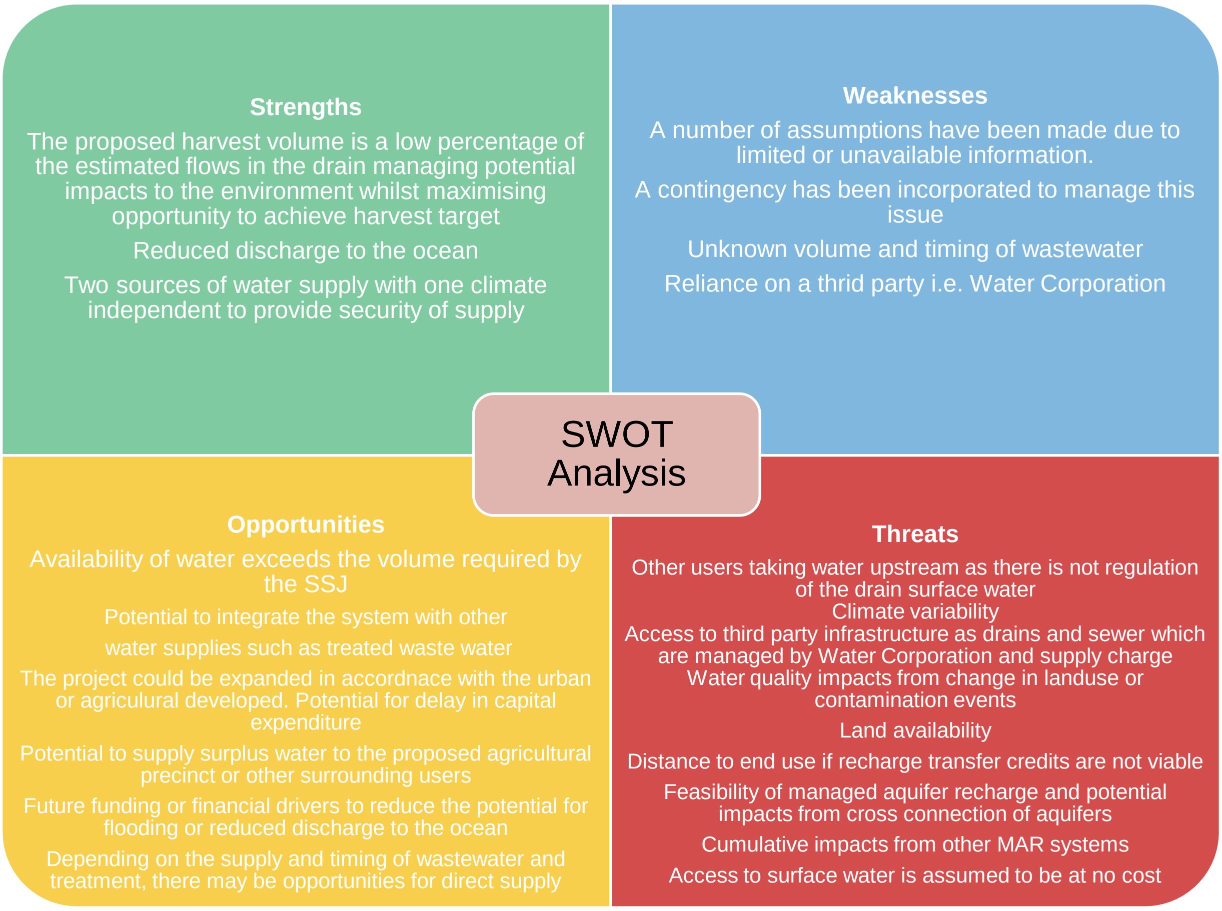
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 11 with a summary of breakdown and assumptions area presented in Appendix B.

Table 11: Summary of Cost Estimate – Option 2

CAPEX	$99,427,000
OPEX	$3,390,500
NPV (4-7% Real Discount Rate)	$2.20- $2.65/ kL

2.2.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the agricultural precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



2.2.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information will be required to address these components. Table 12 provides a recommended forward program of works for this conceptual design.

Table 12: Forward Program of Works – Option 2

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of both the Oakland and Barriga Drains. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Survey of both drains to identify ideal harvest locations and system location.
	The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Seek confirmation from Water Corporation regarding access entitlements.
Wastewater	Access to Water Corporation owned and managed infrastructure and the volume and timing of supply will need to be agreed. This can be a risk or may provide an opportunity to partner.	Seek confirmation from Water Corporation regarding access entitlements and rates and timing of take.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Demand Forecast	The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participant in industry forums or engage with industry to understand the demand and willingness/ capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

2.3 WATER SUPPLY OPTION 3 – WOODLAND GROVE SPORTING FACILITY

2.3.1 Overview

Woodland Grove is a proposed sports recreational site, which includes three drainage basins and a winter creek line, which limits the design possibilities of the sporting fields. The area can accommodate two senior sized ovals and other functions such as a BMX track or skate park. There is little information pertaining to the potential harvest volumes for the sites, surface drainage from the surrounding development will be directed into the proposed onsite drainage basins, however, the catchment is currently unknown. Flow monitoring or catchment modelling has not been carried out for the creek line. Based on these data gaps, the supply volume estimates are likely to be in the order of 20 to >100 ML/a. Additional investigations are recommended to confirm the reliable harvest volume prior to the detailed design of the system.

This concept considers harvesting water from the three drainage basins and the creek via a diversion line into one of the basins. The harvested water will then be treated through passive and / or mechanical means prior to being stored for irrigation in peak demand periods. The storage mechanism should be determined by the estimated harvest volume. Smaller harvest volumes could be stored above ground while larger volumes can be recharged into an underlying aquifer. For the purpose of this conceptual design, a supply volume of 40 ML/a has been adopted and above ground storage included as MAR is likely to be a more expensive option unless existing infrastructure is present at the site and can be utilised. Irrigation infrastructure has not been incorporated.

There is the opportunity to utilise this site as a trial and educational site prior to entering into a larger scale water supply system, differing technology such as biofilters, wetlands and the adoption of MAR can be tested to inform other options. One of the drainage basins could be constructed as a wetland feature to provide not just treatment but amenity and liveability benefits for the local community.

Figure 11 presents the process flow diagram for Concept 3 whilst Figure 12 provides a spatial representation. Table 13 presents the water balance for the system and Table 14 presents the water supply concept components. This concept assumes a harvest volume of 40 ML to ultimately supply 32 ML following losses through the system.

Table 13: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from drainage basin/wetland and creek line	40 ML/a	Flow monitoring or catchment modelling data is not available for the creek line or drainage discharge basins. Based on the harvest of 40 ML over 75 days and 16 hours a day operation, a harvest rate of 10 L/s is proposed.
Above ground storage – wetland and drainage basin	Two drainage basins including existing. 0.5 Ha wetland system A 200 kL balancing tank.	There is an existing drainage basin located in the north-western corner of the site. The size is approximately 180 m^2. An additional 30 ML basin is proposed along with a 0.5 Ha wetland system. A post treatment balancing tank of 200 kL will also be included.
Water Treatment	Treatment Rate 10 L/s	Treatment rate will vary depending on the end use supply demand during peak periods
Irrigation Supply	32 ML/a	Assuming losses through the system from evaporation the losses are assumed to be 20%.

Table 14: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Water from the existing drainage basin and proposed drainage basin will be directed to the wetland. An offtake off of the creek line will divert water into the wetland.	One additional 30 ML basin and 0.5 Ha wetland. A pump to transfer water from the creek line at 10 L/s. Transfer infrastructure from each harvest location will be required to transfer water to the wetland. A nominal 500 m of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Wetland and Transfer Lines	A 0.5 Ha wetland will be contrasted to provide treatment and balancing storage.	Transfer infrastructure from the balancing storage to the treatment facility has been assumed to be 200 m of pipe.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter and UV treatment system. Valves, gauges and non-return valves included. A balancing storage tank of 200 kL has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

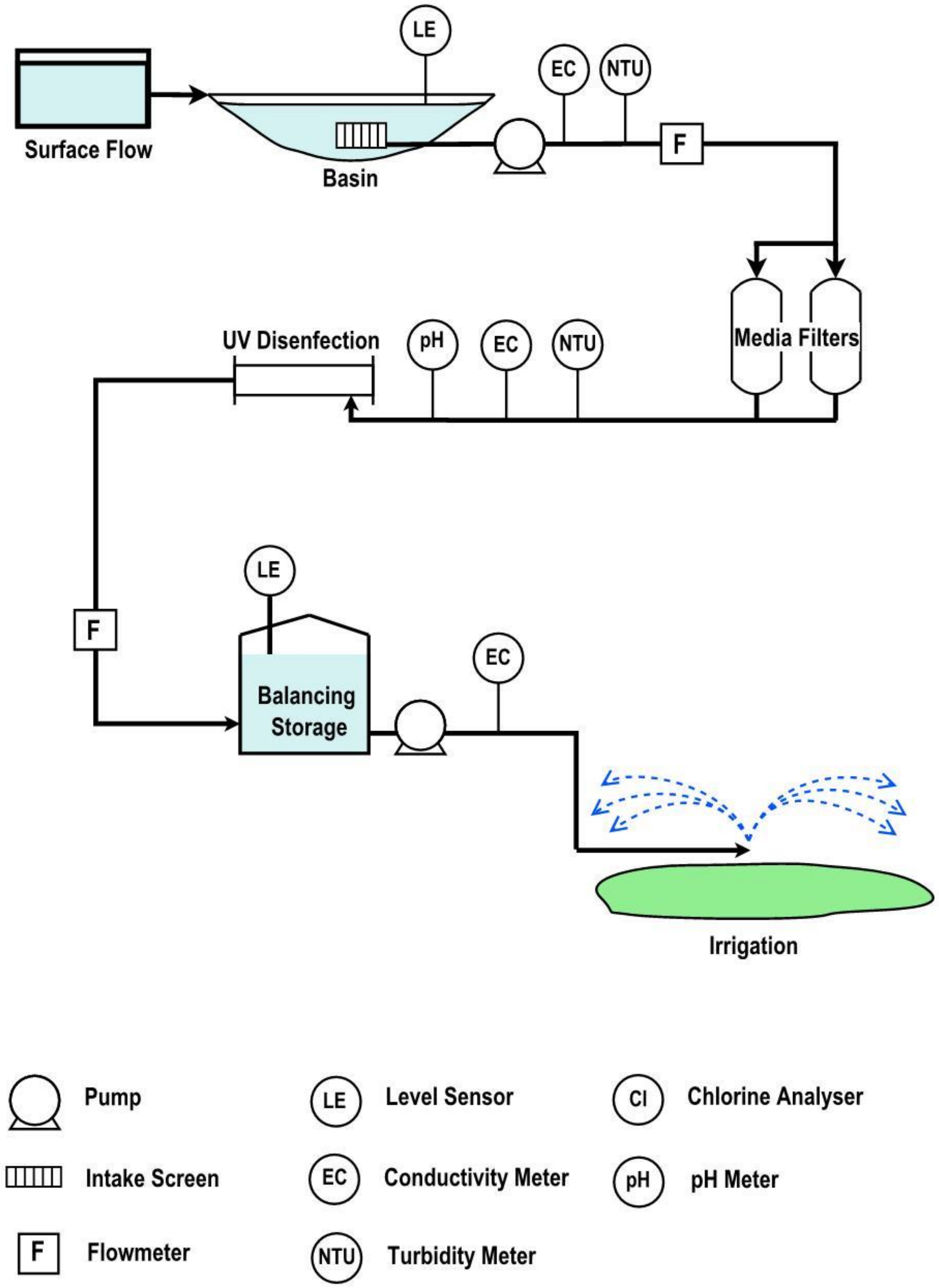


Figure 11: Operational Process Chart – Option 3

Figure **12**

Option 3- Surface Water Harvesting at Woodland Grove Sporting Facility

2.3.2 Cost Estimate

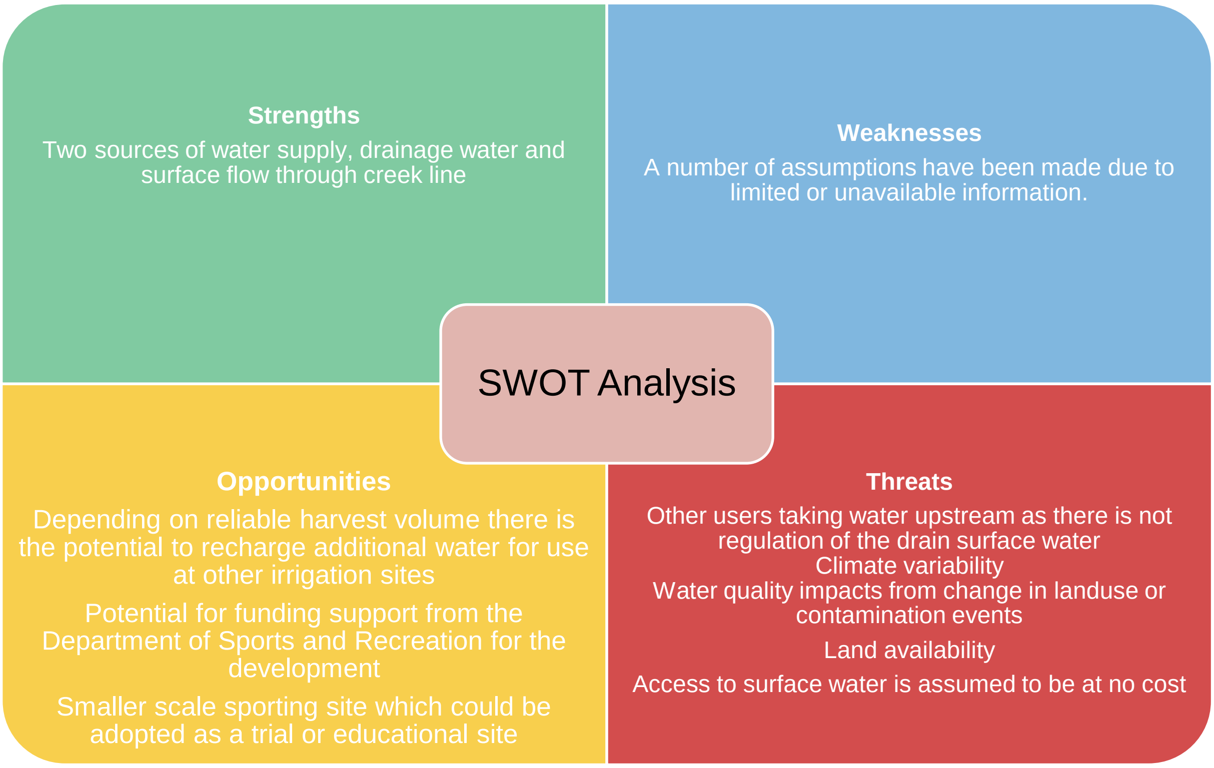
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 15 with a summary of breakdown and assumptions area presented in Appendix B.

Table 15: Summary of Cost Estimate – Option 3

CAPEX	$3,217,145
OPEX	$389,500
NPV (4-7% Real Discount Rate)	$17.70-$20.10

2.3.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of this sporting facility. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



2.3.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 16 provides a recommended forward program of works for this conceptual design.

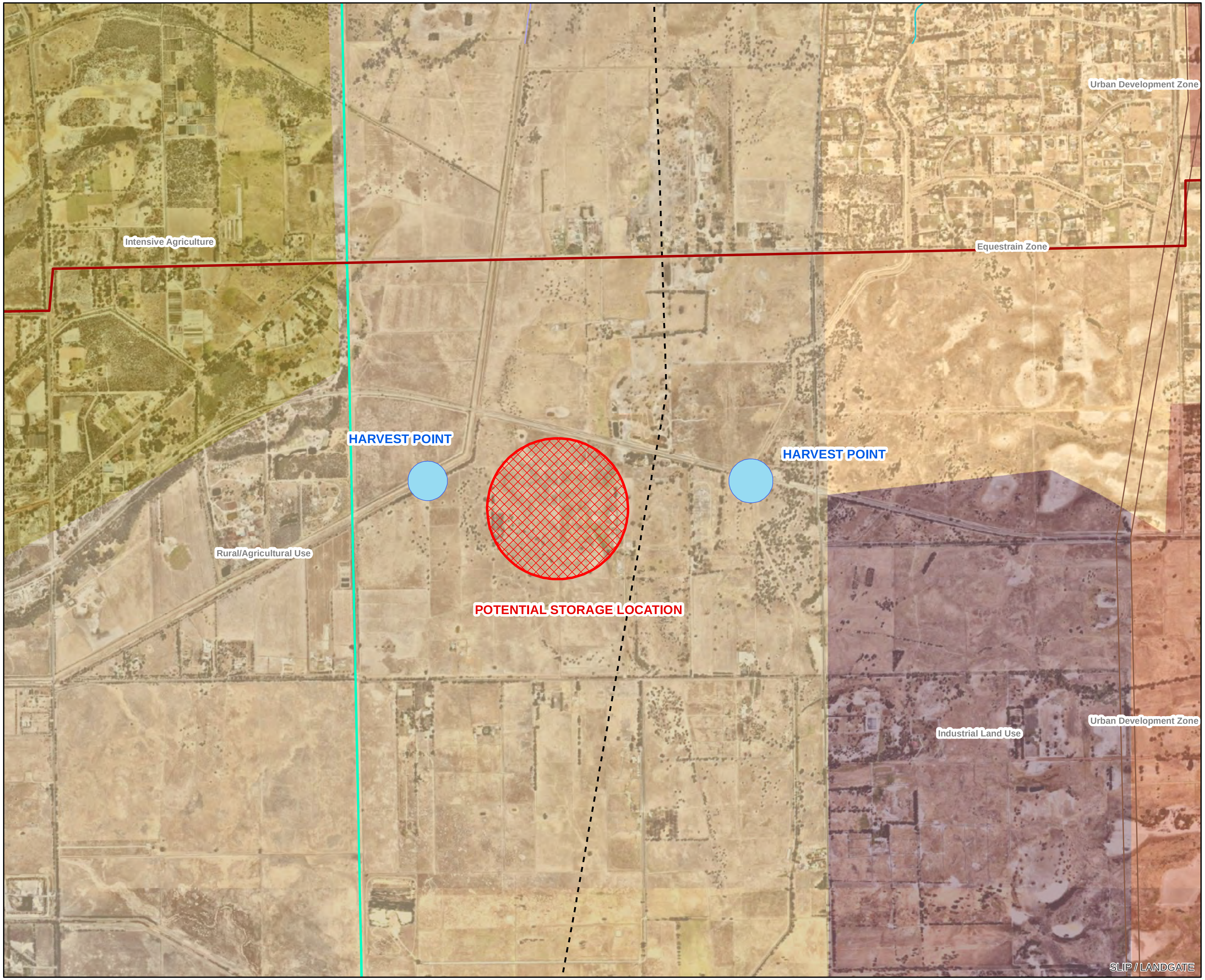
Table 16: Forward Program of Works – Option 3

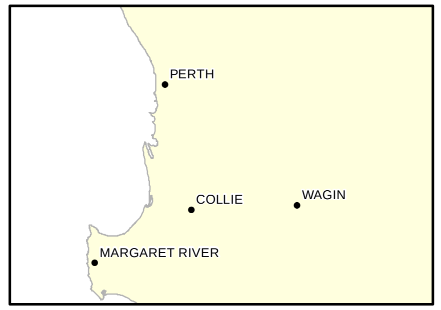
Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of both the creek line. Carry out catchment modelling to estimate potential flows into the drainage basins. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Discuss any permitting requirements with the relevant authorities. Confirm with DWER the requirements to harvest water from the drainage basin.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. The assessment can be completed in a staged approach to allow for sufficient hold points to identify any significant project risks. It is highly recommended that these investigations are to be completed prior to the detailed design.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

3 OLDBURY - MUNDIJONG

3.1 WATER SUPPLY OPTION 4 - SURFACE WATER FLOWS FROM OAKLAND / BARRIGA MAIN DRAIN

This option is identical to that presented in Option 1 with exception of the location. The Oakland and Barriga Main Drains intersect both the Byford and Mundijong regions indicating that the same option can be implemented at either location. There is also the opportunity to implement two schemes of varying size depending on the volume available and the demand locations. The detail pertaining to this option is outlined in Section 2.1. The proposed location is presented in Figure 13. This location also has the opportunity for above ground storage or the development of a recreational water park.





