Stirling Alliance

Stirling City Centre
Utilities Infrastructure Strategy
Preferred Concept - Volume 1

December 2013

Executive summary

This Executive Summary is subject to, and must be read in conjunction with, the limitations set out in Section 1.6 and the assumptions and qualifications contained throughout the Report.

Background

The Stirling City Centre (SCC) is a designated Strategic Metropolitan Centre under Directions 2031 and aims to create an active and diverse urban centre within the inner metropolitan area of Perth. The Centre will be a transit oriented development accommodating 25,000 residents and 30,000 workers.

GHD has been commissioned to develop a Utilities Infrastructure Strategy for the SCC to meet these aims. GHD built on previous studies to provide a comprehensive list of potential initiatives and technologies (GHD 2013). This report was used to inform the development of a Best Available Technology (BAT) strategy to service the SCC. This BAT strategy is documented in the previous report, together with a Business-as-Usual (BaU) approach to servicing. The primary purpose of documenting the BaU approach was to benchmark the BAT strategy in respect of life cycle costs and sustainability performance.

The alternative strategies set out in that report were presented to the SCC Master Strategy Workshop in August 2013, and subsequently to a workshop of the Infrastructure Working Group in September 2013.

Following the workshop, the BAT approach has been refined into a final preferred servicing strategy for the SCC which is presented in this report.

This report (Volume 1) documents the strategy development for the entire Structure Plan area. A companion document (Volume 2) sets out how the strategy will be applied to Stage 1 of the Structure Plan area.

Business as Usual Utility Service Provision

The Stirling Alliance has revised the estimated yields and the report is based on these. These latest yields are still estimates of the ultimate yield for the Structure Plan area and are derived from the latest configuration of developable area and car parking limitation mechanisms. The key information is reproduced in the table below. Residential population figures are based on the assumption of 1.8 persons per dwelling, and Nett Lettable Area (NLA) is assumed to be 85.5% of gross floor area (GFA).

	ULTIMATE DEVELOPMENT YIELD								
	Persons/dwelling		1.8						
Precinct	Dwellings		Population	Office	Health / Welfare / Community	Retail	Entertain't / Recreation / Culture	Total Non-residential	Total
	No.	Floor Space (m2 NLA)							
Southern Precinct	1,550	127,500	2,790	40,910	2,980	119,430	7,680	171,000	298,500
Station Precinct	2,935	254,000	5,283	278,470	4,091	58,426	5,161	346,148	600,148
Innaloo Precinct	1,770	212,400	3,186	0	2,660	400	0	3,060	215,460
Northern Precinct	930	97,350	1,674	16,350	27,515	500	0	44,365	141,715
Woodlands Precinct	1,060	95,400	1,908	12,670	2,015	13,065	0	27,750	123,150
Osborne Park Precinct	2,535	202,800	4,563	101,130	5,460	184,810	0	291,400	494,200
TOTALS	10,780	989,450	19,404	449,530	44,721	376,631	12,841	883,723	1,873,173
	No.	Floor Space (m2 GFA)							
Southern Precinct	1,550	149,123	2,790	47,848	3,485	139,684	8,982	200,000	349,123
Station Precinct	2,935	297,076	5,283	325,696	4,785	68,335	6,036	404,851	701,927
Innaloo Precinct	1,770	248,421	3,186	-	3,111	468	-	3,579	252,000
Northern Precinct	930	113,860	1,674	19,123	32,181	585	-	51,889	165,749
Woodlands Precinct	1,060	111,579	1,908	14,819	2,357	15,281	-	32,456	144,035
Osborne Park Precinct	2,535	237,193	4,563	118,281	6,386	216,152	-	340,819	578,012
TOTALS	10,780	1,157,251	19,404	525,766	52,305	440,504	15,019	1,033,594	2,190,846

Power

The existing Western Power substation at Osborne Park is part of the Northern Terminal Load Area. The substation is served by 3 no. 132kV overhead transmission lines. The current load supplied by the substation is 65 MVA. According to Western Power's Network Capacity Mapping Tool at the time of writing, the residual capacity of the substation is ≤ 10 MVA. High voltage distribution feeders emanating from the substation currently service surrounding buildings.

The development of the SCC will add significant additional demand to the local power grid. Peak loads from conventional development are depicted below.

Land Use	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Residential	13	12.8
Office	51	23.1
Retail	67	25.0
Entertainment and Community	43	2.5
Peak Demand on Grid		63.4

The annual electricity demand arising from this approach (Business as Usual) would be approximately 300 GWh per annum.

From Western Power advice the following will be required:

- retention of the existing Osborne Park substation, which has a capacity of 65 MVA;
- acquisition of a new substation in the area, involving:
- two additional 66MVA transformers by 2017/18;
- installation of an additional 66MVA transformer by 2028/29;
- two additional 66MVA by 2055/56; and
- approximately 20 new distribution feeders over time.

The application of 5 star building efficiency measures could significantly reduce the peak load to around 36 MW pa (a 43% reduction).

Land Use	% Reduction	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Residential (5 Star NABERS)	45%	7	7.0
Office (5 Star NABERS)	27%	38	16.9
Retail (5 Star NABERS)	63%	25	9.3
Entertainment and Community (5 Star NABERS)	83%	7	0.4
Peak Demand on Grid			35.8

Gas

A comprehensive medium, and medium / low pressure system currently services the site, with service pressure between 15 and 70kPa. The major pipes are located along Karrinyup Road, Odin Street, Hertha Road, Ellen Stirling Boulevard, Oswald Street, Scarborough Beach Road, King Edward Road, and Cedric Street.

The closest high pressure gas main is located west on Northstead Street, approximately 2.5km away from the western boundary of the site. Additional high pressure gas mains are located in

Balcatta Road and Dumfries Road; both located approximately 3.5km north and south of the site respectively.

Based on information provided to ATCO Gas about the proposed yield, they have estimated that the gas demand for BaU development will be 381,000 GJ per annum.

Water

The SCC spans three water supply zones, these being:

- West Yokine – Hamersley in the north;
- Bold Park in the west; and
- Mount Hawthorn in the east.

An extensive water distribution main system surrounds the boundary of the proposed development.

The reticulation networks currently source water from various mains, and no single main dominates the servicing to the current site. The 150mm reticulation mains are primarily found in the south east industrial portion of the site, which sources water from the main in Scarborough Beach Road.

The development will increase the water demand on the system by approximately 2.9 GL pa. The Water Corporation are planning to construct a new 600mm diameter steel main pipe line from the existing pipeline located at the junction of Karrinyup Road and Cedric Street. This pipe is to extend south down Cedric Street. It is then to continue south, under the freeway, ending on the east side of Flax Way. A 400mm diameter and 300mm diameter steel branch is to extend off the proposed 600mm pipe.

The adoption of “waterwise” measures at SCC would reduce the quantity of water significantly as shown in the table below.

Totals (ML/year)	Conventional demand	Waterwise demand
Ttl Drinking water	1,500	1,014
Total NDW	1,432	943
Total	**2,932**	**1,957**

Wastewater

The SCC area spans the catchments of several Water Corporation wastewater pump stations, which are ultimately serviced by two wastewater treatment plants (WWTP). Flows from the southern portion of the area (generally the area south of Scarborough Beach Road) are pumped to the Perth Main Sewer, which gravitates wastewater to the Subiaco WWTP. The majority of the site pumps into the Hamersley Main Sewer, which gravitates wastewater to the Beenyup WWTP. Each existing catchment zone (with one exception) gravitates to a downstream pump station.

Business as usual wastewater flows are estimated at 2.5 GL pa, reducing to 1.7 GL pa for waterwise development.

The required wastewater infrastructure required to meet this demand has been based on an initial Water Corporation study, subsequently updated to reflect the yield analysis for Stirling. The assessments are preliminary only, and cannot be taken to be definitive at this stage.

The SCC development will have a significant impact on long term flows. Flows associated with pump stations that are within the catchment of the Beenyup wastewater treatment plant (WWTP) are significantly greater that those assumed in current long term wastewater conveyance planning.

The Water Corporation has presented two options that may be implemented to upgrade the wastewater headworks to accommodate for the projected yield. Both options have been projected to have similar cost implications for the project. For the purposes of this report one of these options has been assumed, which involves a combination of upgrading certain gravity lines, pump stations and re-routing flows in the region of the Twyford Place Pump Station, the Sheldrake Street Pump Station and the Civic Place Pump Station.

This increased flow means that the Main Sewer itself will require upgrading in the future (approximately 2035). This will involve the construction of at least 5km of new sewer mains to augment the capacity of the existing sewers. Whilst the SCC development is not the sole source of the increased flow to the Hamersley Main Sewer, it is a major contributor and a proportion of total costs have been assumed and included in the cost estimates for this project.

Drainage

The current site is serviced by underground reinforced concrete pit and pipe systems that accommodate minor storm events, and overland flow paths governed by the road reserves that manage the major storm events, which eventually flow into the main drain.

The current site drains into the Water Corporation owned 5m wide open channel / reinforced concrete pipe main drain which is proposed to be converted to an urban stream as part of the SCC development. This main drain runs from the north east to the south west of the development. The majority of the site utilises this main drain, with the exception of a small northern portion of the site which will drain into smaller basins located north in the Birralee Reserve and Yuluma Park.

All new road reserves will require a pit and pipe system to keep stormwater off the road pavement during medium frequency events.

Telecommunications

Telstra and Optus 3G wireless coverage currently exists throughout the Precinct with typical speeds being between 1.1Mbps and 20Mbps. 4G coverage in the Precinct is very limited at present. However, optical fibre has significant speed and capacity advantages over both mobile and copper services. Therefore the roll-out of the NBN within the Precinct over the next 3 yearswill significantly benefit the precinct's businesses and residents if they opt for fibre connections.

Services currently are being provided via satellite within the precinct (e.g. Foxtel) will remain. Over the next 3 years it is expected that Foxtel will migrate to the NBN infrastructure. These services will then be provided by NBN Co.

Waste

The City of Stirling operates a single bin system for domestic waste collection. Council's Balcatta Transfer Station (6 km from SCC) is a large but simple facility and is currently operating at full capacity. Council has a contractor that separates organic material and recyclables using simple waste separation technology; trommels, magnets, eddy current and screens. The organic material is composted by the contractor Atlas on its farm outside Perth. Council advises that diversion is about 65%.

Residual waste is disposed of at the Anaeco DiCOM advanced waste treatment (AWT) facility commissioned by the Western Regional Metropolitan Council (WMRC). This facility has a capacity of 55,000 tonnes per year of which Stirling provides 22,000 tonnes per year. Any overflow is disposed of at the Red Hill Landfill, operated by the Eastern Regional Metropolitan Council (EMRC). This landfill has just been extended and the EMRC has no plans for an AWT facility.

GHD has modelled waste generation rates in the proposed SCC Development area and for the City of Stirling as a whole. GHD estimates that by the time of the ultimate development, about 52,000 tonnes of waste will be generated from the SCC area. Of this about 12,800 tonnes will be organics, 33,800 tonnes will recyclables and about 5,100 tonnes will be residual. On total build-out the SCC will contribute some 20% of the total waste quantities for the City of Stirling.

If the SCC development went ahead without any changes to the waste collection and processing system, Council would continue to collect kerbside waste from residential dwellings. Council. Commercial contractors, would also continue to collect waste from businesses, offices and other commercial premises in the SCC area.

The greatest effect of this will be experienced in the Station, Osborne Park and Southern Precincts where more waste will mean more collection vehicle movements. The amounts of waste generated from the Northern, Western and Woodlands Precincts will be relatively small and could probably be incorporated into existing waste collection systems.

A number of measures would have to be put in place in the Station, Osborne Park and Southern Precincts to ensure that waste collection by conventional business as usual means, (bins and trucks and delivery to the Balcatta Transfer Station or other disposal or processing sites) could be undertaken efficiently and without disrupting vehicular and pedestrian traffic, retail and office activities and causing significant visual disamenity.

Best Available Technology Servicing Solution

Graphics depicting the proposed concepts are set out in the figures at the end of this section.

Zoning

Previously it was proposed to provide distributed thermal energy and non-drinking services throughout the SCC area. However it has been assessed by GHD that this is unlikely to be feasible in the purely residential precincts (Woodlands, Northern and Innaloo) as development in these areas is likely to proceed in an ad-hoc lot by lot manner over a number of decades. Accordingly the strategy has been modified to limit the distribution of these services to the mixed use elements of the SCC (referred to in the following as the distributed services zone).

Locally produced electricity will be available throughout the development. Outside of the distributed services zone, i.e. in the purely residential areas, the following has been assumed:

- Thermal energy demands at the building scale will be met by electricity, e.g. high performance heat pump systems; and
- Non-drinking water will either not be available or will be provided at the lot scale, e.g through building scale wastewater or greywater recycling.

Energy

Energy Efficiency

As identified in previous reports by both Parsons Brinckerhoff and Kinesis, energy efficient building design is a core requirement of the BAT strategy. It is assumed that this will be accompanied by best practice measures in respect of occupant behaviour, including the use of smart grid / meter technology to provide feedback on energy consumption and comparisons with other consumers at a local and metropolitan wide basis. Energy efficient building design will need to be a requirement within the planning approval process.

Energy Source Options

The overall objective of the energy strategy is to:

- Reduce the peak and annual electricity demands of the development;
- Remove the thermal loads from the electricity system by providing a distributed thermal energy source for heating and cooling purposes; and
- Achieve energy self-sufficiency on an annual basis while utilising the electricity grid for balancing supply and demand.

Two alternatives have been retained in the final strategy. The trigeneration option identified in the previous report has been retained but modified. The solar PV / geothermal option has been retained.

Trigeneration / Solar PV Option

Previously it was proposed by GHD that the feedstock for the gas engines would be derived from a waste-to-energy process, namely gasification of high calorific value wastes from across the City Stirling. It has now been determined by GHD that the feasibility of this approach is questionable. Accordingly it is now proposed that the gas engines will be natural gas from the ATCO network. The electrical output of the gas engines will be supplemented with solar PV and electrical storage.

Under the trigeneration scenario, heat from the gas engines will provide a source of heat energy circulated to SCC buildings via a district hot water loop. This heat will be used for space heating and water heating. Co-located absorption and electric chillers will utilise the heat to produce cold water, which will similarly be circulated through a district cold water loop.

This service will remove the cooling load from the electricity system completely in the distributed services zone, eliminating the major driver of power system upgrades on the South West Interconnected System (SWIS) in recent times. The absorption chillers will be supplemented with electric chillers and chilled water storage.

Solar PV / Geothermal Option

Under this scenario, all electricity will be supplied from grid connected rooftop solar photovoltaics (solar PV). Sufficient roof space is available both within the development area (Innaloo shopping centre, IKEA and new developments) and in the adjacent Osborne Park light industrial area. A total of approximately 190,000m2 would be required to meet the peak electrical load. The total roof area of the IKEA building is around 15,000m2. The solar system will be coupled with electrical energy storage to meet the evening peak demand.

Under the solar / geothermal scenario the thermal heat source will be derived from geothermal energy. Based on interpretation from the Geothermal Centre of Excellence at the University of WA, this would require a geothermal bore depth of 1,500 - 3,000m for the source to be sufficient to provide the necessary energy to drive the absorption chillers to meet the cooling load.

Water

Water Efficiency

It is assumed and recommended that best practice water efficiency practices would be mandated in the development, including appliances meeting the highest available Water Efficiency Labelling Standards (WELS)[1], and for irrigation. This would be complemented with measures in respect of occupant behaviour, including the use of smart water meter technology to provide feedback on energy consumption and comparisons with other consumers at a local and metropolitan wide basis.

[1] http://www.waterrating.gov.au/

Water and Wastewater

In a parallel commission, GHD has developed a preferred integrated water cycle solution for the SCC. In this work various alternative water supply options were evaluated, including roof collected rainwater, stormwater, groundwater and recycled wastewater. GHD determined that only recycled wastewater was available in sufficient quantities to be a complete solution. Greywater was not considered as an independent source, as the treatment requirements are significant when it is stored, which would be necessary in this case. Under such arrangements separate and parallel treatment systems for greywater and remaining wastewater would be required.

The preferred scenario is therefore to recycle all wastewater and return this as a non-drinking water (NDW) source for irrigation, toilet flushing and cold water for clothes washing. These uses are likely to be acceptable to the Department of Health, subject of course to appropriate risk management. This NDW service will be limited to the distributed services zone.

The demand analysis shows that there is sufficient recycled water to meet the total non-drinking water demand in summer, while in winter when the irrigation demand is small / negligible there is an excess of recycled water. This high quality excess water will be locally discharged to the superficial aquifer and hence contribute to offsetting other abstraction in the area (from irrigation of public open space) and the retention of groundwater levels.

It is proposed that scheme water provided by the Water Corporation through the Integrated Water Supply Scheme (IWSS) is used for all other uses (i.e. those uses requiring drinking water quality).

Drainage

The draft District Water Management Strategy requires best practice water sensitive urban design (WSUD) features for the development. Where possible, all stormwater from frequent events will be collected / treated on lots, and street drainage will incorporate rain gardens, swales and other management devices. Less frequent, higher rainfall events will utilise the street drainage system to convey water through the existing stormwater system. Stormwater within the relevant catchment will be discharged into the urban stream corridor where it will be naturally treated and conveyed into the steam channel.

Design of the streetscape WSUD features and of the urban stream are the subject of separate commissions, and are accordingly described elsewhere.

Waste

It is proposed that mixed bagged waste (including all recyclables) from multi-unit dwellings in the more densely populated areas, and commercial premises will be connected to a vacuum waste collection system. Waste placed in the vacuum system will be transported through the system's pipes to a central terminal in the SCC area. From here it will be collected by Council or a contractor, and taken by road to a Central Waste Processing Facility (CWPF). At the CWPF materials recovery facilities will separate recyclables, organics and high calorific value materials (plastics etc) from other wastes.

Recyclables will be processed through existing markets. The organic fraction will be feedstock to an anaerobic digester which will produce biogas and a solid digestate suitable for use as a soil conditioner. The biogas will be treated and used as feedstock for a gas engine that will be a (relatively minor) supplementary electricity source in addition to those outlined in Section 4.2.2 of this report.

High calorific value materials will be separated. There is an emerging market for such materials to be gasified to produce a syngas, which is a potential feedstock electricity production.

Telecommunications

The NBN rollout at Stirling offers the opportunity to utilise smart meter enabled technology. This will facilitate the use of smart meters for electricity and water, which will be used as part of a consumer behaviour program by providing feedback to building occupants on energy and water use.

Smart meters will be essential in establishing a smart grid network within the SCC. Smart grids involve the installation of smart distribution networks, smart infrastructure such as car charging stations and software for sophisticated control energy management; network shut downs, network stability and network reliability.

Costs

Approximate all-encompassing costs have been estimated for the provision of infrastructure under the BaU and BAT options considered in the report. Costs have been estimated from a large number of sources, and the assumptions embedded in the external sources cannot be fully determined in every case. For those costs built up by GHD, a contingency of 30% has been added to direct costs, and a further 15% added to cover preliminaries.

Capital and estimated operating costs are presented here for BaU and BAT options in 2013 dollar terms (million).

Summary of Costs

Service	Item	BaU		Trigen / Solar		Solar / Geothermal	
		Capex	Opex	Capex	Opex	Capex	Opex
Water							
	Potable (1)	24.100	5.515	22.600	2.803	22.600	2.803
	Wastewater	116.379	0.914	74.642	0.483	74.642	0.483
	Drainage	9.207		9.207		9.207	
	Non-drinking water			54.310	1.274	54.310	1.274
		149.686		160.759		160.759	
Energy							
	Electricity	82.400	1.995	56.770	1.125	56.770	1.125
	SWIS generation	131.225	79.138				
	Local Generation			100.032	9.635	107.861	1.871
	Thermal Network			111.720	3.910	145.878	4.981
	Gas	3.340	4.803	4.580	10.665	3.340	4.803
		216.965		273.102		313.849	
Waste			9.665	121.25	19.464	121.250	19.464
Telecoms		13.283	0.332	13.283	0.332	13.283	0.332
	Total Infrastructure	**379.934**		**568.393**		**609.140**	
Building costs		250.500	6.263	67.500	-	67.500	-
	Total	**630.434**		**635.893**		**676.640**	

(1) relates to differences between the options in respect of the cost of energy systems within buildings

The estimation of costs set out above does not readily facilitate a full life cycle cost assessment of the options. To complement these figures, a quasi-economic assessment of the options has been made. The prime objective of the following is to compare the options rather than explicitly allocate costs to any particular party. The following table outlines the economic costs of the options, i.e. the cost of constructing and operating the necessary assets over a 50 year period

commencing in 2015. The discounted cash flow (DCF) analysis embeds a number of assumptions.

	DCF - BaU			DCF - BAT3 Solar / Trigen			DCF - BAT5 Solar / Geothermal		
	Capex	Opex	Total	Capex	Opex	Total	Capex	Opex	Total
Water									
Potable	15	63	78	14	32	46	14	32	46
Wastewater	69	7	76	43	3	45	43	3	45
Drainage	6	-	6	6	-	6	6	-	6
Non-drinking water	-	-	-	28	15	42	28	15	42
	90	70	161	91	49	140	91	49	140
Energy									
Electricity	50	19	69	38	13	50	38	13	50
SWIS Generation	84	488	572	-	32	32	-	-	-
Local Generation	-	-	-	52	18	70	52	15	67
Thermal Network	-	-	-	72	38	109	102	58	160
Gas	2	55	57	3	122	125	2	55	57
	136	561	697	164	222	386	194	140	335
Waste	-	111	111	78	199	276	78	199	276
Telecoms	9	3	12	9	3	12	9	3	12
Building costs	143	47	190	39	-	39	39	-	39
Total	**378**	**792**	**1,170**	**380**	**473**	**853**	**410**	**391**	**801**

The differences in costs between the options are summarised in the table below.

	Trigeneration / Solar	Geothermal / Solar
BaU	1,170	1,170
Water & wastewater savings	-21	-21
Energy savings	-311	-363
Additional waste costs	166	166
Building savings	-151	-151
Net costs	853	801

As can be seen from the above, major savings in energy and building costs can be achieved through the BAT solutions.

Implementation

Identifying an implementation strategy for delivery of the preferred concept is beyond the scope of this study. The options are:

1. Separate implementation of each component through existing agencies, i.e. electricity (Western Power, Synergy / other retailers and generators), gas (ATCO and Alinta), water (Water Corporation) and waste (City of Stirling).
2. Separate implementation of each component through involvement of the private sector (electricity generation / retail, recycled water, waste-to-energy).
3. A new utility formed specifically to provide services at SCC which would provide integrated energy, water and waste services.

Under the first option each utility would implement the strategy, i.e.

- Verve / Synergy would deliver the energy elements with ATCO / Alinta cooperation;
- Water Corporation to fully own, operate and maintain the water recycling plant, third pipe system and groundwater injection facilities, while energy options would involve the private sector; and
- The City of Stirling would implement the waste elements.

This option would involve complex contractual arrangements between the parties to fully integrate the services.

Although it would be a novel approach for Western Australia, a local government owned utility providing integrated energy, water and waste services is a logical way of implementing the strategy. This approach would need to be integrated with, and facilitated by the local planning scheme and associated development contribution plan. It is envisaged under such an arrangement that a private sector partner would design, build and operate the facilities as an integrated service contract, offering the additional benefit of risk mitigation and private sector investment.

Larger councils with higher levels of financial capacity and service delivery capability are an objective of the government's amalgamation strategy. The expansion of their service delivery from waste to energy and water would involve considerable upgrading of existing capacity. However, a partnership with a private utility offers the attraction of the requisite skills together with private investment and risk sharing. Increasing the involvement of the private sector is also an objective of the state government. Such a model is potentially applicable to Activity Centres more generally in the metropolitan area.

It is recommended that the findings of this report are canvassed with a range of stakeholders, namely:

- the City of Stirling; and
- the WAPC Infrastructure Coordination Committee.

Subject to these consultations the following authorities should be consulted:

- the Economic Regulatory Authority; and
- the relevant ministers and departments (Planning, Water, Energy, Local Government).

Regulatory Issues

It is anticipated that the following licences would be needed under the Electricity Industry Act 2004 (not including normal licensing of the centralised energy and water agencies):

- to construct or operate generating works (electricity generation licence or an integrated regional licence).
- to sell electricity to customers except under the authority of a retail licence or an integrated regional licence.

This assumes that a local utility generates electricity at Stirling and retails to all eligible customers, i.e. those that consume more than 50MWh per annum (which could include multi-residential buildings with individual sub-metering of premises).

Under the recommendations in this report, a local utility would provide sewerage and non-potable water services to customers, and accordingly licences would be required for both.

The Department of Water (DoW) and Department of Health (DoH) will be consulted by the ERA in considering a licence, and will a have direct regulatory role in some cases.

- The DoW is responsible for protecting and managing the State's water resources, including management of the licensing system for water source allocation.
- The DoH regulates health standards for water supplied by the service providers.

Under the recommendations in this report, a local utility would retail thermal energy to customers in the form of hot water (for space and water heating) and cold water (for space cooling).

There are presently no regulations governing the supply of thermal energy in Western Australia or in any other state. Although cogeneration or trigeneration schemes are operating at the building level, the resulting energy supplies are the subject of private contracts between the system owner and building occupants.

It is recommended that the ERA be consulted with respect to setting a price per unit energy (tariff) for thermal energy, and establishing minimum service and performance standards. Following practices in Europe for district heating systems, it is recommended that the principle is established that the aggregate cost to the consumer should be no more than it otherwise would be if the heating / cooling service was supplied in a conventional manner.

For heating this could be determined as the equivalent of natural gas use for space and water heating and electricity for space cooling.

Land

A preliminary estimate of the required land for the facilities described above is set out in the table below. The assumptions in calculating these requirements are:

- waste facilities at existing Balcatta site;
- trigenaration plants to be distributed across development;
- recycled water plant needs to be as central as possible but assumed to be in the Osborne Park Industrial Area; and
- an additional site for a Western Power substation site is necessary, probably located adjacent to or in the nearby industrial area.

Plant	Hectares
Waste	
Clean MRF	0.50
Dirty MRF	0.96
Anaerobic digestion plant	0.50
Storage and loading	0.25
	2.21
Energy	
Power plant (6no. X 1600m2)	0.96
Second substation	0.35
	1.31
Water	
Recycled water plant	0.45
NDW storage / pumps	0.30
Abstraction / discharge plant	0.20
	0.95
Total land take	**4.47**

Performance against targets

The following tables set out the performance of the BAT concept against the KPIs in the performance framework in respect of energy and water.

Energy KPI	Performance against Target		
	Targets		**BAT**
	Aspire	Agreed	
% of renewable energy production	100%	50%	**>50% Tri > 90% Geo**
Rate of power consumption per dwelling (in kWh)	4MWh	10MWh	**2.6**
Rate of power consumption per m2 retail (kWh)	Yet to be confirmed		**70**
Rate of power consumption per m2 office commercial annual	50	59.7	**105**
% reduction in peak power demand	50%	30%	**65%**

Water KPI	Performance against Target		
	Targets		**BAT**
	Aspire	Agreed	
% of all water recycled	100%	80%	**100%**
% of nutrients from wastewater that are reused	100%	80%	**100%**
% stormwater captured and reused	100%	80%	**0%**
Rate (Kilolitres) of potable water consumption per person (household)	40kl/p	50kl/p	**33**
Rate (Kilolitres) of potable water consumption m2	Not stated		**0.64**
Rate (Kilolitres) of potable water consumption m2 office commercial per annum	0.5	1	**0.58**

The preferred energy concept involves solar energy in concert with 2 options – trigeneration and geothermal.

The trigeneration option involves the use of fossil fuels (natural gas) as a feedstock. As the use of fossil fuels will be constrained during the life of this infrastructure due to climate change and / or depletion, this option does not offer the same sustainability performance or risk profile of the geothermal option which is potentially an inexhaustible non-polluting form of energy. However it involves mature technology with a track record which is presently available in the market place. This option can be progressed with desk top technical and financial studies.

The geothermal option involves novelty in terms of application in Australia and requires field testing via a trial bore, which itself will incur costs and take time. At the time of writing it is not clear who the proponent for this trial would be.

Ultimately the advantages and disadvantages for each technology will need to be evaluated from the perspective of sustainability, risk and financial viability. As both options provide potential solutions for Activity Centres more generally, this evaluation will be important not only for the SCC development.

Further Studies

This study identifies that the preferred servicing concept offers significant sustainability benefits, is technically feasible and economically viable. However a significant amount of further study and consultations are necessary before the proposed infrastructure concept will be progressed to a level that is required for State Government endorsement and financial commitment. Some of these studies can be carried out in parallel but some will need to be staged.

The following assumes that a development proponent is identified following the cessation of the Stirling Alliance and that this proponent, acting on behalf of the WAPC is the sponsor of the studies identified. It also assumes that a final Structure Plan and staging plan is in place and describes development in sufficient detail for servicing infrastructure to be sized and costed.

Pre-funding infrastructure is a challenge for the project whether or not it is undertaken through a business as usual or best available technology approach. The shortfall between costs and revenue is likely to be similar in the early years. It is recommended that a separate parallel study is undertaken to identify pre-funding sources, including the potential involvement of the private sector.

Phase 1 studies

The following studies are envisaged in Phase 1:

Feasibility Study – Service Delivery Implementation Options

The central plank of the proposed strategy is the introduction of a distributed services network in the mixed-use areas of the SCC, involving the reticulation of thermal energy and nondrinking water. Progressing this concept is subject to the identification of potential service providers for one or both of these services. If a model for this service delivery cannot be devised, then further detailed design studies would be superfluous.

Feasibility Study – Distributed Thermal Energy

The results of this study will determine the feasibility of the thermal energy distribution concept. If viability is not confirmed, the energy concept would be default to a renewable electricity service only.

If viability is confirmed, further studies related to the thermal energy source, and the scope of renewable electricity can follow as detailed below.

Feasibility Study – Recycled Water

If viability is confirmed, the recycled water initiative can be progressed. If not, water efficiency initiatives would revert to the building scale only.