WGA
WALLBRIDGE GILBERT AZTEC

Figure **13**

Option 4- Surface Water Flows from Oakland / Barriga Main Drain -Alternative Location

3.2 WATER SUPPLY OPTION 5 – DECENTRALISED WASTEWATER SYSTEM

3.2.1 Overview

The township of Mundijong is predicted to grow from 2,000 people to 50,000 by 2050. Wastewater in the area is managed predominantly through onsite septic systems, with the exception of a recent development where Water Corporation has extended their network into the area. Water Corporation has a sewer main from that development up to the township of Byford. There exists the opportunity to develop a decentralised wastewater system in the area or implement a sewer mining system from the Water Corporation infrastructure.

Figure 14 presents the process flow diagram for option 5 whilst Figure 15 provides a spatial representation. Table 17 presents the water balance for the system and Table 18 presents the water supply concept components. This concept assumes a harvest volume of 1,000 ML to ultimately supply 800 ML/a following losses through the system. The potential volume from a decentralised system will depend on the residential area serviced by the system. The concept does not consider retrofitting of the septic tanks of the existing residents however, this could also be considered in future. As Water Corporation is starting to service the area, it is expected that development will increase and therefore the area serviced will increase prior to such time that a decentralised system could be developed.

Table 17: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised community system	1,000 ML/a	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a.
Sewer Network	Nil	It has been assumed that the sewer network and associated pump stations are installed by the developer and have not been incorporated into this cost analysis.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 400 ML storage facility has been adopted	The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses serviced.
Water Treatment	Treatment Rate 50 L/s	A treatment rate of 50 L/s has been adopted based on the expected daily flow. Primary, secondary and tertiary treatment.
Irrigation Supply	800 ML/a Irrigation Distribution Network 10 km	Assuming losses through the system from evaporation and backwash the losses are assumed to be 20%. Irrigation Distribution Network of 10 km has been adopted.

Table 18: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a. It is assumed that no land acquisition is required to install the infrastructure.	1,000 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Allowance has been made for balancing tank primary and secondary treatment. Valves, gauges and non-return valves included.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.	A 400 ML storage facility has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 10 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

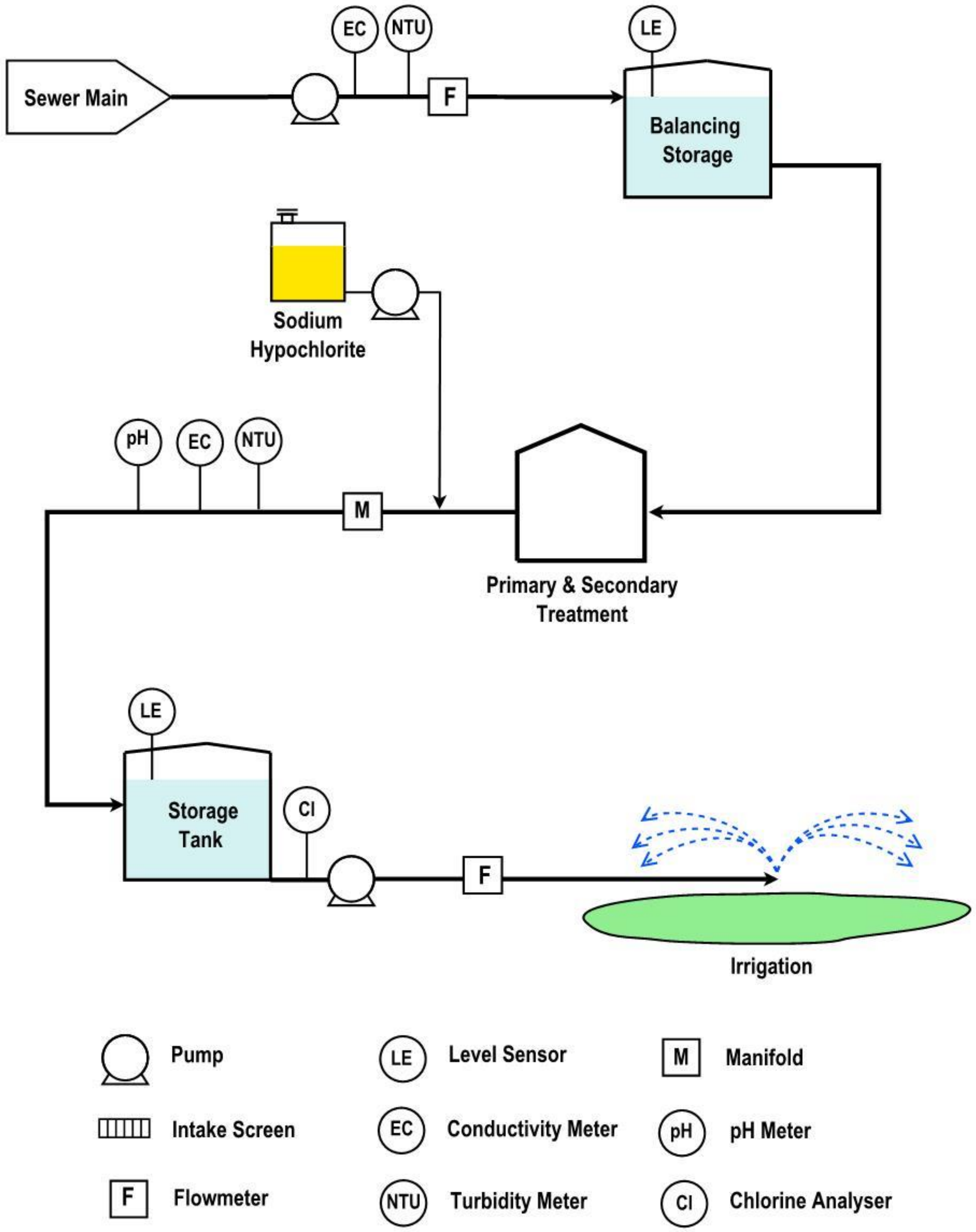


Figure 14: Operational Process Chart – Option 5

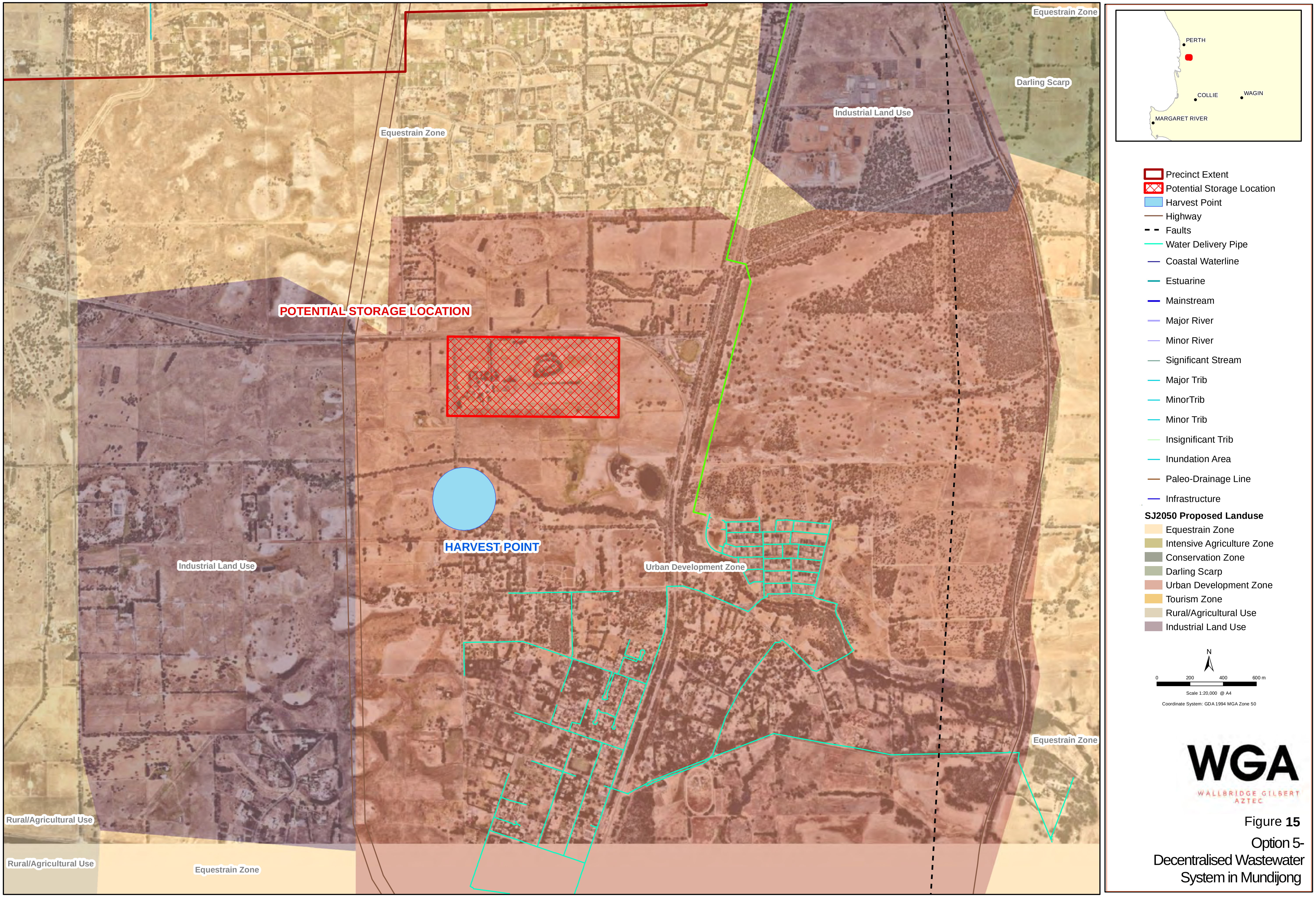


Figure 15
Option 5- Decentralised Wastewater System in Mundijong

3.2.2 Cost Estimate

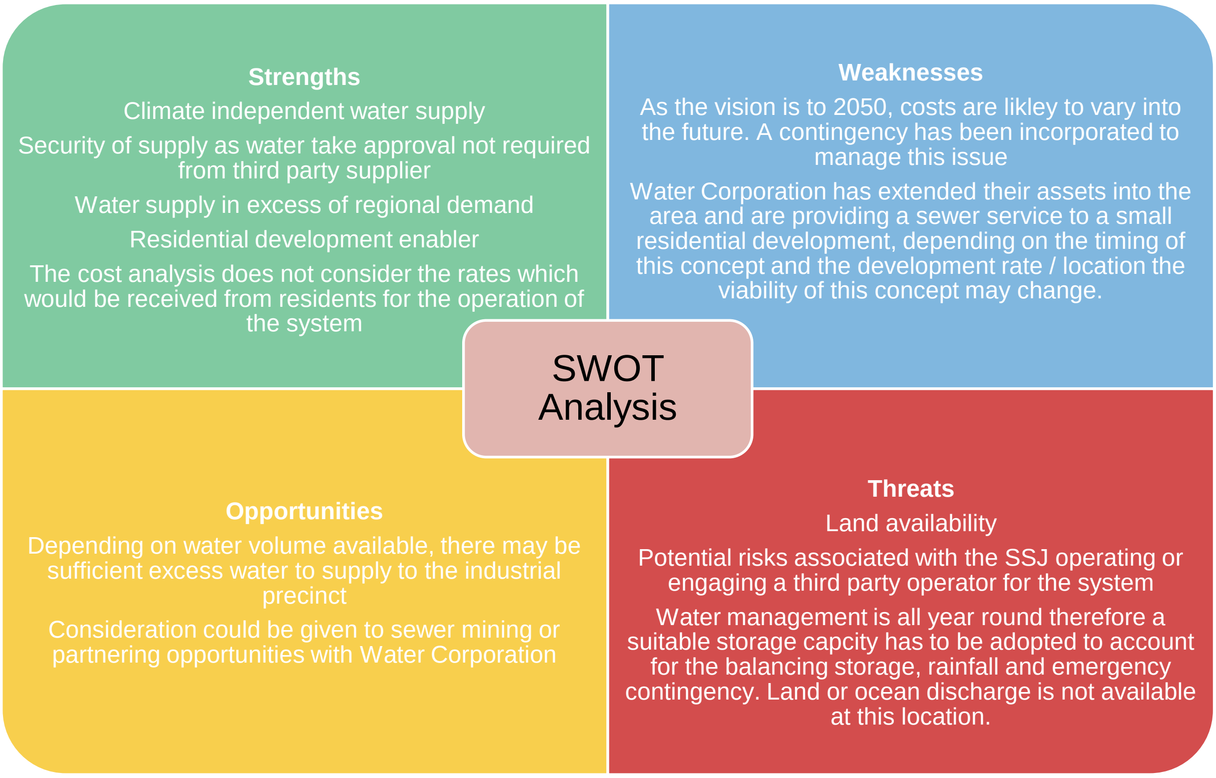
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 19 with a summary of breakdown and assumptions are presented in Appendix B. This option does not consider the income from residential sewer rates, this will provide an income stream that can offset some of the costs.

Table 19: Summary of Cost Estimate – Option 5

CAPEX	$23,905,000
OPEX	$1,905,500
NPV (4-7% Real Discount Rate)	$3.95 – $4.70 / kL

3.2.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the industrial precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



3.2.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 20 provides a recommended forward program of works for this conceptual design.

Table 20: Forward Program of Works – Option 5

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities.

3.3 WATER SUPPLY OPTION 6 – DECENTRALISED WASTEWATER SYSTEM WITH SURFACE WATER FROM MANJEDAL BROOK

3.3.1 Overview

This water supply concept considers the operation of a decentralised wastewater system as outlined in Option 5 and integrating the system with surface water from the Manjedal Brook. Flow monitoring of the Manjedal Brook has not been undertaken, however, square modelling completed by DWER (2012) indicated that 18.1 GL/a of water flows in the Manjedal Brook. This modelling is very high level and flow and water quality monitoring is recommended to determine the reliable harvest volume. This section described the components of the surface water component only, a description of the process of the decentralised wastewater system is presented in Section 3.2.

Based on the high-level flow modelling, a harvest volume of 3,000 ML/a has been adopted. Surface water is to be harvested, when available which is predominantly in winter, and transferred to the treatment / storage site adopted for the wastewater facility. Surface water does not require the same level of treatment as wastewater, therefore, a separate capture / balancing storage and treatment site will be incorporated. The use of MAR and above ground storage has been adopted for this concept.

Figure 16 presents the process flow diagram for Concept 6 whilst Figure 17 provides a spatial representation. Table 21 presents the water balance for the system and Table 22 presents the water supply concept components. This concept assumes a harvest volume of 3,000 ML of surface water and 1,000 ML of treated wastewater to ultimately supply 3,200 ML/a following losses through the system.

Table 21: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised community system	1,000 ML/a	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a.
Source water – Manjedal Brook	3,000 ML/a	3,000 ML/a based on the modelled 18.1 ML/a of flow and the increase in flow through the region as a result of urbanisation. It is assumed that the flow will be available of 100 days per annum at 30 ML/d. A harvest rate 520 L/s has been adopted.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 500 ML storage facility has been adopted.	The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.
Water Treatment for Treated Wastewater	Treatment Rate 50 L/s	A treatment rate of 50 L/s has been adopted based on the expected daily flow. Primary, secondary and tertiary treatment.
Water Treatment for Surface water and Aquifer Replenishment	Injection rate of 25 L/s Number of bores 21 Treatment Rate 520 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 L/s and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores can be reduced. The number of bores is based on the injection rate of 25 L/s, a target daily recharge rate of 30 ML/d.
Irrigation Supply	3,200 ML/a Irrigation Distribution Network 10 km	Assuming losses through the system from evaporation, backwash, scour and for environmental benefit the losses are assumed to be 20%. Irrigation Distribution Network of 10 km has been adopted.

Table 22: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a. It is assumed that no land acquisition is required to install the infrastructure.	1,000 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Allowance has been made for balancing tank, primary and secondary treatment. Valves, gauges and non-return valves included.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.	A 500 ML storage facility has been adopted.
Source Water and Transfer Lines	Surface water from the Mandejal Brook to the storage and treatment site.	No significant variation to the drain has been proposed other than the installation of the harvest offtake. Transfer infrastructure to the storage location will be required and a nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest and balancing storage.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted for the surface water component.	A 100 ML dam has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated in to the cost analysis component. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water). Transfer infrastructure from the balancing storage to the treatment facility and to the 21 production wells has been assumed to be 5 km of pipe based on 200-250 m spacing.

Parameter	Discussion	Allowance
		Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed.
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however this approach may vary depending on future rainfall patterns.	Based on a volume of 3,000 ML/a, an injection rate of 25 L/s, 100 recharge days. 21 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on yield, location, risks and surrounding users. The depth to aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallow systems may be required. Two monitoring bores have been adopted.	Installation of 21 production bores assuming not suitable bores exist. Installation of five monitoring bores. Headworks infrastructure, pump infrastructure and monitoring infrastructure. SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 10 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

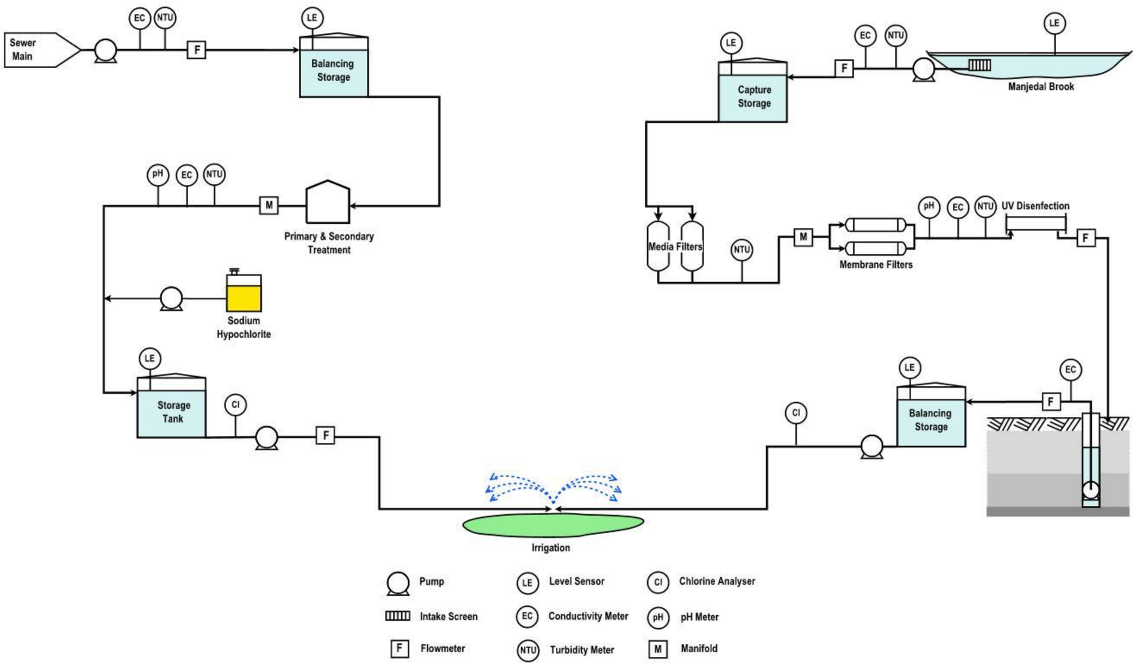


Figure 16: Operational Process Chart – Option 6

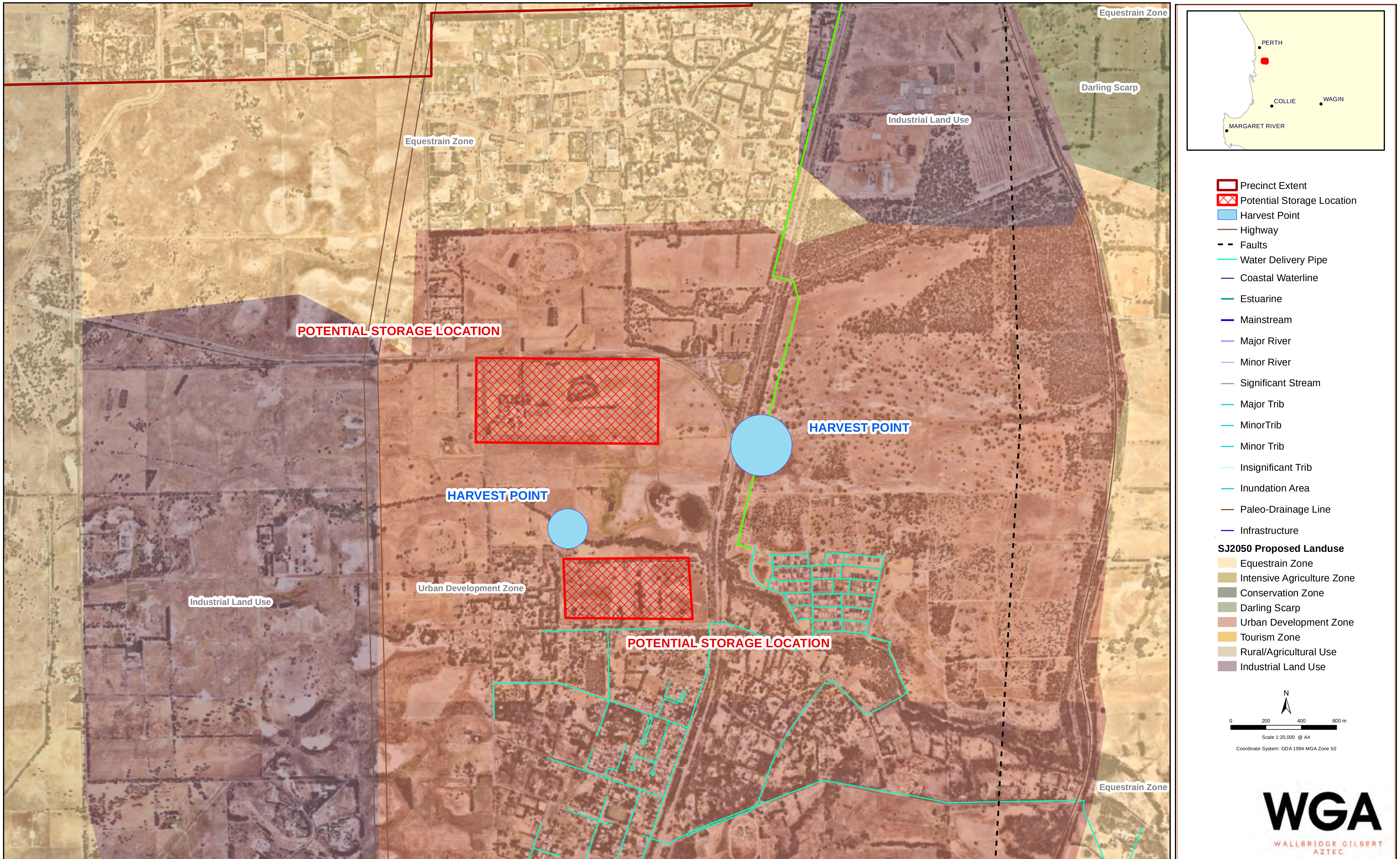


Figure 17

Option 6- Decentralised Wastewater System in Mundijong with Surface Water from Manjedal Brook

3.3.2 Cost Estimate

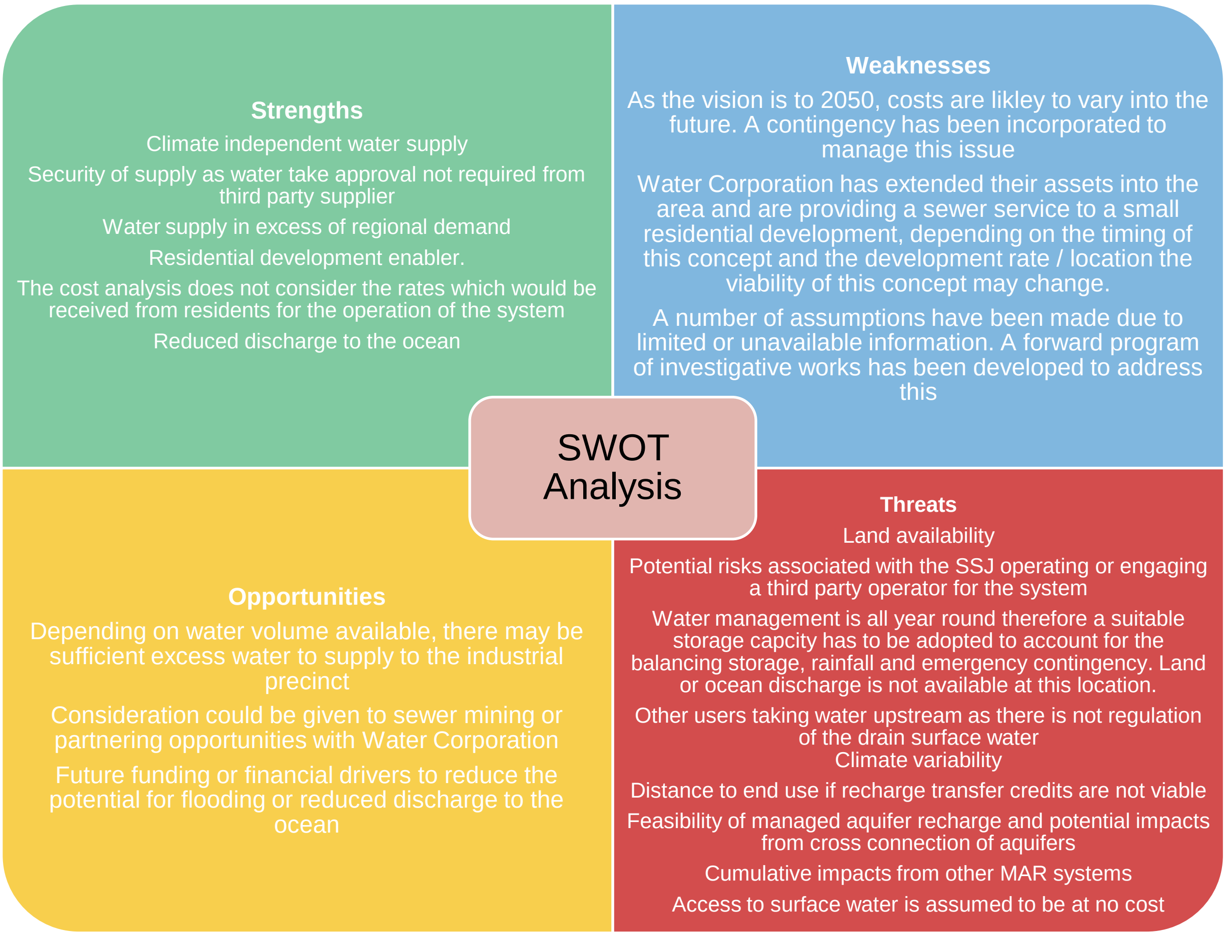
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 23 with a summary of breakdown and assumptions area presented in Appendix B.

Table 23: Summary of Cost Estimate – Option 6

CAPEX	$77,990,000
OPEX	$4,686,000
NPV (4-7% Real Discount Rate)	$3.25-3.85

3.3.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the industrial precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



3.3.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 24 provides a recommended forward program of works for this conceptual design.

Table 24: Forward Program of Works – Option 6

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities.
Surface Water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of Mandejal Brook. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Survey of both drains to identify ideal harvest locations and system location.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

3.4 WATER SUPPLY OPTION 7 – RECHARGE RUNOFF FROM MUNDIJONG WHITBY DISTRICT SPORTING FACILITY

3.4.1 Overview

A district sporting facility is required to support the Whitby High School and proposed Mundijong High School. The 12 Ha facility is to include two senior sized ovals and supporting infrastructure and will be incorporated into the same site as the high school facilities. The proposed location has not been confirmed, however, consideration to the land on Haywire Ave is a possibility due to limited surrounding environmental features.

The concept design for the facility is high level, however, is it considered likely that roof run off from the buildings and surrounding land will be directed to a drainage basin on site. It is proposed that this water be harvested and stored in an above ground storage, then treated and supplied for irrigation. Catchment modelling for the system has not been completed, however, based on the proposed area, the supply volume estimates are likely to be in the order of 20 to 100 ML/a. Additional investigations are recommended to confirm the reliable harvest volume prior to the detailed design of the system. For the purpose of this conceptual design, a supply volume of 50 ML/a has been adopted and MAR included.

There is the opportunity to utilise this site as a trial and educational site prior to entering into larger scale water supply system, differing technology such as biofilters, wetlands and the adoption of MAR can be tested to inform other options. One of the drainage basins could be constructed as a wetland feature to provide treatment, amenity and liveability benefits for the local community. For the purpose of this assessment, a drainage basin followed by mechanical treatment has been proposed.

The source water quality is unknown therefore the level of treatment is unclear, due to the low proposed recharge volumes, a moderate level of treatment has been proposed.

Figure 18 presents the process flow diagram for Concept 7 whilst Figure 19 provides a spatial representation. Table 25 presents the water balance for the system and Table 26 presents the water supply concept components. This concept assumes a harvest volume of 50 ML to ultimately supply 40 ML following losses through the system.

Table 25: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from drainage basin which captures roof runoff and runoff from surrounding land	50 ML/a	Catchment modelling data is not available. Based on the harvest of 50 ML over 75 days and 16 hours a day operation, a harvest rate of 12 L/s is proposed.
Above ground storage – drainage basin	One drainage basin A 200 kL balancing tank.	A drainage basin of approximately 180 m^2 is proposed. A post treatment balancing tank of 200 kL will also be included.
Water Treatment	Treatment Rate 12 L/s	Treatment rates has been assumed based on peak irrigation rates
Irrigation Supply	40 ML/a	Assuming losses through the system from evaporation losses are assumed to be 20%.

Table 26: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Water from the basin will be directed to the treatment facility.	A 40 ML basin A pump to transfer water from the drainage basin at 12 L/s. Transfer of water from the basin to the treatment facility. Stormwater infrastructure to direct water from the building to the drainage basin has not been incorporated.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter and UV treatment system. Valves, gauges and non-return valves included. A balancing storage tank of 200 kL has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. The use of transfer credits in the aquifer so users can extract water from an onsite bore has been assumed.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

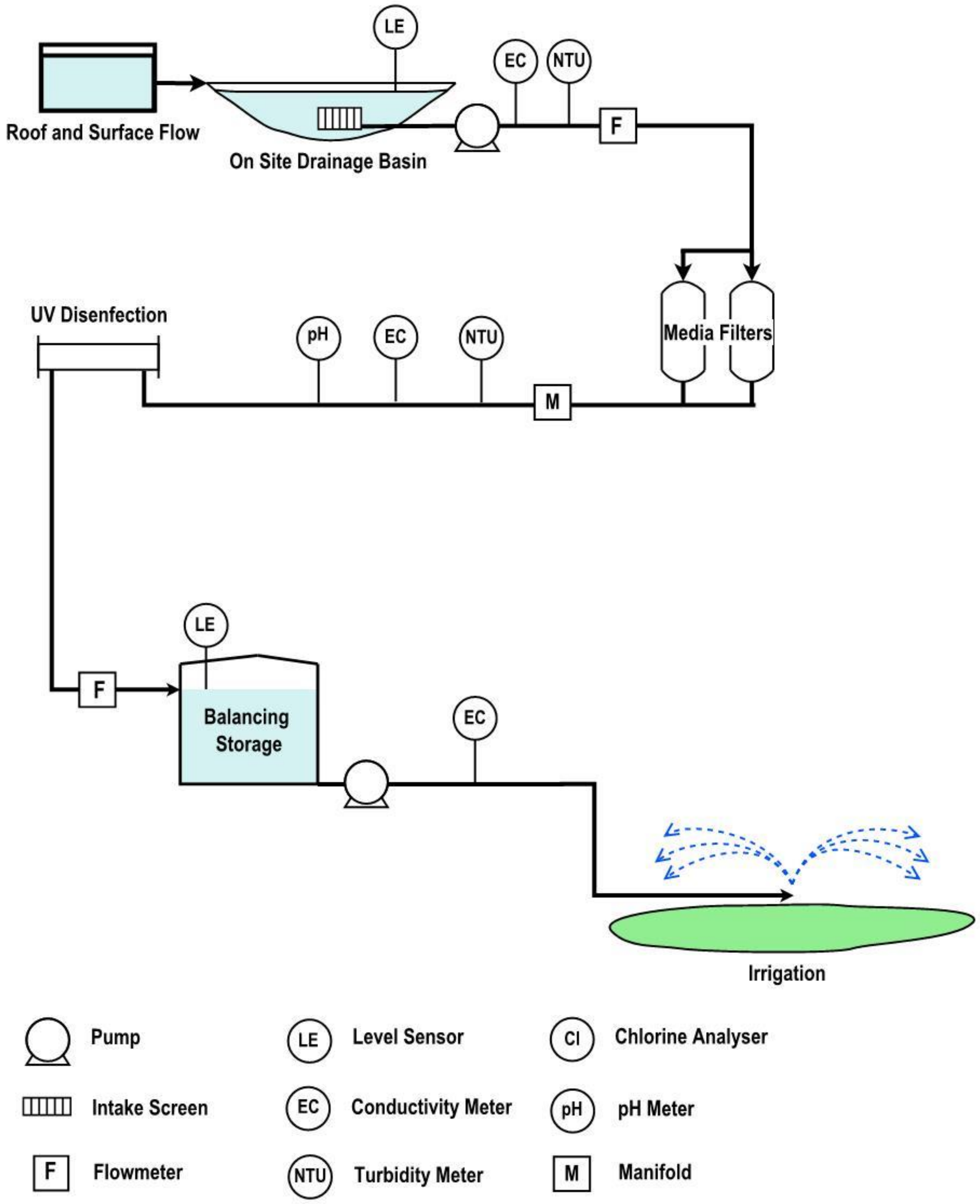


Figure 18: Operational Process Chart – Option 7

WGA
WALLBRIDGE GILBERT AZTEC

Figure **19**

Option 7-
Whitby and Mundijong
District Sporting Facility

3.4.2 Cost Estimate

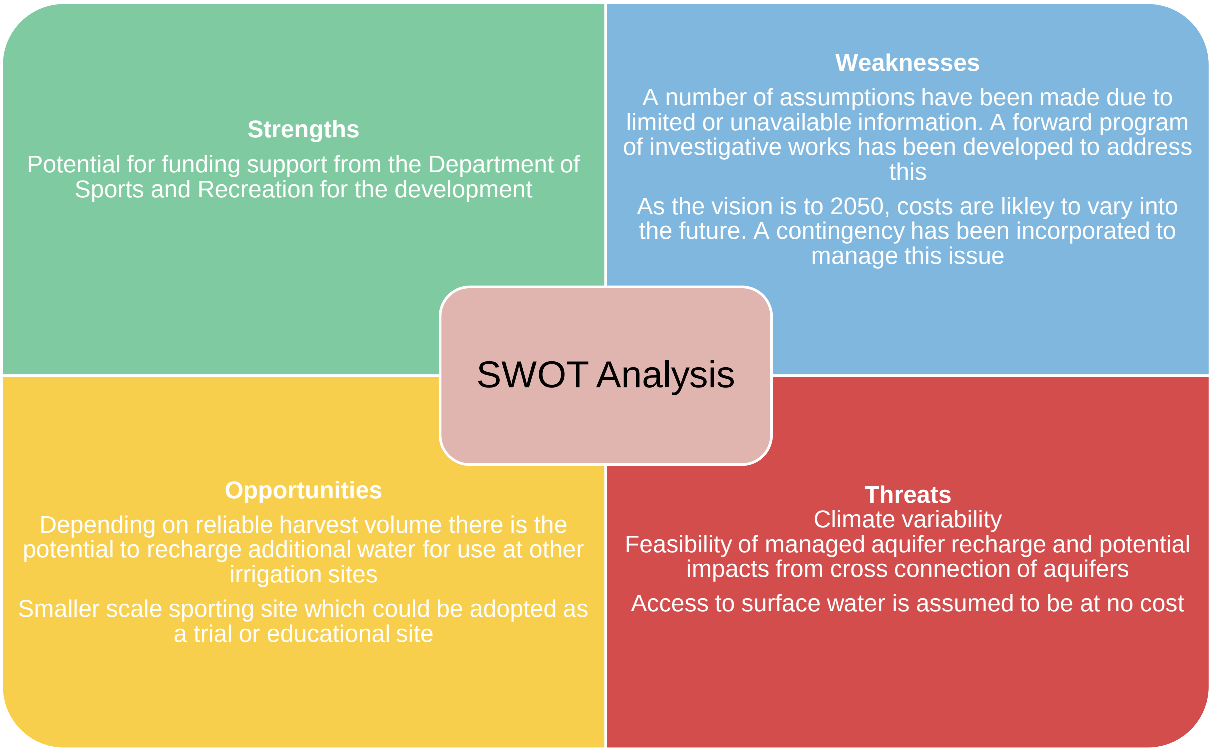
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 27 with a summary of breakdown and assumptions area presented in Appendix B.