Phase 2 studies

Following this first phase of studies and subject to their outcome, the following steps can be progressed, with a view to finalising the services concept.

Study – contractual arrangements for service provider(s)

Once the manner of service delivery is resolved, plans can be progressed on the contractual arrangements necessary to implement the distributed services strategy.

Study – planning processes

The planning control mechanisms that will facilitate the connection of premises to the thermal network and the recycled water network need to be resolved.

Feasibility study – thermal energy source

The findings of this report identify natural gas-fired tri-generation and geothermal energy as potential sources of thermal energy.

Further examination of the viability of geothermal energy to provide (initially) thermal energy should be progressed through the further interpretation of existing data followed by a trial bore.

This trial would establish the depth at which suitable temperatures exist and the hydraulic characteristics of the aquifer which will determine potential pumping rates.

Subject to the outcome of this trial a concept design could be progressed and costed for the geothermal energy headworks.

The study should also take the tri-generation concept to the next level of design. This would involve sizing of the plant, resolving the natural gas demand and connection arrangements and confirming costs.

Feasibility study – solar PV

It is only when the tri-generation option is adopted or discarded that further design development of solar photovoltaic's can be finalised (as this will confirm electricity requirements), although it could be commenced in parallel with the other phase 2 studies.

Feasibility study – vacuum waste system

The proposed use of a vacuum waste system in the distributed services zone should be reviewed.

Feasibility study – central waste processing facility

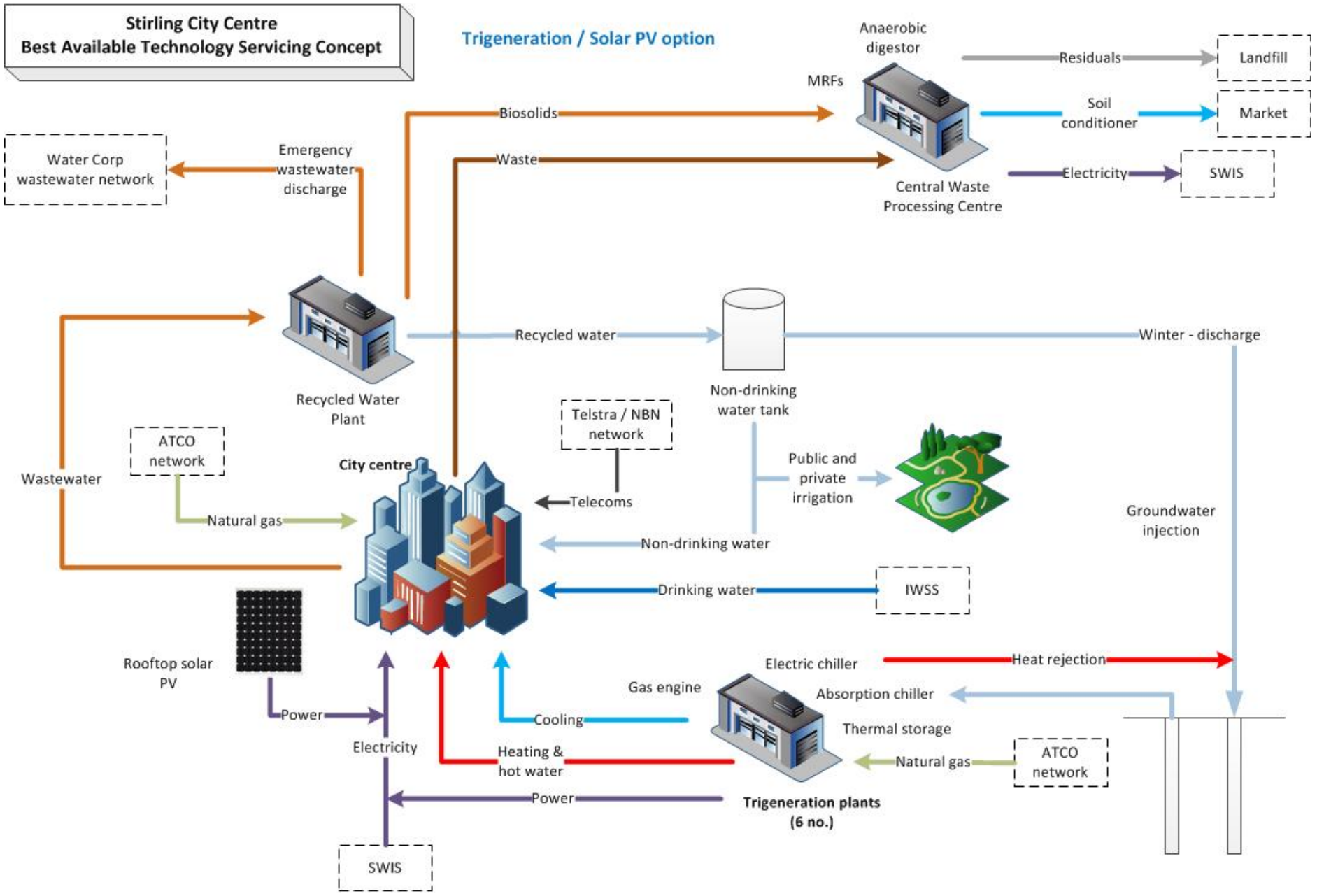
The recommendation for an integrated processing facility at Balcatta (or elsewhere) requires further study. If shown to be viable, the City could progress the central waste processing facility separately and in parallel to the other studies as this element could proceed irrespective of other initiatives.

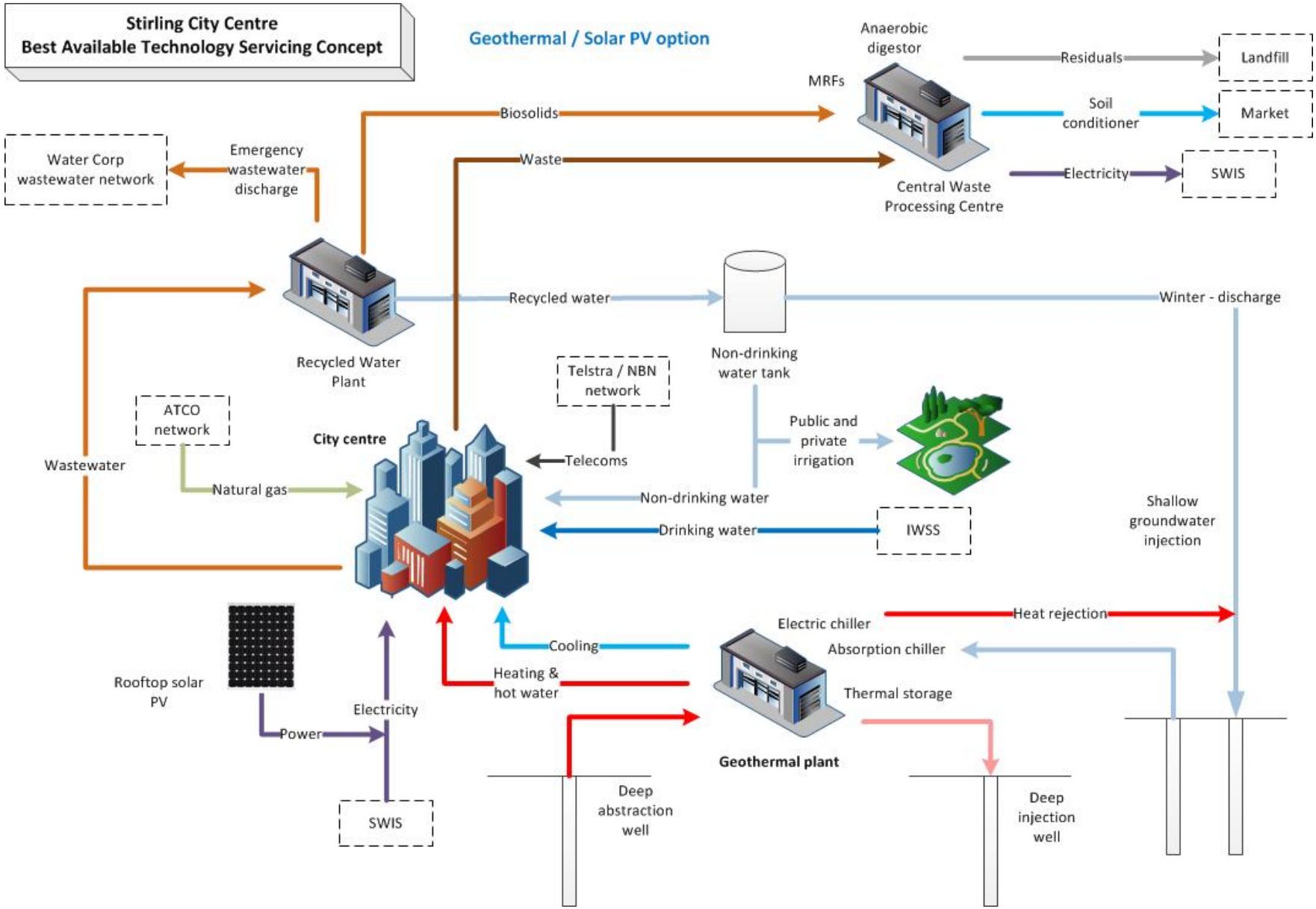
Phase 3 studies

At the completion of Phase 2, the complete servicing concept should be finalised. This will allow the finalisation of both the development contributions plan in respect of infrastructure, and the finalisation of design guidelines for the mixed-use areas. If at this stage the service delivery model is not yet confirmed then this work may need to follow the Expression of Interest (EOI) process discussed below.

The increased level of detail available from the Phase 1 and two studies would facilitate the development of an expression of interest for private sector involvement in the delivery of services infrastructure. The nature of this involvement is dependent on the outcome of earlier studies and may involve the private sector in building or operating some or all of the identified infrastructure. Under the requirements of State Planning Policy 3.6, any infrastructure funded through a development contributions plan must be publicly owned. Accordingly any private sector involvement will need to reflect this requirement.

Following these processes it should be possible to finalise contractual arrangements to deliver the services.


Stirling City Centre
Best Available Technology Servicing Concept
Trigeneration / Solar PV option
Anaerobic digestor
MRFs
Residuals
Landfill
Soil conditioner
Market
Biosolids
Waste
Water Corp wastewater network
Emergency wastewater discharge
Electricity
SWIS
Central Waste Processing Centre
Recycled water
Winter - discharge
Recycled Water Plant
Non-drinking water tank
Telstra / NBN network
ATCO network
City centre
Public and private irrigation
Wastewater
Natural gas
Telecoms
Groundwater injection
Non-drinking water
Drinking water
IWSS
Rooftop solar PV
Electric chiller
Heat rejection
Gas engine
Absorption chiller
Power
Cooling
Thermal storage
Electricity
Heating & hot water
Natural gas
ATCO network
Power
Trigeneration plants (6 no.)
SWIS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Non-drinking water tank
Telstra / NBN network
ATCO network
City centre
Public and private irrigation
Wastewater
Telecoms
Natural gas
Non-drinking water
Drinking water
IWSS
Shallow groundwater injection
Electric chiller
Heat rejection
Absorption chiller
Cooling
Heating & hot water
Thermal storage
Rooftop solar PV
Electricity
Power
Geothermal plant
Deep abstraction well
Deep injection well
SWIS

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1. Introduction

1.1 Project Background

The Stirling City Centre (SCC) is a designated Strategic Metropolitan Centre under Directions 2031 and aims to create an active and diverse urban centre within the inner metropolitan area of Perth. The Centre will be a transit oriented development potential to accommodate 25,000 residents and 30,000 workers.

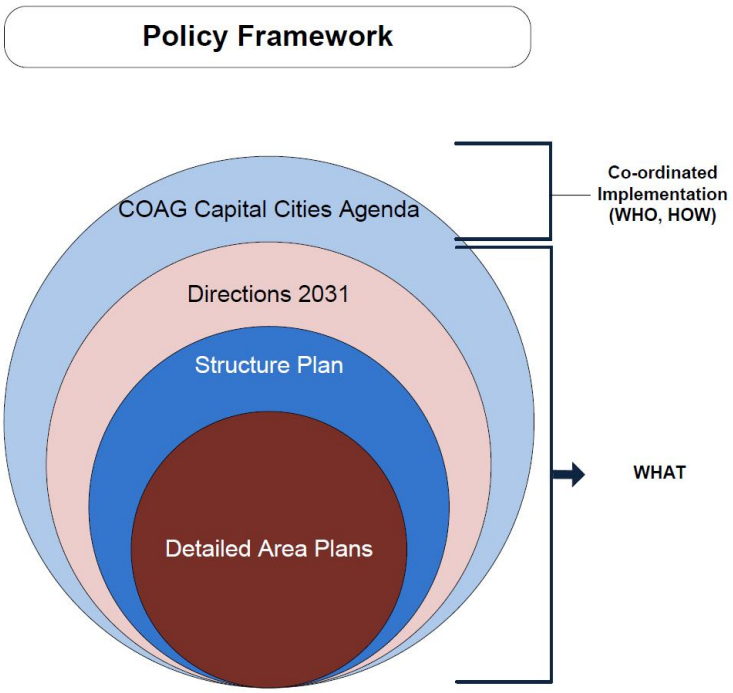
The City of Stirling and the Western Australian Planning Commission are co-sponsoring the planning of the SCC in collaboration with Western Power, Water Corporation, Department of Planning, Department of Transport, Main Roads WA, Public Transport Authority, LandCorp and representatives from business and the community. This novel partnership offers a unique opportunity to integrate infrastructure with land use planning in one of Perth's most important Activity Centres.

Delivery of the vision for the SCC will be guided by statutory planning instruments which are currently being prepared by the Stirling Alliance (the Alliance) to provide the framework for the redevelopment of the SCC. It aims to deliver innovative urban design and development that ensures an enduring, natural environment and water management system, underpinned by new technologies and approaches to the management of water, waste, energy and the environment.

GHD has been commissioned to develop a Utilities Infrastructure Strategy for the SCC to meet these aims.

1.2 Stirling City Centre Performance Framework

The Stirling Alliance has prepared a comprehensive Performance Framework[2] to guide the planning of the SCC.



[2] http://www.stirlingcitycentre.com.au/assets/Uploads/RPTStirlingCityCentrePerformance-FrameworkNov2010.pdf

The framework defines the objectives, Key Result Areas (KRAs) and Key Performance Indicators (KPIs) for each of the Areas of Strategic Focus. A number of targets are defined for the KRAs/KPIs. The Performance Framework establishes aspirational, agreed, minimum and current targets.

The framework and targets provide guidance on development of the servicing strategy in respect of sustainability performance.

1.3 Purpose of this report

Two previous studies have identified the potential for innovative initiatives and technologies to service the SCC:

- PB Green Infrastructure Report (Parsons Brinckerhoff 2010); and
- Kinesis Reports (Kinesis 2012):-
  - CCAP Precinct Analysis of Stage 1 land area
  - CCAP Precinct Sustainability Analysis Report.

GHD built on these studies to provide a comprehensive list of potential initiatives and technologies (Review of Sustainable Initiatives & Technologies – GHD April 2013). This report was used to inform the development of a Best Available Technology (BAT) strategy to service the SCC. This BAT strategy is documented in the previous report (Stirling Utilities Infrastructure Strategy, Volume 1 – GHD Oct 2013), together with a Business-as-Usual (BaU) approach to servicing. The primary purpose of documenting the BaU approach was to benchmark the BAT strategy in respect of life cycle costs and sustainability performance.

The alternative strategies set out in that report were presented to the SCC Master Strategy Workshop in August 2013, and subsequently to a workshop of the Stirling Alliance's Infrastructure Working Group in September 2013.

Following the workshop, the BAT approach has been refined into a final preferred servicing strategy for the SCC which is presented in this report.

This report (Volume 1) documents the preferred strategy for the entire Structure Plan area. A companion document (Volume 2) sets out how the strategy will be applied to Stage 1 of the Structure Plan area.

1.4 Development Yield

The previous report was based on yields developed by Hassell in 2011. These yields have been revised by the Stirling Alliance (September 2013) and this report is based on that revised yield information.

1.5 Layout of report

Section 2 describes the demands on utility services arising from the development of the SCC. These have been revised from the previous report.

Section 3 sets out the likely upgrades required to conventional centralised services necessary to meet the future demands with these revised yields.

Section 4 provides a detailed description of the preferred concept.

Section 5 contains a high level assessment of the total costs of best available technology servicing of the development, including capital and operating costs in comparison with a business as usual approach, for which revenues have also been assessed.

Section 6 sets out the relevant governance and regulatory issues that need to be considered in implementation of the preferred concept.

1.6 Scope and limitations

This report: has been prepared by GHD for Stirling Alliance and may only be used and relied on by Stirling Alliance for the purpose agreed between GHD and the Stirling Alliance as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Stirling Alliance arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Stirling Alliance and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimates set out in this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD. The Cost Estimate has been prepared mainly for the purpose of comparing the options considered and must not be used for any other purpose.

The Cost Estimate is an order of magnitude estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

2. Future Service Demand

2.1 Draft Structure Plan

The draft Stirling City Centre Structure Plan was released in July 2011 (SA 2011). The draft plan describes a vibrant, mixed use, green, transit oriented development, combining mixed use and residential development.

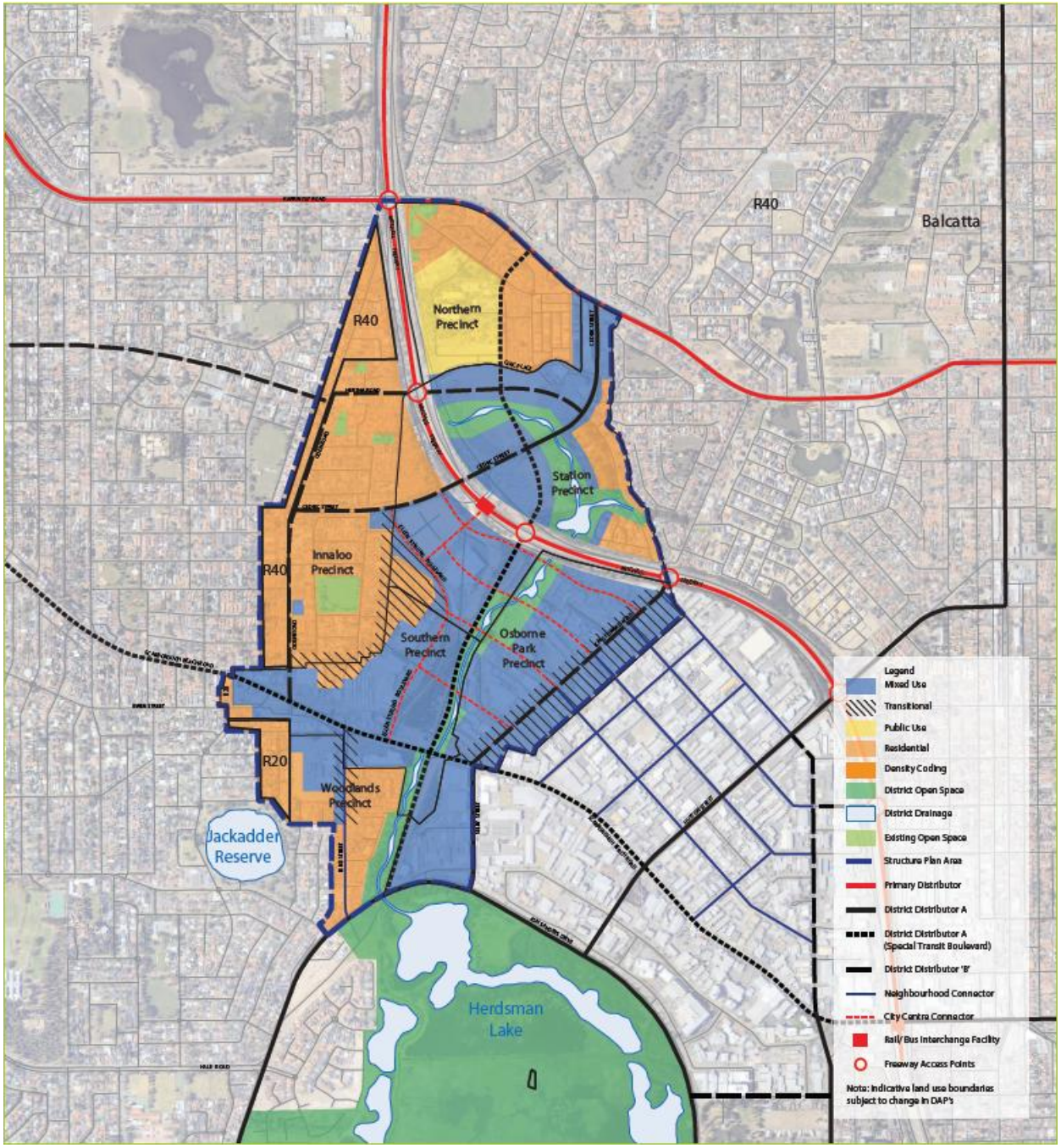


Figure 2-1 Draft Structure Plan

2.2 Yield

The yield of the Structure Plan area was originally taken from the detailed yield analysis undertaken by Hassell in 2011 (Hassell 2011).

The Stirling Alliance has revised the estimated yields and these are the basis of this report. These latest yields are still estimates derived from the latest configuration of developable area and car parking limitation mechanisms. The key information is reproduced in Table 2.1. Residential population figures are based on the assumption of 1.8 persons per dwelling, and Nett Lettable Area (NLA) is assumed to be 85.5% of gross floor area (GFA).

Table 2.1 Ultimate Development Yield

	ULTIMATE DEVELOPMENT YIELD								
	Persons/dwelling		1.8						
Precinct	Dwellings		Population	Office	Health / Welfare / Community	Retail	Entertain't / Recreation / Culture	Total Non-residential	Total
	No.	Floor Space (m2 NLA)							
Southern Precinct	1,550	127,500	2,790	40,910	2,980	119,430	7,680	171,000	298,500
Station Precinct	2,935	254,000	5,283	278,470	4,091	58,426	5,161	346,148	600,148
Innaloo Precinct	1,770	212,400	3,186	0	2,660	400	0	3,060	215,460
Northern Precinct	930	97,350	1,674	16,350	27,515	500	0	44,365	141,715
Woodlands Precinct	1,060	95,400	1,908	12,670	2,015	13,065	0	27,750	123,150
Osborne Park Precinct	2,535	202,800	4,563	101,130	5,460	184,810	0	291,400	494,200
TOTALS	10,780	989,450	19,404	449,530	44,721	376,631	12,841	883,723	1,873,173
	No.	Floor Space (m2 GFA)							
Southern Precinct	1,550	149,123	2,790	47,848	3,485	139,684	8,982	200,000	349,123
Station Precinct	2,935	297,076	5,283	325,696	4,785	68,335	6,036	404,851	701,927
Innaloo Precinct	1,770	248,421	3,186	-	3,111	468	-	3,579	252,000
Northern Precinct	930	113,860	1,674	19,123	32,181	585	-	51,889	165,749
Woodlands Precinct	1,060	111,579	1,908	14,819	2,357	15,281	-	32,456	144,035
Osborne Park Precinct	2,535	237,193	4,563	118,281	6,386	216,152	-	340,819	578,012
TOTALS	10,780	1,157,251	19,404	525,766	52,305	440,504	15,019	1,033,594	2,190,846

The figures included in Table 2.1 represent the ultimate development potential of the Structure Plan. It is recognised that for a number of reasons, this full potential is unlikely to be fully achieved, and that the proportion that is achieved will take a number of decades.

2.3 Demand Assumptions

The demand for services is dependent on a number of factors including:

- resident, worker and visitor population;
- the number and type of buildings;
- the “performance” of each building type in respect of energy and water efficiency; and
- the behaviour of occupants.

Each of these has been taken into account in the development of the demand calculations set out below.

Inherently, a BAT approach to development includes adoption of best practice in respect of energy and water efficiency. Accordingly the BAT demand assessment assumes these practices.

The BaU approach to servicing development adopts conventional demands for energy and water.

The opportunities for waste reduction are mainly related to factors outside the direct influence of urban development, and so both BaU and BAT waste volumes are based on existing City of Stirling data.

2.4 Power – Future Demand

2.4.1 Demand Profiles

GHD built up a demand profile for the peak demand for a typical day for thermal and electrical energy. These profiles reflect a typical day in summer, mid-season and winter.

A profile for each land use type was modelled, drawing on a number of sources:

- a GHD derived model using Revit (3D architectural software) and the energy modelling software Virtual Environment IES 2012;
- using profiles from the BCA 2013; and
- the AIRAH design calculations handbook.

2.4.2 Peak Demands - Residential

To develop the high rise residential demand profile a model was created using Revit and Virtual Environment IES 2012. This is industry standard energy modelling software used in modelling NABERS and Green Star ratings.

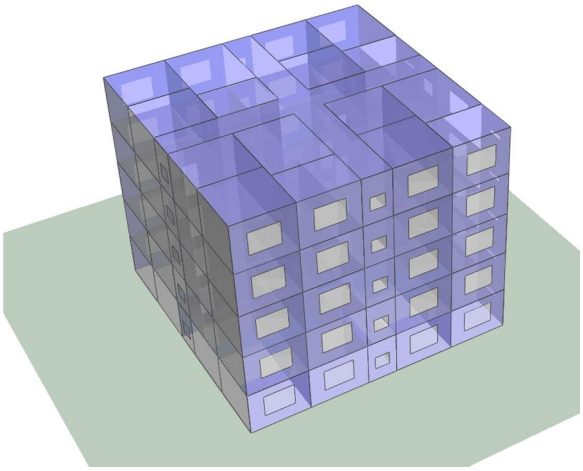


Figure 2-2 IES Residential model

The modelling software uses assumptions from the National Construction Code for lighting and general appliance demands to calculate an electrical demand profile. It uses these figures to generate a heating and cooling profile which also contributes to electrical consumption. The resulting energy demand model provided the following peaks.

Table 2.2 Residential Peak Demand

Time of Year	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Summer	22	21.4
Mid Season	17	16.5
Winter	16	15.3

2.4.3 Peak Demands - Office Space

To develop the office demand profile a model was made using Revit and Virtual Environment IES 2012.

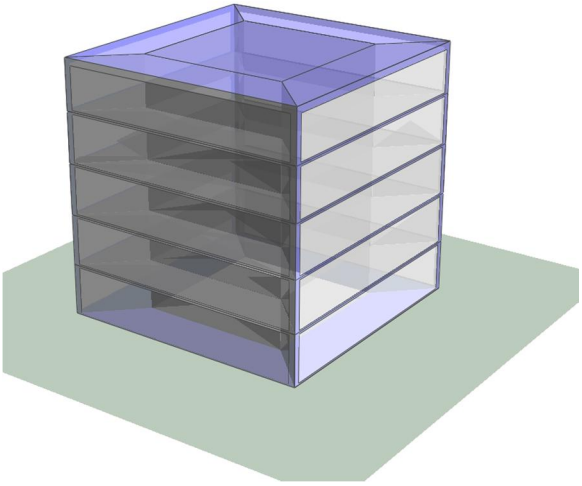


Figure 2-3 IES Offices model

The resulting energy demand model provided the peaks described in Table 2.3 below.

Table 2.3 Offices Peak Demand

Time of Year	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Summer	56	25.2
Mid-Season	45	20.1
Winter	34	15.1

2.4.4 Peak Demands - Retail Space

To develop the retail demand profile a model was developed using the National Construction Code Series 2012 Volume A – Specification JV – Annual Energy Consumption Criteria and the AIRAH Design Calculations as a guide. The resulting energy demand model provided the peaks described in Table 2.4 below.

Table 2.4 Retail Peak Demand

Time of Year	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Summer	66	25.0
Mid-Season	66	25.0
Winter	66	25.0

2.4.5 Entertainment and Community Space

To develop the entertainment and community demand profile a model was developed using the National Construction Code Series 2012 Volume A – Specification JV – Annual Energy Consumption Criteria and the AIRAH Design Calculations as a guide. The resulting energy demand model provided the peaks described in Table 2.5 below.

Table 2.5 Entertainment and Community Peak Demand

Time of Year	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Summer	72	4.1
Mid-Season	72	4.1
Winter	72	4.1

2.4.6 Auxiliary Demand

The demand from street lighting was calculated based on the existing road layout for the SCC area and standard street lighting design principles. The demand was found to be 134kW, noting however this does not coincide with the peak for other loads.

The waste treatment facility is estimated to be a constant load of 1.77MVA.

With the inclusion of a thermal energy source for the distributed services zone, the electrical load attributable to cooling loads can be removed. This reduction was calculated using a coefficient of performance COP of 3.85 for Residential and 3 for office, retail and entertainment and community space.

2.4.7 Electric Vehicles

The demand from electric vehicles has not been included directly in this study, as the take up at ultimate development is not readily assessable. However, if it is assumed that regulation and / or incentives are in place to charge vehicles overnight, the impact on peak power will be minimal.

2.4.8 Profile / Diversification

Hourly profiles for daily use were developed to reflect when the peak demand of each land use type would occur. This provides a diversification factor as not all land uses will be consuming their peak at the same time (i.e. residential and office space).

The resulting peak demand occurs in summer at approximately 5pm and is 63 MVA and is shown in Table 2.6 below.

Table 2.6 Total Peak Demand

Land Use	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Residential	13	12.8
Office	51	23.1
Retail	67	25.0
Entertainment and Community	43	2.5
Peak Demand on Grid		63.4

A map of the energy density of the development (energy efficient buildings) is depicted in Figure 2-4.