Table 27: Summary of Cost Estimate – Option 7

CAPEX	$2,462,000
OPEX	$420,000
NPV (4-7% Real Discount Rate)	$14.15-15.70

3.4.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation for this precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



3.4.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 28 provides a recommended forward program of works for this conceptual design.

Table 28: Forward Program of Works – Option 7

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out catchment modelling to estimate potential flows into the drainage basins. Discuss any permitting requirements with the relevant authorities. Confirm with DWER the requirements to harvest water from the drainage basin.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. The assessment can be completed in a staged approach to allow for sufficient hold points to identify any significant project risks. It is highly recommended that these investigations are to be completed prior to the detailed design.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

4 HOPELAND – SERPENTINE - KEYSBROOK

4.1 WATER SUPPLY OPTION 8 – HARVEST OF SURFACE WATER FLOWS FROM PUNRACK DRAIN

4.1.1 Overview

This water supply concept considers harvesting surface water flows from Kardup or Dirk Brooks or downstream in the Punrack Drain. Kardup and Dirk Brooks are located in the southern portion of the project area and feed into the Punrack Drain. Flows at Yangedi Punrack Drain are estimated to be between 35 and 42 GL/a with daily flows between 100 and 800 ML/day depending on rainfall. Salinity monitoring at this location indicates a winter and summer cycle whereby salinity in winter is in the order of 250-300 mg/L whilst in summer it increases to greater than 1,500 mg/L.

Water will be harvested, and following treatment, will be transferred to either an above ground storage or underground using MAR for storage. The water will be subsequently recovered and transferred for irrigation of SSJ land or for agriculture / industry. Figure 20 presents the process flow diagram for Concept 8 whilst Figure 21 provides a spatial representation. Table 29 presents the water balance for the system and Table 30 presents the water supply concept components. This concept assumes a harvest volume of up to 5,000 ML to ultimately supply 4,000 ML following losses through the system. This may be impacted by climate variability, monitoring of the flows and water quality is required to accurately predict a reliable harvest volume.

Water quality variability (e.g. suspended solids or salinity) is currently unknown, water quality monitoring in the form of grab samples for a broad range of contaminants and inline monitoring of salinity, turbidity and pH is recommended to refine the treatment process required to achieve the reliable harvest volume. This concept considers a high level of treatment due to the data gaps and risk around source water quality and the receiving aquifer risk profile. Additional assessments will assist in determining the level of treatment required.

The drains are managed by Water Corporation and approval to access the infrastructure would be required. The take of water from the drain is not currently prescribed.

The water supply concept has the opportunity to be implemented in a staged approach to meet demand requirements or budget expenditure. The timing of the development of the agri-precinct is unknown, therefore a staged approach assists the SSJ to manage their risk. The concept adopts an above ground balancing storage dam, this facility could be constructed in a way to provide public amenity and provide recreational facilities (land based only), this has not been incorporated into the cost estimate at this stage.

Table 29: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Punrack Main Drain / Kardup or Dirk Brooks	5,000 ML/a total assumed to be 2,500 ML/a per drainage feature	Flow monitoring data indicates that flows in the order of 800 ML/d occur during rainfall events. Based on rainfall and a 150 days of available harvest, an extraction rate of 285 L/s is required from each drainage ling based on 16 hours of operation per day. Depending on the configuration of the drainage line, a single offtake point may be feasible.
Balancing Storage / Capture Storage	100 ML	Balancing storage provides flexibility in the operation of the system to manage injection and extraction rates, provide treatment or holding times. The flow in the drains may be such that a high extraction rate is required to capture the higher rainfall events, having a balancing storage allows for continual injection (not just limited to rainfall periods) which reduces the number of bores required. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Water Treatment and Aquifer Replenishment	Injection rate of 25 L/s Number of bores 23 Treatment Rate 570 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 L/s and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores can be reduced. The number of bores is based on the injection rate of 25 L/s, 16 hours a day over 150 days of operation and a target daily recharge rate of 33 ML/d.
Irrigation Supply	4,000 ML/a	Assuming losses through the system from evaporation, backwash, scour and for environmental benefit the losses are assumed to be 20%.

Table 30: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Surface water from Kardup or Dirk Brook / Punrack Drain. Pumps to harvest water from each locations and transfer water to a centralised balancing storage.	No significant variation to the drain has been proposed other than the installation of the harvest offtakes. To manage the level in the drain multiple harvest locations have been proposed, based on a flow rate of 285 L/s at each drainage feature. Transfer infrastructure from each harvest location will be required to transfer water to the balancing storage. A nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted	A 100 ML dam has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated in to the cost analysis component. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water). Transfer infrastructure from the balancing storage to the treatment facility and to the 23 production wells has been assumed to be 5 km of pipe. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter, membrane filter, UV treatment and chlorination system. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration may not be required.
Storage using ASR	Based on a volume of 5,000 ML/a, an injection rate of 25 L/s, 153 recharge days and 16 hours a day operation.	Installation of 23 production bores assuming not suitable bores exist.

Parameter	Discussion	Allowance
Typically, replenishment will be carried out in winter and recovery during summer, however this approach may vary depending on future rainfall patterns.	23 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on yield, location, risks and surrounding users. The depth to aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallow systems are likely to be required. Five monitoring bores have been adopted.	Installation of five monitoring bores. Headworks infrastructure, pump infrastructure and monitoring infrastructure. SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site - specific irrigation infrastructure has not been considered. If transfer infrastructure is required a transfer pump and 20 km of pipe to the agricultural precinct. Ultimately, the use of transfer credits in the aquifer so users can extract water from an onsite bore is the priority approach. This assumes that the groundwater at the end user location can be taken (i.e. is of suitable quality, there is no risk to the environment or human health).	Final design would need to consider onsite irrigation infrastructure. Assumes 20 km of transfer pipework. If credit transfers are viable, the cost for the installation of additional bores has not been incorporated.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

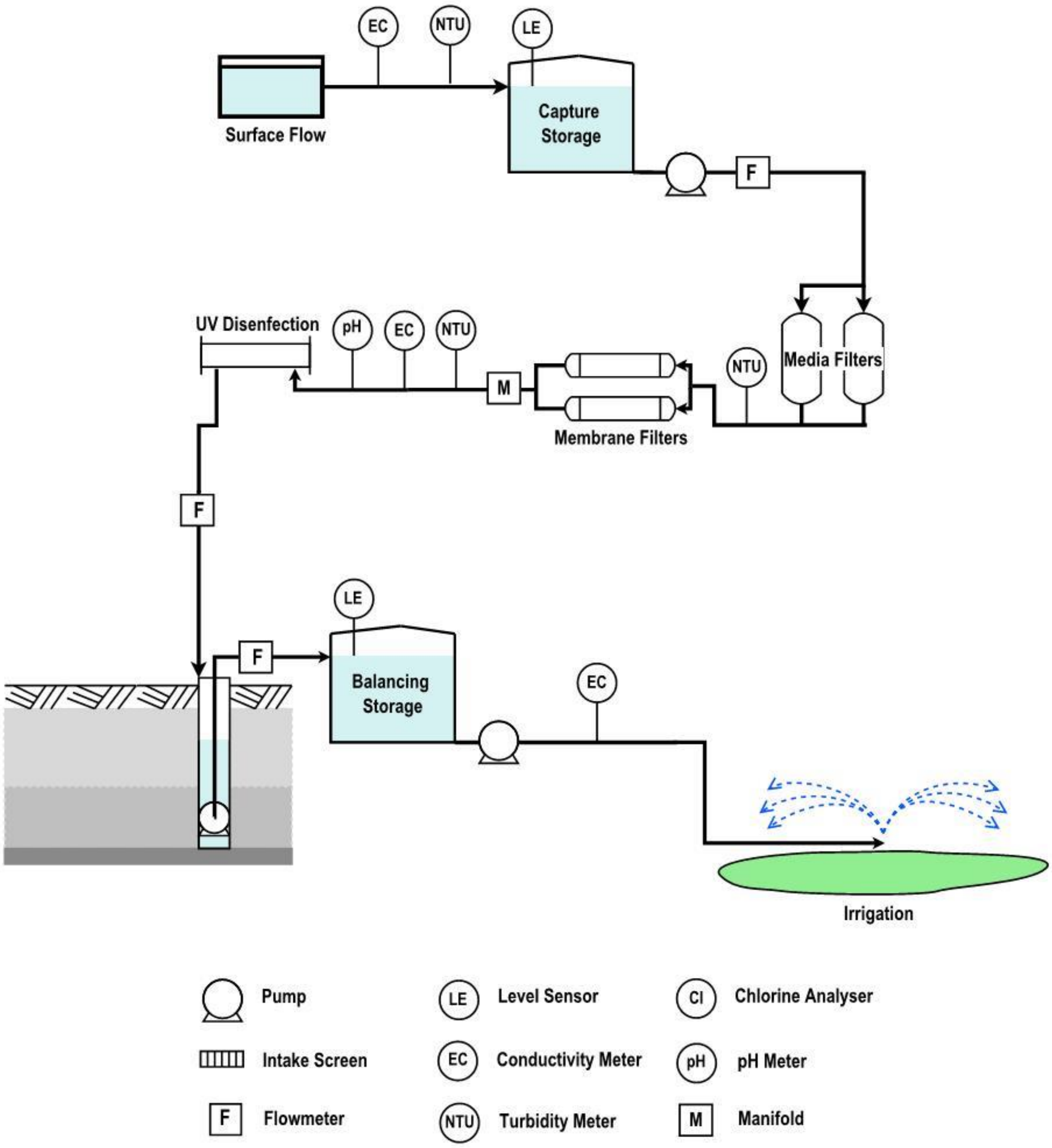
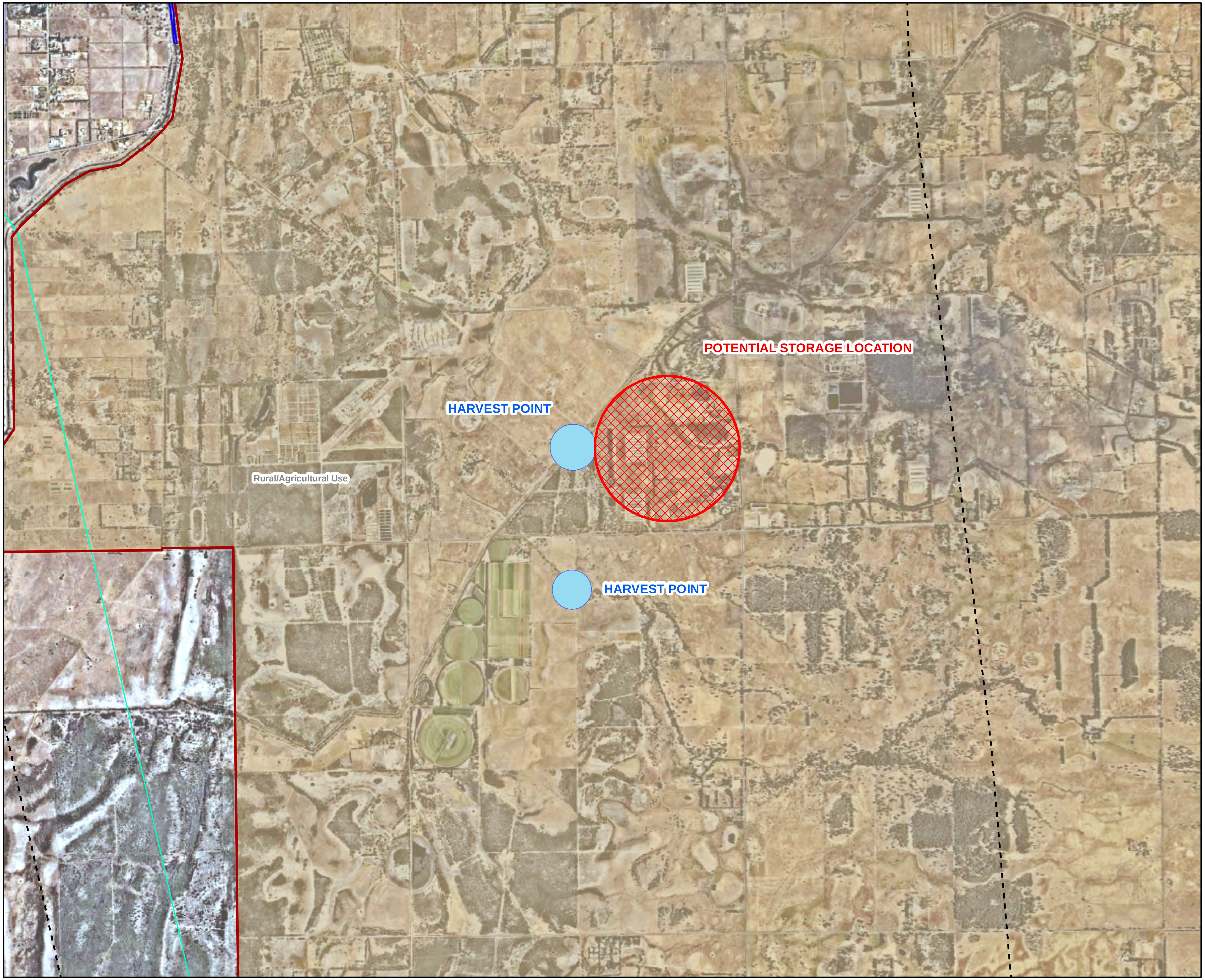
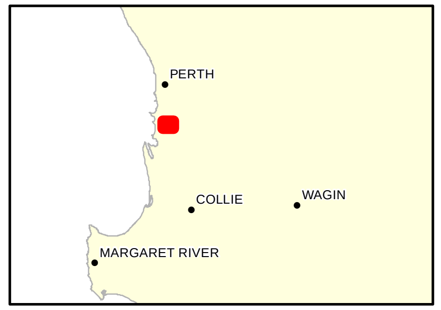


Figure 20: Operational Process Chart – Option 8





Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

N
0 250 500 750 m
Scale 1:35,000 @ A4
Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure **21**

Option 8- Surface Water Flows from Kardup or Dirk Brook/Punrack Drain

4.1.2 Cost Estimate

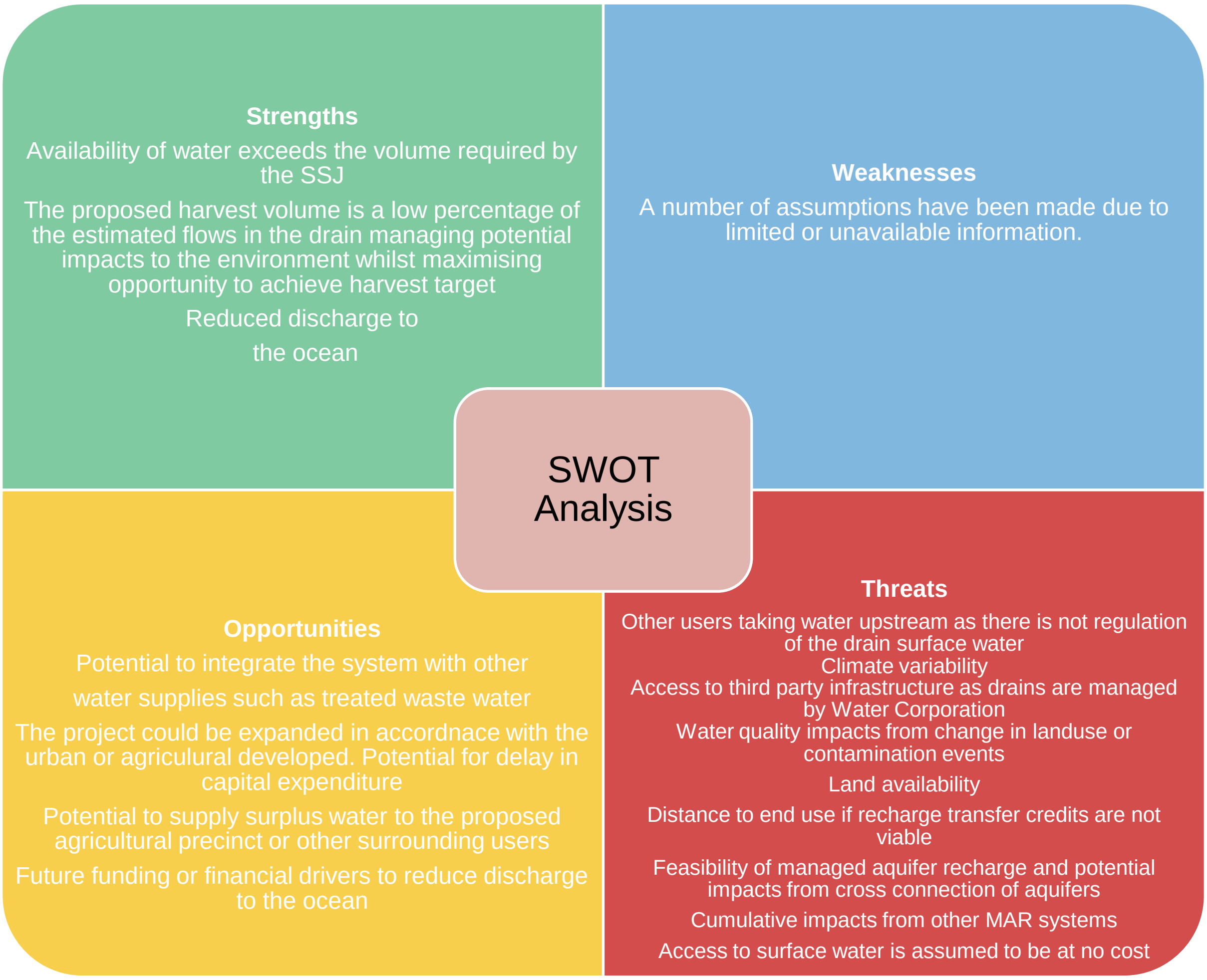
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 31 with a summary of breakdown and assumptions area presented in Appendix B.