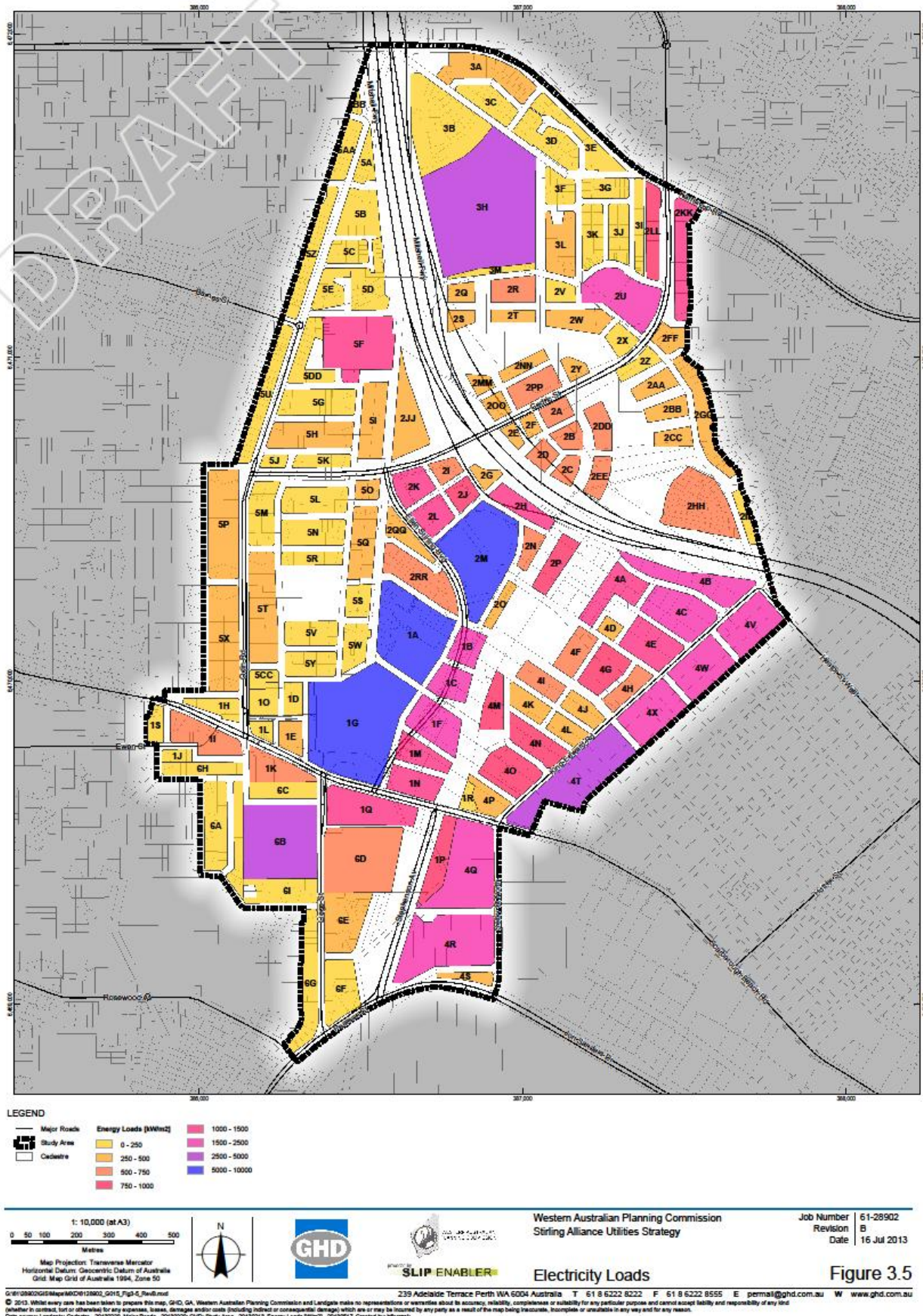


Figure 2-4 Energy density

2.4.9 Reduction due to Energy Efficient Buildings

Energy efficient building can greatly reduce the peak demand on the grid. Using the NABERS reverse calculator for offices and shopping centres, and the NABERS rating calculator for households, the following peak demands for summer has been calculated and are shown in Table 2.7 below.

Table 2.7 Peak Demand - Energy Efficient Buildings

Land Use	% Reduction	Peak Electrical Demand (VA/m2)	Total Peak Demand (MVA)
Residential (5 Star NABERS)	45%	7	7.0
Office (5 Star NABERS)	27%	38	16.9
Retail (5 Star NABERS)	63%	25	9.3
Entertainment and Community (5 Star NABERS)	83%	7	0.4
Peak Demand on Grid			35.8

2.4.10 Daily Demand Profile Comparison

The graphs below show the daily demand profiles (summer peak day) for the land use types comparing green buildings to business as usual.

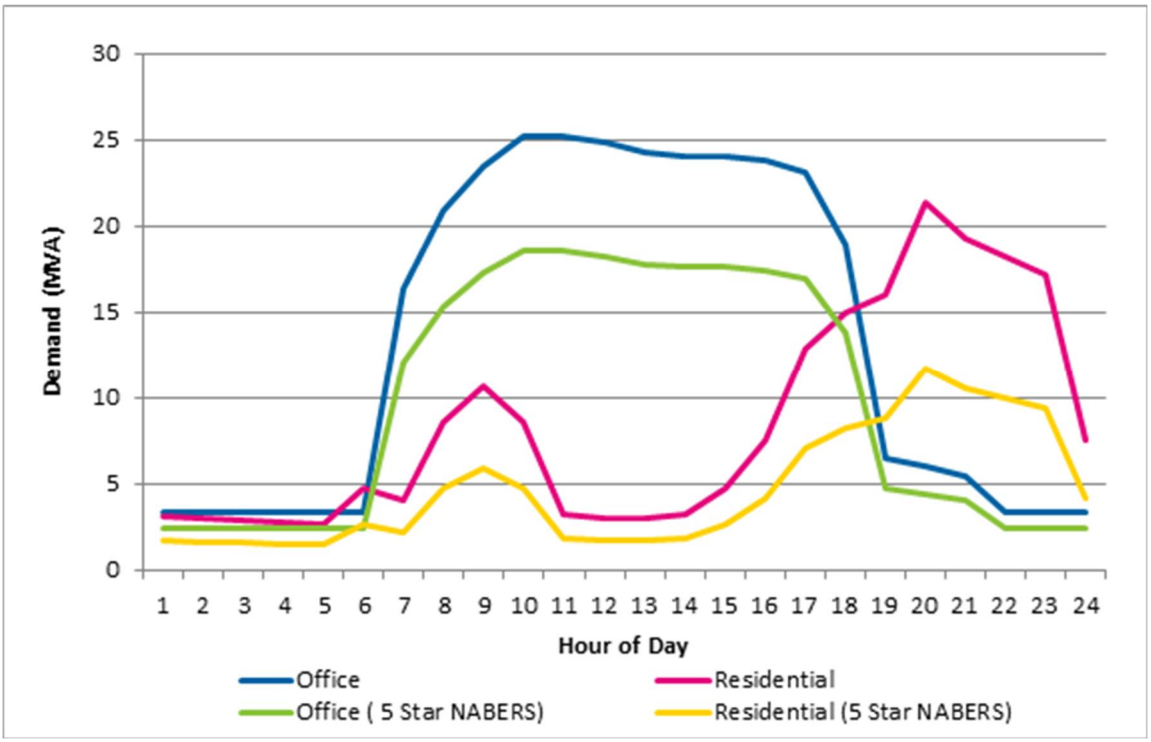


Figure 2.5 Peak Summer Demand – effect of energy efficient office & residential buildings

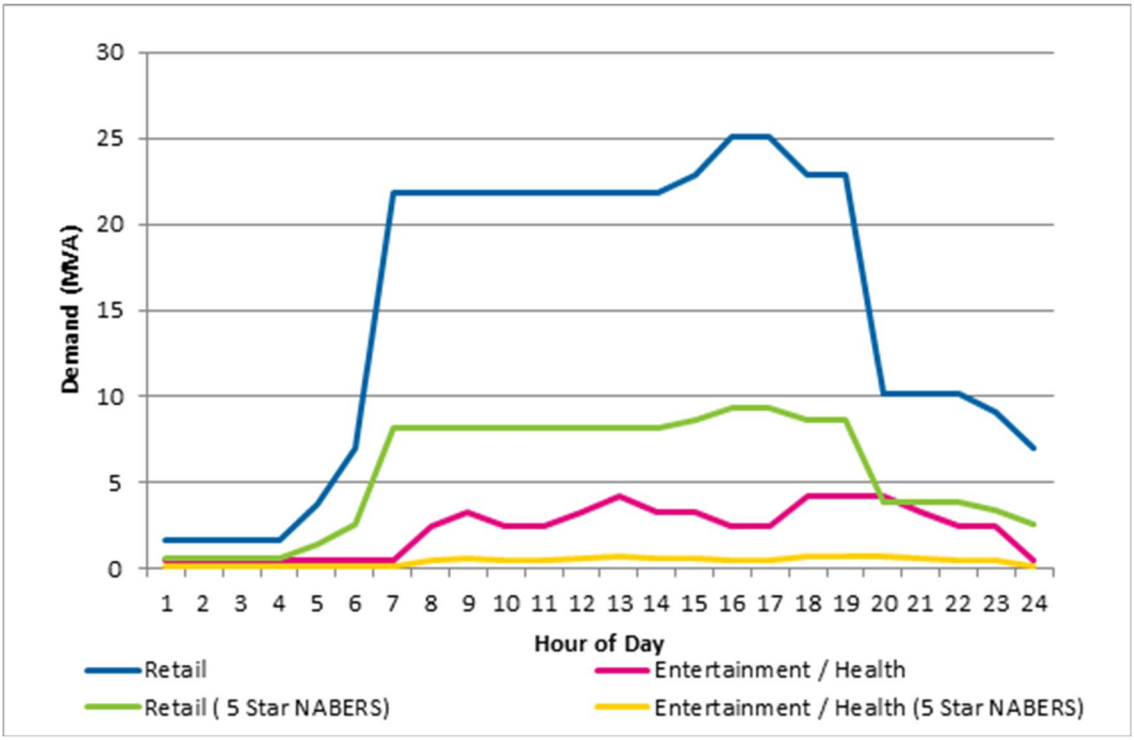


Figure 2.6 Peak Summer Demand – effect of energy efficient retail & entertainment / community buildings

2.4.11 Summary of Demands

All electrical and thermal energy demands are summarised in the table below.

Table 2.8 Summary of Energy Demands

		Weighted average demand (MVA per m2)				Total demand per annum (GWh)		
		(W_e)	(W_{th})	(W_{th})		(GWh_e)	(GWh_{th})	(GWh_{th})
	Area (m2)	Electrical (1)	Heating / HW	Cooling		Electrical (1)	Heating / HW	Cooling
Conventional demand (BaU)								
Residential	989,450	7.01	1.53	6.98		61.41	13.41	61.18
Office	449,530	10.45	0.30	11.15		91.53	2.62	97.65
Retail	376,631	14.75	0.30	23.15		129.20	2.64	202.77
Community and Entertainment	57,562	2.25	0.05	3.29		19.67	0.46	28.85
						301.82	19.12	390.44
Street lights						0.61		
						302.43		
Energy efficient buildings (BAT) Ultimate Development								
Residential	989,450	3.20	0.84	3.81		28.00	7.32	33.41
Office	449,530	5.39	0.22	8.18		47.22	1.92	71.68
Retail	376,631	2.99	0.11	8.62		26.21	0.98	75.55
Community and Entertainment	57,562	0.22	0.01	0.55		1.96	0.08	4.81
						103.39	10.31	185.45

Street lights					0.61		
Waste to energy plants					15.51		
Recycled water plant					3.2		
					122.71		
Energy efficient buildings (BAT) DGA Area							
Residential	584,300	1.86	0.54	2.48	16.30	4.77	21.75
Office	420,510	4.89	0.21	7.65	42.88	1.80	67.05
Retail	362,666	2.66	0.11	8.11	23.32	0.92	71.02
Community and Entertainment	25,372	0.18	0.01	0.48	1.57	0.07	4.23
					84.07	7.56	164.06
Street lights, waste and recycled water					19.32		
					103.39		

(1) Incorporates cooling load

2.5 Gas – Future Demand

Based on information provided to ATCO Gas about the proposed original yields, they estimated that the gas demand for BaU development will be 508,000 GJ per annum or 1,526 standard cubic metres per hour (scmh) on average. GHD have revised this estimate to 381,000 GJ pa based on the revised yield.

ATCO Gas advice received on demands and costs is included in Appendix A.

2.6 Water & Wastewater – Future Demand

Water usage estimates were undertaken using a combination of current water use data, the Water Corporation water demand calculator and current industry knowledge (in respect of irrigation of public open space).

Two demand scenarios were developed to provide a potential range of consumption figures for infrastructure sizing and water source requirements.

Scenario 1 – Waterwise

Assumes all internal fixtures and fittings are waterwise and the landscaped areas consist of waterwise plants. This demand is assumed for the BAT option.

Scenario 2 – Conventional

Assumes all internal fixtures and fittings are conventional and the landscaped areas consist of European plants

The demands adopted for “conventional” are similar to the measured data for existing residential multi-unit dwellings. Demand for commercial development is based on existing unit consumption figures. This demand is assumed for the BaU option.

There is a more complete explanation of how these demands were calculated in GHD’s *Total Water Cycle Options (2013)* report.

Table 2.9 Summary of Water Demands

	QUANTITIES		ANNUAL DEMANDS (ML/year)				
			Conventional Demand				
			Drinking water	NDW - internal	NDW - Irrigation	Total	% total
Dwellings	no.	10,780	647	582	183	1,412	48%
Office	m2 GFA	525,766	423	247	35	705	24%
Health / Welfare / Community	m2 GFA	52,305	141	70	23	235	8%
Retail	m2 GFA	440,504	280	140	47	467	16%
Entertain't / Recreation / Culture	m2 GFA	15,019	10	5	2	16	1%
Public Open space	ha	4.4	-	-	33	33	1%
Verges	ha	13.0	-	-	65	65	2%
			1,500	1,044	388	2,932	100%
			Waterwise Demand				
Dwellings			464	367	122	952	49%
Office			252	147	21	421	21%
Health / Welfare / Community			25	13	4	42	2%
Retail			264	132	44	441	23%
Entertain't / Recreation / Culture			9	5	2	15	1%
Public Open space (1)			-	-	22	22	1%
Verges (1)			-	-	65	65	3%
			1,014	663	279	1,957	100%

2.7 Waste – Future Waste Quantities

The City of Stirling has provided data on waste flows through its Balcatta Transfer Station. GHD has also drawn upon data from other sources to estimate the quantities and composition of waste streams likely to be generated from the SCC and the City of Stirling as a whole.

There are 87,400 dwellings in Stirling which equates to 1,790 kg per dwelling per year or 34.4 kg per dwelling per week. However, GHD has made three assumptions in regard to waste types and quantities generated from the SCC. These are:

- Little or no additional green waste will be generated by households as they will be mostly medium density;
- Little or no additional other municipal waste, such as from parks and reserves, will be generated; and
- There will be no increase in road sweeper waste.

This brings the estimated average amount of waste generated per dwelling per year in the SCC to 1709 kg or 32.9 kg per week.

Assuming that per household is a valid measure of waste generation and that 34.4 kg per household per week will remain constant in the balance of the City of Stirling as a whole; GHD

has used projected increases in the number of dwellings to estimate possible waste generation in the future.

When the SCC Development is complete and operating at full capacity, the number of dwellings in Stirling is estimated to be about 100,000[3]. Incorporating the original 1,790 kg per household per year for non-SCC households, this equates to about 200,000 tonnes of waste per year by the time of the ultimate development, an increase of 14.5% over 2012 figures. This percentage increase has been used to project the quantity of each waste stream in Stirling by the time of the ultimate development.

The City of Stirling also provided data from the results of an audit of kerbside garbage generated by councils, other than itself, that were members of Mindarie Regional Council in 2004. GHD has also used typical kerbside domestic recycling stream composition and typical transfer station composition obtained from other audit sources.

With this data GHD has modelled waste generation rates in the SCC development area and for the City of Stirling as a whole. GHD estimates that by the time of the ultimate development, about 51,700 tonnes of waste will be generated from the SCC area. Of this about 12,800 tonnes will be organics, 33,800 tonnes will recyclables and about 5,100 tonnes will be residual.

Table 2.10 Future Waste Quantities

Location	Collected by	Qty (tonnes)
Non SCC areas		
Domestic waste	Council	93,685
Green waste	Self - hauled	25,739
Construction waste	Self - hauled	17,352
Other municipal waste, street litter, parks and reserves	Council	994
Mixed waste delivered to Recycling Centre Balcatta	Self - hauled	54,290
Inert waste	Self - hauled	5,098
Road sweeper waste	Council	2,767
	S/total	**199,804**
SCC		
Low rise residential	Council / contractor	6,427
High rise residential	Council / contractor	11,999
Non-residential		33,278
	S/total	51,704
Total		**251,508**

On total build-out the SCC will contribute some 21% of the total waste quantities for the City of Stirling.

[3] forecast.id (2010) City of Stirling Population and Household Forecasts http://forecast2.id.com.au/templates/forecast2/Clients/270Stir/PDF/10.pdf

3. Business as Usual - Conventional Servicing Concept

3.1 Introduction

The required upgrades to the conventional centralised services are described in detail in Volume 1 of the previous report. The revised yield analysis has not qualitatively changed this scenario, and so in the main the descriptions in that report hold.

Accordingly, the sections below outline only variations in approach from that documented in the previous report.

3.2 Power

3.2.1 Upgrades Required

Distribution

From the GHD energy load data provided in the previous stage of the project[4], Western Power provided a layout of the upgrades to the high voltage network that would be required to service future increased demands from SCC and surrounding areas (see Appendix B). This advice has been conservatively interpreted in the following sections and is based on that initial advice. Further, it is now assumed that expansion of the existing Osborne Park substation will not be made, and a new site will be required. A land area of 0.35 ha has been assumed.

It was previously estimated that peak load arising from development (summer peak day) was 86 MVA. With the revised yield this figure reduces to 64 MVA, and based on previous advice the necessary upgrades will be as follows:

- retention of the existing Osborne Park substation, which has a capacity of 65 MVA;
- acquisition of a new substation in the area, involving:
    - two additional 66MVA transformers by 2017/18;
    - installation of an additional 66MVA transformer by 2028/29;
    - two additional 66MVA by 2055/56; and
    - approximately 20 new distribution feeders over time.

The contribution of the SCC towards these upgrades is assessed to be approximately 40% on the basis of pro-rata peak demand.

3.3 Wastewater

3.3.1 Approach and Assumptions

The required wastewater headworks infrastructure has been based on the recent study 'Water Corporation Stirling City Wastewater Advice', originally provided to GHD on the 29th of May 2013. GHD provided Water Corporation with the Hassell Stirling City Centre Detailed Yield Analysis, and the Water Corporation refined their ultimate wastewater flow estimates to reflect this analysis.

[4] Reported in "Stirling Utilities Infrastructure Strategy, Volume 1 – GHD Oct 2013"

GHD has estimated reticulation requirements with pipe sizes based on the yield analysis and Water Corporation Standard No. DS50 Tables 4.1, 4.2 and 4.3.

For estimation purposes, assumptions include:

- all existing reticulation that is adequately sized within existing road reserve will be retained;
- no allowance has been made for removal of redundant sewer;
- all existing connections on reusable pipe will be made redundant. New 150mm diameter connections are to be used. A short and long connection is to be provided every 40m;
- reticulation is to be laid at a conservative average of 3m depth;
- no provision has been made for dewatering;
- standard headworks charges apply per sewer connection;
- to accommodate for mixed use multi storey buildings, connections will utilise a 150mm diameter PVC pipe with valve and meter.
- no provision has been made for the extraction and replacement of peat, ASS treatment, or any other soil remediation;
- no allowance has been made for the reinstatement of crossovers, based on the assumption that all existing lots will be demolished before or during the time of sewer construction; and
- all private networks that are not shown in the maps will not be reused in the new fit out and will be made redundant.

Various studies have indicated that ASS soils, peat deposits, and various pollutants are present on the site. Depending on the level of ASS / unideal soil conditions that is encountered on site, the treatment of soils can become a significant cost.

3.3.2 Upgrades Required

The Water Corporation has completed a preliminary review of options available to serve the SCC and surrounding areas. This review found that:

- WWPSs that are within the catchment of the Subiaco WWTP: the SCC development will have negligible impact on long term flows (revised flow estimates similar to those assumed in current long term wastewater conveyance planning).
- WWPSs that are within the catchment of the Beenyup WWTP; the SCC development will have a significant impact on long term flows (revised peak flow estimates significantly greater that those assumed in current long term wastewater conveyance planning).

The Water Corporation has presented two options that may be implemented to upgrade the wastewater headworks to accommodate for the projected yield. Both options have been projected to have similar cost implications on the project.

Option One provided by the Water Corporation has been used for the purposes of this study, and states that the following upgrades will be required:

- Upgrade of the gravity line between the Twyford Place Pump Station (PS10) and the Sheldrake Street Pump Station (PS2) from 300mm / 450mm diameter pipes to 600mm / 750mm diameter pipes;
- Reroute flows from the Civic Place Pump Station (PS11), through a 150mm diameter pressure main, to the gravity main feeding the Sheldrake Street Pump Station (PS2)

- Upgrade of the Sheldrake Street Pump Station (PS2), increasing its pump rate to approximately 245 L/s; and
- Increasing the pump rate of the Civic Place Pump Station (PS11) to achieve a design flow of 77 L/s.

Ultimately the new combined flow rate flowing into the Hamersley Main Sewer will be 322 L/s. This flow rate is approximately 150L/s greater than the current flow rate. A diagram of the current pressure and gravity main system is shown in Figure 3-1, and the proposed upgrade in Figure 3-2.

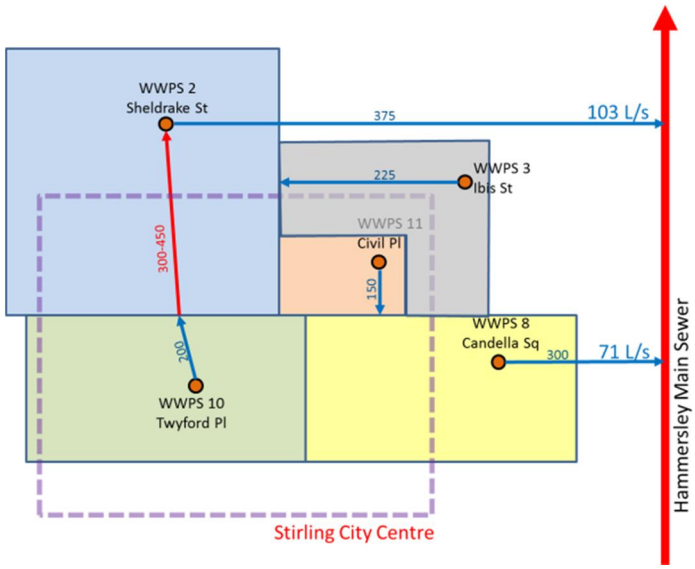


Figure 3-1 Current Hamersley MS Pressure and Gravity Main Layout

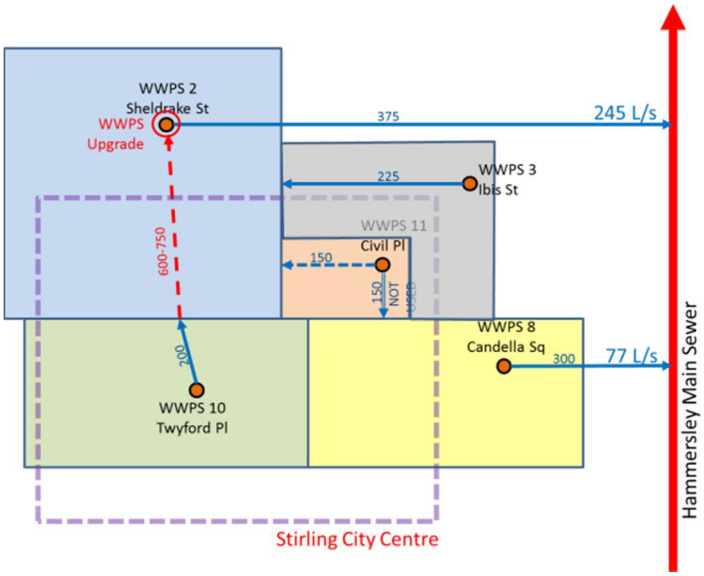


Figure 3-2 Proposed Hamersley MS Pressure and Gravity Main Layout for BaU Case

This increased flow has provided indication that the Main Sewer itself will require upgrading. This will involve the construction of at least 5 km of new sewer mains (600mm, 900mm, 1050mm and/or 1200mm diameter) to augment the capacity of the existing sewers. Whilst the SCC development is not the sole source of the increased flow to the Hamersley Main Sewer, it is a major contributor.

The sewer reticulation has been estimated to predominantly consist of 150mm diameter PVC sewers, with selected lengths of 225mm diameter PVC sewer. When projecting flows using Water Corporation Design Standard No. DS50, 300mm diameter sewers may be required in the Station Precinct to accommodate for flows equivalent to CBD flows. Further, detailed analysis will be required to confirm the actual pipe sizes required to service each precinct.

3.4 Summary of Upgrade Costs

The total cost of the items set out above is summarised below in Table 3.1. This is a revision of the figures presented in the previous report, modified in accordance with the revised yield and the sections above. The figures represent the 2013AUD value of the total capital spend and operating costs at ultimate development.

Table 3.1 Summary of Upgrade Costs

Service	Item	Description	Capex $m	Opex $m pa	Upper estimate $m pa
Water					
	Potable	Upgrade source / treatment / conveyance (1)		5.129	
		Upgrade distribution mains	5.000	0.147	
		New & upgraded reticulation	19.100	0.239	
	Wastewater	Upgrade WWTP	41.819	0.509	
		Upgrade main sewer	32.400	0.405	
		Upgrade pump stations	8.744		
		Local trunk sewers / rising mains	5.031		
		Upgrade local reticulation	28.385		
	Drainage	New road drainage	9.207		
Energy					
	Electricity	New substation - land	1.600		
		Substation upgrades	30.800	1.078	
		New distribution feeders	5.200	0.182	
		LV transformers & switchgear	21.000	0.735	
		Undergrounding and line removal	23.800		
	Generation	Additional 40 MW required	131.225		
		Fixed & variable O&M		4.487	
		Fuel (2)		21.978	44.000
		Carbon price (2)		52.672	106.416
	Gas	Distribution upgrades	1.24	0.043	
		Gas pipe upgrades	2.10	0.074	
		Gas consumption (3)		4.686	
Waste		Additional operating costs		9.665	
Telecoms		Upgrades / NBN	13.283	0.332	
		Total Infrastructure	**379.934**		
Building costs (4)					
		Boilers / Chillers	250.000	6.263	
		Total	**630.434**		

Notes:

(1) This figure is an annualised cost based on the current long run marginal cost of water (LRMC) determined by the Water Corporation and agreed with the Economic Regulatory Authority. $1.75 is the average of the LRMC for demand reductions ($1.51 in 2012) and for demand increases ($1.90 in 2012) escalated by 2.5% to obtain a 2013AUD figure. This per kL figure incorporates both capital and operating costs.

(2) The operating costs noted for energy generation in respect of the carbon price represent the best estimate and upper bound assumptions in the BREE report referred to in Section 3.2.1.

(3) Based on an average cost of gas during the project life of $12.30/GJ in 2013AUD.

(4) This cost represents the cost of thermal energy equipment normally incorporated within buildings, but avoided in BAT options.

4. Best Available Technology Concepts

4.1 Refinement of Shortlisted Concepts

Following issue of the previous report[5], the proposed BAT concepts were reviewed by the Alliance, Kinesis and the Stirling Alliance's Infrastructure Working Group. As a result, some modifications to the approach in respect of energy and waste services have been incorporated in the revised strategy. The following sections provide an overview, followed by a more detailed description of the strategy.

Schematics of the BaU (Figure 4-2) and BAT options (Figure 4-3 and Figure 4-4) are depicted at the end of this section.

4.2 Overview of Strategy

4.2.1 Zoning

Previously it was proposed to provide distributed thermal energy and non-drinking services throughout the SCC area. However it has been assessed by GHD that this is unlikely to be feasible in the purely residential precincts (Woodlands, Northern and Innaloo) as development in these areas is likely to proceed in an ad-hoc lot by lot manner over a number of decades. Accordingly the strategy has been modified to limit the distribution of these services to the mixed use elements of the SCC (referred to in the following as the distributed services zone).

The proposed boundaries of the distributed services zone are set out in Figure 4-1. This zone has been nominally divided into sub-zones (Central, Eastern, Western and Northern) which reflect the possible staging of the roll-out of distributed services.

Locally produced electricity will be available throughout the development. Outside of the distributed services zone, i.e. in the purely residential areas, the following has been assumed:

- Thermal energy demands at the building scale will be met by electricity, e.g. high performance heat pump systems; and
- Non-drinking water will either not be available or will be provided at the lot scale, e.g through building scale wastewater or greywater recycling.

[5] Stirling Utilities Infrastructure Strategy, Volume 1 – GHD Oct 2013

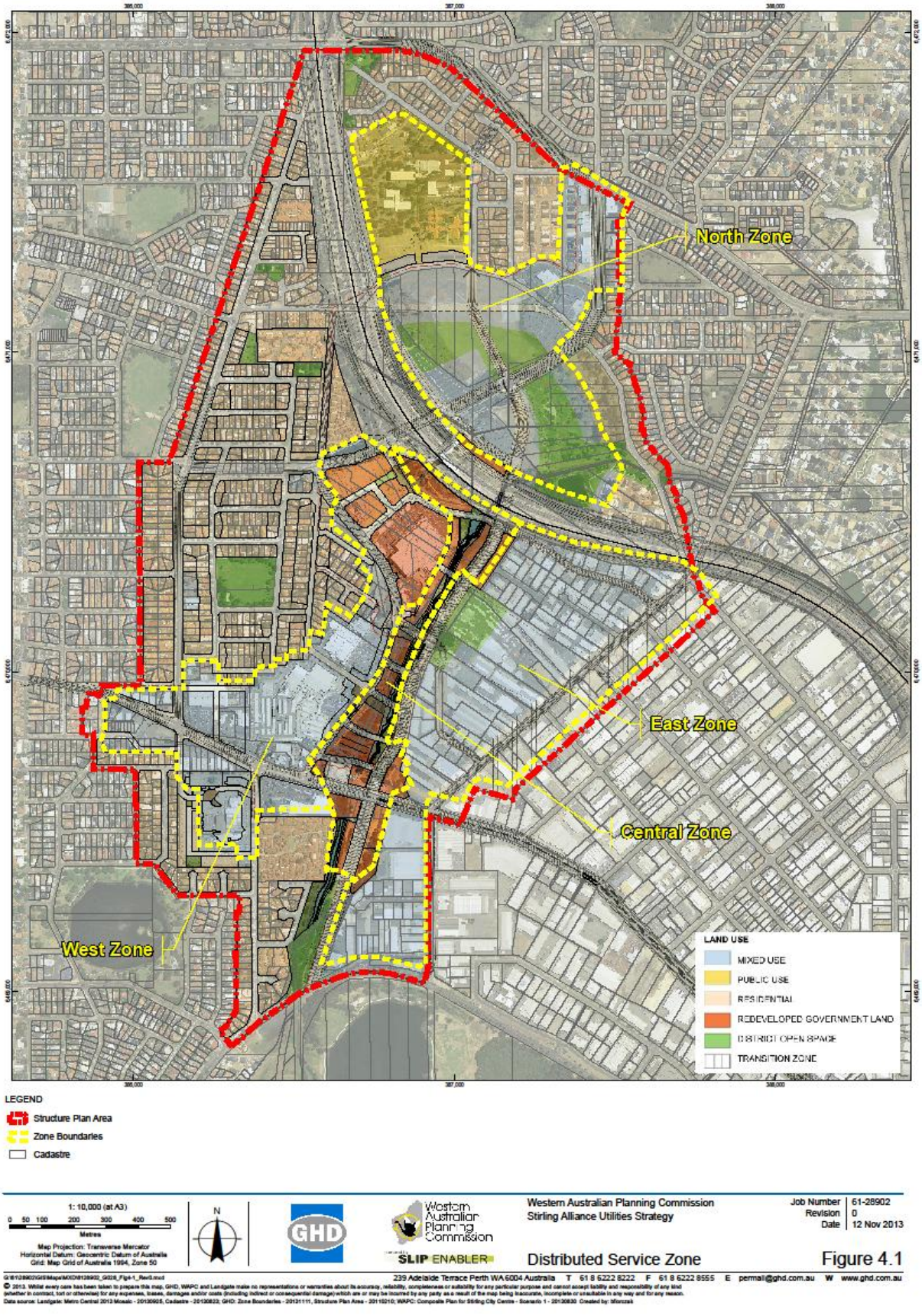


Figure 4-1 Distributed Services Zone

4.2.2 Energy

Energy Efficiency

As identified in previous reports by both Parsons Brinckerhoff and Kinesis (see Section 1.3), energy efficient building design is a core requirement of the BAT strategy. It is assumed that this will be accompanied by best practice measures in respect of occupant behaviour, including the use of smart grid / meter technology to provide feedback on energy consumption and comparisons with other consumers at a local and metropolitan wide basis.

Energy Source Options

The overall objective of the energy strategy is to:

1. Reduce the peak and annual electricity demands of the development.
2. Remove the thermal loads from the electricity system by providing a distributed thermal energy source for heating and cooling purposes.
3. Achieve energy self-sufficiency on an annual basis while utilising the electricity grid for balancing supply and demand.

Two alternatives have been retained in the final strategy. The trigeneration option identified in the previous report has been retained but modified. The solar PV / geothermal option has been retained.

Trigeneration / Solar PV Option

In the previous report it was proposed that the feedstock for the gas engines would be derived from a waste-to-energy process, namely gasification of high calorific value wastes from across the City Stirling. GHD has now determined that the feasibility of this approach is questionable (discussed further in Section 4.4 below). Accordingly it is now proposed that the gas engines will be fuelled by natural gas from the ATCO network. The electrical output of the gas engines will be supplemented with solar PV and electrical storage. Electricity supply may be supplemented by additional generation from a gas engine at the waste recovery facility using a feedstock derived from anaerobic digestion of organic wastes (see Section 4.6.3).

Under the trigeneration scenario, heat will be produced from the gas engines which will provide a source of heat for circulation to SCC buildings via a district hot water loop. This heat will be used for space heating and water heating. Co-located absorption and electric chillers will utilise the heat to produce cold water, which will similarly be circulated through a district cold water loop. This service will remove the cooling load from the electricity system completely in the distributed services zone, eliminating the major driver of power system upgrades on the SWIS in recent times. The absorption chillers will be supplemented with electric chillers and chilled water storage.

Solar PV / Geothermal Option

Under this scenario, all electricity will be supplied from grid connected rooftop solar photovoltaics (solar PV). Sufficient roof space is available both within the development area (Innaloo shopping centre, IKEA and new developments) and in the adjacent Osborne Park light industrial area. A total of approximately 190,000m2 would be required to meet the peak electrical load. The total roof area of the IKEA building is around 15,000m2. The solar system will be coupled with electrical energy storage to meet the evening peak demand. As for the trigeneration / solar option, electricity supply may be supplemented by additional generation from a gas engine at the waste recovery facility using a feedstock derived from anaerobic digestion of organic wastes.

Under the solar / geothermal scenario the thermal heat source will be derived from geothermal energy. Based on interpretation from the Geothermal Centre of Excellence at the University of WA, this would require a geothermal bore depth of 1,500 - 3,000m for the source to be sufficient to provide the necessary energy to drive the absorption chillers to meet the cooling load.

4.2.3 Water

Water Efficiency

It is assumed and recommended that best practice water efficiency practices would be mandated in the development, including appliances meeting the highest available Water Efficiency Labelling Standards (WELS)[6], and for irrigation. This would be complemented with measures in respect of occupant behaviour, including the use of smart water meter technology to provide feedback on energy consumption and comparisons with other consumers at a local and metropolitan wide basis.

Water and Wastewater

In a parallel commission, GHD has developed a preferred integrated water cycle solution for the SCC. In this work various alternative water supply options were evaluated, including roof collected rainwater, stormwater, groundwater and recycled wastewater. GHD determined that only recycled wastewater was available in sufficient quantities to be a complete solution. Greywater was not considered as an independent source, as the treatment requirements are significant when it is stored, which would be necessary in this case. Under such arrangements separate and parallel treatment systems for greywater and remaining wastewater would be required.

The preferred scenario is therefore to recycle all wastewater and return this as a non-drinking water (NDW) source for irrigation, toilet flushing and cold water for clothes washing. These uses are likely to be acceptable to the Department of Health, subject of course to appropriate risk management. This NDW service will be limited to the distributed services zone.

The demand analysis shows that there is sufficient recycled water to meet the total non-drinking water demand in summer, while in winter when the irrigation demand is small / negligible there is an excess of recycled water. This high quality excess water will be locally discharged to the superficial aquifer and hence contribute to offsetting other abstraction in the area (from irrigation of public open space) and the retention of groundwater levels.

It is proposed that scheme water provided by the Water Corporation through the Integrated Water Supply Scheme (IWSS) is used for all other uses (i.e. those uses requiring drinking water quality).

4.2.4 Drainage

The draft District Water Management Strategy (Essential Environmental Services 2010) requires best practice water sensitive urban design (WSUD) features for the development. Where possible, all stormwater from frequent events will be collected / treated on lots, and street drainage will incorporate rain gardens, swales and other management devices. Less frequent, higher rainfall events will utilise the street drainage system to convey water through the existing stormwater system. Stormwater within the relevant catchment will be discharged into the urban stream corridor where it will be naturally treated and conveyed into the steam channel.

Design of the streetscape WSUD features and of the urban stream are the subject of separate commissions, and are accordingly described elsewhere.

[6] http://www.waterrating.gov.au/

4.2.5 Waste

It is proposed that mixed bagged waste (including all recyclables) from multi-unit dwellings in the more densely populated areas, and commercial premises will be connected to a vacuum waste collection system.

Waste placed in the vacuum system will be transported through the system's pipes to a central terminal in the SCC area. From here it will be collected by Council or a contractor, and taken by road to a Central Waste Processing Facility (CWPF). At the CWPF materials recovery facilities will separate recyclables, organics and high calorific value materials (plastics etc) from other wastes.

Recyclables will be processed through existing markets. The organic fraction will be feedstock to an anaerobic digester which will produce biogas and a solid digestate suitable for use as a soil conditioner. The biogas will be treated and used either as a feedstock for a gas engine that will be a (relatively minor) supplementary electricity source in addition to those outlined in Section 4.2.2 above, or as a vehicle fuel (see Section 4.6.3).

High calorific value materials will be separated. There is an emerging market for such materials to be gasified to produce a syngas, which is a potential feedstock for offsite electricity production. Onsite generation of this type is no longer proposed by GHD as part of the SCC utility strategy.

4.2.6 Telecommunications

The NBN rollout at Stirling offers the opportunity to utilise smart meter enabled technology. This will facilitate the use of smart meters for electricity and water, which will be used as part of a consumer behaviour program by providing feedback to building occupants on energy and water use.

Smart meters will be essential in establishing a smart grid network within the SCC. Smart grids involve the installation of smart distribution networks, smart infrastructure such as car charging stations and software for sophisticated control energy management; network shut downs, network stability and network reliability.

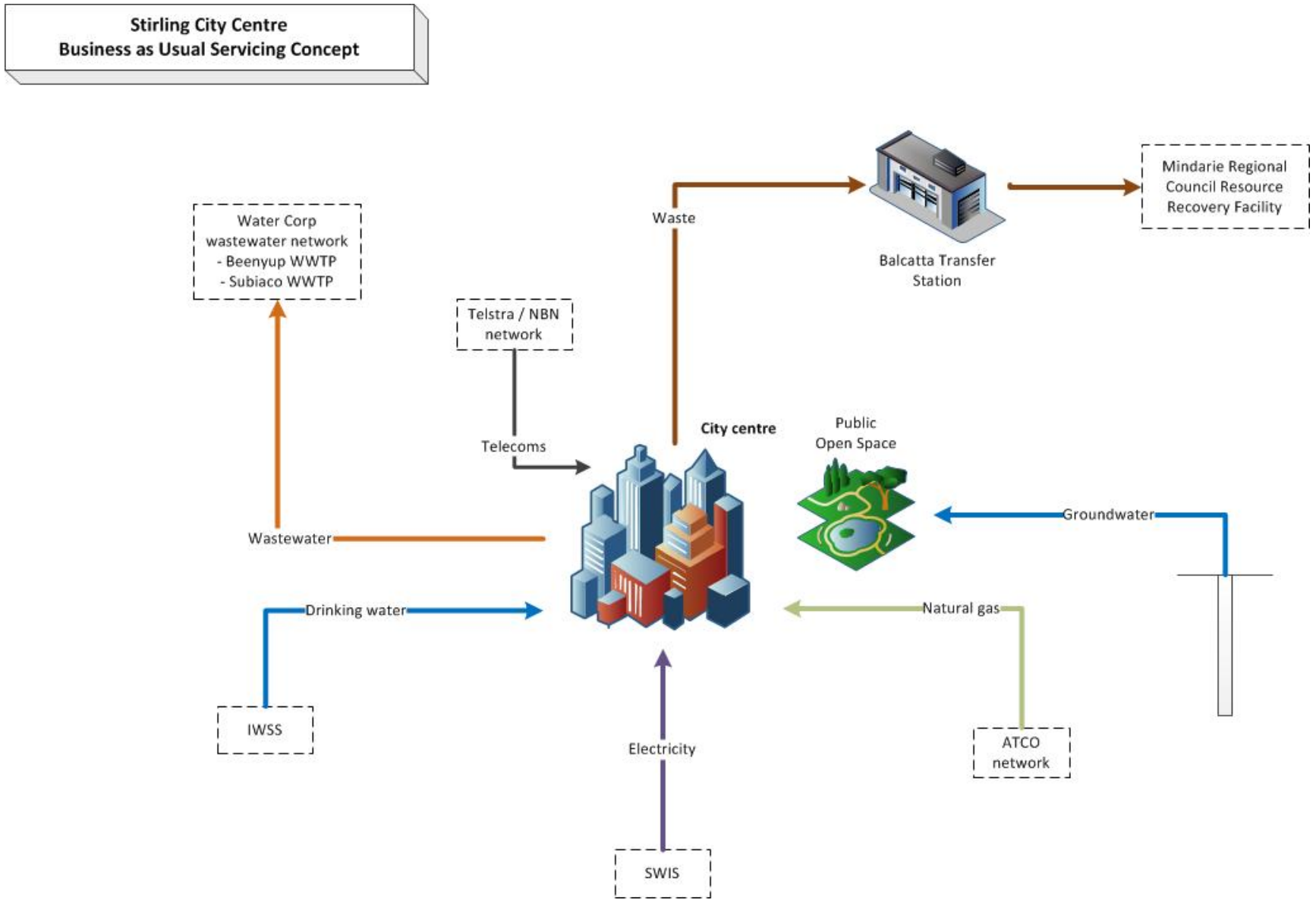


Figure 4-2 Business as Usual Option

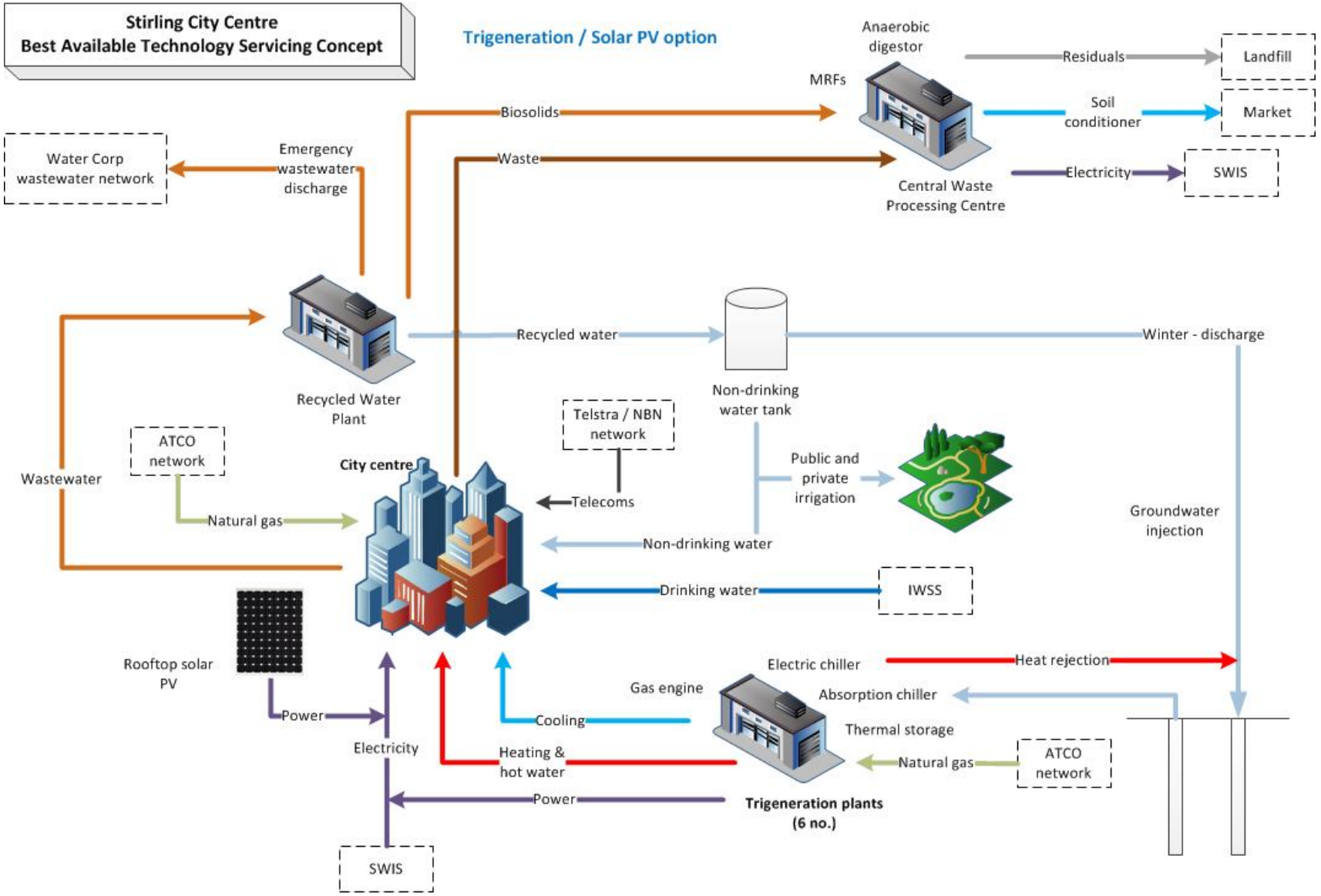


Figure 4-3 Trigeneration / Solar PV Option

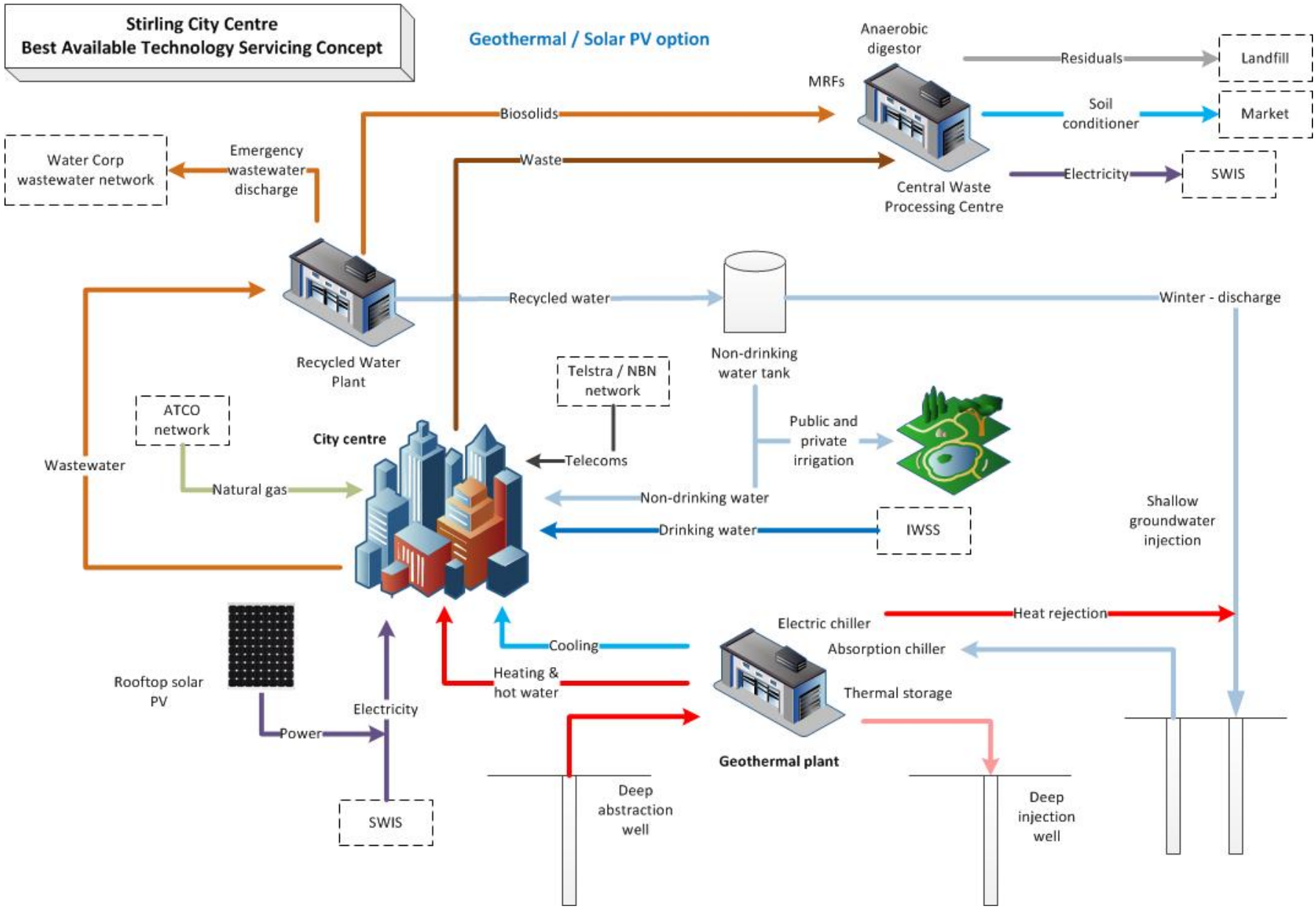


Figure 4-4 Solar PV / Geothermal Option

4.3 Energy supply – Trigeneration / Solar PV option

4.3.1 Description

The district energy plan for this option consists of six energy hubs which provide electricity to the entire SCC development, and heating and cooling to the distributed services zone of the SCC. Each hub consists of a number of gas engines, absorption chillers, electric chillers and a thermal storage tank. Each hub will be connected by a primary hot and cold water loop.

The specifications used for the engine calculations are based of the GE Energy Jenbacher J616 engine. The engine will provide electricity which will feed directly into the SWIS from each hub. Under this option, the feedstock for the gas engines will be natural gas.

The energy output from this feedstock produces around 40% electricity and 50% heat (10% losses). The heat from the gas engine is captured to provide district hot water in the first instance and excess heat is used to drive a set of absorption chillers, supplemented with electric chillers and cold water storage.

The benefit of a precinct scale trigeneration system is the avoidance of the need to install chillers and boilers at the building level. This equipment is replaced by simple heat exchangers and associated connections to the thermal network.

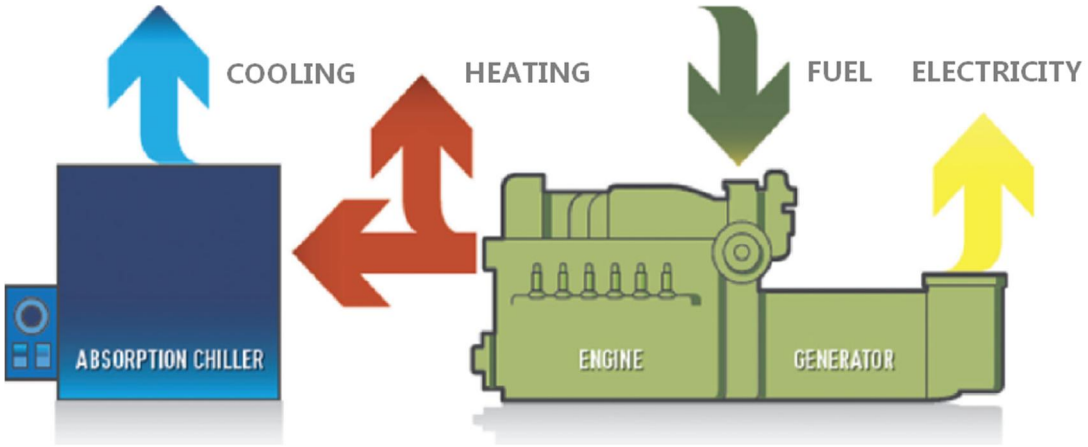


Figure 4-5 Trigeneration Schematic

The trigeneration equipment has been sized to meet a baseload of approximately 75% of the winter thermal loads in the distributed services zone. The balance of the thermal loads will be met by electric chillers, supplemented with chilled water storage.

At each station excess heat will be transported via the hot water loop to the RWP. Here the heat will be transferred though heat exchangers to a closed loop groundwater circulation system by linking abstraction and injection bores at the surface. In this way the excess heat will be rejected to the superficial aquifer. Although this adds more equipment at the RWP site, it avoids cooling towers at each of the hubs. As it is a closed system there is no drawdown on the aquifer – groundwater would merely be recirculated, with no treatment required.

Under this scenario additional electricity supply will be required to meet the demands within the distributed services zone and the full electrical and thermal loads in the purely residential precincts. This shortfall will be met though grid connected solar PV systems constructed at a building level and aggregated across the development. Installations of 1-2 MW may be possible on buildings with large roof areas (such as the IKEA building). Conventional rooftop systems are envisaged. The estimated capacity of the solar PV systems is 38.75 MW.

Solar energy will not be available to meet the summer evening peak demands of the development. Accordingly it has been assumed that electrical storage of about 4 hours will be required. A specific storage technology solution has not been determined at this stage, although several are reviewed in a recent report prepared for the Clean Energy Council (Marchment Hill 2011) [7] including flow and lithium ion batteries and compressed air.

As the system is grid-connected, any short term shortfall in solar electricity production overnight or during cloudy weather would be met by the SWIS.

Concerns about the potential impact of local solar saturation on power quality on the grid have been alleviated by the recently completed Solar Cities project[8]. However, close coordination with Western Power will be required in the grid integration design process.

4.3.2 Siting and Staging of Trigeneration Infrastructure

The design of the energy system utilising energy hubs rather than a central energy plant is due to a number of factors. Firstly, the siting of a plant large enough to house all of the equipment is considered too large a landtake in a high density mixed use area and secondly the size of the primary water loops extending to the fringes of the distributed services zone would be prohibitively large.

There are also significant advantages to the decentralised energy hubs. These can be built in stages as the development progresses. The first can be a test case providing a learning curve and ensuring future plant capacity to be based on actual demand from the buildings. Additional hubs can then be built as development progresses and the size of the primary loop connecting each hub can then be adjusted if necessary.

The energy hubs are significantly smaller than a single central plant. This means that the plants can easily be located in a number of ways, these including:

- plantrooms in major buildings or car parking facilities;
- co-located with existing infrastructure; or
- designed as landmark and / or educational facilities within the development.

Supply security is also improved through the interconnection of hubs.

4.3.3 Infrastructure Requirements

The plant has been sized from the demand profiles generated from the modelling reported in Section 2.4. The gas engines have been sized to cover the thermal baseload demand for the distributed services zone, and take account of efficiencies in chillers and the thermal network. The solar PV has been sized to meet the remaining electrical demands from the entire development, including the recycled water plant, waste treatment facilities, street lighting and the energy infrastructure. During the day the engines will operate at full load, providing electricity, hot water to the district water loop and thermal energy to the absorption chillers. The chillers will operate at full load during the summer months. To service the full peak load in the summer months, chilled water storage is charged over night to supplement the chillers during the day. These will be capable of 116 MWh total storage; with a peak discharge of 31 MWth.

Table 4.1 below shows the sizing of all equipment for the development.

[7] http://www.marchmenthill.com/docs/mhc-perspectives/MHC%20Perspective%20-%20The%20future%20of%20energy%20storage%20in%20Australia.pdf
[8] http://www.westernpower.com.au/documents/smartGrid/PSC_-_2012_ANNUAL_REPORT_-_FINAL_FOR_DISTRIBUTION_(LO-RES_18.pdf

Table 4.1 Trigeneration Equipment

Equipment	Full Development Size	Energy Hub Size	Units
Gas Engines	11.4	1.9	MWe
Absorption Chillers	12	2	MWth
Solar PV	38.75	N/A	MW
Electrical Chillers	20	3.3	MWth
Central Heating Loop	24,000	N/A	m
Central Cooling Loop	24,000	N/A	m
Chilled Water Storage	116	20	MWh

A map of the proposed trigeneration network is depicted in Figure 4-6.

4.3.4 Building design and performance implications

The demand profiles reported here are based on assumptions about the performance of buildings within the development. High energy and thermal performance buildings are critical to the feasibility of the district energy scheme. Reducing and avoiding energy consumption from design, through construction and maintaining efficient operation is significantly more economical than installing energy infrastructure to service the building. The energy scheme is designed on all buildings achieving the applicable 5 star National Australian Built Environment Rating Scheme (NABERS) Energy Office, Residential or Shopping Centre performance.

A 5 star NABERS office "whole building"[9] is becoming the standard benchmark for commercial buildings with 41 buildings in Australia achieving 5 stars or higher. NABERS for residential and shopping centre buildings is a newer scheme and slightly more difficult to achieve, however 2 shopping centres have achieved 6 star NABERS energy ratings.

During the period that the SCC development occurs, 5 Star or higher NABERS Energy across all buildings should become the benchmark, although cannot be assumed.

The incorporation of a thermal network obviates the need for boilers and chillers at the building scale, thereby avoiding the costs of this equipment.

4.3.5 Network implications – electricity / gas

As noted in Section 3.1, significant power upgrades will be necessary in the development area. GHD has estimated that the lower electrical demand arising from adoption of the preferred concept would reduce the peak electrical demand from 63 MVA to 27 MVA (57%) through the requirement of energy efficient buildings and the substitution of electrical energy with thermal energy in the distributed services zone.

GHD has estimated that this scenario would reduce the necessary upgrades to three 66MVA transformers and 16 additional distribution feeders. It is estimated that this would generate an overall saving of $33m of which some $ 23m is attributable to the SCC development.

As the SCC develops and demand grows, there will be an increasing reliance on natural gas as a feedstock for the trigeneration system. This would necessitate a significantly greater upgrade of gas infrastructure than for the BaU scenario.