Table 31: Summary of Cost Estimate – Option 8

CAPEX	$74,597,000
OPEX	$3,112,500
NPV (4-7% Real Discount Rate)	$2.15-2.60 / kL

4.1.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the agricultural precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



4.1.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 32 provides a recommended forward program of works for this conceptual design.

Table 32: Forward Program of Works – Option 8

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out water quality grab samples for a broad range of analysis based on the catchment land use. Survey of both drainage lines and drain to identify ideal harvest locations and system location.
	The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Seek confirmation from Water Corporation regarding access entitlements.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Demand Forecast	The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participant in industry forums or engage with industry to understand the demand and willingness/ capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

4.2 WATER SUPPLY OPTION 9 – CONSTRUCTION OF A DECENTRALISED WASTEWATER SYSTEM IN SERPENTINE

4.2.1 Overview

The township of Serpentine is predicted to grow from 1,800 people to 10,000 by 2050. Wastewater in the area is managed through onsite septic systems. The construction of a decentralised wastewater system is required to support the predicted residential growth. The adoption of a septic based system which discharges to the shallow groundwater system is not consider environmentally viable at the predicted population. There are several different designs for community based wastewater systems, to determine the most appropriate approach would require a detailed study of the area including survey.

Figure 22 presents the process flow diagram for option 9 whilst Figure 23 provides a spatial representation. Table 33 presents the water balance for the system and Table 34 presents the water supply concept components. This concept assumes a harvest volume of 150 ML to ultimately supply 120 ML/a following losses through the system. The potential volume from a decentralised system will depend on the residential area serviced by the system. The concept does not consider retrofitting of the septic tanks of the existing residents, but this could be considered in the future with a STEDS Septic Tank Effluent Drainage scheme being one option for increasing the serviced area.

Table 33: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised community system	150 ML/a	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 300 ML/a.
Sewer Network	Nil	The sewer network is considered to be a component installed by the developer therefore has not been included in the cost analysis.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 60 ML storage facility has been adopted	The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.
Water Treatment	Treatment Rate 10 L/s	A treatment rate of 10 L/s has been adopted based on the expected daily flow. Primary, secondary and tertiary treatment.
Irrigation Supply	120 ML/a Irrigation Distribution Network 10 km	Assuming losses through the system from evaporation and backwash the losses are assumed to be 20%. Irrigation Distribution Network of 10 km has been adopted.

Table 34: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 600 ML/a. It is assumed that no land acquisition is required to install the infrastructure.	150 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Allowance has been made for balancing tank, primary and secondary treatment. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration may not be required.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.	A 60 ML storage facility has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 10 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

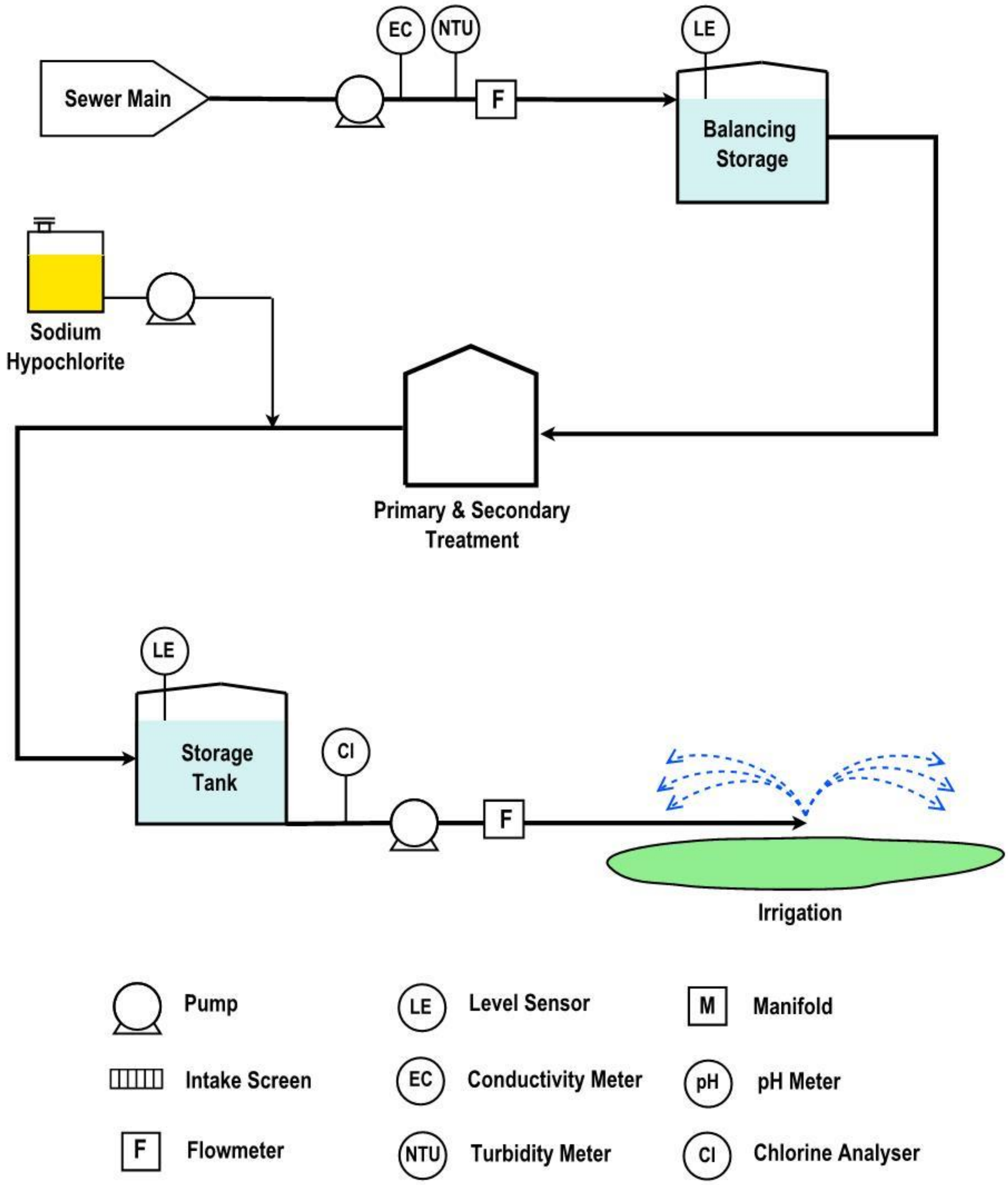
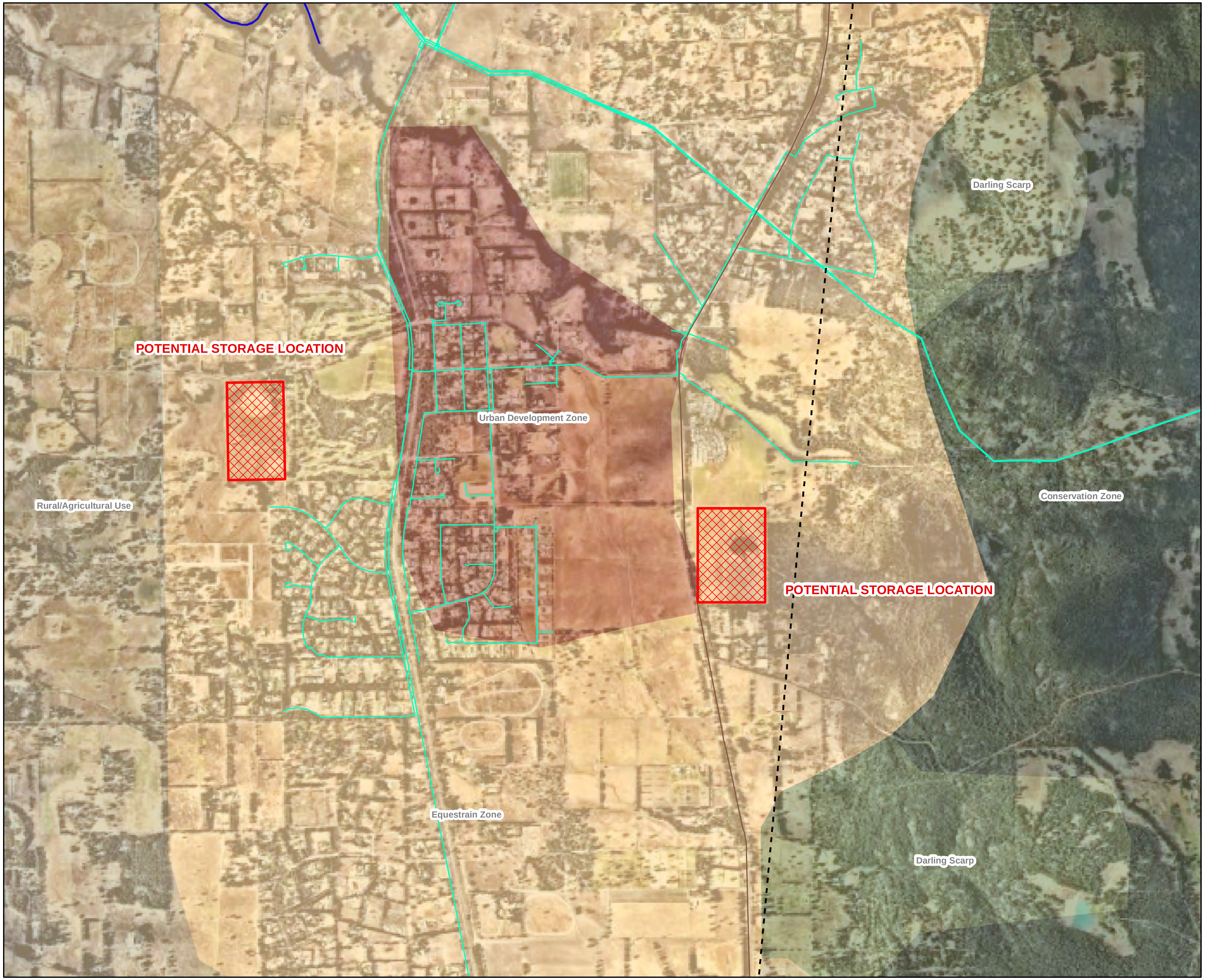
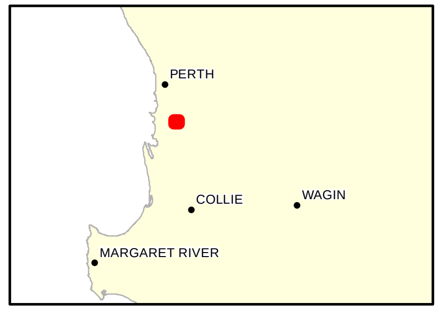


Figure 22: Operational Process Chart – Option 9





WGA
WALLBRIDGE GILBERT AZTEC

Figure 23
Option 9- Decentralised Wastewater System in Serpentine

4.2.2 Cost Estimate

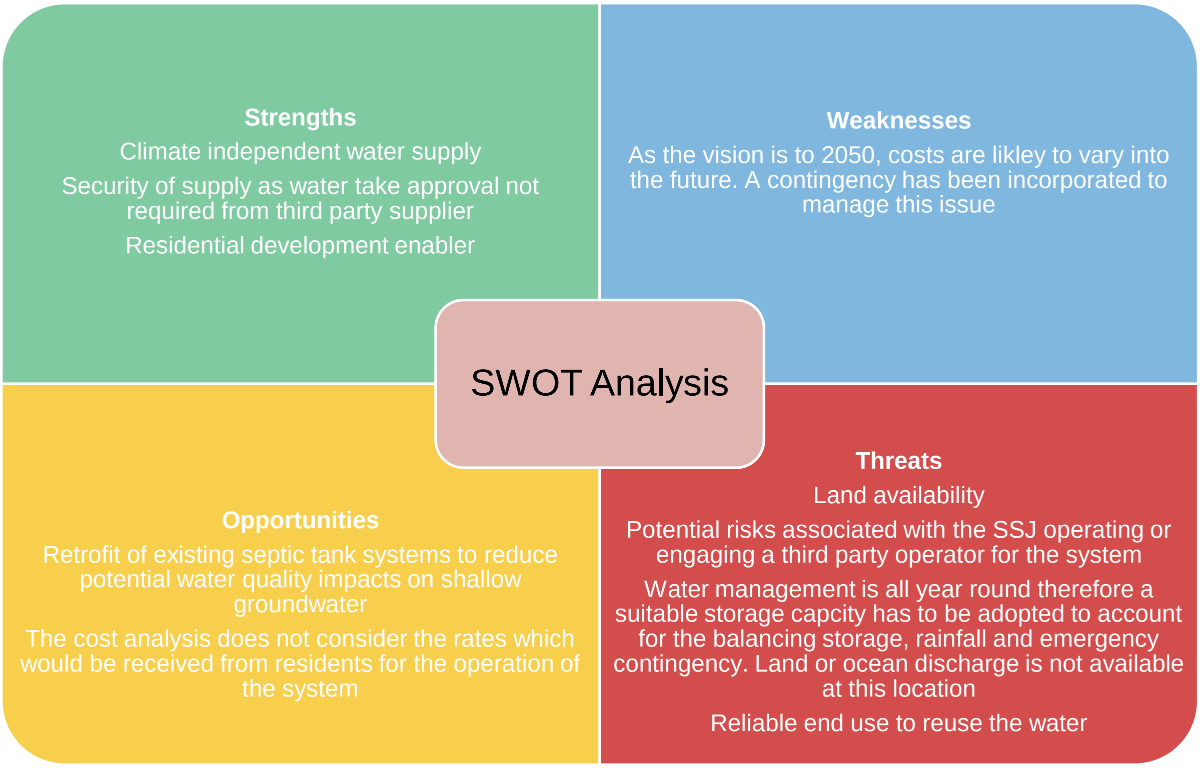
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 35 with a summary of breakdown and assumptions area presented in Appendix B.

Table 35: Summary of Cost Estimate – Option 9

CAPEX	$8,978,000
OPEX	$1,345,500
NPV (4-7% Real Discount Rate)	$2.45-$2.75

4.2.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the majority of the requirements for irrigation in the township of Serpentine. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



4.2.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 36 provides a recommended forward program of works for this conceptual design.

Table 36: Forward Program of Works – Option 9

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities.

4.3 WATER SUPPLY OPTION 10 – GALLERY RECHARGE INTO DECOMMISSIONED OPEN PIT MINES

4.3.1 Overview

The region is known to have shallow groundwater and during the winter period or high rainfall events, ponding or flooding occurs. A number of drains have been constructed across the region to capture shallow water or surface drainage water and divert it to the ocean. Salinity monitoring in the Punruck Drain indicates that brackish groundwater discharges into the drain during the drier summer months. The salinity of groundwater in the vicinity of Hopeland is between 250 and 1,000 mg/L. The depth to water decreases closer to the ocean, in the western parts of the Hopeland – Serpentine – Keysbrook region the depth to groundwater is approximately 10 m below ground level.

Recharge to the shallow groundwater system was discounted in the preliminary long options due to the risk associated with exacerbating the water ponding and flooding conditions. The opportunity to recharge the shallow system using decommissioned open pit sand mines has been discussed and is being considered in this concept. This is a relatively new approach and therefore the concept has some risk and requires further investigations to determine the level of risk and treatment requirements. Further investigations will allow for modification of the concept to better understand the cost implications. The current concept design does not appear financially viable, however, if water prices increase, water scarcity increases or technology or legislation changes then the concept may become viable.

The primary risk associated with this concept is the storage capacity of the unconfined Superficial Aquifer. Hydrogeological investigation to determine the storage capacity would be required to further assess the risk of water logging. For the purpose of this concept the open pit will be considered a recharge gallery as the base and sides would intersect the highly permeable sand layers. The intent would be to recharge at the nominated location and, using recharge credits, extract groundwater at the irrigation location in the township of Serpentine.

The SSJ has identified two registered open pit sand mines that have a limited life span, which may be suitable to adopt as recharge galleries. One is located close to Kardup Brook suggesting that the groundwater would be shallow and potentially connected to the drainage line. Recharge at this location may result in increased recharge to the drainage channel, which does not meet the intent of the concept.

The second mine is located to the west of Kardup Brook, closer to Hopeland. This location is likely to have a higher aquifer storage potential without the risk of increased groundwater recharge to surface features. For the purpose of this concept, a recharge volume of 50 ML/a has been adopted, however, the aquifer storage capacity and recharge rates require investigation.

The water would be sourced from Kardup Brook which is located approximately 2 km to the east of the site. There exists a risk that, over time, the recharge rates will reduce due to groundwater mounding to the base of the pit. This would result in limited to nil recharge through the base, however, recharge radially through the pit walls may still occur. Distribution infrastructure has not been incorporated as it has been assumed that recharge transfer credit can be adopted at this site.

The source water quality is unknown therefore the level of treatment is unclear, due to the low proposed recharge volumes, a moderate level of treatment has been proposed.

Figure 24 presents the process flow diagram for Concept 10 whilst Figure 25 provides a spatial representation. Table 37 presents the water balance for the system and Table 38 presents the water supply concept components. This concept assumes a harvest volume of 50 ML to ultimately supply 40 ML following losses through the system.

Table 37: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Kardup Brook	50 ML/a	Flow monitoring or catchment modelling data is not available for the creek line. Based on the harvest of 50 ML over 75 days and 16 hours a day operation, a harvest rate of 10 L/s is proposed.
Above ground storage and Aquifer Replenishment – existing open pit sand mine	Existing decommissioned open pit sand mine assumed recharge rate of 10 L/s	The aquifer recharge rate will be limited the extraction rate or the requirement for additional balancing storage. A recharge rate of 10 L/s across the mine pit is considered acceptable and no balancing storage has been adopted.
Irrigation Supply	40 ML/a	Assuming losses through the system from aquifer losses are assumed to be 20%.

Table 38: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Water from Kardup Brook and 2 km of transfer main to deliver 10 L/s.	A pump to transfer water from the creek line at 10 L/s. A nominal 2 km of transfer pipework
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for a media filter. Valves, gauges and non-return valves included.
Storage using open pit as a recharge gallery Typically, replenishment will be carried out in winter and recovery during summer, however, this approach may vary depending on future rainfall patterns.	Monitoring bore targeting the same formation and shallow systems may be required. A single monitoring bore has been adopted to a depth of 20 m below ground level.	Installation of two shallow monitoring bores. SCADA system allowance and inline water quality and pressure monitoring.

Parameter	Discussion	Allowance
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure including groundwater wells have not been considered. The use of transfer credits in the aquifer so users can extract water from an onsite bore has been assumed.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

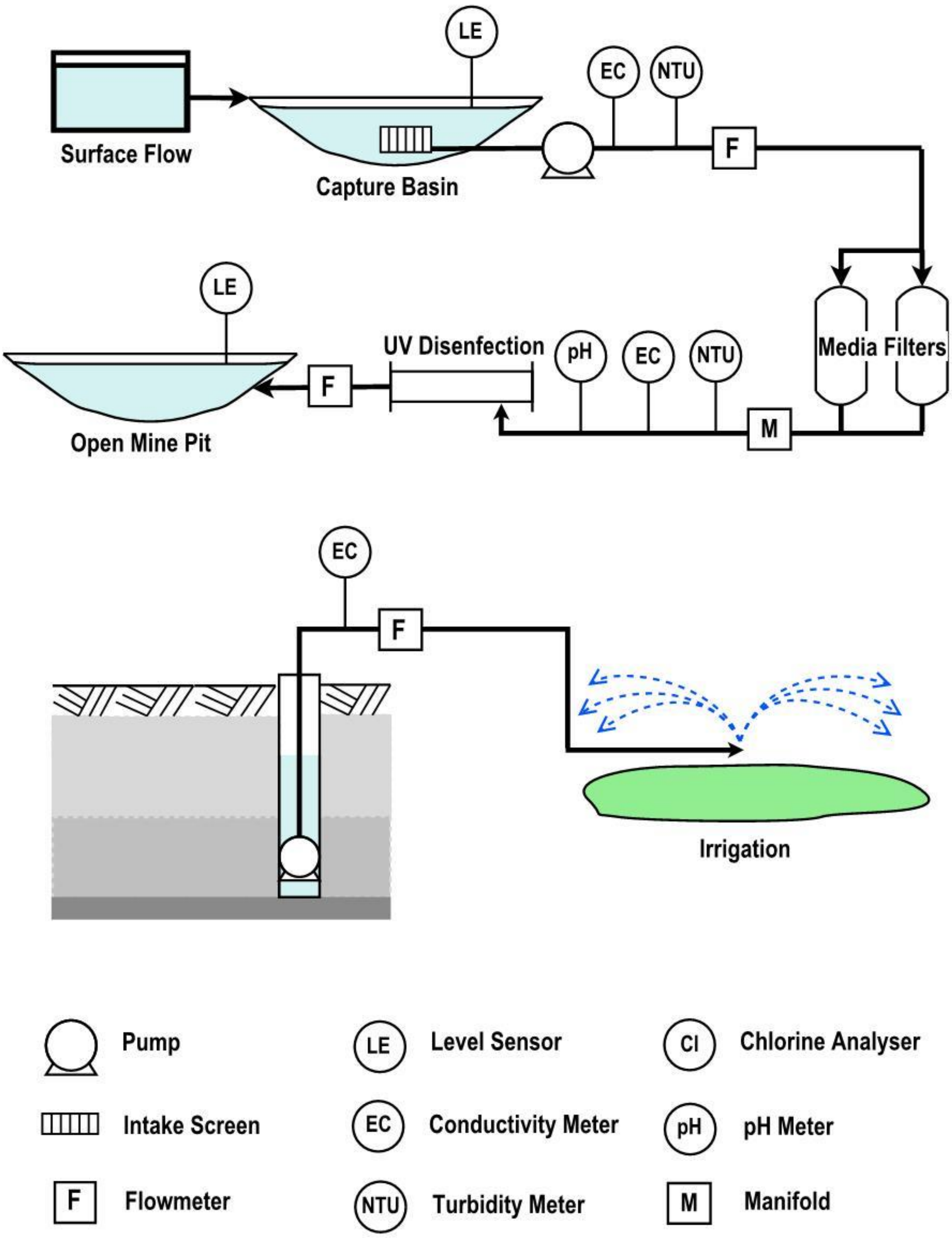
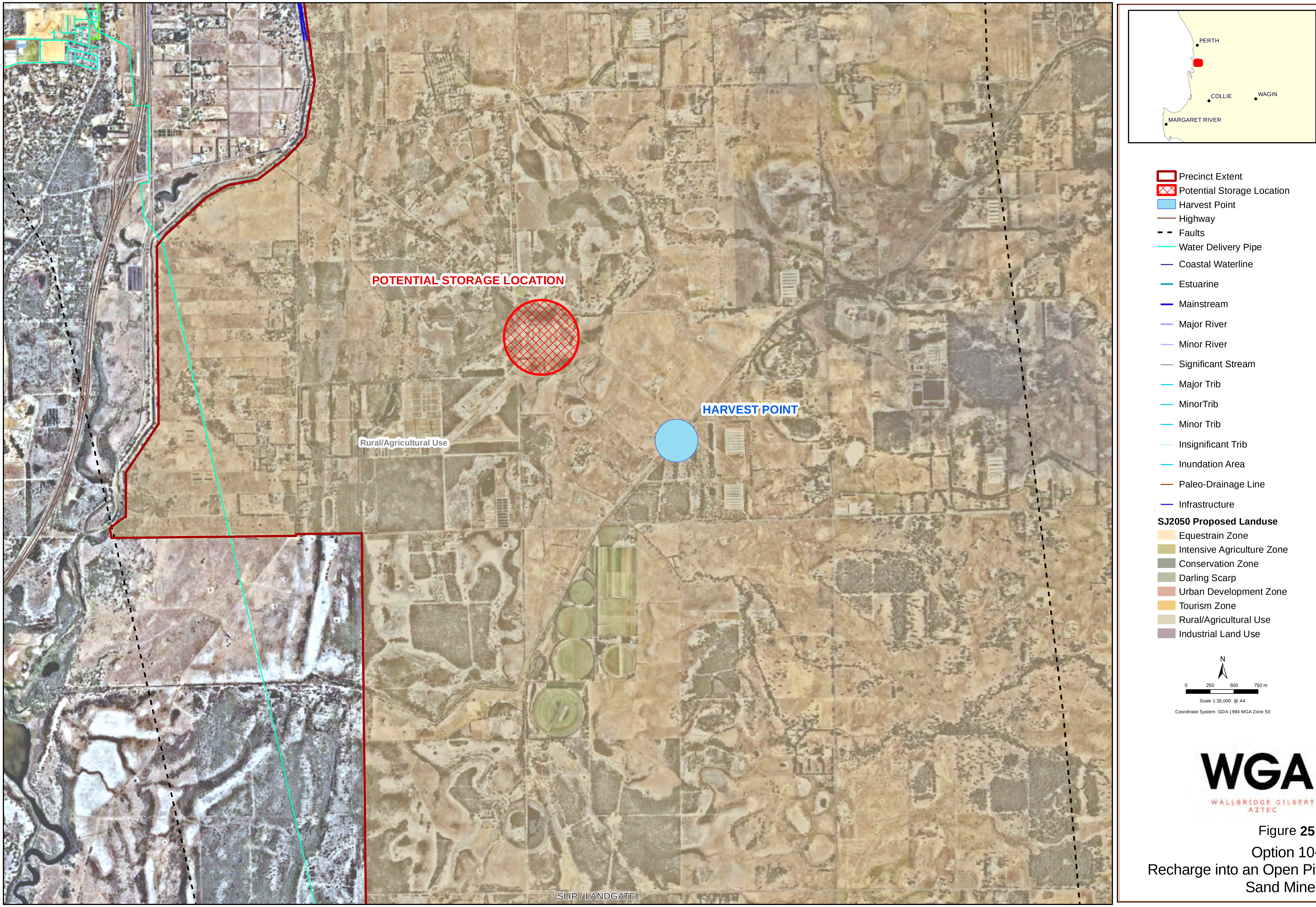


Figure 24: Operational Process Chart – Option 10



WGA
WALLBRIDGE GILBERT AZTEC

Figure **25**

Option 10- Recharge into an Open Pit Sand Mine

4.3.2 Cost Estimate

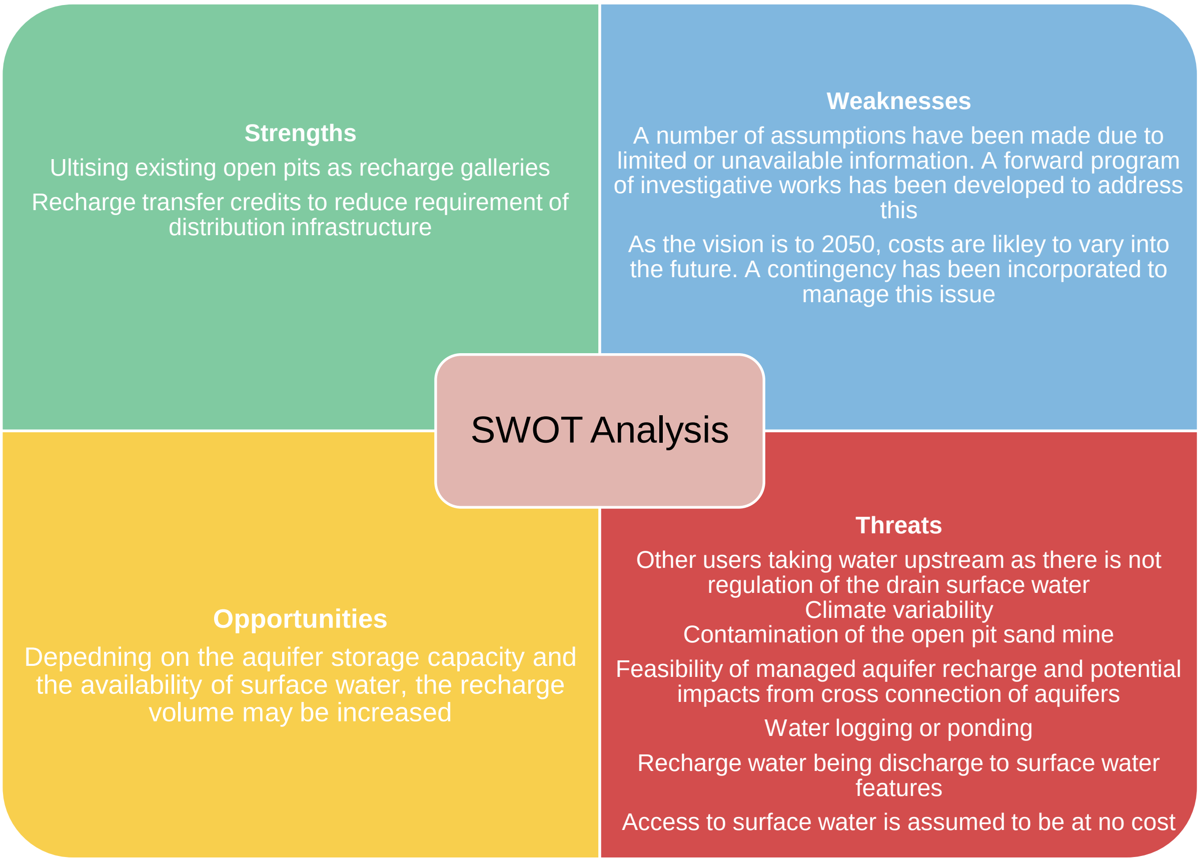
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 39 with a summary of breakdown and assumptions area presented in Appendix B.

Table 39: Summary of Cost Estimate – Option 10

CAPEX	$2,020,000
OPEX	$295,000
NPV (4-7% Real Discount Rate)	$10.25 -11.45 / kL

4.3.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of this precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



4.3.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 40 provides a recommended forward program of works for this conceptual design.

Table 40: Forward Program of Works – Option 10

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Conduct flow (rate and timing) monitoring of the creek line. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Discuss any permitting requirements with the relevant authorities. Confirm with DWER the requirements to harvest water from the drainage basin.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to determine the risk of water logging or ponding. The assessment can be completed in a staged approach to allow for sufficient hold points to identify any significant project risks. It is highly recommended that these investigations are to be completed prior to the detailed design.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

5 JARRAHDALE TOWNSHIP

5.1 WATER SUPPLY OPTION 11 – SURFACE WATER HARVEST FROM GOORALONG BROOK

5.1.1 Overview

The township of Jarrahdale currently sources water for irrigation from Water Corporation's scheme supply. Irrigation of public open space in the area is limited with approximately 3 ML sourced annually. The SSJ has identified that redevelopment of the Jarrahdale Oval Facility as one of their key community projects, currently the oval is not irrigated and is considered to be of a suitable standard for sporting or community events. The sporting facility is expected to have one senior sized sporting oval and associated facilities.

The township's permanent residential population is not expected to grow; however, the tourism / recreational community is expected to increase due to access to the state forest and the Millbrook Winery, which is a world-class popular destination for food and wine enthusiasts. The SSJ tourism strategy (Economic Development Advisory Committee, 2018) has identified the development of a tourist park (refer to Section 5.2) to service overnight and holiday visitors. The facility is designed to accommodate the equestrian community with facilities for stables, float parking and exercise areas. The demand for water for this development will include potable supplies as well as washdown and irrigation.

This concept considers harvesting of surface water from Gooralong Brook during winter for storage in above ground tanks or a dam structure for supply during summer via a pipe distribution network. Flow monitoring of the drainage line is not available and upstream dam structures are noted as being present which may impact yield. Flow and water quality monitoring is recommended to determine the reliable harvest volume and to inform the detailed design. The supply volume estimate is likely to be in the order of 20 to 200 ML/a. For the purpose of this conceptual design, a supply volume of 50 ML/a has been adopted as this will meet the irrigation requirements and a portion of the tourist park washdown requirements. The source water quality is unknown therefore the level of treatment is unclear, due to the low proposed recharge volumes, a moderate level of treatment has been proposed.

Figure 26 presents the process flow diagram for Concept 11 whilst Figure 27 provides a spatial representation. Table 41 presents the water balance for the system and Table 42 presents the water supply concept components. This concept assumes a harvest volume of 50 ML to ultimately supply 40 ML following losses through the system.

Table 41: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Gooralong Brook	50 ML/a	Flow monitoring is not available and catchment modelling has not been carried out. Based on the harvest of 50 ML over 75 days and 16 hours a day operation, a harvest rate of 12 L/s is proposed.
Above ground storage –drainage basin	One above ground structure with a 40 ML capacity A 200 kL balancing tank.	40 ML above ground storage facility A post treatment balancing tank of 200 kL will also be included.
Water Treatment	Treatment Rate 10 L/s	Peak demand will be during summer and holiday periods.
Irrigation Supply	40 ML/a	Assuming losses through the system from evaporation, backwash, the losses are assumed to be 20%.

Table 42: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water, above ground storage and Transfer Lines	Water from Gooralong Brook to the above ground storage facility.	A 40 ML above ground storage facility. A pump to transfer water from the brooke at 12 L/s. Transfer of water from the dam to the treatment facility.
Treatment	Depending on the end use and potential for environment and human health impacts, the minimum water quality requirements may be high. For the purpose of this assessment a moderate level of treatment has been adopted.	Allowance has been made for media filter and chlorination system. Valves, gauges and non-return valves included. A balancing storage tank of 200 kL has been adopted.