[9] One of three ratings available for office buildings - http://www.nabers.gov.au/public/WebPages/ContentStandard.aspx?module=21&template=3&include=ratewhat.htm&side=RatingTertiary.htm

4.3.6 Costs

Option 1 – Trigen / Solar system		Capital Costs ($)		
Item	Size	Unit	Cost per unit	Total cost
Trigen Plant	11.4	MW	2,000,000	22,800,000
Absorption chillers	12	MW	500,000	6,000,000
Solar PV	38.75	MW	1,760,000	68,200,000
Electrical storage	12.92	MW	700,000	9,044,000
Electrical chillers	20	MW	260,000	5,200,000
Heating Loop	24,000	m	1,700	40,800,000
Cooling Loop	24,000	m	2,000	48,000,000
Pits	147		3,000	441,000
Pumps	8		50,000	400,000
Chilled Water Storage	116	MWh	71,800	8,328,800
Heat rejection system				2,500,000
			Total	211,713,800

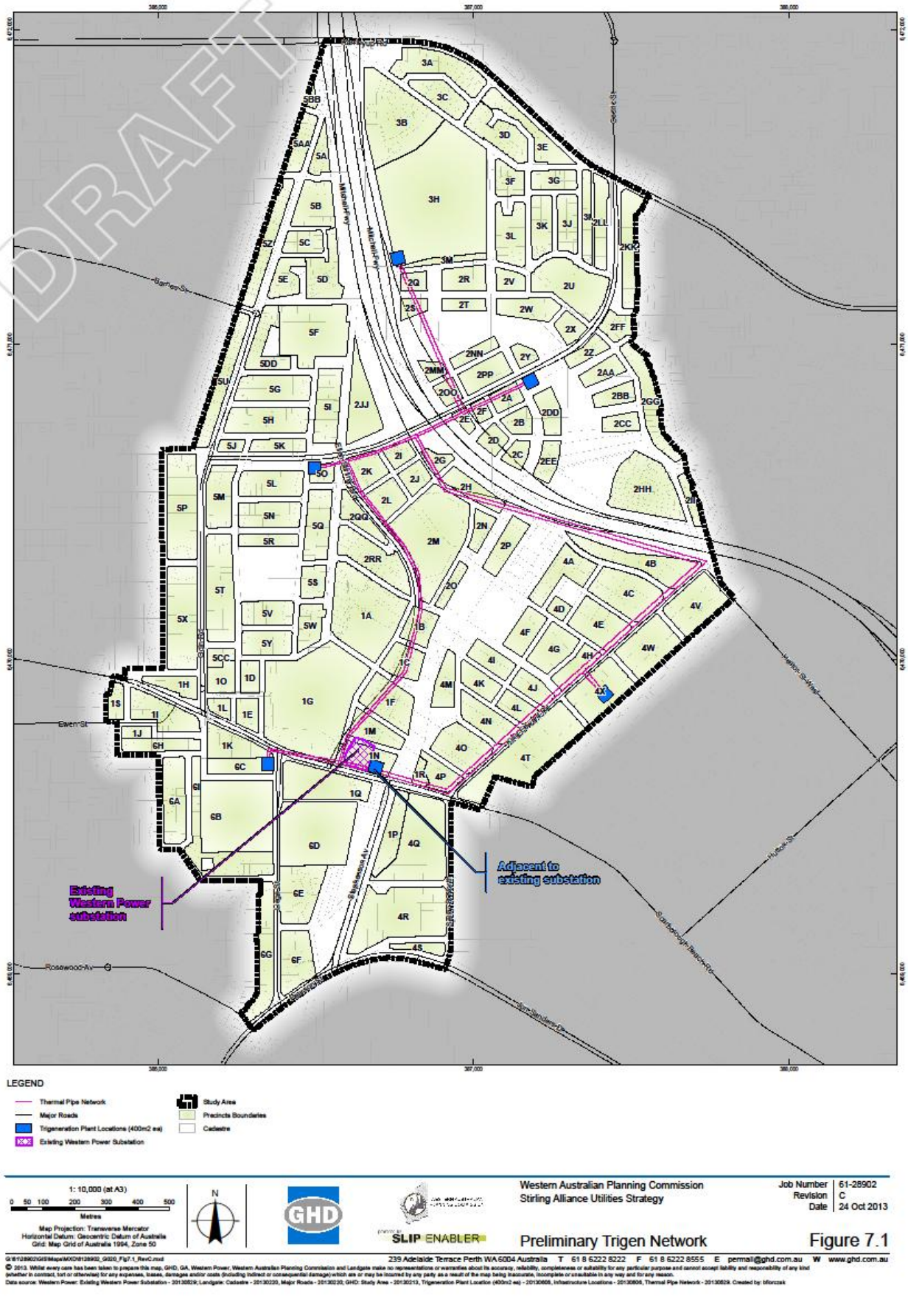


Figure 4-6 Trigeneration Network

4.4 Energy supply – Solar PV / Geothermal option

4.4.1 Electricity

In this scenario (see Figure 4-4) the total electricity supply will be provided via the SWIS through grid connected solar PV systems constructed at a building level and aggregated across the development. The PV has been sized to meet the peak electrical demands arising from building electrical loads (including the thermal loads in the residential precincts), electric chillers, and ancillary electrical loads.

Assuming 0.2 kW / m2 panel size, some 270,500 m2 of solar panels would be required. Noting that the IKEA site is some 15,000 m2, the required capacity to meet peak power of around 54 MW could be obtained from the roofs of around 25-30 equivalent sized buildings. It is envisaged that the local utility would either secure or negotiate access rights to roofs within the development[10] for solar PV installations, and have leasing arrangements with building owners. Buildings to be considered include the IKEA building, the Westfield shopping centre, energy stations and other buildings within the development, plus light industrial buildings in the adjacent Osborne Park area.

Solar energy will not be available to meet the summer evening peak demands of the development. Accordingly it has been assumed that electrical storage of about 4 hours will be required (see 4.3.1). As the system is grid-connected, any short term shortfall in solar electricity production overnight or during cloudy weather would be met by the SWIS.

4.4.2 Geothermal Energy

The thermal network under this scenario would be supplied by geothermal energy. Although Perth is presently using geothermal energy only for heating swimming pools, the opportunity to tap deep sedimentary basins such as the Perth Basin is recognised. The WA Geothermal Centre of Excellence (WAGCoE) has provided the necessary inputs into this element of the study.

Although geothermal energy can potentially be used to generate electricity, in the context of this project it is being considered as a heat source for the proposed thermal network given the uncertainties about the resource at this stage.

The SCC is centrally located in the Perth Sedimentary Basin, a 10-15 km deep north to north-northwest trending, onshore and offshore sedimentary basin, for which reasonable hydrological, geological and geophysical information is available. This resource is known as a hot sedimentary aquifer (HSA). The heat extraction from a hot sedimentary aquifer (HSA) is fundamentally different to that of an enhanced geothermal system (EGS). In the EGS reservoir a spatially confined fracture network is stimulated between an extraction and an injection well. Since heat can only be abstracted from that small engineered reservoir the rock cools with time. The engineering design of the EGS reservoir is ideally formulated to ensure that the project time scale is sufficiently large to justify the investment (20 years, typically).

A HSA is a completely different reservoir as it is as large as the aquifer itself. In most sedimentary basins these are several orders of magnitude larger than EGS reservoirs and is therefore an “energy elephant” in the geothermal context[11]. The WAGCOE was the first initiative that pioneered research into this under investigated energy source (see reports on

[10] It is beyond the scope of this study to identify the specific mechanism to secure access rights. However Notification under s.70A of the Transfer of Land Act may be one option.
[11] http://www.sedheat.org

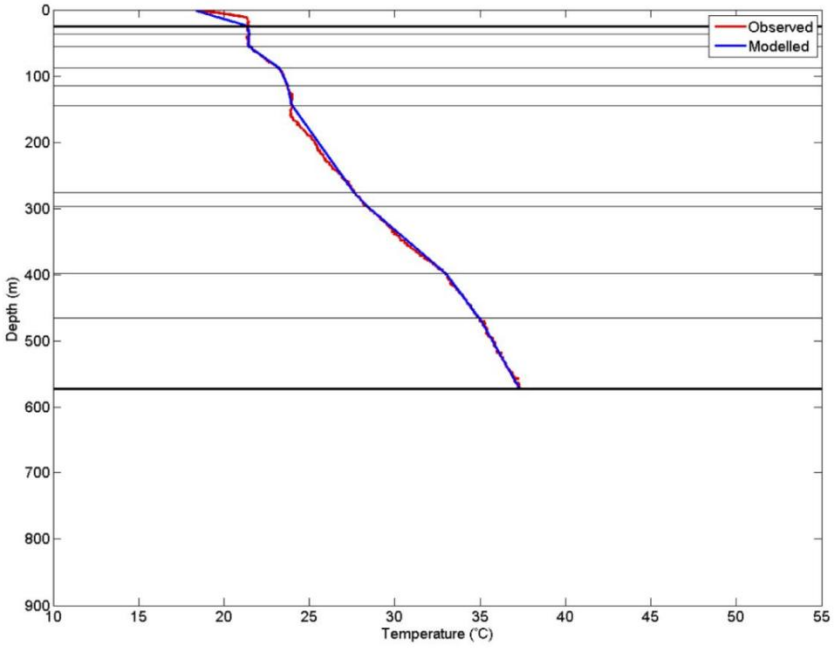
www.geothermal.org). Based on this outcome CSIRO has also released a document for information to the Australian public[12].

For large aquifers such as the Perth basin the HSA reservoir is not limited by the available heat but by the necessity to reinject cold water into the same aquifer to sustain water levels. If the injection well is placed too close to the extraction well a phenomenon known as thermal breakthrough can occur and the heat from the HSA cannot be extracted efficiently. The distance between the wells can be, however, designed such that thermal breakthrough does not occur. An Australian example of such a design is the Pawsey Supercomputer. This system has just been switched on and designed to provide 2 MW cooling for the supercomputer[13].

In order to minimise planning risk and highlight areas of further investigation and higher potential in Perth WAGCoE has performed a high level study of the subsurface temperature regime in the Perth metropolitan area, and in the Stirling area. Of particular relevance to the potential geothermal project at Stirling are the results at the Yarragadee aquifer, which has excellent permeability. The aquifer monitoring well AM 36, which has unfortunately not been logged by WAGCoE is closest to the Stirling Centre (adjacent to the Freeway at the eastern end of Edward St). The well has, however, been digitised from the DoW logs and the analysis is shown in Figure 4-7.

AM36

Digitised by WAGCOE, April 2010



Temperature vs depth for AM36 (red line) and subsequent linearly modelled gradients (blue line)
Bold lines indicate interval analysis was conducted over. Logging speed: 9 m min^{-1}; time constant: 0.5 sec

Well specifics

Date construction completed:	15/04/1982	**Ground level (m AHD):**	15.941
Date logged:	16/07/1982	**Top of casing (m AHD):**	15.957
Geodetic datum:	GDA94	**Total well depth below GL (m):**	616
Horizontal coordinate system:	MGA94 Zone 50	**Perforated interval (m) (formation):**	526 - 532 (Yarragadee)
Easting (X):	387766	**Status:**	Operating
Northing (Y):	6470299	**Depth to reliable measurements (m):**	25

[12] http://www.csiro.au/Outcomes/Energy/Renewables-and-Smart-Systems/CSIRO-Geothermal-Project/Hot-Sedimentary-Aquifers.aspx.
[13] http://www.csiro.au/Portals/Multimedia/CSIROpod/Supercomputer-cools-off-with-groundwater.aspx

Figure 4-7 Geothermal Well AM36

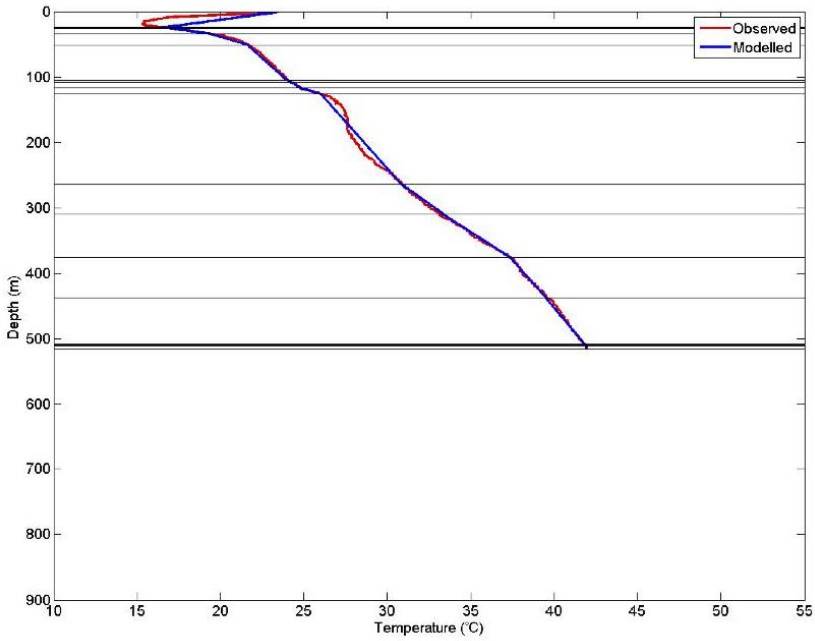
AM36 has reached the top of the Yarragadee at 465 m depth where the temperature is 34.9 °C and the gradient is 22°C/km. This result is in sharp contrast to the result of the next well AM33A (in Duncraig), which has been logged by WAGCoE (Figure 4-8). This well has an anomalous high reading of 39.5°C at the top of the Yarragadee at slightly shallower depth of 437m. The temperature gradient for this depth was inferred to be 33°C/km.

In the absence of heat transfer through fluid flow (advection) it is generally a relatively safe procedure to linearly extrapolate conductive gradients with depth, i.e. assume that the temperature continues in a given formation with the measured 1-D gradient. It would, for instance be common practice in geothermal exploration to extrapolate the inferred 1-D gradient of 22°C/km at AM36 and 33°C/km at AM 33A through an assumed thick Yarragadee aquifer and obtain:

- a predicted temperature of 56.9 °C at 1465m depth for AM36; and
- a predicted temperature of 72.5°C at 1437m depth for AM33A.

AM33A

Digitised by WAGCOE, April 2010



Temperature vs depth for AM33A (red line) and subsequent linearly modelled gradients (blue line)
Bold lines indicate interval analysis was conducted over. Logging speed: 10 m min^{-1}; time constant: 1 sec

Well specifics

Date construction completed:	N/A	**Ground level (m AHD):**	7.182
Date logged:	02/02/1983	**Top of casing (m AHD):**	7.662
Geodetic datum:	GDA94	**Total well depth below GL (m):**	535
Horizontal coordinate system:	MGA94 Zone 50	**Perforated interval (m) (formation):**	495 - 505 (Yarragadee)
Easting (X):	385150	**Status:**	Operating
Northing (Y):	6477342	**Depth to reliable measurements (m):**	25

Figure 4-8 Geothermal Well AM33A

However, in spite of the similarity between predicted and measured/digitised 1-D temperature profiles this simple method of predicting temperatures at depth is not advised on the grounds of the existing data. The sharp lateral variation in temperature is unusual and contradicts such a general geothermal prospect definition. The contrast could have many sources of which a measurement error or alternatively heat transfer through fluid flow or 3-D heat transfer are the most probable sources.

Further interpretation of this data, followed by a trial bore would be necessary to definitively determine the temperature profile at the SCC site. However, according to the WAGCoE research, it can be expected that the groundwater temperature increases from around 20°C at the water table to around 50-80°C at 1500 m depths. A large uncertainty is assigned to the strong measured lateral gradients in temperatures. Extrapolating this geothermal gradient, the groundwater temperature may reach well in excess of 100°C at 3000 m depth. This temperature is suitable to drive an absorption chiller for thermal energy (mainly air-conditioning), given a suitably productive geothermal resource. It is also possible to operate absorption chillers at the lower temperature of 80°C with accompanying lower coefficients of performance.

4.4.3 Network implications – electricity / gas

The use of geothermal as a thermal energy source removes the need for natural gas as a feedstock and hence upgrades for the gas distribution network for this purpose will not be necessary. With appropriate design of the abstraction and injection well, this is effectively an infinite source of thermal energy.

4.4.4 Solar PV / geothermal Costs

The sizing of equipment accounts for efficiencies and losses in the geothermal system, chillers and thermal network is shown below.

Option 2 – Solar PV / Geothermal system		Capital Costs ($)		
Item	Size	Unit	Cost per unit	Total cost
Solar PV	54.1	MW	1,760,000	95,216,000
Electricity storage	18.1	MW	700,000	12,670,000
Geothermal bore completion	1	Doublet	25,000,000	25,000,000
Absorption chillers	28.35	MW	500,000	14,175,000
Electrical chillers	23.8	MW	260,000	6,188,000
Heating Loop	24,000	m	1,700	40,800,000
Cooling Loop	24,000	m	2,000	48,000,000
Pits	147		3,000	441,000
Pumps	8		50,000	400,000
Chilled Water Storage	116	MWh	71,800	8,328,800
Heat rejection system				2,500,000
			Total	253,718,800

4.5 Water, Wastewater and Drainage

4.5.1 Scheme Water

The proposed water efficiency measures and water recycling scheme is expected to reduce potable demands by nearly 60%. If it is assumed that the peak instant demand on the potable network reduces in proportion to this, larger potable water mains within the area would be able to be downsized.

Over the size range relevant here (approx DN100 to DN600), mains would generally only be able to be downsized to the next standard WC main size.

4.5.2 Water Recycling

The water recycling scheme proposed for the SCC is based on the following assumptions:

- Wastewater collected from residential and commercial properties will be treated at a Recycled Water Plant (RWP);and
- Recycled water from the RWP will be used to meet all non-potable water demands within the SCC distributed services zone including residential in-house non-potable uses (toilet flushing and cold washing machine tap), commercial toilet flushing, 'new' POS irrigation (POS that doesn't currently exist and is established within the SCC), and road verge irrigation for areas established within the SCC.

New POS irrigation and verge irrigation water will be sourced from recycled water created within SCC while the existing POS irrigation source will remain local groundwater using current groundwater licences.

4.5.3 Wastewater Conveyance

The required wastewater upgrades for BaU are described in Section 3.3.2.

For the alternative servicing strategy it is proposed to construct a Recycled Water Plant (RWP), and reconfigure WWPSs and associated pressure mains to pump all wastewater from WWPSs 10 (Twyford Place) and 11 (Civic Place) to the RWP. A schematic of the proposed ultimate arrangement of those WWPSs which serve the SCC area and are within the catchment of the Beenyup WWTP is provided in Figure 4-9. Under this arrangement, the combined pump rate of those pump stations discharging into the Hamersley MS will be approximately 237 L/s, which is approximately 63 L/s more than the current pump rate. This is however approximately 85 L/s less than the ultimate combined pump rate from these pump stations with the BaU servicing strategy.

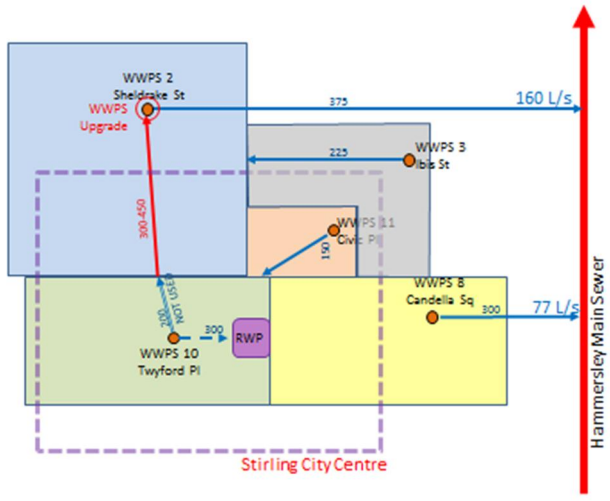


Figure 4-9 Potential Arrangement of Wastewater Pump Stations and Sewer Mining Scheme

The current and ultimate average daily flow to the pump stations within the ultimate catchment of the WRP is provided in Table 4.2.

Table 4.2 Current and Estimated Ultimate Average Daily Flow to Wastewater Pump Stations

Wastewater Pump Station	Average Daily Flow (ML/d)	
	Current	Ultimate (WC estimate)
10 (Twyford Place)	1.0	4.1
11 (Civic Place)	0.1	0.9

Total	1.1	5.0

Whilst it is not possible to directly compare the GHD 'waterwise' wastewater flow estimates with the more conservatively derived flows estimates by WC in their planning review, it is considered that these two pump stations will provide sufficient wastewater to meet the ultimate maximum day recycled water demand within the area (3.3 ML/d). If necessary flexibility exists to better balance wastewater flows and recycled water demands by either:

- reducing or expanding the area served by the recycled water scheme; and/or
- diverting flow from the catchment of WWPS 8 (Candella Square) to the RWP.

Initial transfer of the Twyford Place pump station to the WRP will provide approximately 1.0 ML/d of recycled water to meet early recycled water demands within the area.

4.5.4 Recycled Water Plant

A Recycled Water Plant (RWP) is proposed to be built to treat wastewater from a number of WC WWPSs with catchments within or extending into the SCC area. The plant will provide high quality recycled water which will be used to meet non-drinking water demands within the area. A secondary benefit is that it will reduce the volume of wastewater that needs to be conveyed to the Beenyup WWTP, and subsequently treated at this plant and discharged via ocean outfall.

At this stage it is envisaged that the RWP will be a membrane bioreactor type (MBR) type wastewater treatment plant, complete with:

- fine screens and grit removal facilities;
- MBR type secondary treatment process units (process reactor comprising aerobic and anoxic zones and associated recycles, submerged or pressure type membrane solids separation facilities);
- disinfection facilities (e.g. chlorination and UV disinfection systems);
- sludge stabilisation and dewatering facilities;
- associated chemical dosing facilities; and
- odour control facilities to minimise the required buffer distance, full enclosure of all process units and sludge storage tanks is proposed, with a forced air ventilation system, scrubbing of collected foul air and released on scrubbed air via a stack.

The odour control facilities will be designed to ensure that odour concentrations at the nearest existing/future odour sensitive premises comply with regulatory requirements. Further assessment of this will need to occur during the preliminary design phase.

The assumed design criteria for the RWP are detailed in Appendix B. A potential site for the proposed RWP has not been identified at this time. For the purpose of this study it was assumed that:

- the RWP will be located within industrial land within the Osborne Park Industrial Area;
- as well as the RWP itself, the recycled water storage tank and delivery pump station will be located at the RWP site; and
- the overall footprint of the RWP will be approximately 0.45 ha, and that an additional 0.3 ha will be required for the recycled water storage and delivery pump station.

Table 4.3 Design Criteria for RWP

Parameter	Units	Design Value
Hydraulic Capacity		
Initial, Average Annual Flow	ML/d	1.0 (nominal)
Ultimate, Average Annual Flow	ML/d	3.5
Treated Wastewater Quality		
Biochemical Oxygen Demand	mg/L	< 5
Total Suspended Solids	mg/L	< 2
Turbidity	NTU	< 0.5
Total Nitrogen	mg/L	< 5-10
Total Phosphorus	mg/L	< 1
Total Alkalinity	mg/L (as CaCO3)	> 100
Chlorine Residual	mg/L	> 1.0
E. Coli	TFC/100mL	< 1
Faecal Coliforms	Org/100mL	
Pathogen removal (Indicator organism) Bacteria (Campylobacter) Virus (Rotavirus) Protozoa (Cryptosporidium)	Log removal	 > 5 > 6.5 > 5
E coliforms	cfu/100mL	< 1
Coliphages	pfu/100mL	< 1
Clostridia	cfu/100mL	< 1

4.5.5 Recycled Water Distribution System

It is proposed to supply NDW from centralised NDW storage tanks located at the RWP site, via an adjacent booster pump station designed to meet the minimum pressure requirement over the full range of potential NDW demands. The key design criteria for the recycled water distribution system are detailed in Table 4.4.

Hydraulic modelling has not been undertaken as part of this study to size NDW distribution and reticulation pipe networks. Rather, for the purpose of the preliminary cost estimate included in the report, it has been assumed that 5%, 10%, 15% and 70% of the total length of reticulation mains are DN250, DN200, DN150 and DN100 reticulation mains, respectively.

Table 4.4 Design Criteria for Recycled Water Distribution System

Parameter	Units	Design Value
NDW Demand		
Maximum day, ultimate	ML/d	3.5
Peak instant, ultimate	L/s	100
Recycled Water Storage Capacity		
Initial (effective)	ML	1.5 (1 x 1.5 ML tank))
Ultimate	ML	3.0 (2 x 1.5 ML tanks)
Minimum Supply Pressure (reticulation system)	m (gauge)	30

4.5.6 Aquifer Storage and Recovery (ASR)

ASR is being considered as a means of storing excess recycled water in the winter months, to be abstracted in the summer months if / when there is a shortfall of recycled water. The abstracted recycled water from the groundwater will then be added to the non-potable network within the SCC.

If the excess recycled water produced is not required for the non-drinking water scheme it will remain in the superficial aquifer. The quality of the water being injected into the superficial aquifer will be that which is produced by the recycled water treatment plant as described in Table 4.3. The disinfection arrangements for the RWP would be configured such that surplus water would not be disinfected prior to injection.

The concept for ASR is to inject excess recycled water when it is produced into 4 bores in the superficial aquifer at the proposed plant site in / near King Edward Rd. Further modelling is required to determine the feasibility of this disposal option.

Note: it is estimated that an area of 20x20m is required for a superficial ASR bore.

4.5.7 Water quantity summary

During winter the daily recycled water injection required is estimated to be 1.85 ML/day. This is for five months from May to September (based on watewise water use). This is equivalent to 22 L/s for injection in the winter months. During the summer months (December to February), the daily recycled water injection required ranges from 0.52 to 0.66 ML/day.

Overall, the aquifer storage scheme will be required to inject an estimated 490 ML/year. Preliminary modelling suggests that this will have some impact on the groundwater levels – preliminary estimations suggest that the groundwater level will increase by approx. 0.75 - 1m during injection. There may be some minimal losses to the stream (previously Osborne Park Branch Drain). However, more detailed modelling will be required to further interpret the interaction between injection, groundwater levels and losses to the stream. The results of this modelling will be included in the Total Water Cycle Options Report (GHD 2013).

4.5.8 Building design and performance implications

The delivery of the proposed water cycle and recycled water network has implications for building design.

Waterwise demands have been assumed meaning that water efficiency practices will need to be mandated for buildings, including water efficient fixtures and fittings internally, and water efficient irrigation practices.

The recycled water network will require additional plumbing in buildings to accommodate a second water supply. For present purposes it has been assumed that the cost of this is incorporated in the increased building costs to achieve 5 star building performance (see Section 4.3.4).

4.5.9 Network implications

The proposed recycled water system will have significant implications for the Water Corporation's potable water supply and wastewater networks, and also affect the quantity and quality of groundwater entering the urban stream. A brief summary of these implications is provided below.

Water Supply

Using locally produced NDW to meet all non-potable water demands will significantly reduce annual and peak potable water demands from the SCC. The main benefit of the annual potable water demand reduction is to defer the time when future IWSS sources and associated bulk water conveyance and treatment facilities are required.

The primary benefit of the peak potable water demand reduction is to reduce the distribution system storage capacity required to meet balance plus reserve storage requirements, and reduce the required hydraulic capacity of the distribution pipelines. Whilst no attempt was made

to quantify the former, it was estimated that distribution mains would be able to be downsized by approximately one standard pipe diameter as a result of this demand reduction. Of note potable water reticulation main sizing is unlikely to be affected, as sizing of these mains is more governed by design criteria associated with fire fighting water demands.

Wastewater

As discussed above, a key element of the proposed recycled water system is reconfiguration of two Water Corporation wastewater pump stations to convey wastewater to the proposed RWP. This will reduce the scope of local wastewater conveyance upgrade works required to service the SCC.

Year-round diversion of local flows to the RWP will also reduce the load on the Beenyup WWTP. This will enable deferral of future capital works required to upgrade the capacity of the plant, and lead to wastewater treatment operational cost savings.

Urban Stream

Preliminary hydrogeological modelling associated with GHD's water and environment commission indicated that injection of excess recycled water to the superficial aquifer in the winter will cause groundwater levels to rise, which will increase groundwater flows to the urban stream. Further modelling is underway to quantify the effect on urban stream flows.

4.5.10 Costs

Scheme Water Headworks: The capital cost of the proposed headworks upgrades is estimated at $2.5m for the mains upgrades (a saving of $0.5m on BaU). A provisional amount of $1m has been assumed for additional distribution upgrades (a saving of $1m on BaU).

The saving arising from the avoidance of additional source has been estimated at the value of the long run marginal cost of water, taken as $1.55 / kL (2012/13 figure plus inflation). This amount effectively reflects the capital and operating costs of new sources of water on the IWSS. This rate leads to a cost of $2.5m pa for the 1.2 GL pa demand.

Scheme Water Reticulation: The cost of scheme water reticulation is assumed to be the same as in the BaU case, i.e. $19.1 m including contingency and preliminaries.

Sewer Headworks: The cost of WWTP upgrades is reduced considerably with this option. The cost of upgrades to the local wastewater system are estimated as follows.

Item	Capital cost
WWTP upgrades	$7.7 m
Main sewer upgrade (2035)	$31.2 m
Pump Stations	$6.4 m
Total	**$45.3 m**

Sewer reticulation: is assumed to be the same as the BaU scenario, i.e. $28.4 m.

Recycled Water Plant: The cost of providing a recycled water plant with an ultimate capacity of 3.5 ML/day (staged) is $29m including contingency and preliminaries. Operating costs are estimated at $0.85/kL.

Non Drinking Water distribution / reticulation: The cost of the distribution and reticulation (third pipe) network is $12.5m. Operating costs are estimated at $0.15/kL.

Non Drinking Water disposal: The cost of the groundwater disposal system is estimated at $1.5m with operating costs of $0.15/kL.

4.6 Waste

4.6.1 Waste Collection

Waste will be generated from several different sources in the SCC. Domestic waste from single dwellings in the lower density areas, such as the Western, Northern and Woodlands Precincts, will be collected using conventional waste collection vehicles running on biogas generated from the anaerobic digestion plant. This waste will be delivered by road directly to the Central Waste Processing Facility (CWPF).

Normal mixed bagged waste from multi-unit dwellings in the more densely populated areas, such as Station, Osborne Park and Southern Precincts, will be placed by residents in chutes in their buildings which will be connected to a vacuum waste collection system. No system for the separate collection of recyclables will be provided within residential buildings. Bagged waste from multi-unit dwellings will include all recyclables.

Commercial premises generating mixed bagged waste will also place this into the vacuum waste system through separate entry points. A system for the collection of separated recyclables will be available for commercial premises and in public areas, although it is expected that some recyclables will remain in the mixed waste system.

Waste placed in the vacuum system will be transported through the systems pipes to a central terminal in the SCC area. From here it will be collected by Council, or a contractor, and taken by road to the CWPF.

Bulk bins, either in-ground or above ground, will be provided for recyclables in public areas for commercial premises and the public to use. The bins will allow commercial businesses and the public to separate and dispose of recyclable containers and recyclable paper and cardboard. These bins will be collected by Council (using vehicles running on biogas generated from the anaerobic digestion plant), or a contractor, and taken by road to the CWPF.

Periodically and according to a schedule, skips for bulky waste will be positioned in designated public areas for commercial and residential premises to dispose of larger bulky waste materials and items. Residents may also be able to request these skips be placed at other times as required. These skips will be in position for short periods only and will be collected by Council, or a contractor, and taken by road to the CWPF.

Outside the SCC area, the waste collection system will operate as before with Council (using vehicles running on biogas generated from the anaerobic digestion plant) collecting domestic waste from kerbside bins, as well as commercial waste from its customers. This waste will be delivered to the transfer station at the CWPF. The transfer station will also have access to allow residents and small businesses to deliver self-hauled waste.

4.6.2 Waste Separation

At the CWPF, bagged waste collected from the vacuum terminal, as well as bulky waste collected in the occasional bulky waste skips, will be processed through a ‘dirty MRF’. This will separate the different components using a series of plant and equipment that takes advantage of the physical characteristics of the waste. Typical elements include rotating trommels, vibrating and rotating screens, magnets and eddy currents, air classifiers and possibly some sorting by hand.

Materials likely to be separated include organics, glass, ferrous and non-ferrous metals, hazardous materials, recyclable and non-recyclable paper and cardboard, timber, textiles, organics and recyclable and non-recyclable plastics. Waste from the transfer station will also be processed through the dirty MRF.

The recyclable containers, paper and cardboard collected from the bulk bins will be processed through a clean MRF using similar technology as the dirty MRF. Residual materials from this MRF will be transferred for processing through the dirty MRF. Materials likely to be separated include glass, ferrous and non-ferrous metals, hazardous materials, recyclable paper and cardboard and plastics, non-recyclable paper and cardboard. Residual material will be sent to the dirty MRF.

Depending on the quality, recyclables recovered from the dirty MRF will be aggregated with recyclables recovered from the clean MRF. Hazardous materials will be sent for suitable disposal or recovery.

4.6.3 Waste Processing

Anaerobic Digestion

Separated organics will be co-processed with biosolids from the recycled water plant in a thermophilic anaerobic digester.

Anaerobic digestion (AD) is the breaking down of organic material by micro-organisms in the absence of oxygen. In the case of thermophilic anaerobic digestion (TAD) the micro-organisms operate at higher temperatures than the alternative mesophilic process. The higher TAD temperatures, around 50 - 55°C, require higher energy input but result in faster processing, greater sterilisation of material and greater energy output compared to mesophilic systems.

The AD process produces biogas and solid digestate. The biogas has several potential uses as fuel in the SCC including as a feedstock for a gas engine to produce electricity and heat, or a fuel for Council vehicles. This process will provide the heat necessary to operate the thermophilic AD process. The opportunity to feed the biogas into the Perth network (which is occurring for example in Vancouver), however, is unlikely for a single project. The market for the digestate is as a soil conditioner and for mine site rehabilitation.

GHD's projections indicate that the capacity of the dirty MRF required by the time of the ultimate development would be about 180,000 tonnes per year of which about 73,000 tonnes would be separated for AD feedstock. This would generate about 8.1 million m^3 of biogas, 14,500 t of digestate, 16,700 t of leachate and 8,700 t of water vapour.

Waste to Energy

Separated non-recyclable material (non-recyclable paper, plastics and other high-calorific materials such as timber and textiles) will be used as a fuel in a proposed waste to energy facility in East Rockingham[14] in which gasification technology is used to produce electricity. At some stage in the future, when the technology was appropriately robust, a similar waste-to-energy facility could be constructed at the CWPF.

4.6.4 Waste Facilities

Facility Footprints

An indication of the footprints of existing waste processing facilities is described below.

The UR-3R (Urban Resource – Reduction, Recovery and Recycling) facility at Eastern Creek in Western Sydney was originally designed and constructed as an anaerobic digestion operation that would process 200,000 tonnes per year. It has a footprint of 5.6 ha that includes a dirty MRF. The process originally included anaerobic digesters, however, these have been removed and it currently functions as a composting facility.

[14] http://www.newenergycorp.com.au/projects/perth-metro-wa/

The Earthpower facility at Camellia in Sydney anaerobically processes up to 100,000 tonnes of separated food waste per year on a site of about 2 ha. This facility accepts only clean separated organics so no MRF is required. The ArrowBio facility at Jacks Gully, which used water separation technology and anaerobic digesters, was designed to process 90,000 tonnes per year on a site about 2 ha in size. This facility is no longer operating.

The DiCOM facility in Perth, currently being commissioned, uses a hybrid aerobic/anaerobic technology to process about around 75,000 tonnes of waste per year. The site is on about 2 ha and includes a dirty MRF and transfer station. The DiCOM processor itself occupies less than 1 ha.

A new clean MRF is being built at the Kimbriki facility in Northern Sydney to process 60,000 tonnes per year of separated recyclable paper and containers. It will occupy less than 1 ha.

The City of Stirling owns and operates a transfer station at Balcatta several kilometres north of the SCC area. Originally it was proposed that the entire integrated system be located at this site. However, the infrastructure required to transport (particularly) water between the two sites provides some problems. Instead two other possible options are proposed.

For the first, only the waste elements of the process would be located at Balcatta and gas generated from there would be piped to the other elements which would be located on a site in the industrial area within, or adjacent to, the SCC area.

For the second, all elements of the process would be located on a site in the industrial area within, or adjacent to, the SCC area, including all the waste elements. This site would replace Council's transfer station at Balcatta which could then be disposed of to the City's advantage.

There are a number of implications for each of these options for the City of Stirling. The main advantages and disadvantages of each are listed below and these relate primarily to the waste management system.

Original Option – All facilities at Balcatta

Advantages

- existing site owned by Council, no new waste site required;
- licence conditions may need to be varied but no new licence required;
- location of site already known to residents and commercial customers;
- site is adjacent to Council's depot; and
- waste processing and other elements co-located and entirely integrated in one facility.

Disadvantages

- site may not be big enough for all elements;
- site is remote from the SCC and waste would need to be transported by road from the SCC area;
- sensitive receptors are located within 500 m of site;
- a separate site close to the SCC would be required for the vacuum terminal; and
- site would need to be entirely redeveloped which will disrupt normal disposal services.

Potential site layouts for these arrangements are set out in Appendix D.

Option 2 – Waste elements at Balcatta, others near SCC

Advantages

- existing Balcatta site owned by Council, no new waste site required;
- licence conditions may need to be varied but no new licence required;
- location of Balcatta site already known to residents and commercial customers;
- Balcatta site is adjacent to Council's depot;
- vacuum terminal could be located on proposed new site;
- smaller area of site required for development; and
- normal disposal services would not be as severely disrupted during redevelopment and construction.

Disadvantages

- waste needs to be transported by road from the SCC area; and
- sensitive receptors are located within 500 m of site.

Option 3 – All elements near SCC

Advantages

- vacuum terminal could be completely integrated into waste process;
- fewer truck movements and less transport of waste by road would be required;
- waste process and other elements co-located and entirely integrated;
- sufficient space for all elements;
- normal disposal services would not be affected at Balcatta site and once new site was completed, services could be seamlessly transferred; and
- potential financial windfall for Council with sale or redevelopment of Balcatta site.

Disadvantages

- site selection could be problematic;
- potential for community resistance;
- new licence will be required;
- location of new site would need to be communicated to residents and commercial customers;
- council's main waste facility no longer adjacent to Council depot; and
- sensitive receptors may be close to site.

4.6.5 Building design and performance implications

The major implication for buildings arising from the strategy is revised collection facilities. It is proposed that a vacuum waste system operates in the SCC. The vacuum pipe system will need to be integrated into the building design, but it has been assumed at this stage that this can be readily accommodated within conventional service cores.

Conventional waste storage will not be necessary, which will reduce space requirements and costs at the building scale.

4.6.6 Implications for the City of Stirling's waste management

It is apparent from the figures calculated by GHD that a separate waste processing system of the type proposed (mechanical separation and anaerobic digestion) is not viable for the low tonnages likely to be generated from the SCC area. Only processing all of the waste generated in the City of Stirling would provide the volume that would make the proposed process viable. It is considered that the City of Stirling is large enough to take on a development of this size.

Stirling currently uses a one bin system across all residential areas, all waste generated from each household is placed in a single bin. There is no separation of recyclables or organics at the source, separation is undertaken mechanically at a processing facility. If the processing system detailed above was adopted, the one bin system would remain and the majority of residents would notice no change in their waste collection service.

Regardless of the technology chosen, a system like that proposed would provide Council with significant independence for its waste system. Council would not depend on external operators or organisations, such as Mindarie Regional Council, to process its waste. With this independence however, comes significant expense and risk.

While anaerobic digestion technologies are well developed for processing specific single stream waste types, biosolids for example, few successfully process municipal and mixed waste. The capital costs are high and should the technologies fail, Council could be severely compromised logistically and financially. The risk model for ownership and operation of the facility will have to be carefully considered.

4.6.7 Costs

Anaerobic Digestion

Table 4.5 shows some recent costs for anaerobic digestion facilities in Australia. The throughput capacity of these facilities is similar to the capacity required for the SCC.

Table 4.5 Capital costs for existing anaerobic digestion facilities

Facility	Technology type	Capacity per year	Approximate capital cost	Approximate annual operating costs per tonne
Anaeco DiCOM, Shenton Park, WA	Hybrid aerobic and anaerobic processing	75,000 t	$40-$50m	$100
Earthpower, Camellia, NSW	Anaerobic digestion	100,000 t	$35m	$90

The cost of the Anaeco facility includes a dirty MRF for separating organics and other materials. No MRF is required at the Earthpower facility as it accepts only separated organics. Table 4.6 lists estimated capital and operating costs for anaerobic digestion facilities from a recent (URS 2010) study for the ACT Department of Environment, Climate Change and Water.

Table 4.6 Estimated capital and operating costs for anaerobic digestion facilities[15]

Technology	Capacity per year	Initial investment (million)	Additional module (million)	Operating cost per tonne
Anaerobic Digestion	50,000	$24.4	$23.3	$78
	100,000	$46.7		$72
	150,000	$70		

[15] URS (2010) Final Report – Supplementary Report – Economic modelling of Options for Waste Infrastructure in the ACT for ACT Department of the Environment, Climate Change, Energy and Water

The figures in Table 4.5 and Table 4.6 indicate that the cost of a 204,000 t dirty MRF with 86,000 t AD facility for Stirling might be more than $70 million.

Table 4.7 Costs for anaerobic digestion facilities in Europe[16]

Facility	Capacity (tpy)	Investment cost ($A million)[17]	Investment cost ($A tpy)	Operational cost ($A/t)	Gate fee ($A/t)
Passavant Roediger Anlagenbau, Germany	20,000	$15.7	$787		
	40,000	$24.1	$603		
BEKON, Munich, Germany18	25,000	$10.2-$11.4	$406-$457		
Ashford, Kent, UK	40,000	$15.0	$374		$56-$66
Vaasa, Finland	40,000	$7.9	$197	$50	$50
Arrow Bio, Israel	70,000	$14.6			$27-$32
Amiens, France	72,000	$1.5	$20	$62	$48
Oaktech, UK[19]	75,000	$22.3	$298		
Hese, Leicestershire, UK	110,000	$57.1	$501		
Linde, Madrit, Spain	140,000	$44.4	$317		
SBI, Heerenveen, Netherlands	220,000	$48.2	$220	$113	
Ecopark 1, Barcelona	245,000	$165.2	$674		
Ecopark 2, Barcelona	240,000	$86.8	$362		
Ecopark 3, Barcelona	260,000	$74.6	$287		
Farington Waste Recovery Park, Lancashire, UK	305,000	$178.0	$584		
Vargon, Netherlands	328,000	$24.2	$74	$50	$50

Materials Recovery Facilities (MRFs)

Some recent estimated capital and operating costs for MRFs are provided in Table 4.8. Recent MRF projects indicate that capital costs for MRFs are in the order of $10 million in Australia. These facilities have the capacity to process 100,000 tonnes per year or more.

GHD's projections indicate that the capacity of a clean MRF for the City of Stirling may need to be about 38,500 tonnes per year and for a dirty MRF about 204,000 tonnes per year. An indicative capital investment cost of a clean MRF with suitable capacity would be up to $10 million while for a dirty MRF of suitable capacity could be more than $15 million.

[16] http://www.epem.gr/waste-c-control/database/html/costdata-00.htm

[17] Converted from euros at a rate of 1.26887 dollars per euro.

[18] http://www.bekon.eu/

[19] http://oaktech-environmental.com/

Table 4.8 Estimated capital and operating costs MRFs

Location	Waste type	Capacity per year	Capital cost	Operating costs per t	Status
Perth (Instant Waste Management)[20]	C&D and C&I	140,000 t	$10 m		Planned
Broome (Toxfree)[21]	Recyclables	2,100 t	$1 m		Planned
Canberra[22]	C&I	150,000 t	$15 m	$35	Planned
	Mixed waste	100,000 t	$10 m	$35	Planned
	Recyclables			$28	Existing
	C&D			$20	Existing
Elefsina, Attika, Greece[23]		30,000	$6.8 m[24]		
Greece[25]		50,000	$6.3 m[26]	$126[27]	Estimate

4.7 Summary of BAT Costs

While the costs for the local infrastructure are reasonably comprehensive, the costs do not include a number of regional scale items that are either unavailable or difficult to allocate to this specific development area. These items include:

- The capital and operating cost of regional scale water distribution and storage (those elements that fall between local infrastructure and the IWSS supplementation costs);
- The capital and operating cost of electricity transmission (those elements that fall between local infrastructure and the SWIS supplementation costs); and
- The capital and operating cost of gas transmission and distribution (those elements that extend beyond local infrastructure).

These items mainly affect the completeness of the BaU strategy because this is the most reliant on regional infrastructure.

The assessment also includes some costs that are not completely attributable to the SCC project area:

- The capital and operating costs of the waste infrastructure is attributable to the entire City of Stirling area. The full costs have been included here as they would be triggered by the SCC development.

Estimated capital and operating costs are presented below for both BAT options. This is a revision of the figures presented in the previous report, modified in accordance with the revised yield and the sections above. The figures represent the 2013AUD value of the total capital

[20] Serpo, Alex (2012) *$10 million buys a new MRF for Perth* WME Business Environment Network 24 July http://www.ben-global.com/storyview.asp?storyID=9589684&section=Select+Site+Section&sectionsource=s

[21] *Toxfree invest $1 million in Broome MRF* WME Business Environment Network 22 June http://www.ben-global.com/storyview.asp?storyID=9588470&section=Select+Site+Section&sectionsource=s

[22] URS (2010) Final Report – Supplementary Report – Economic modelling of Options for Waste Infrastructure in the ACT for ACT Department of the Environment, Climate Change, Energy and Water

[23] http://www.epem.gr/waste-c-control/database/html/costdata-00.htm

[24] €5.39 million

[25] http://www.epem.gr/waste-c-control/database/html/costdata-00.htm

[26] €5.0 million

[27] €100

spend and operating costs at ultimate development. The figures include contingencies and preliminaries.

A land cost has been included (at a rate of $1.5m per ha) in respect of:

- A reasonable share of the additional sub-station costs (40% for BaU and 21% for BAT); and
- Land for the recycled water plant (0.75 ha).

It has been assumed that:

- the energy hubs can be incorporated without land costs within other buildings (e.g. car parking structures);
- the geothermal plant can be accommodated within the recycled water plant; and
- the geothermal and excess recycled water discharge bores can be accommodated within public open space.

Table 4.9 Summary of estimated capital and operating costs – Trigeneration / Solar Option

Service	Item	Description	Capex $m	Opex $m pa
Water				
	Potable	Upgrade source / treatment / conveyance (1)		2.503
		Upgrade storage		
		Upgrade distribution mains	3.500	0.062
		New & upgraded reticulation	19.100	0.239
	Wastewater	Upgrade WWTP	7.677	0.093
		Upgrade main sewer	31.200	0.390
		Upgrade pump stations	6.435	
		Local sewers	0.945	
		Upgrade local reticulation	28.385	
	Drainage	New road drainage	9.207	
	Non-drinking water			
		Land for RWP	11.250	
		Recycled Water Plant	29.000	1.020
		RW distribution	4.260	0.180
		RW reticulation	8.280	
		RW disposal	1.52	0.074
Energy				
	Electricity			
		Substation site – land costs	0.840	
		Substation upgrades	9.030	0.316
		New distribution feeders	2.100	0.074
		LV transformers & switchgear	21.000	0.735
		Undergrounding and line removal	23.800	
	Local Generation			
		Gas engines	22.800	0.798
		Solar PV	68.191	1.023
		Electricity storage	9.041	0.316

	Thermal Network			
		Absorption chillers	6.000	0.210
		Electric chillers	5.200	0.182
		Chilled water storage	8.359	0.293
		Hot water network	40.800	1.428
		Chilled water network	48.000	1.680
		Pits and pumps	0.861	0.030
		Heat rejection	2.500	0.088
	Gas	Distribution upgrades	2.480	0.087
		Reticulation upgrades	2.100	0.074
		Gas consumption (2)		4.686
		Additional fuel for trigeneration		5.818
		Carbon costs		7.498
Waste		Additional operating costs		6.370
		Vacuum waste system	45.000	0.675
		Dirty MRF	15.000	7.000
		Clean MRF	10.000	1.400
		Anaerobic digestor	50.000	4.000
		Gasification plant		
		Biogas treatment	1.250	0.019
		Syngas treatment		
Telecoms		Upgrades / NBN	13.283	0.332
		Total Infrastructure	**568.394**	
Building costs				
		Improved thermal efficiency	67.500	
		Total	**635.894**	

Table 4.10 Summary of estimated capital and operating costs – Solar / Geothermal Option

Service	Item	Description	Capex $m	Opex $m pa
Water				
	Potable	Upgrade source / treatment / conveyance (1)		2.503
		Upgrade storage		
		Upgrade distribution mains	3.500	0.062
		New & upgraded reticulation	19.100	0.239
	Wastewater	Upgrade WWTP	7.677	0.093
		Upgrade main sewer	31.200	0.390
		Upgrade pump stations	6.435	
		Local trunk sewers / rising mains	0	
		Upgrade local reticulation	28.385	
	Drainage	New road drainage	9.207	
	Non-drinking water			
		Recycled Water Plant	29.000	1.020
		RW distribution	4.260	0.180
		RW reticulation	8.280	

		RW disposal	1.520	0.074
Energy				
	Electricity			
		Substation – land costs	0.840	
		Substation upgrades	9.030	0.316
		New distribution feeders	2.100	0.074
		LV transformers & switchgear	21.000	0.735
		Undergrounding and line removal	23.800	
	Local Generation			
		Solar PV	95.231	1.428
		Electrical storage	12.648	0.443
	Thermal Network			
		Geothermal bore - doublet	25.000	0.750
		Absorption chillers	14.174	0.496
		Electric chillers	6.184	0.216
		Chilled water storage	8.359	0.293
		Hot water network	40.800	1.428
		Chilled water network	48.000	1.680
		Pits and pumps	0.861	0.030
		Heat rejection	2.500	0.088
	Gas	Distribution upgrades	1.240	0.043
		Reticulation upgrades	2.100	0.074
		Gas consumption (2)		4.686
Waste		Additional operating costs		6.370
		Vaccum waste system	45.000	0.675
		Dirty MRF	15.000	7.000
		Clean MRF	10.000	1.400
		Anaerobic digestor	50.000	4.000
		Biogas treatment	1.250	0.019
Telecoms		Upgrades / NBN	13.283	0.332
		Total Infrastructure	**596.946**	
Building costs				
		Improved thermal efficiency	67.500	
		Total	**664.446**	

(1) This figure is an annualised cost ($2.02 / kL) derived from the current long run marginal cost of water (LRMC) determined by the Water Corporation and agreed with the Economic Regulatory Authority. $1.75 is the average of the LRMC for demand reductions ($1.51 in 2012) and for demand increases ($1.90 in 2012) escalated by 2.5% to obtain 2013AUD figures. This per kL figure incorporates both capital and operating costs.

(2) Based on an average cost of gas during the project life of $12.30/GJ in 2013AUD.

The costs set out above are compared with BaU costs in the table below.

Table 4.11 Summary of estimated capital and operating costs – BaU vs BAT ($m)

Service	Item	BaU		Trigen / Solar		Solar / Geothermal	
		Capex	Opex	Capex	Opex	Capex	Opex
Water							
	Potable (1)	24.100	5.515	22.600	2.803	22.600	2.803
	Wastewater	116.379	0.914	74.642	0.483	74.642	0.483
	Drainage	9.207		9.207		9.207	
	Non-drinking water			54.310	1.274	54.310	1.274
		149.686		160.759		160.759	
Energy							
	Electricity	82.400	1.995	56.770	1.125	56.770	1.125
	SWIS generation	131.225	79.138				
	Local Generation			100.032	9.635	107.861	1.871
	Thermal Network			111.720	3.910	145.878	4.981
	Gas	3.340	4.803	4.580	10.665	3.340	4.803
		216.965		273.102		313.849	
Waste			9.665	121.25	19.464	121.250	19.464
Telecoms		13.283	0.332	13.283	0.332	13.283	0.332
	Total Infrastructure	**379.934**		**568.393**		**609.140**	
Building costs		250.500	6.263	67.500	-	67.500	-
	Total	**630.434**		**635.893**		**676.640**	

This indicates that the infrastructure capital costs are lower for BaU but similar / higher in total if savings at the building scale are included, noting that some of the capital costs for scheme water source upgrades have been estimated as annual costs.

4.8 Land Requirements

A preliminary estimate of the required land for the facilities described above is set out in Table 4.12 below. Assumptions are:

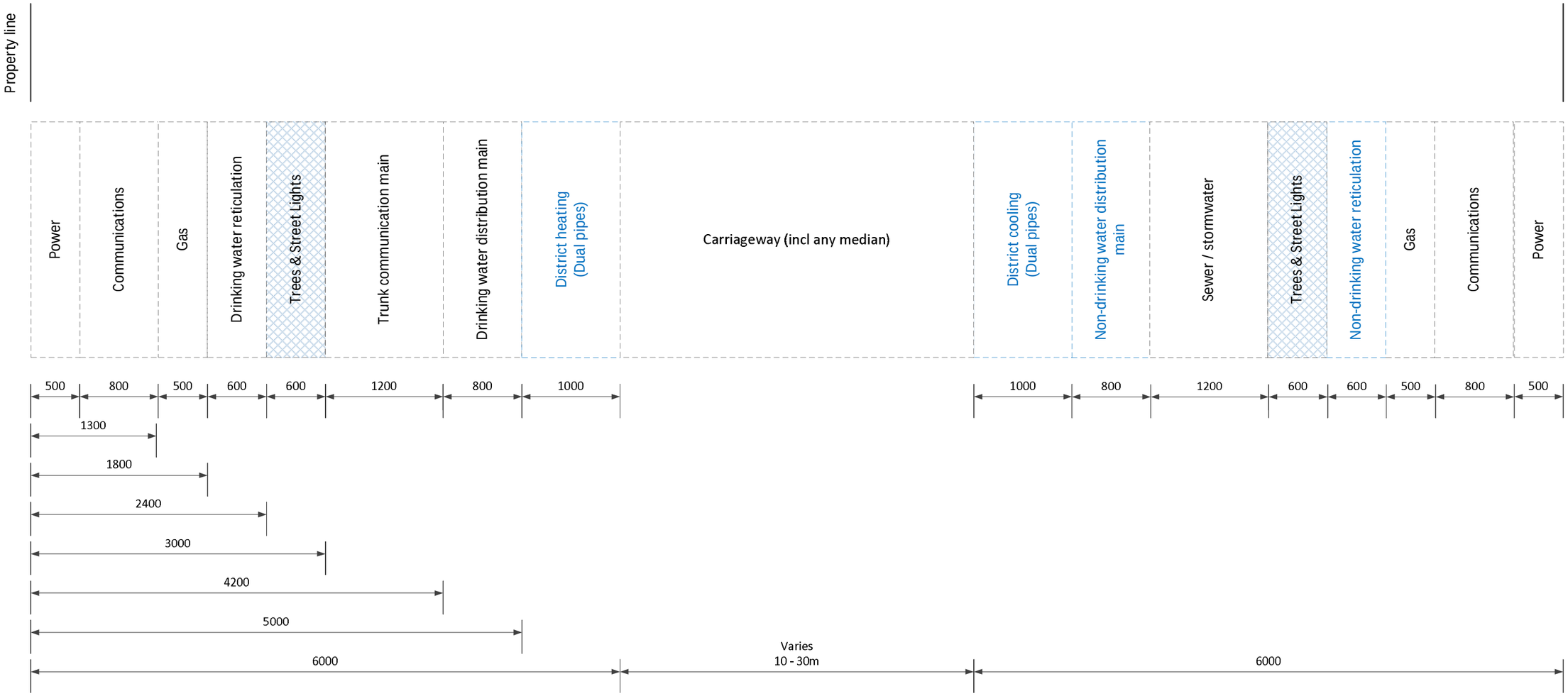
- waste facilities at existing Balcatta site;
- trigen plants to be distributed across development;
- recycled water plant needs to be as central as possible but assumed to be in the Osborne Park Industrial Area; and
- an additional site for a Western Power substation site is necessary, probably located adjacent to or in the nearby industrial area.

Table 4.12 Land requirements

Plant	Hectares
Waste	
Clean MRF	0.50
Dirty MRF	0.96
Anaerobic digestion plant	0.50
Storage and loading	0.25
	2.21
Energy	
Power plant (6no. X 1600m2)	0.96

Second substation	0.35
	1.31
Water	
Recycled water plant	0.45
NDW storage / pumps	0.30
Abstraction / discharge plant	0.20
	0.95
Total land take	**4.47**

A very preliminary concept has been identified for the service corridor. This is depicted in Figure 4-10.



Notes:
1. General concept only – will vary for specific road types
2. Subject to final design of recycled water and district thermal network
3. Existing side entry pits may affect stormwater location
4. Services may be relocated to medians where appropriate
5. District heating / cooling may require location under carriageway in some locations
6. Additional corridor may be required in some streets for biogas pipeline

Figure 4-10 Preliminary Services Corridor

4.9 Sustainability Performance

4.9.1 Performance against Targets

The following tables set out the performance of the BAT concept against the KPIs in the performance framework in respect of energy and water.

Table 4.13 Performance against targets - Energy

Energy KPI	Performance against Target		
	Targets		**BAT**
	Aspire	Agreed	
% of renewable energy production	100%	50%	**>50% Tri > 90% Geo**
Rate of power consumption per dwelling (in kWh)	4MWh	10MWh	**2.6**
Rate of power consumption per m2 retail (kWh)	Yet to be confirmed		**70**
Rate of power consumption per m2 office commercial annual	50	59.7	**105**
% reduction in peak power demand	50%	30%	**65%**

Table 4.14 Performance against targets - Water

	Performance against Target		
	Targets		**BAT**
	Aspire	Agreed	
% of all water recycled	100%	80%	**100%**
% of nutrients from wastewater that are reused	100%	80%	**100%**
% stormwater captured and reused	100%	80%	**0%**
Rate (Kilolitres) of potable water consumption per person (household)	40kl/p	50kl/p	**33**
Rate (Kilolitres) of potable water consumption m2	Not stated		**0.64**
Rate (Kilolitres) of potable water consumption m2 office commercial per annum	0.5	1	**0.58**

Performance for waste is not included as no total reductions in waste generation have been assumed in this study.

4.9.2 Energy Options

The preferred energy concept involves solar energy in concert with 2 options – trigeneration and geothermal.

The trigeneration option involves the use of fossil fuels (natural gas) as a feedstock. As the use of fossil fuels will be constrained during the life of this infrastructure due to climate change and / or depletion, this option does not offer the same sustainability performance or risk profile of the geothermal option which is potentially an inexhaustible non-polluting form of energy. However it involves mature technology with a track record which is presently available in the market place. This option can be progressed with desk top technical and financial studies.

The geothermal option involves novelty in terms of application in Australia and requires field testing via a trial bore, which itself will incur costs and take time. At the time of writing it is not clear who the proponent for this trial would be.

Because the geothermal bore doublet needs to be established in the early stages of the development, while trigeneration gas engines can be staged, the upfront capital costs of the geothermal option will be higher.

The federal government's Australian Renewable Energy Authority (ARENA) has recently appointed an expert panel to evaluate geothermal opportunities in Australia[28]. One outcome of the review will be:

"to prepare for the ARENA Board an analysis of risks and rewards for geothermal energy which will help inform the Board's consideration of how to allocate and prioritise funding for geothermal energy as part of its portfolio approach to supporting renewable energy in Australia."

The outcome of this review will likely inform the future attitude of ARENA to funding geothermal energy. The Expert Group is expected to provide its report to the ARENA Board in early 2014.

It is possible that trigeneration could be the initial thermal energy source at the SCC, with a transition to geothermal energy occurring at a later time. However given the high cost of the trigeneration equipment, this is a questionable strategy from a financial perspective. Gas engines are generally considered to be long life assets with GE quoting 60,000 hours of use before a major overhaul being required.

Ultimately the advantages and disadvantages for each technology will need to be evaluated from the perspective of sustainability, risk and financial viability. As both options provide potential solutions for Activity Centres more generally, this evaluation will be important not only for the SCC development.

[28] http://arena.gov.au/about-renewable-energy/geothermal-energy/expert-group/

5. Economic Assessment of Options

5.1 Scope of Assessment

The estimation of costs set out in Sections 3.4 and 4.7 do not readily facilitate a full life cycle cost assessment of the options. To complement these figures, a quasi-economic assessment of the options has been made. The prime objective of the following is to compare the options rather than explicitly allocate costs to any particular party.