Parameter	Discussion	Allowance
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrological Investigations Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 1 km of distribution pipe has been allowed for.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

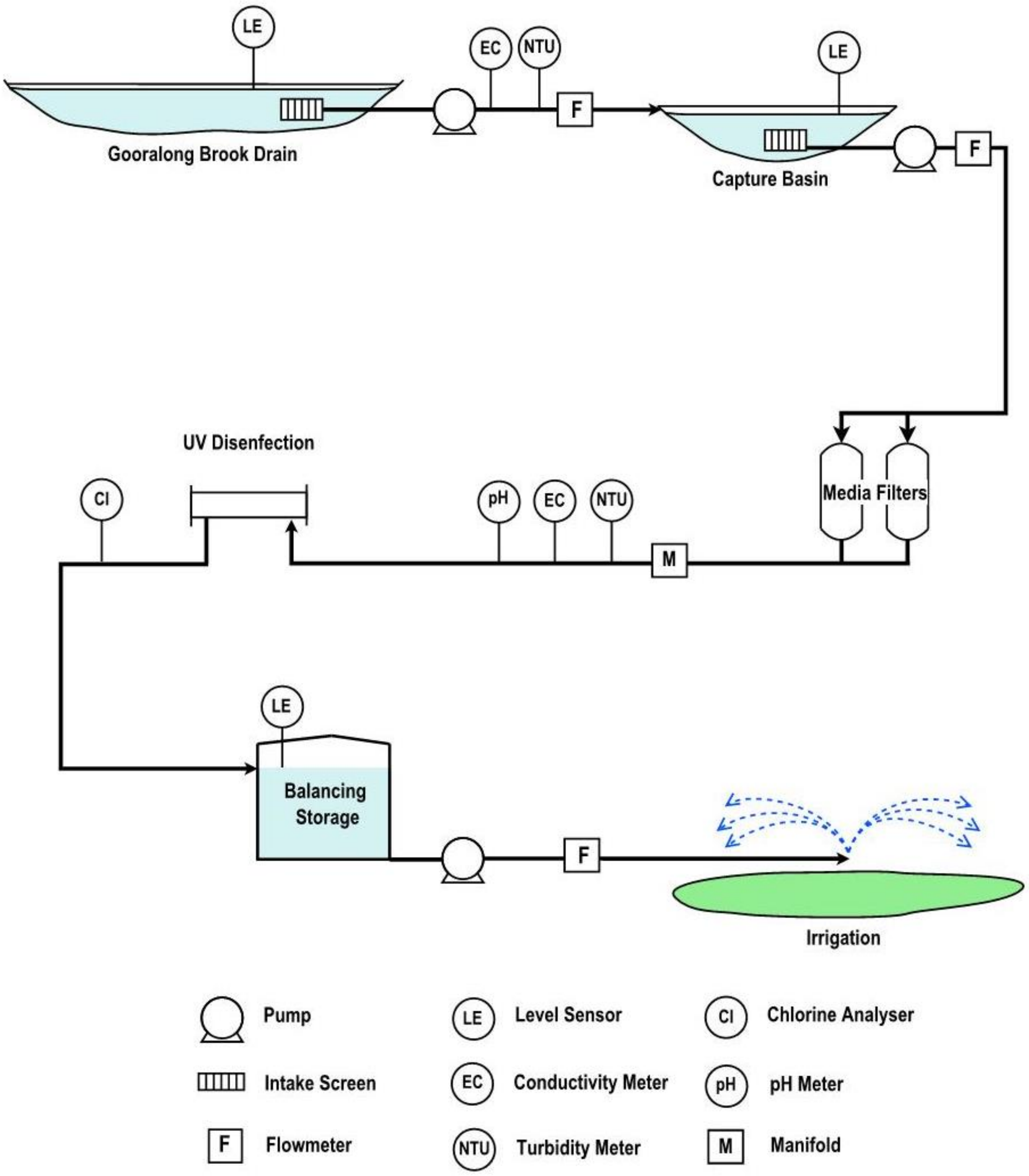
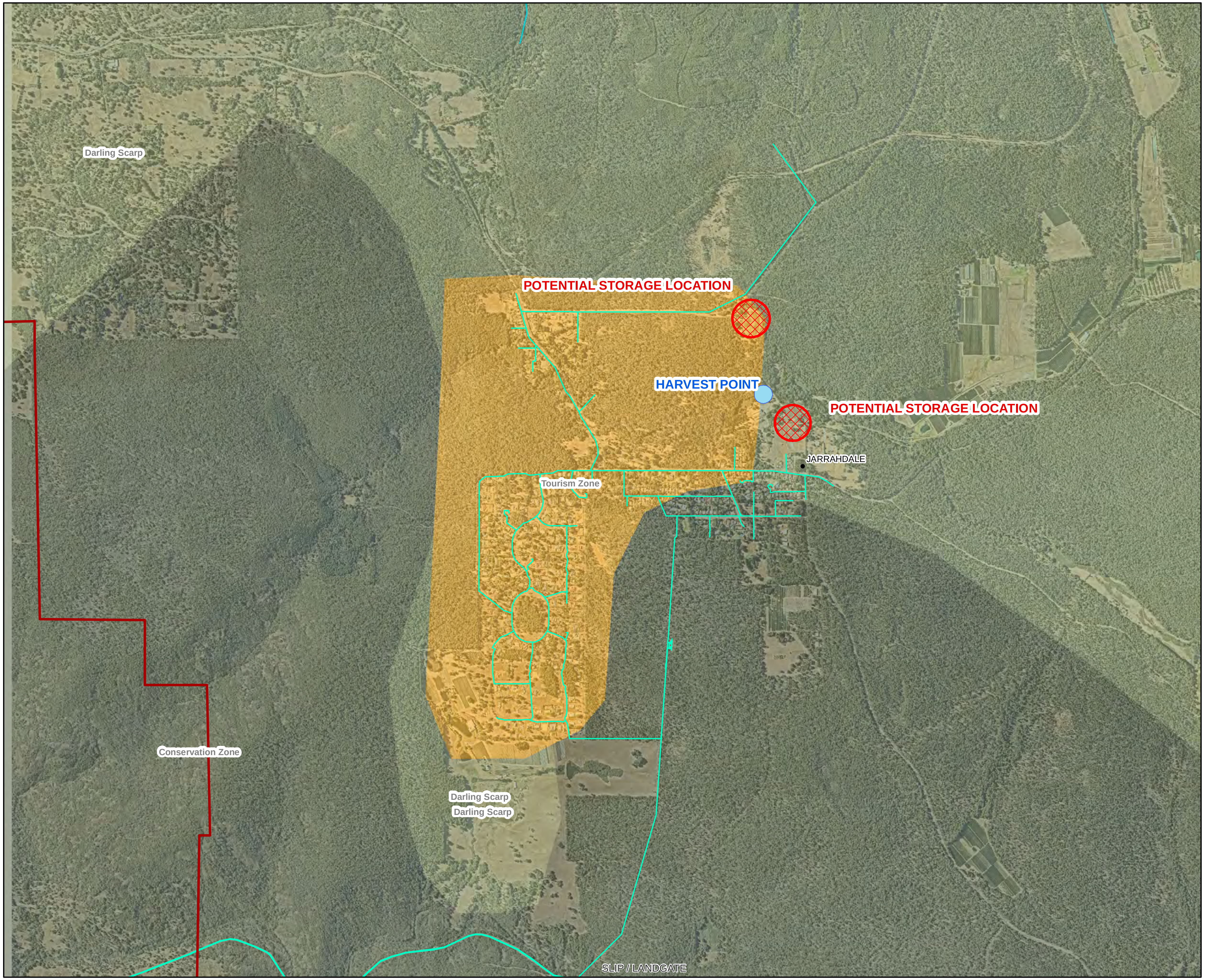
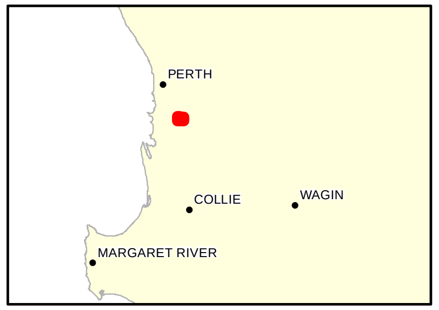


Figure 26: Operational Process Chart – Option 11





- Precinct Extent
- Potential Storage Location
- Harvest Point
- Highway
- Faults
- Water Delivery Pipe
- Coastal Waterline
- Estuarine
- Mainstream
- Major River
- Minor River
- Significant Stream
- Major Trib
- MinorTrib
- Minor Trib
- Insignificant Trib
- Inundation Area
- Paleo-Drainage Line
- Infrastructure

SJ2050 Proposed Landuse

- Equestrain Zone
- Intensive Agriculture Zone
- Conservation Zone
- Darling Scarp
- Urban Development Zone
- Tourism Zone
- Rural/Agricultural Use
- Industrial Land Use

N

0 250 500 750 m

Scale 1:20,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure **27**

Option 11- Harvest of Surface water from Gooralong Brook

5.1.2 Cost Estimate

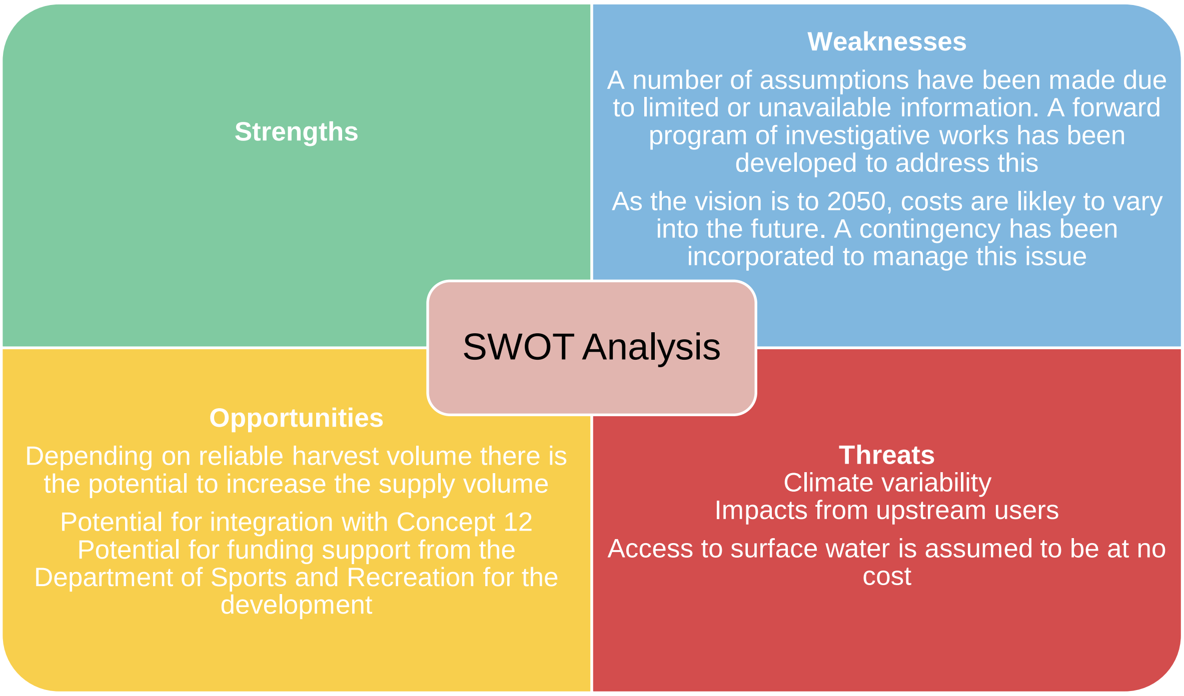
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 43 with a summary of breakdown and assumptions area presented in Appendix B.

Table 43: Summary of Cost Estimate – Option 11

CAPEX	$3,376,900
OPEX	$332,625
NPV (4-7% Real Discount Rate)	$13.15-15.15 / kL

5.1.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation for this precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.1.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 44 provides a recommended forward program of works for this conceptual design.

Table 44: Forward Program of Works – Option 11

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow modelling to estimate potential flows in the brook. Carry out water quality sampling to determine the level of treatment required. Review the cost- benefit analysis of treatment level versus end use – i.e. there may be a significant increase in the level of treatment required to supply the washdown area. Discuss any permitting requirements with the relevant authorities.

5.2 WATER SUPPLY OPTION 12 – CONSTRUCTION OF A DECENTRALISED WASTEWATER SYSTEM FOR THE TOURIST PARK

5.2.1 Overview

The development of a tourist park was identified as part of SSJ tourism strategy (Economic Development Advisory Committee, 2018) to service overnight and holiday visitors. The region is home to a number of accessible trails in the surrounding forest areas for equestrian, bike riding and walking purposes. Figure 28 presents a concept design which formed part of an expression of interest in 2018. The park concept includes 166 accommodation sites including camping and caravan sites, cabins, a wellness centre with units and tree houses. A water park has also been included.

The facility is designed to accommodate the equestrian community with facilities for stables, float parking and exercise areas.

Provision of potable water to the site is assumed to be sourced from Water Corporation's Scheme Water network. In addition to drinking water supplies, water would be required for washdown facilities and irrigation. Wastewater from the site would include the plumbed facilities plus caravan disposal sites. Based on Water Corporations assumption of 180 L/d of wastewater per person and a recycling water factor, the facility may generate between 5 ML/a and 20 ML/a of wastewater for reuse depending on occupation rates. There is opportunity to capture, treat and reuse the wastewater onsite for irrigation or supply irrigation water to the Jarrahdale Oval.

Wastewater from the site would be captured, treated and stored for irrigation. Water could be used in the wash down bay, however, would require a higher level of treatment, for the purposes of this concept the end use is irrigation only.

Figure 29 presents the process flow diagram for Concept 12. Table 45 presents the water balance for the system and Table 46 presents the water supply concept components. This concept assumes a harvest volume of 10 ML to ultimately supply 8 ML/a following losses through the system.

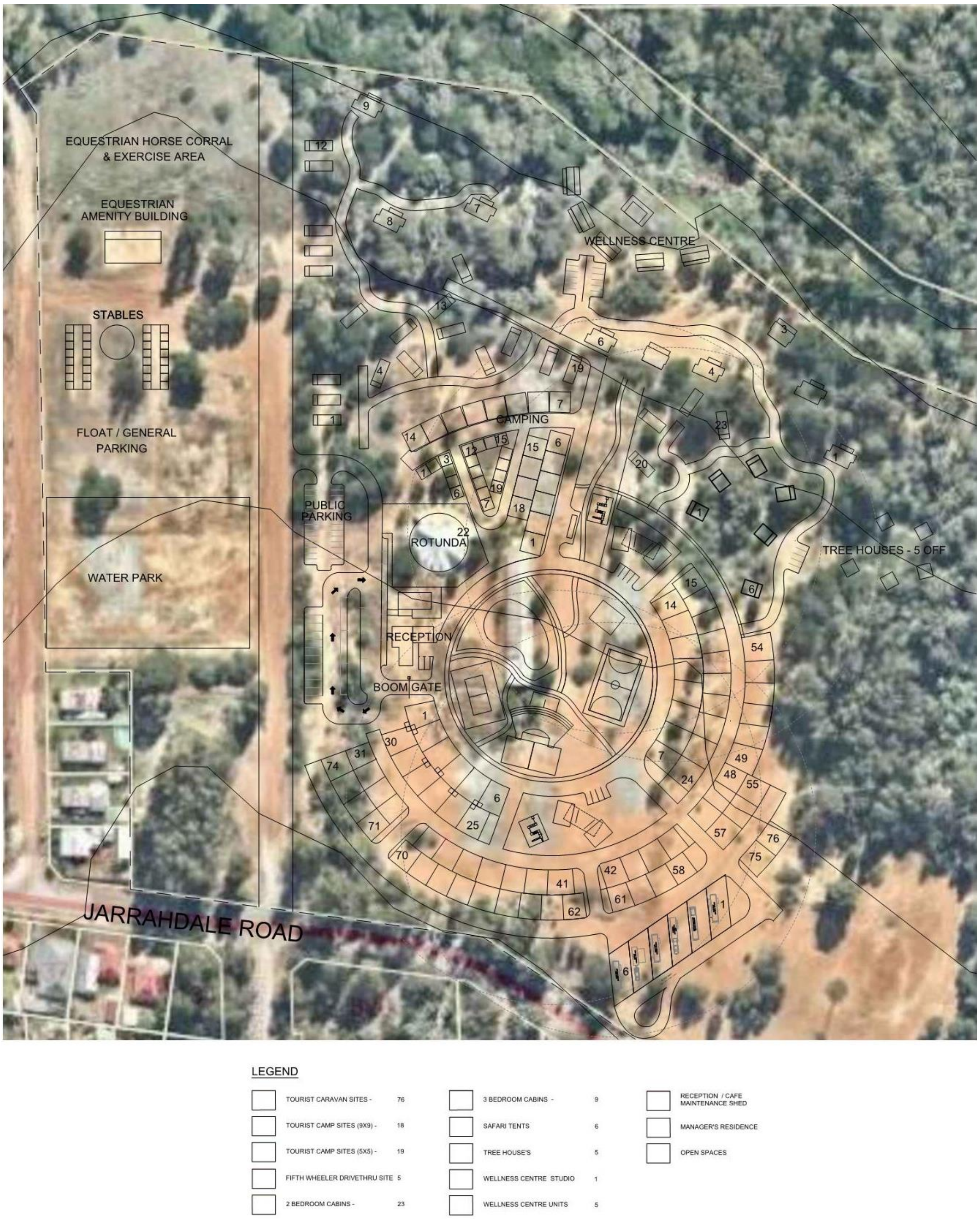


Figure 28: Tourist Park Concept Design

Table 45: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised tourist park system	10 ML/a	Volume has been based on the predicted occupancy rate. A supply volume could be up to 20 ML/a if the development occurs as designed with high occupancy rates.
Network to Treatment Plant	Nil	The internal pipe network has not been incorporated as this is required regardless of the wastewater system adopted. This cost forms part of the development cost.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 5 ML storage facility has been adopted Two 100 kL storage tanks have been included	The size of the storage volume will depend on a winter irrigation demand and the final number of facilities serviced.
Irrigation Supply	8 ML/a Irrigation Distribution Network 1 km	Assuming losses through the system from evaporation and backwash the losses are assumed to be 20%. Irrigation Distribution Network of 1 km has been adopted.

Table 46: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the concept design and average occupancy rates. If occupancy rates are higher, additional volumes may be available. The sewer capture network is difficult to determine as the development area and design. A nominal number of pump stations have been included, however, this would need to be revised as part of the detailed design.	10 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Primary and secondary treatment has been adopted.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter wash down demand.	A 5 ML storage facility has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 1 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

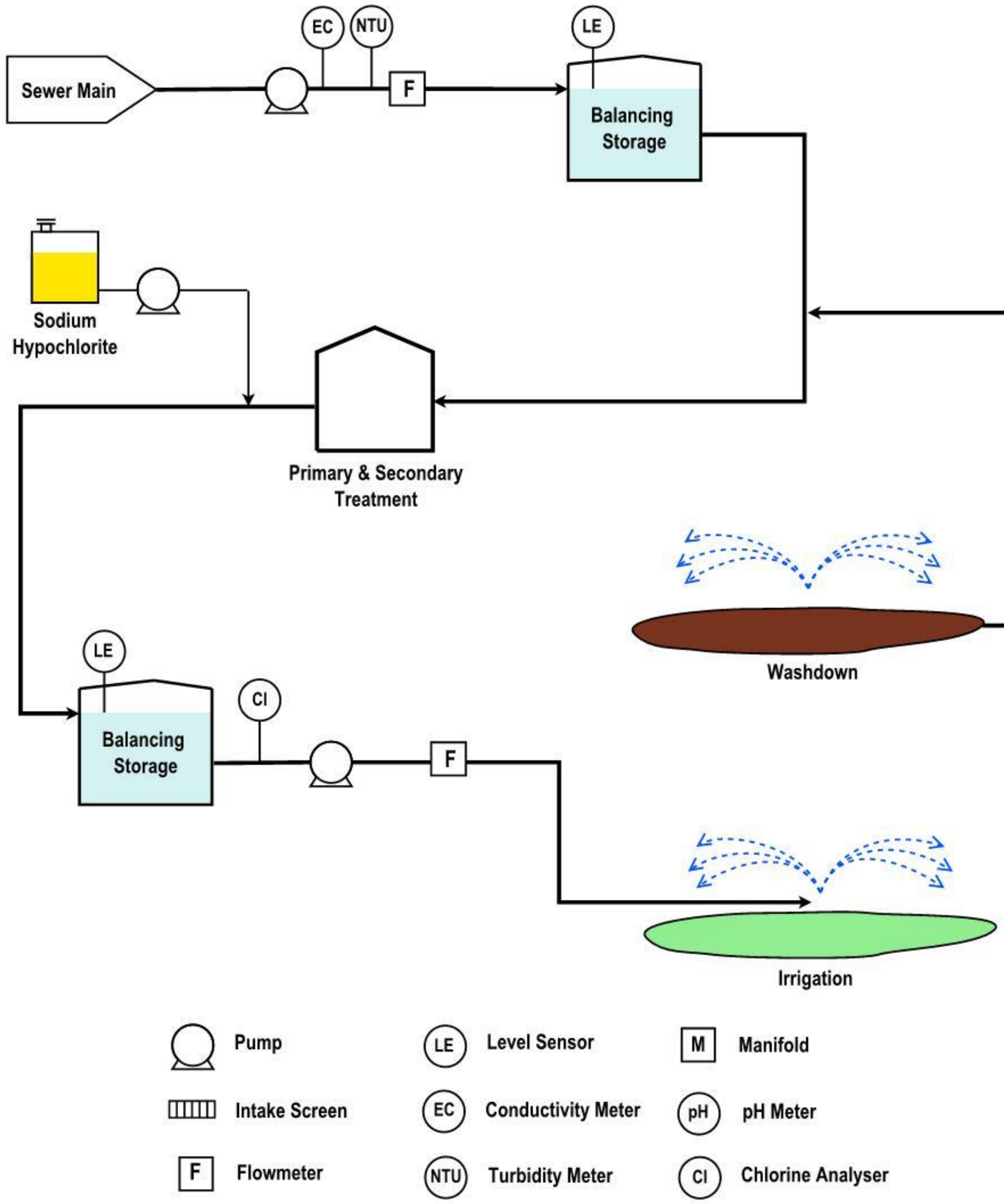


Figure 29: Operational Process Chart – Option 12

5.2.2 Cost Estimate

Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 47 with a summary of breakdown and assumptions area presented in Appendix B.

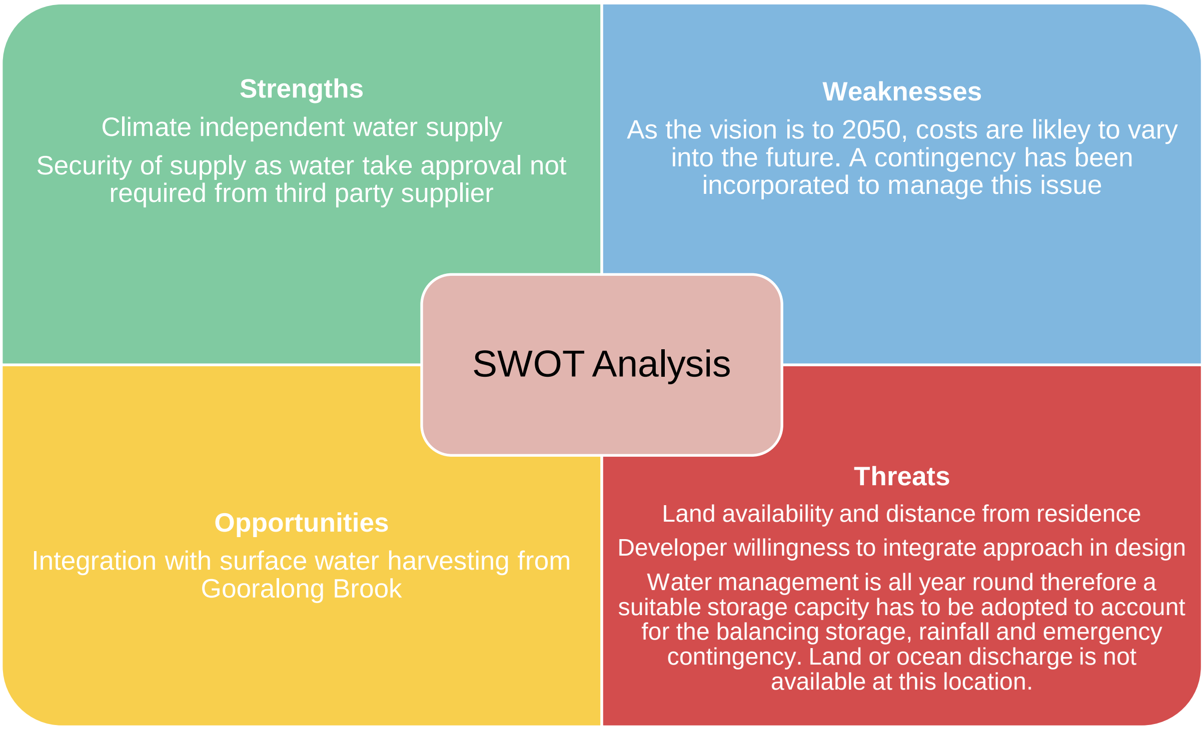
Cost offset against traditional wastewater management fees should be considered as, the capital will be required for the infrastructure, regardless.

Table 47: Summary of Cost Estimate – Option 12

CAPEX	$2,126,500
OPEX	$520,500
NPV (4-7% Real Discount Rate)	$80.30-86.50 / kL

5.2.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the majority of the requirements for irrigation of Jarrahdale Oval. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.2.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. Table 48 provides a recommended forward program of works for this conceptual design.

Table 48: Forward Program of Works – Option 12

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities. Willingness of developers to integrate approach

6 SUMMARY OF SHORT OPTIONS

This section provides a summary of the short list of water supply opportunities to source water to meet predicted demand across the four precincts in the Shire of Serpentine Jarrahdale. Table 49 below presents a summary of the 12 water supply concepts considered, the potential yield, capital costs and unit cost of water. For each precinct, the predicted demand is also outlined. The concepts have been developed based on the assumption that the end use is restricted irrigation, if unrestricted irrigation is required then additional treatment may be required in some circumstances.

The aim is to identify a fit-for-purpose water supply to meet SSJ's predicted public open space irrigation demand. This will allow SSJ to reduce their reliance of scheme water now and in the future and provide the recreational parks and amenities for the community.

For comparative purposes, the cost to supply fit-for-purpose water would traditionally be compared to the cost of scheme water. This is relevant if scheme water is available for this purpose, if Water Corporation's system cannot meet the demand then the cost comparison should be against the various alternative water supplies. The current cost of scheme water for SSJ is $2.457 /kL, in some circumstances it may be economically more feasible to source scheme water assuming the infrastructure is available.

The concepts where water is sourced from Water Corporation sewer mains or from a drainage channel, no supply charge has been adopted. Any supply charge would be over and above the rate presented in Table 49. Where a dedicated wastewater system is proposed, financial income from residential rates for sewer have not been considered in the economic analysis and this provides an income source that can offset the costs show in this report.

The larger scale options presented here are scalable and can be developed over time allowing SSJ to manage the capital investment and meet demand whilst managing their risk.

Table 49: Summary of Short List Options Assessment

Region	Demand (ML)	Option	Description	Yield (ML/a)	CAPEX	Cost per kL (4-7%RDR)
Byford – Oakford	555	1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	4,000	$74.6 M	$2.15-$2.60
		1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	4,000	$134.1 M	$2.10-$2.92
		2	Integration of Option 1 with Sewer Mining	4,800	$99.5 M	$2.20-$2.65
		3	Woodland Grove Sporting Facility	32	$3.2 M	$17.70-$20.10
Oldbury – Mundijong	750	4	Option 1 – Alternative Location	4,000	$74.6 M	$2.15-$2.60
		5	Mundijong Decentralised Wastewater System	800	$23.9 M	$3.95-$4.70
		6	Decentralised Wastewater System with Surface Water from Manjedal Brook	3,200	$77.99 M	$3.25-$3.85
		7	Recharge Runoff from Mundijong Whitby District Sporting Facility	40	$2.5 M	$14.15-$15.70
Hopeland – Serpentine - Keysbrook	340	8	Harvest of Surface Water Flows from Punrack Drain	4,000	$74.6 M	$2.15-$2.60
		9	Construction of a Decentralised Wastewater System in Serpentine	120	$8.98 M	$2.45-$2.75

Region	Demand (ML)	Option	Description	Yield (ML/a)	CAPEX	Cost per kL (4-7%RDR)
		10	Gallery Recharge into Decommissioned Open Pit Mines	40	$2 M	$10.25-$11.45
Jarrahdale	32	11	Surface Water Harvesting from Gooralong Brook	32	$3.38 M	$13.15-$15.15
		12	Construction of a Decentralised Wastewater System for the Tourist Park	8	$2.12 M	$80.30-$86.50

A number of the water supply concepts are economically unviable based on the current price of water, however, in the future these options may become viable if:

- The price of water increases.
- Water scarcity worsens, and scheme water is not available.
- External funding becomes available to subsidise the capital costs (I.e. Federal Government Grants).
- Assumptions in the underlying concept design vary (i.e. the level of treatment required to inject into the aquifer).

The most appropriate option for each precinct will depend on the primary driver at the time, where funding becomes available, the agricultural precinct develops or urbanisation occurs at a different rate to that predicted. Prior to finalising the implementation of the concepts additional investigations should be undertaken to further understand the requirements.

A significant risk to the viability of the identified concepts is the water quality treatment requirements associated with Managed Aquifer Recharge. The target aquifers are typically fresh (less than 500 mg/L), therefore, the source water may need to be treated to near potable standards prior to recharge as not to reduce the overall quality or beneficial end use of the aquifer system. As this study is high-level, a detailed assessment is required to determine the risk and therefore appropriate level of treatment, which was beyond the scope of this stage of the study. The risk level will also likely vary in different locations.

At this initial stage a high level of treatment, including membrane filtration, has been adopted in systems where a large volume is being recharged to the aquifer. The cost of such a system is significant and could be the difference between the concept being viable or unviable. For example, for Option 1, the cost per kL price is $2.15 to $2.60 (4-7% RDR) with membrane but reduces to $1.50 to $1.85 (4-7% RDR) if a lower standard of treatment is acceptable.

A detailed assessment into the feasibility of MAR in the particular regions of interest and detailed discussion with DWER along with a risk assessment should be developed as the next stage of works. The aim of the assessment is to confirm the viability, determine if recharge credit transfers are viable and to what extent and the level of water treatment required. The inclusions and cost of each option should be reviewed following this assessment.

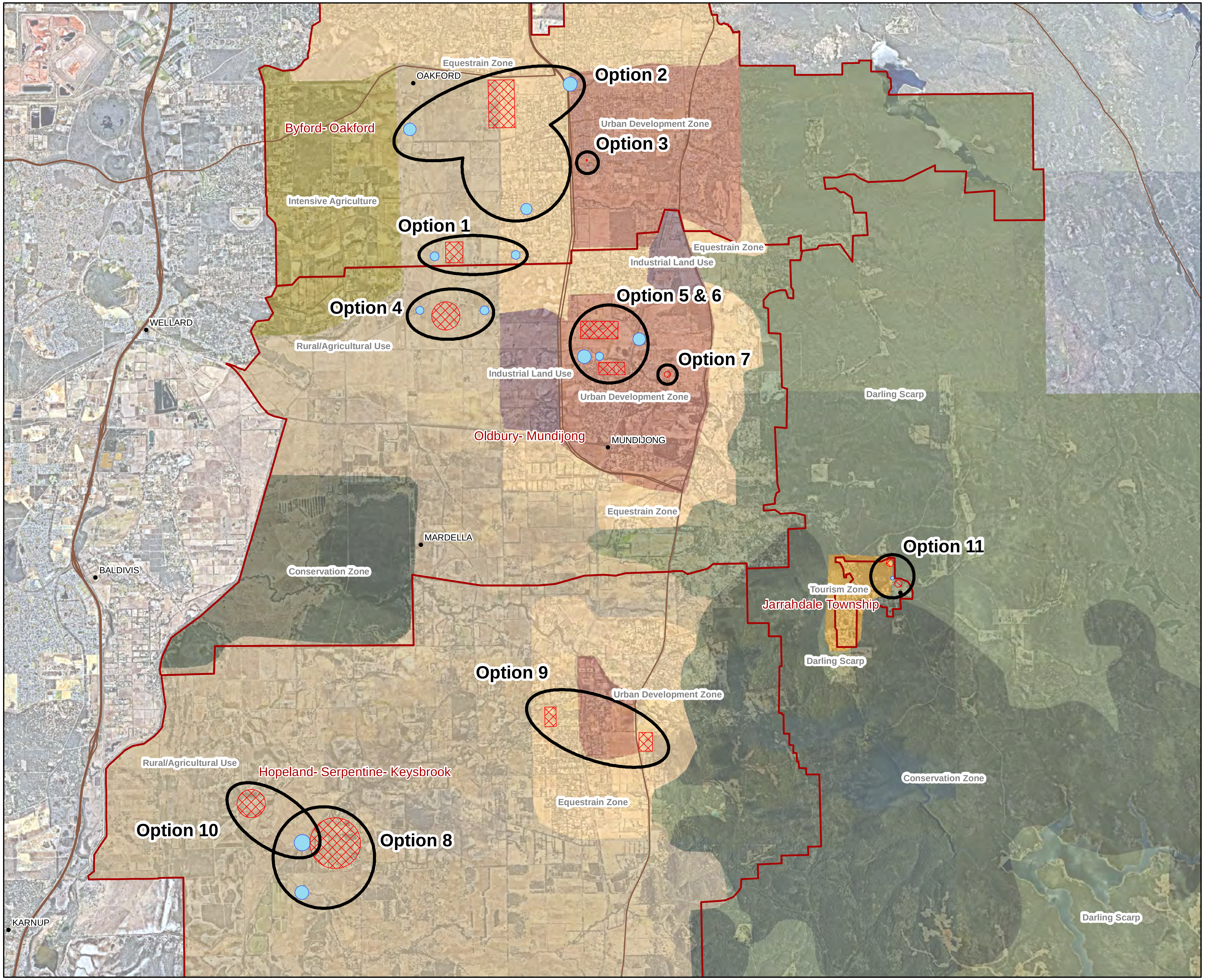
Funding opportunities should also be sought, from the Federal, or State governments to assist in offsetting the capital expenditure for the water supply concepts. If funding can be sought for all or a portion of the capital construction costs of a system, this increases the viability of the system. For example, with Option 1 (with membrane) the cost per kL price is $2.15 to $2.60 (4-7% RDR), however, if 50% of the capital costs are funded through a government scheme then the cost per kL price reduces to $1.70 to $1.90 (4-7% RDR).

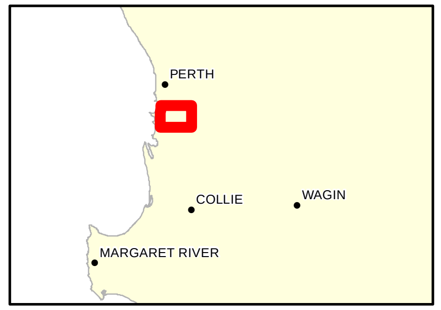
SSJ are considering their long term water supply requirements to ensure that the area has security into the future, being proactive means that there is sufficient time to implement the necessary investigation works and reviewing the potential risks or opportunities for each option. Undertaking the recommended forward program of works enables SSJ to be proactive instead of reactive and be in a position to understand their options and apply for funding when it becomes available. If SSJ is considering adopting the MAR technique, it is strongly recommended that the investigations are undertaken in the short terms the impact on the system viability could be significant.

APPENDIX A

SHORT OPTIONS

CONCEPT MAP





Shortlisted Option
Precinct Extent
Potential Storage Location
Harvest Point
Highway

SJ2050 Proposed Landuse

Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

N
0 1,000 2,000 3,000 m
Scale 1:100,000 @ A3
Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Apendix A

Overall Shortlist Options

APPENDIX B

COST ESTIMATES

At this stage the economic modelling is considered to be high level. A number of assumptions have been necessary due to the number of data gaps and risk presented in this assessment. The economic assessment is considered to provide a suitable estimate to ±40% for planning and budgeting purposes. Assumptions underpinning the economic modelling are presented in this Section. Pre-feasibility investigations have not been incorporated into the CAPEX estimates.

The Net Present Value (NPV) has been calculated to determine an equivalent cost per kilolitre rate allowing for capital and operational costs over the life of the scheme. This can be used to compare the financial viability of the option to other source water supplies. The NPV assessment assumptions are outlined in Table A.1.

Table A.1: Net Present Value Assumptions

<table>
<tr><th colspan="2">Period</th><th>Full Life Cycle</th></tr>
<tr><td colspan="2">Real Discount Rate</td><td>4-7%</td></tr>
<tr><td rowspan="5">Asset Life</td><td>Civil Elements (including pipes, conduits)</td><td>70</td></tr>
<tr><td>Above Ground Storage</td><td>50</td></tr>
<tr><td>Electrical Elements (including bores, controls, power)</td><td>30</td></tr>
<tr><td>Mechanical Elements (including pumps, fittings)</td><td>15</td></tr>
<tr><td>Treatment Equipment</td><td>10-30</td></tr>
</table>

The NPV has considered that capital costs are incurred in the year of construction. The NPV assessment has considered the design life of the asset such that if an asset has a design life less than the system design life, the full cost is renewed within the NPV assessment at the end of the asset design life e.g. a design life of 10 years and a project life of 15 years would see the asset cost be incurred at the construction phase and renewed following 10 years of the project life.

Danni Haworth
SENIOR HYDROGEOLOGIST

Telephone: 08 8223 7433

Email: dhaworth@wga.com.au

ADELAIDE
60 Wyatt St
Adelaide SA 5000
Telephone: 08 8223 7433
Facsimile: 08 8232 0967

MELBOURNE
Level 2, 31 Market St
South Melbourne VIC 3205
Telephone: 03 9696 9522

PERTH
Level 1, 66 Kings Park Road
West Perth WA 6005
Telephone: 08 9336 6528

DARWIN
Suite 7/9 Keith Ln
Fannie Bay NT 0820
Telephone: 08 8941 1678
Facsimile: 08 8941 5060

WHYALLA
1/15 Darling Tce
Whyalla SA 5600
Phone: 08 8644 0432

WALLBRIDGE GILBERT AZTEC
www.wga.com.au