The following seeks to establish the economic costs of the options, i.e. the cost of constructing and operating the necessary assets over a 50 year period commencing in 2015. The analysis embeds the following assumptions:

- capital and operating costs are as set out in Sections 3.4 and 4.7;
- development proceeding in accordance with the curve set out in Figure 5-1;
- infrastructure is (generally) built in five yearly blocks preceding the demand;
- Western Power upgrades have been timed in accordance with their advice (Appendix A);
- the upgrade of the Hamersley main sewer has been timed in accordance with Water Corporation advice;
- costs are in 2013AUD and then escalated 3% per annum for all items throughout the project development phase; and
- a discount rate of 7% pa applies throughout.

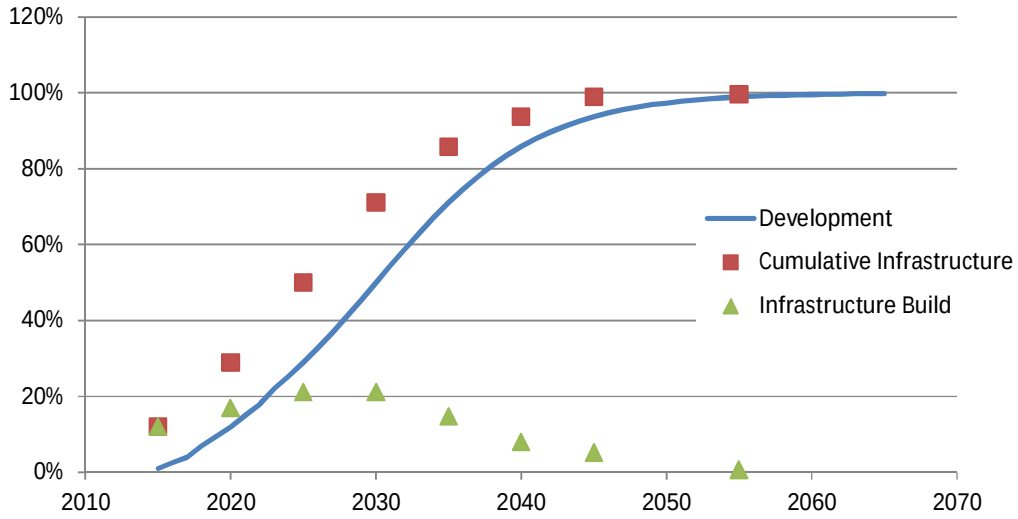


Figure 5-1 Assumed development curve

5.2 Life Costs

Table 5.1 sets out the results of the lifecycle cost assessment. The full life cycle costings are included in Appendix E.

Table 5.1 Summary of life costs ($m)

	DCF - BaU			DCF - BAT3 Solar / Trigen			DCF - BAT5 Solar / Geothermal		
	Capex	Opex	Total	Capex	Opex	Total	Capex	Opex	Total
Water									
Potable	15	63	78	14	32	46	14	32	46
Wastewater	69	7	76	43	3	45	43	3	45
Drainage	6	-	6	6	-	6	6	-	6
Non-drinking water	-	-	-	28	15	42	28	15	42
	90	70	161	91	49	140	91	49	140
Energy									
Electricity	50	19	69	38	13	50	38	13	50
SWIS Generation	84	488	572	-	32	32	-	-	-
Local Generation	-	-	-	52	18	70	52	15	67
Thermal Network	-	-	-	72	38	109	102	58	160
Gas	2	55	57	3	122	125	2	55	57
	136	561	697	164	222	386	194	140	335
Waste	-	111	111	78	199	276	78	199	276
Telecoms	9	3	12	9	3	12	9	3	12
Building costs	143	47	190	39	-	39	39	-	39
Total	**378**	**792**	**1,170**	**380**	**473**	**853**	**410**	**391**	**801**

This illustrates that in life cycle cost terms, the cost of the BAT options are similar, and both significantly lower that for BaU. A higher discount rate reduces the difference, and a lower discount rate increases the difference.

Further the BaU curve represents the best estimate of fuel costs and carbon price per tonne. For example, if the price of natural gas increases beyond the assumed 3% from 2035 (around the time that peak gas is expected globally) by an additional 2.5% pa, the ultimate annual fuel cost from equivalent generation on the SWIS would increase from $22m pa to $40m by 2065.

Carbon prices have been estimated on the basis of the BREE report[29] referred to in Section 4.1.2 of Volume 1 of the previous report. The 'best estimate' curve has been used in the assessment above. The report also contains a 'high' estimate, and if the average of the best and high estimates of the carbon price is used, the annual cost of carbon from generation on the SWIS would escalate from the estimated $53m in 2065 to over $100m.

Incorporating these figures in the analysis increases the present value of BaU costs considerably to around $1,400m from $1,200. While the Trigeneration / Solar option is also reliant on natural gas, and therefore subject to the same issues, the scale of generation is much lower (11 MW compared with 65MW). The balance of energy production in the BAT options are not reliant on fossil fuels (solar PV and geothermal) and hence offer an improved risk profile in respect of these future cost elements.

The differences in costs between the options is summarised in the following sections.

[29] http://www.bree.gov.au/publications/aeta.html

5.2.1 Water & Wastewater

The combined effect of water efficiency measures and local water recycling reduces the ultimate demand on the scheme water system from 2.9 to 1.2GL per annum. This leads to around $32m savings, mainly due to the avoidance of additional source in the IWSS. This saving offsets the cost of the recycled water system at $42m.

The combined effect of water efficiency measures and local water recycling also reduces the ultimate demand on the centralised wastewater from 2.5GL to 0.5GL per annum at ultimate development. Again the main benefit is in the avoidance of costs associated with WWTP upgrades, leading to a saving of a further $31m.

The net effect of the BaU savings and the additional cost of the recycled water system create a net saving of $22m in combined water and wastewater costs.

5.2.2 Energy

Savings of around $18m are made in the cost of provision of the local power distribution system by reducing the peak electrical demand from 65MVA to 22MVA through energy efficiency measures and the introduction of a thermal energy supply.

The most significant saving of all is the avoidance of incurring all power generation costs on the SWIS by producing electricity locally. This saving is estimated at $540m and more than offsets the cost of local generation (around $70m), the thermal network ($110-$160m) and the additional cost of natural gas (fuel and carbon) for the trigeneration option ($68m).

5.2.3 Waste

The capital and operating costs of developing a sophisticated waste infrastructure are very high ($276m) are more accurately attributable to the whole of City of Stirling. In this analysis they are attributed to the SCC only and incur an additional cost of $166m over BaU.

5.2.4 Building costs

The elimination of boilers and chillers in the buildings in the distributed services zone has been assessed to save around $190m. This saving is reduced by virtue of the additional cost in achieving thermal efficiencies in these buildings ($39m).

The differences are summarised in Table 5.2.

Table 5.2 Summary of BaU vs BAT life costs ($m)

	Trigeneration / Solar	Geothermal / Solar
BaU	1,170	1,170
Water & wastewater savings	-21	-21
Energy savings	-311	-363
Additional waste costs	166	166
Building savings	-151	-151
Net costs	853	801

5.3 Cost Recovery

Figure 5-2 includes the cost profiles but also depicts the cost recovery of the BaU scheme over time due to existing supply charges and usage tariffs for electricity, gas, water and wastewater (see Appendix F). This curve cannot be directly related to the cost curve, as many of the regional scale BaU costs are not included (as noted in Section 4.7) but indicates that although

there is a shortfall in revenue over cost in the early life of the project, costs will be recovered over time.

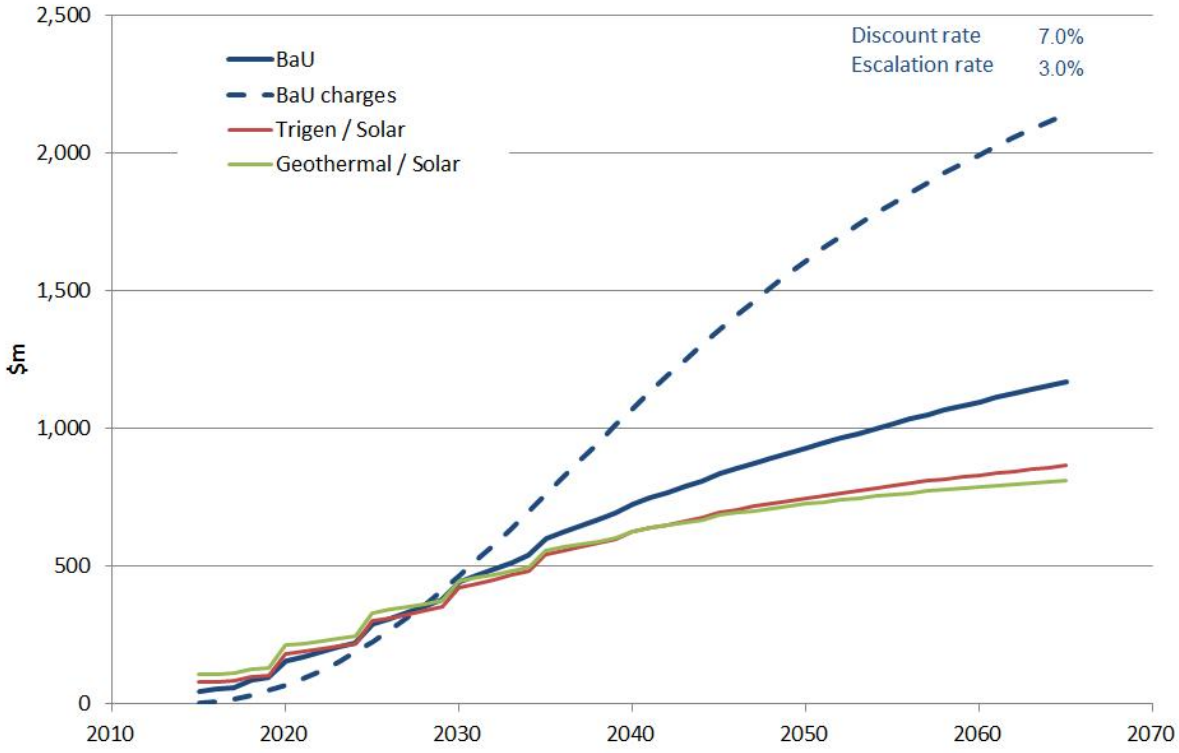


Figure 5-2 Cumulative discounted costs

No attempt has been made to estimate cost recovery for the BAT options as to do so requires the development of a pricing regime for recycled water, locally generated electricity and thermal energy. Such an exercise is beyond the scope of this preliminary study and would require both more accurate costs, and a prospective institutional structure for provision of the services. However as the life cycle costs of the alternatives are less than the BaU costs, the analysis indicates that the provision of such services would be financially feasible with similar overall cost recovery to BaU.

The analysis also indicates that there is a pre-funding requirement for infrastructure, whichever strategy is adopted. The early costs of BAU and the Trigeneration / Solar option are similar, while the Geothermal / Solar option requires a larger early investment associated with the once only establishment of the geothermal wells and associated plant. This analysis indicates that the peak revenue to cost shortfall for the BaU scenario is approximately $86m the period around 2020 (depending on development take up). The shortfall will be higher for the BAT options but cannot be readily quantified without a price structure identified.

6. Implementation of the Strategy

6.1 Governance Arrangements

Identifying an implementation strategy for delivery of the preferred concept is beyond the scope of this study. The options are:

- Separate implementation of each component through existing agencies, i.e. electricity (Western Power, Synergy / other retailers and generators), gas (ATCO and Alinta), water (Water Corporation) and waste (City of Stirling);
- Separate implementation of each component through involvement of the private sector (electricity generation / retail, recycled water, waste-to-energy); and
- A new utility formed specifically to provide services at the SCC which would provide integrated energy, water and waste services.

Under the first option each utility would implement the strategy, i.e.:

- Verve / Synergy would deliver the energy elements with ATCO / Alinta cooperation;
- Water Corporation to fully own, operate and maintain the water recycling plant, third pipe system and groundwater injection facilities, while energy options would involve the private sector; and
- The City of Stirling would implement the waste elements.

The complexity of realising the identified opportunities through conventional means (option 1) is likely to be very high, requiring cooperation between local government and several utilities, each with their own business strategies centred on business as usual practices, and most with a much broader geographical focus. For example the City of Stirling would need a commercial agreement with the electricity utility to provide electricity from, and with Water Corporation to receive biosolids. Water and waste providers would require agreements to receive renewable electricity from the energy provider. Such agreements would involve significant risk and changes in current operations for each individual party.

The second option would likely to be more complex, as even more interfaces would be required, i.e. not only between the providers but also with the existing agencies whose networks and assets will remain integral to the system.

The third option would reduce the complexities significantly with energy and material flows all occurring within a single business entity, although interface agreements with the broader network providers (Western Power, ATCO and Water Corporation) would still be required. Such a utility could be formed through a special purpose vehicle involving existing utilities, other private sector firms, local government, or a combination of the above. However if development contributions are to provide some of the funding for assets, these assets must be held by publicly owned authorities under the requirements of State Planning Policy 3.6 Development Contributions for Infrastructure.

Although it would be a novel approach for Western Australia, a local government owned utility providing integrated energy, water and waste services is a logical way of implementing the strategy. It would need to be integrated with, and facilitated by the local planning scheme and associated development contribution plan. It is envisaged under such an arrangement that a private sector partner would design, build and operate the facilities as an integrated service contract, offering the additional benefit of risk mitigation and private sector investment.

Larger councils with higher levels of financial capacity and service delivery capability are an objective of the government's amalgamation strategy[30]. The expansion of their service delivery from waste to energy and water would involve considerable upgrading of existing capacity. However, a partnership with a private utility offers the attraction of the requisite skills together with private investment and risk sharing. Increasing the involvement of the private sector is also an objective of the state government. Such a model is potentially applicable to Activity Centres more generally in the metropolitan area.

It is recommended that the findings of this report are canvassed with a range of stakeholders, namely:

- the City of Stirling; and
- the WAPC Infrastructure Coordination Committee.

Subject to these consultations the following authorities should be consulted:

- the Economic Regulatory Authority; and
- the relevant ministers and departments (Planning, Water, Energy, Local Government).

6.2 Regulatory Issues

A full description of the required licensing arrangements for the BAT strategies is included in the previous report and summarised below.

The Economic Regulation Authority (ERA) is the independent economic regulator for Western Australia. The ERA was established under section 4 of the Economic Regulation Authority Act 2003.

The ERA regulates monopoly aspects of the gas, electricity and rail industries and licenses providers of gas, electricity and water services. The ERA also has a range of responsibilities in the retailing of gas and surveillance of the wholesale electricity market in Western Australia.

6.2.1 Electricity

It is anticipated that licences would be needed under the Electricity Industry Act 2004 (not including normal licensing of the centralised energy and water agencies), these include:

- to construct or operate generating works (electricity generation licence or an integrated regional licence); and
- to sell electricity to customers except under the authority of a retail licence or an integrated regional licence.

This assumes that a local utility generates electricity at Stirling and retails to all eligible customers, i.e. those that consume more than 50MWh per annum (which could include multi-residential buildings with individual sub-metering of premises).

The Public Utilities Office (PUO) within the Department of Finance provides advice on energy matters to the Minister for Energy and the Western Australian Government. Amongst other functions, the Public Utilities Office supports the performance of the statutory functions (Energy Coordination Act 1994) of the Coordinator of Energy. Accordingly the PUO will have a role in establishing the alternative arrangements under which electricity would be supplied as set out here.

30 http://www.mediastatements.wa.gov.au/pages/StatementDetails.aspx?listName=StatementsBarnett&StatId=7607

6.2.2 Water

Under the recommendations in this report, a local utility would provide sewerage and non-potable water services to customers, and accordingly licences would be required for both. This will require the utility to demonstrate:

- sufficient financial and technical ability to operate the service;
- that the application is not contrary to public interest; and
- it can meet the minimum service and performance standards set by ERA in respect of:
  - sewerage service standards;
  - non-drinking water quality standards;
  - non-drinking water pressure and flow standards;
  - non-drinking water continuity standards;
  - irrigation water quality and delivery standards;
  - customer service and complaint handling standards.

The DoW and DoH will be consulted by the ERA in considering a licence, and will a have direct regulatory role in some cases.

- The DoW is responsible for protecting and managing the State's water resources, including management of the licensing system for water source allocation; and
- The DoH regulates health standards for water supplied by the service providers.

6.2.3 Thermal energy

Under the recommendations in this report, a local utility would retail thermal energy to customers in the form of hot water (for space and water heating) and cold water (for space cooling).

For a thermal energy scheme to be financially viable, take up of the service would need to be mandated by the planning and development approval processes, noting that the scheme will result in reduced building equipment capital costs. A possible exemption arrangement from this would be for building owners that can demonstrate they can supply the same service within the building at a lower cost and with lower greenhouse gas emissions.

There are presently no regulations governing the supply of thermal energy in Western Australia or in any other state. Although cogeneration and trigeneration schemes are operating at the building level, the resulting energy supplies are the subject of private contracts between the system owner and building occupants.

A new regime will need to be established for setting a price per unit energy for thermal energy, and establishing minimum service and performance standards. Following practices in Europe for district heating systems, it is recommended that the principle is established that the aggregate cost to the consumer should be no more than it otherwise would be if the heating / cooling service was supplied in a conventional manner. For heating this could be determined as the equivalent of natural gas use for space and water heating and electricity for space cooling.

The provision of a district heating and cooling service for the distributed services zone is a central component of the strategy. Ensuring that its take up can be mandated (albeit with exemptions) and a pricing regime can be established is critical to the strategy.

6.3 Initial Capital Costs

For the purposes of establishing life costs, the staging of development has been assumed to be in accordance with the development curve in Figure 5-1, with development commencing in 2015.

Volume 2 of this report will address the servicing of the Stage 1 area in more detail. However irrespective of which elements of the development are established first, the capital costs will be in the order of the figures in Table 6.1 in the period 2015-2020, based on the timing assumptions adopted in this report.

Table 6.1 Capital costs to 2020

Capital Item		BaU (2013 $m)	Trigeneration / Solar (2013 $m)	Geothermal / Solar (2013 $m)
Water				
	Potable	6	6	6
	Wastewater	22	12	12
	Drainage	3	3	3
	Non-drinking water		12	12
Energy				
	Electricity	25	19	19
	SWIS Generation	34		
	Local Generation		25	26
	Thermal Network		29	57
	Gas	1	2	1
Waste			32	32
Telecoms		4	4	4
Additional building costs		27	8	8
		121	152	180
Direct local infrastructure costs		60	144	172
Indirect costs		61	8	8
		121	152	180

Notes

1. The cost of SWIS generation in the BaU scenario will be recovered through network electricity charges over time and is therefore not a direct infrastructure cost to SCC development.
2. The additional building costs will be met by developers and therefore is also not a direct infrastructure cost to SCC development.
3. Direct costs of infrastructure will be recovered through a combination of development contribution charges, headworks and through tariffs.

6.4 Further Studies

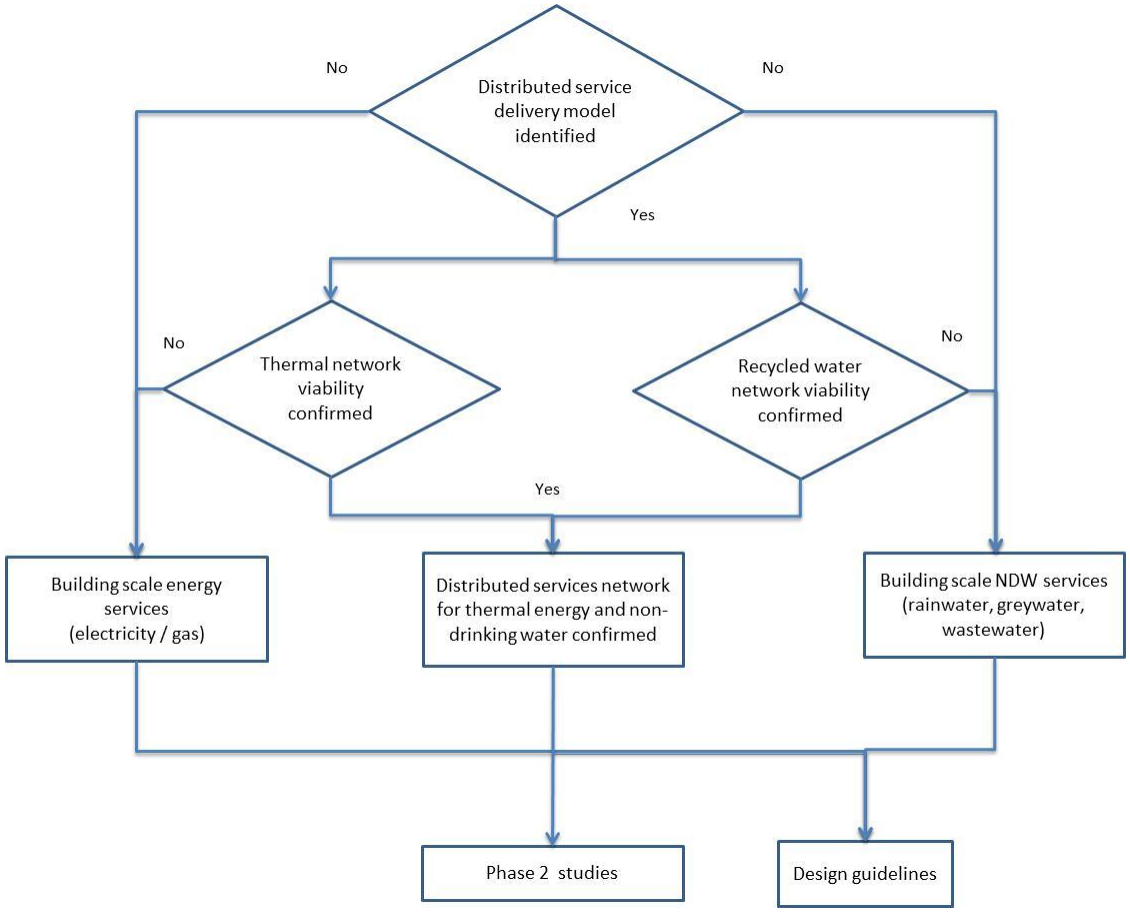
This study identifies that the preferred servicing concept offers significant sustainability benefits, is technically feasible and economically viable. However a significant amount of further study and numerous consultations are necessary before the proposed infrastructure concept can be progressed. Some of these studies can be carried out in parallel but some will need to be staged.

The following assumes that a development proponent is identified following the cessation of the Stirling Alliance and that this proponent, acting on behalf of the WAPC is the sponsor of the studies identified. It also assumes that a final Structure Plan and staging plan is in place that describes development in sufficient detail for servicing infrastructure to be sized and costed.

Pre-funding infrastructure is a challenge for the project whether or not it proceeds along business as usual or best available technology lines. The shortfall between costs and revenue is likely to be similar in the early years. It is recommended that a separate parallel study is undertaken to identify pre-funding sources, including the potential involvement of the private sector.

6.4.1 Phase 1 studies

The central plank of the proposed strategy is the introduction of a distributed services network in the mixed-use areas of the SCC, involving the reticulation of thermal energy and nondrinking water. Progressing of this concept is subject to the identification of potential service providers for one or both of these services. If a model for this service delivery cannot be devised, then further detailed design studies would be superfluous. Resolving this issue is also required to inform the development of design guidelines for buildings. If the distributed services model is to apply, the requirement to connect to them and the implications for building design must be reflected in design guidelines. Alternatively if distributed services are not to be provided, sustainability alternatives at the lot scale must be reflected in design guidelines. A flowchart setting out the logic of Phase 1 studies is set out below.



Feasibility Study – Service Delivery Implementation Options

This report suggests 3 alternative delivery options are available:

1. Separate implementation of each component through existing agencies, i.e. electricity (Western Power, Synergy / other retailers and generators), gas (ATCO and Alinta), water (Water Corporation) and waste (City of Stirling).
2. Separate implementation of each component through involvement of the private sector (electricity generation / retail, recycled water, waste-to-energy).
3. A new utility formed specifically to provide services at the SCC which would provide integrated energy, water and waste services.

Examination of these options is a priority as the outcome of the strategy as presently formulated is dependent on the identification of one or service providers.

Feasibility Study – Distributed Thermal Energy

The feasibility of providing a service that delivers heating and cooling to buildings requires further study. This study would consider:

- further concept design of the proposed heating and cooling, i.e. absorption and electric chillers and thermal storage;
- further concept design of the proposed heat rejection system;
- further concept development of the thermal network including extent, sizing and the location layout of energy stations;
- the cost / benefit to building owners of such an arrangement;
- whether the planning system can mandate developers to connect to and purchase thermal energy from a utility;
- any exemptions that would apply to such arrangements;
- implications for buildings;
- costs of providing the service;
- pricing of the service; and
- regulation of the service.

The results of this study will determine the feasibility of the thermal energy distribution concept. If viability is not confirmed, the energy concept would default to a renewable electricity service only.

If viability is confirmed, further studies related to the thermal energy source, and the scope of renewable electricity can follow as detailed below.

Feasibility Study – Recycled Water

The proposed approach to recycled water set out in this report should be reviewed. In particular the following issues need to be progressed:

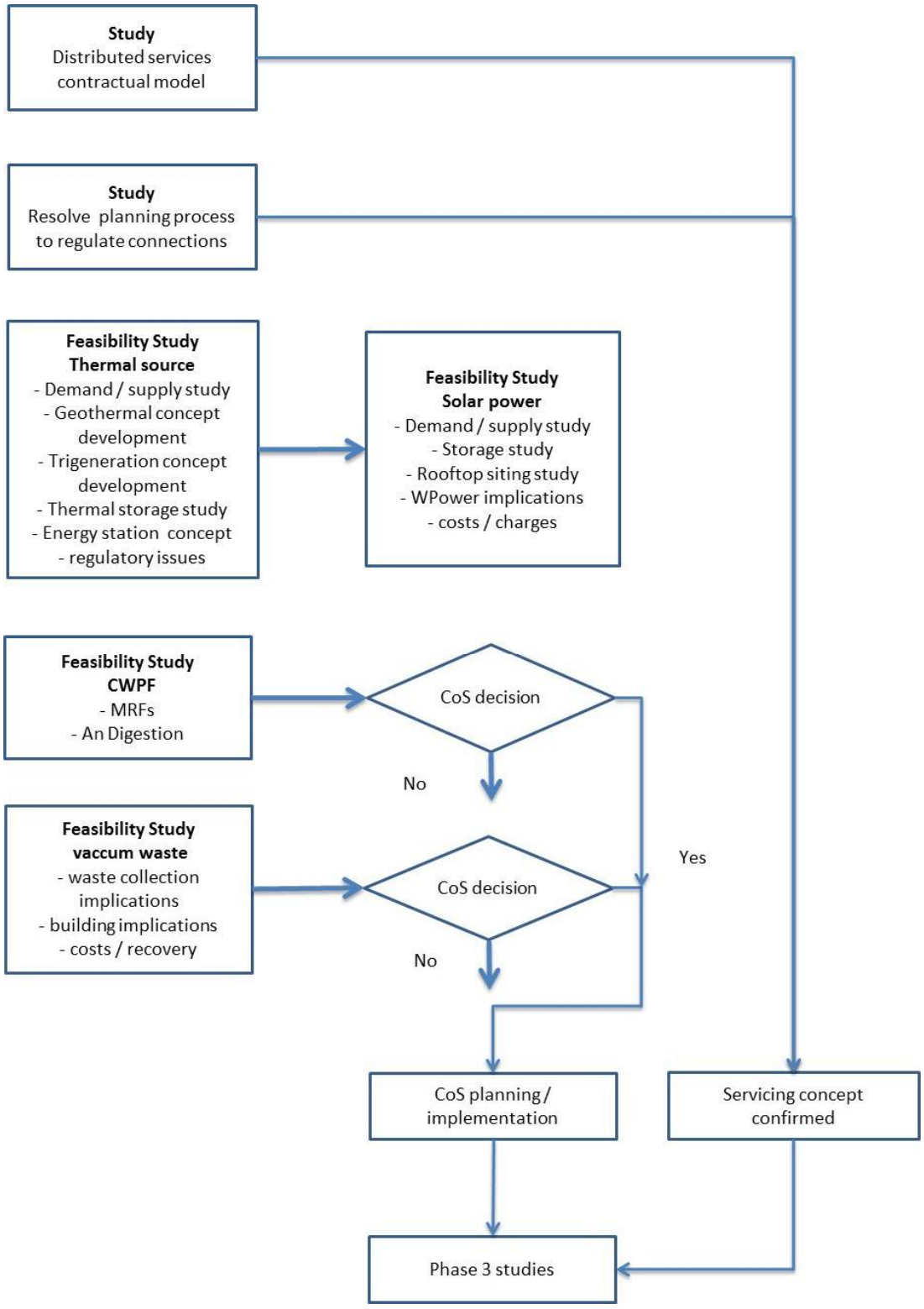
- further concept design of the rerouting of sewers;
- further concept design of the recycled water plant including layout/footprint;
- the ongoing interface with the Water Corporation system including emergency discharge;
- further concept design of the recycled water distribution and reticulation network;
- further concept design of the excess water discharge arrangements;

- the implications for buildings of the nondrinking water system; and
- costing and pricing.

If viability is confirmed, the recycled water initiative can be progressed. If not, water efficiency initiatives would revert to the building scale only.

6.4.2 Phase 2 studies

Following this first phase of studies and subject to their outcome, the following steps can be progressed, with a view to finalising the services concept.



Study – contractual arrangements for service provider(s)

Once the manner of service delivery is resolved, plans can be progressed on the contractual arrangements necessary to implement the distributed services strategy. A study on cost recovery is also necessary to resolve an appropriate approach to headworks and development contributions and pre-funding.

Study – planning processes

The planning control mechanisms that will facilitate the connection of premises to the thermal network and the recycled water network need to be resolved.

Feasibility study – Thermal energy source

The findings of this report identify natural gas-fired tri-generation and geothermal energy as potential sources of thermal energy.

Further examination of the viability of geothermal energy to provide (initially) thermal energy should be progressed through the further interpretation of existing data followed by a trial bore. This trial would establish the depth at which suitable temperatures exist and the hydraulic characteristics of the aquifer which will determine potential pumping rates.

Subject to the outcome of this trial a concept design could be progressed and costed for the geothermal energy headworks.

The study should also take the tri-generation concept to the next level of design. This would involve sizing of the plant, resolving the natural gas demand and connection arrangements and confirming costs.

Following the consideration of the thermal energy source the design of energy stations can be progressed including locations and layouts. The study should also progress regulatory issues surrounding the supply of thermal energy including licensing and pricing.

Feasibility study – solar PV

It is only when the tri-generation option is adopted or discarded that further design development of solar PV can be finalised (as this will confirm electricity requirements), although it could be commenced in parallel with the other phase 2 studies. This study will:

- examine in detail the demand / supply balance and identify more accurately the contribution of solar to meet peak and annual electrical demands;
- examine in detail the types of electrical storage that are feasible for the site (centralised or distributed);
- develop a strategy for locating PV panels on rooftops (including access options);
- devise the inverter, grid connection and metering design;
- identify the implications for the Western Power high-voltage network at and downstream of the substation; and
- confirm costs.

Feasibility study – vacuum waste system

The proposed use of a vacuum waste system in the distributed services zone should be reviewed, in particular in respect of:

- the degree of waste separation desired within buildings and the concept derived for the collection points and pipework within buildings;

- concept design for the in-street infrastructure including pipework access points and waste collection station(s);
- labour, equipment and transport infrastructure required to operate the system; and
- costing and pricing.

Feasibility study – central waste processing facility

The recommendations for an integrated processing facility at Balcatta or elsewhere requires further study:

- further concept design of the materials recovery facilities and the separation of organic wastes;
- further concept design of anaerobic digestion facilities;
- consideration of odour and noise constraints;
- further development of the site layout.

These two studies, to be conducted under the auspices of the City of Stirling (which could be conducted in either Phase 1 or Phase 2) will confirm whether the vacuum waste proposal will be progressed, and whether waste to energy is feasible as part of the energy solution. The vacuum waste proposal needs to be incorporated in building design guidelines.

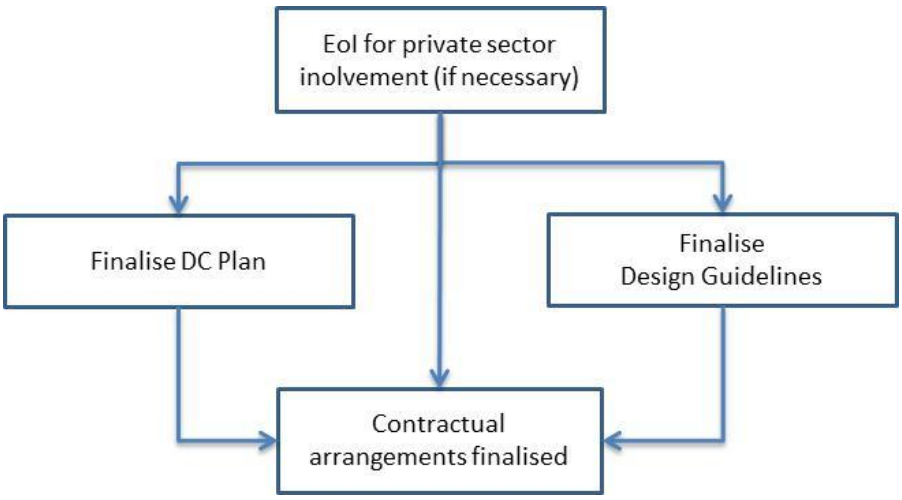
If shown to be viable, the City of Stirling could progress the central waste processing facility separately and in parallel to the other studies as this element could proceed irrespective of other initiatives.

6.4.3 Phase 3 studies

At the completion of Phase 2, the complete servicing concept should be finalised. This will allow the finalisation of both the development contributions plan in respect of infrastructure, and the finalisation of design guidelines for the mixed-use areas. If at this stage the service delivery model is not yet confirmed then this work may need to follow the EOI process discussed below.

The increased level of detail available from the Phase 1 and 2 studies would facilitate the development of an EOI for private sector involvement in the delivery of services infrastructure. The nature of this involvement is dependent on the outcome of earlier studies and may involve the private sector in building or operating some or all of the identified infrastructure. Under the requirements of State Planning Policy 3.6, any infrastructure funded through a development contributions plan must be publicly owned. Accordingly any private sector involvement will need to reflect this requirement.

Following these processes it should be possible to finalise contractual arrangements to deliver the services.


EoI for private sector inolvement (if necessary)
Finalise DC Plan
Finalise Design Guidelines
Contractual arrangements finalised

Appendices

This document is in draft form. The contents, including any opinions, conclusions or recommendations contained in, or which may be implied from, this draft document must not be relied upon. GHD reserves the right, at any time, without notice, to modify or retract any part or all of the draft document. To the maximum extent permitted by law, GHD disclaims any responsibility or liability arising from or in connection with this draft document.

Appendix A – ATCO Gas Advice

Bill Grace

From:	Lude, Nathan <Nathan.Lude@atcogas.com.au>
Sent:	Thursday, 16 May 2013 1:32 PM
To:	Duane Quek
Cc:	Stubbs, Marc; Pemberton, Chris; Frederik Mulder
Subject:	RE: Gas Distribution Network - Stirling City Centre Area
Attachments:	mains extension.pdf
CompleteRepository:	6128902
Description:	Stirling Alliance Utilities Strategy
JobNo:	28902
OperatingCentre:	61
RepoEmail:	6128902@ghd.com
RepoType:	Job

Duane,

Based on a load of 508,000 GJ/year which works out to be 1526scmh, we have modelled the requirement within our infrastructure capabilities.

We have assumed a location in stage 1 in order to determine the distance for mains extension. Please refer to the attached diagram.

The MP network is unable to supply gas to the site.

The gas will need to be supplied from the HP network. Stage 1 is located south of the freeway therefore, it will easier to connect from the existing HP in Northstead St.

We have modelled several scenarios and the most economical result is installing a HP regulator set and mains extension of 3000m x DN160 80B along Beatrice St. The main will be operated with a maximum operating pressure of 350kPa.

We need more definition around peak loads and the total number of Trigen's installed. Upon receiving this we would be able to supply cost estimates etc.

Under a 'Business as Usual' approach there are minor extensions that may be required, dependent on the staging however this will be minimal.

Regards,

Nathan Lude
Business Development

ATCO Gas AUSTRALIA | ATCO Gas Australia Pty Ltd
12-14 The Esplanade
Perth WA 6000
Telephone: (08) 6218 1734 | Mobile: 0427 496 890 | Facsimile: (08) 6218 1703
Email: Nathan.lude@atcogas.com.au

From: Duane Quek [mailto:Duane.Quek@ghd.com]
Sent: Wednesday, 15 May 2013 10:27 AM
To: Lude, Nathan
Cc: Stubbs, Marc; Pemberton, Chris; Frederik Mulder
Subject: RE: Gas Distribution Network - Stirling City Centre Area

To: Duane Quek
Cc: Stubbs, Marc; Pemberton, Chris
Subject: FW: Gas Distribution Network - Stirling City Centre Area

Duane,

Marc Stubbs has passed on your email to me. We have previously conducted a preliminary assessment based on loads we were given however we would like to confirm these and also establish projected timing/staging for the development.

Are you available to meet next week Tuesday and we can discuss the various aspects. Tuesday the 30th of April is relatively open for me at this stage?

Regards,

Nathan Lude
Business Development

<image001.jpg>
Telephone: (08) 6218 1734 | Mobile: 0427 496 890 | Facsimile: (08) 6218 1703
Email: Nathan.lude@atcogas.com.au

From: Duane Quek [mailto:Duane.Quek@ghd.com]
Sent: Tuesday, 23 April 2013 10:46 AM
To: Stubbs, Marc
Cc: Frederik Mulder
Subject: Gas Distribution Network - Stirling City Centre Area

Good day Marc,

GHD have been appointed by the Stirling Alliance to assist with the preparation of the Stirling City Centre Structure Plan. As part of this study, we are acquiring electronic versions of the data available for all utilities, including ATCO Gas. The Master Plan shows a higher density redevelopment of the area in the future. As part of our study we would like to determine:

- The capacity of the existing system, and capability to cope with higher density redevelopment (See attached yield summary)
- Gas usage information within the area and highlighted on the Precinct plan – broad usage per area only, not on a detailed level

Attached is the proposed precinct plan for the study, highlighting the current existing gas network and current precinct plan. I have also added the dwelling and population yields for each of the precincts, if it may be of use to you in forecasting future use.

Can you please give us an indication on whether usage information can be obtained for the area(s), and what information you will require from us in order to verify the capacity of the gas network to service high density redevelopment? Please note that the PDF has been extracted from our GIS maps, which have attached data including pipe sizes and pressure ratings, which can be provided if required. If you currently do not have capacity for this work, are you able to point us in the right direction towards whom we can contact?

Duane Quek
Civil Engineer – Land Development

GHD
T: 08 6222 8122 | V: 618122 | E: duane.quek@ghd.com
239 Adelaide Terrace, Perth WA, 6004 Australia | www.ghd.com

ATCO Gas Australia Pty Ltd
ACN 089 531 975
12-14 The Esplanade
Perth WA 6000
Locked Bag 2507
Perth BC WA 6849
p. 08 6218 1700
f. 08 6218 1703
w. www.atcogas.com.au

SUBJECT TO CONTRACT

19 June 2013

Duane Quek
GHD
239 Adelaide Terrace, Perth
Western Australia, 6000

via email: duane.quek@ghd.com

Dear Duane,

Desktop Estimate - Main Extension Inquiry:
Stirling City Centre Area ("Customer")

In regard to the increased gas supply for the Stirling City Centre Area Redevelopment (**"Project"**) being considered by the Customer (**"Customer Requirements"**):

a) based on the load data and information provided to ATCO Gas Australia and information available to ATCO Gas at the date of this Desktop Estimate, (**"Base Information"**);
b) subject to the Conditions overleaf

ATCO Gas Australia is pleased to provide the following Desktop Estimate:

Total Cost Estimate

Stage:	***Estimated Cost / Contribution:***
Stage One: *consists of 3000m of 160 PE mains with 1 High Pressure Reg.*	$1,240,000
Total Cost Estimate (ex GST)	**$1,240,000**

Conditions

ATCO Gas Australia provides this Desktop Estimate:

(a) In reliance on the Base Information and Load Data supplied by GHD;

(b) On the basis that the Base Information is complete, accurate and up to date; and

(c) Without warranty as to its completeness, accuracy or suitability for any purpose.

If additional Service or Asset Items are required, further charges may apply – details are available upon request.

The Total Cost figure may be reduced if:

(a) ATCO Gas Australia is requested to and is able to provide a contribution to the main; and

(b) a take or pay arrangement is entered into between ATCO Gas Australia and the Customer's nominated gas Retailer.

For illustrative purposes only, ATCO Gas Australia has assessed that its contribution to the cost of the main extension for such a project may be offered, subject to:

(a) internal approvals; and

(b) the Conditions of this Desktop Estimate; and

(c) if the load is guaranteed on a take or pay basis for three years at the prevailing A1 Reference Tariff rate.

We can discuss several scenarios that may increase ATCO Gas Australia's ability to invest in the main, and therefore reduce the Customer upfront costs, for example, increasing the take or pay haulage TJ amount.

As mentioned, the Total Cost Estimate is indicative only and the final Total Cost payable may be higher or lower than the Total Cost Estimate due to factors including but not limited to site access restrictions, ground conditions, or fluctuations in the cost of materials or labour.

No modification, variation or amendment to any part of this Desktop Estimate shall be effective. If a more detailed Total Cost Estimate or any estimation or investigation activities over and above a Desktop Estimate is required ATCO Gas Australia can undertake such activities for a fee – details are available upon request.

All Service and Asset Items required, as outlined above, are to be requested and processed at the appropriate time via the usual Commercial Gas Connection Enquiry (CGCE) form, submitted by the Customer's nominated gas Retailer.

Should the Customer wish to proceed with the Project on the basis of this Desktop Estimate, ATCO Gas Australia will:

(a) enter into a Memorandum of Understanding direct with the Customer;

(b) (subject to the Customer agreeing to proceed with the Project) process the CGCE form submitted by the Customer's nominated gas Retailer;

(c) (if accepting any contribution offered by ATCO Gas Australia) enter into a Take or Pay Agreement direct with the Customer's nominated gas Retailer; and

(d) enter into a Construction Agreement direct with the Customer.

Approximate timings and milestones for the Project (subject to change based on ATCO Gas Australia operational commitments) are as follows (from the date of execution of a Memorandum of Understanding):

Circulation, Internal approvals (including CGCE form submission and processing, confirmation of any contribution) and signing of Take or Pay Agreement with the Customer's nominated gas Retailer and Construction Agreement with Customer	5 - 6 weeks
Engineering design and approval	4 weeks
Tender & Contract Award	4 weeks
Material sourcing	10 weeks
Construction	6 weeks
Commissioning	1 weeks

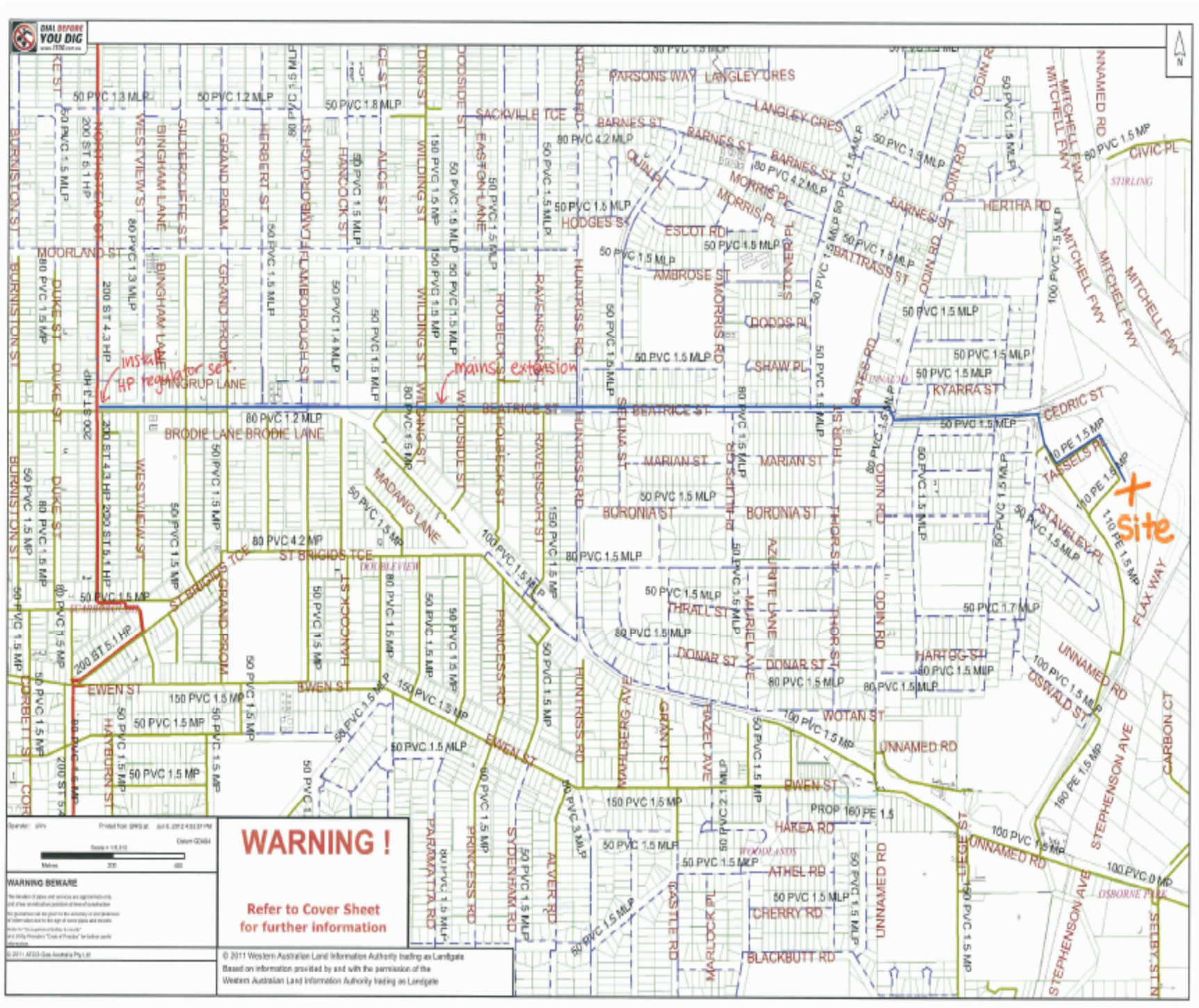
Firmer timings will be provided at the time of entering into a Construction Agreement direct with the Customer.

Please don't hesitate to contact me should you have any questions.

Yours faithfully

Nathan Lude
Business Development
cc: AGA.CGCE@atcogas.com.au

Map: Possible network reinforcement routing: Stirling City Centre Area Redevelopment



Appendix B Western Power Substation Upgrade Costs

Our ref: 10792344
Contact: Claire Vanderplank 08 93266775

30 May 2013

Bill Grace
Principal Sustainability Consultant
GHD
239 Adelaide Terrace
Perth WA 6004

Dear Bill

Western Power indicative investments for supply of Stirling City Centre

Western Power is pleased to provide information to assist in development of the Utilities Strategy for the Stirling City Centre Alliance. The following information has been prepared based on development data provided by GHD consultants in May 2013 and Western Power's forecast for the Osborne Park substation. The current load supplied from OP substation is 65 MVA.

Scenario 1 - Development assumed as underlying growth (Western Power's expectation) - forecasts suggest 146 MVA by 2063

Transmission reinforcements total capital cost -$43M:

- 2017/18 - Expand the existing Osborne Park substation, 2 x 66 MVA transformers - $30M
- 2032/33 - Install additional transformer at Osborne Park, 1 x 66 MVA transformer - $13M

Distribution reinforcements total capital cost - $11M

- Approximately 17 distribution feeders will be required

Total capital cost (transmission + distribution) for Scenario 1 approximately $54M

Scenario 2 - Ultimate demand with GHD load projections - forecasts suggest 187 MVA by 2063

Transmission reinforcements total capital cost - $77M:

- 2017/18 - Expand the existing Osborne Park substation, 2 x 66 MVA transformers - $30M
- 2026/27 - Install additional transformer at Osborne Park, 1 x 66 MVA transformer - $13M
- 2044/45 - New substation (including land purchase), 2 x 66 MVA transformers - $34M

Distribution reinforcements total capital cost - $16M

- Approximately 25 distribution feeders will be required

Total capital cost (transmission + distribution) for Scenario 2 approximately $93M

Scenario 3 - Ultimate demand with GHD load projections (Stage 1: City Centre only) - forecasts suggest 163 MVA by 2063

363 Wellington Street Perth WA 6000
GPO Box L921 Perth WA 6842
enquiry@westernpower.com.au

T 13 10 87 | F (08) 9225 2660
TTY 1800 13 13 51 | TIS 13 14 50
westernpower.com.au

Electricity Networks Corporation
ABN 18 540 492 861

Transmission reinforcements total capital cost - $77M

- 2017/18 - Expand the existing Osborne Park substation, 2 x 66 MVA transformers - $30M
- 2028/29 - Install additional transformer at Osborne Park, 1 x 66 MVA transformer - $13M
- 2055/56 - New substation (including land purchase), 2 x 66 MVA transformers - $34M

Distribution reinforcements total capital cost - $13M

- Approximately 20 distribution feeders will be required

Total capital cost (transmission + distribution) for Scenario 3 approximately $90M

The above information has been compiled using the following assumptions and guidance:

- Planning has been undertaken based on the Transmission and Distribution System Planning Criteria outlined in the Western Power Technical Rules. More information is available in Western Power's Annual Planning Report http://www.westernpower.com.au/aboutus/publications/Annual_planning_report_.html
- Transmission reinforcements represent the preferred development of the transmission network based on the current information regarding capacity, demand, asset conditions and feasibility of alternative options. Plans may change as new information arises.
- The timing stated for each transmission and distribution reinforcement is based on current load growth rates and the load projections provided by GHD. No assessment of deliverability has been undertaken and the timing assumes an unconstrained funding environment.
- Reinforcement costs have been developed with a sole focus on local supply (IE. Zone substations, zone substation transformers and distribution feeders). Costs to reinforce the wider transmission network surrounding Osborne Park have been excluded from the assessment.
- Land purchases in the Osborne Park area were assessed in October 2012 at $1500/m2. These costs may change depending on market conditions and value at the time the land purchase is required.
- The analysis assumes that the existing Osborne Park zone substation distribution feeders are currently out of capacity, and any new incremental loads of 5 MVA would require a new distribution feeder.
- It is assumed that each new distribution feeder required that is required to supply the Osborne Park load growth is approximately 1.5 km in length.
- Each distribution feeder installed and energised is estimated at approximately $650 000.
- Western Power's building blocks are used to develop the cost estimates. They represent +-50% accuracy.
- The estimates do not include escalation and is based on today's 2012/2013 dollars.

It should be noted that the Distribution network is dynamic and is subject to change. Changes to the network will effect substation catchments and growth rates.

The cost assessment provided is indicative in nature only and not binding on Western Power or Western Power personnel, and Western Power is not liable for any error or omission, which is made as a reasonable and prudent person, in this proposal. All information is provided based on a network development scenario based on the information available at the time of the assessment. The actual network development will vary depending on factors including, but not limited to, actions of other network users, variations from the forecast in load growth, availability of capital funds, the results of detailed analysis of reinforcement options, installation of generation or load not envisaged at the time, access to suitable line corridors and land, condition of plant in the load area, Western Power's priorities and policy revisions, regulatory considerations, changes in planning criteria and changes in technology.

Western Power does not warrant that the information provided as part of these works will be included in any subsequent connection offer to service the potential new developments and it should not be relied upon by any party as final or binding.

Western Power accepts and bears no risk or responsibility for any loss or damage suffered by any party that is caused, contributed to by or in connection with the use of the information within this document or any other document which refers to or mentions this document. Any use of this information is at the user's or users' sole risk.

If you have any questions about the above information please do not hesitate to contact Claire Vanderplank on 93266775 who will put you in touch with the appropriate Western Power officer.

Yours Sincerely

Tom Pearcy
A/Planning and Projects Manager

cc: Bernie O'Leary (Stirling Alliance)

Appendix C – Recycled Water Plant Specifications

Table 1 Basis of Ultimate NDW Demand Estimates

Parameter	Value	Comments
Residential		
Total Dwellings	7,020	
Resident Population	12,600	Based on assumed occupancy of 1.8 residents/dwelling (rounded)
Annual in-house NDW demand	34 kL/dwelling/day	
Annual irrigation demand	11.3 kL/dwelling/day	Assumes 15% of on-lot area irrigated, at 500 mm/year.
Maximum Day Peaking Factor (x Average Annual Demand)		
In-House NDW Demand	1.3	
Irrigation Demand	3.0	
Peak Instant Peaking Factor (x Max Day Demand)	3.0	
Commercial		
Commercial land served		
Offices	491,825 m^2GFA	
Retail buildings	424,171 m^2GFA	
Entertainment, recreation and cultural buildings	15,019 m^2GFA	
Health, education and community welfare buildings	14,656 m^2GFA	
Average annual water demand (potable plus NDW)		Water Corporation H2Options.
Offices	0.8 kL/m^2/year	
Retail buildings	1.0 kL/m^2/year	
Entertainment, recreation and cultural buildings	1.0 kL/m^2/year	
Health, education and community welfare buildings	0.8 kL/m^2/year	
Split of Annual Water Demand	Potable : Internal NDW : External NDW	
Offices	60% : 35%: 5%	
Retail buildings	60% : 30% : 10%	
Entertainment, recreation and cultural buildings	60% : 30% : 10%	
Health, education and community welfare buildings	60% : 30% : 10%	
Maximum Day Peaking Factor (x Average Annual Demand)		

Parameter	Value	Comments
Internal demand	1.16	
External demand	3.0	
Peak Instant Peaking Factor (x Internal Max Day Demand)	2.4	Assumes peak demand = 2.4 x average demand (flat demand over 10 hours), and coincides with time of peak residential NDW demand.
Peak Instant Peaking Factor (x External Max Day Demand)	0.0	Assumes commercial irrigation demand not coincident with times of peak residential NDW demand.
Public Open Space		
Area under irrigation	3.23 ha	30% of “new” POS (“existing POS assumed to be irrigated with groundwater)
Annual irrigation demand	500 mm/year	Waterwise application rate assumed
Maximum Day Peaking Factor (x Average Annual Demand)	3.0	
Peak Instant Peaking Factor (x Internal Max Day Demand)	0.0	Assumes irrigation areas not irrigated at times of peak residential NDW demand.
Verges		
Verge area under irrigation	9.64 ha	15% x total road reserve area
Annual irrigation demand	500 mm/year	Waterwise application rate assumed
Maximum Day Peaking Factor (x Average Annual Demand)	3.0	
Peak Instant Peaking Factor (x Max Day Demand)	3.0	

Appendix D – Balcatta Waste Facility Layouts

Site layout

The development of a Central Waste Processing Facility at the Balcatta site would require the complete redevelopment of the site. Although some potential options for the site layout are shown in the figures below, any number of options are possible. Similar layouts could also be developed for sites of similar size.

Option 1 shows the site with one entrance and exit using current site access points. The waste infrastrucutre is most located on the western side of the site with a large area in the south-eastern corner available for other functions. All traffic would enter the site from the Balcatta Road entrance. After crossing the eastern weighbridge, transfer station traffic would proceed directly ahead, drop off waste at the transfer station, cross the western weighbridge and leave the site through the Natalie Way exit.

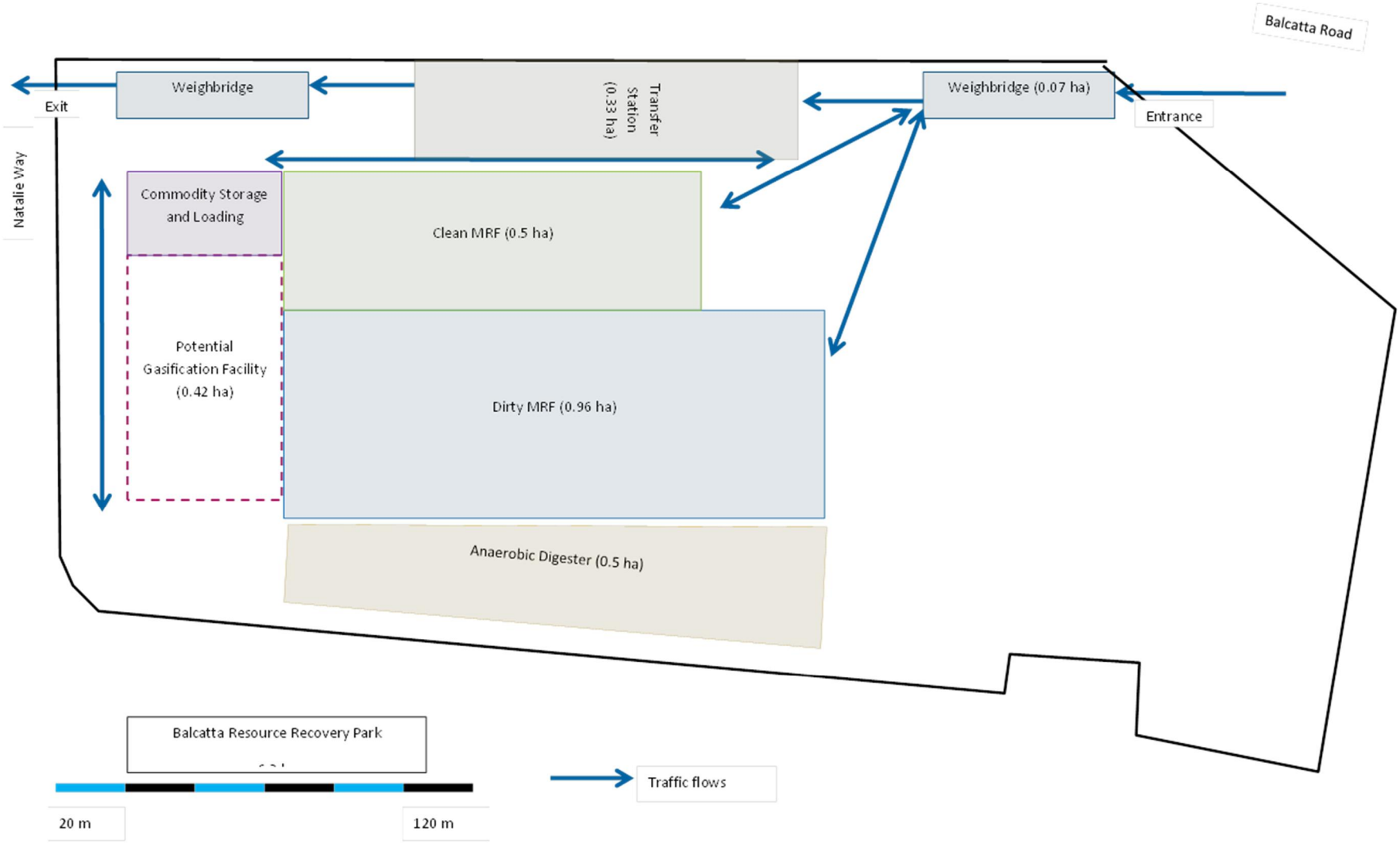
Vehicles accessing the processing facilities would proceed directly from the eastern weighbridge to each area and back again to the eastern weighbridge before exiting the site through the Balcatta Road exit. Vehicles collecting product from the processing areas would use the area on the far western edge of the site and could also leave the site through the Natalie Way exit.

Option 2 shows the site with two entrances, one from Natalie Way and one from Balcatta Road and one exit onto Balcatta Road. There is one weighbridge across which all vehicles would pass. Vehicles using the transfer station would proceed directly ahead, dispose of waste at the transfer station, return to the weighbridge via the internal road network and then leave the site through the Balcatta Road exit.

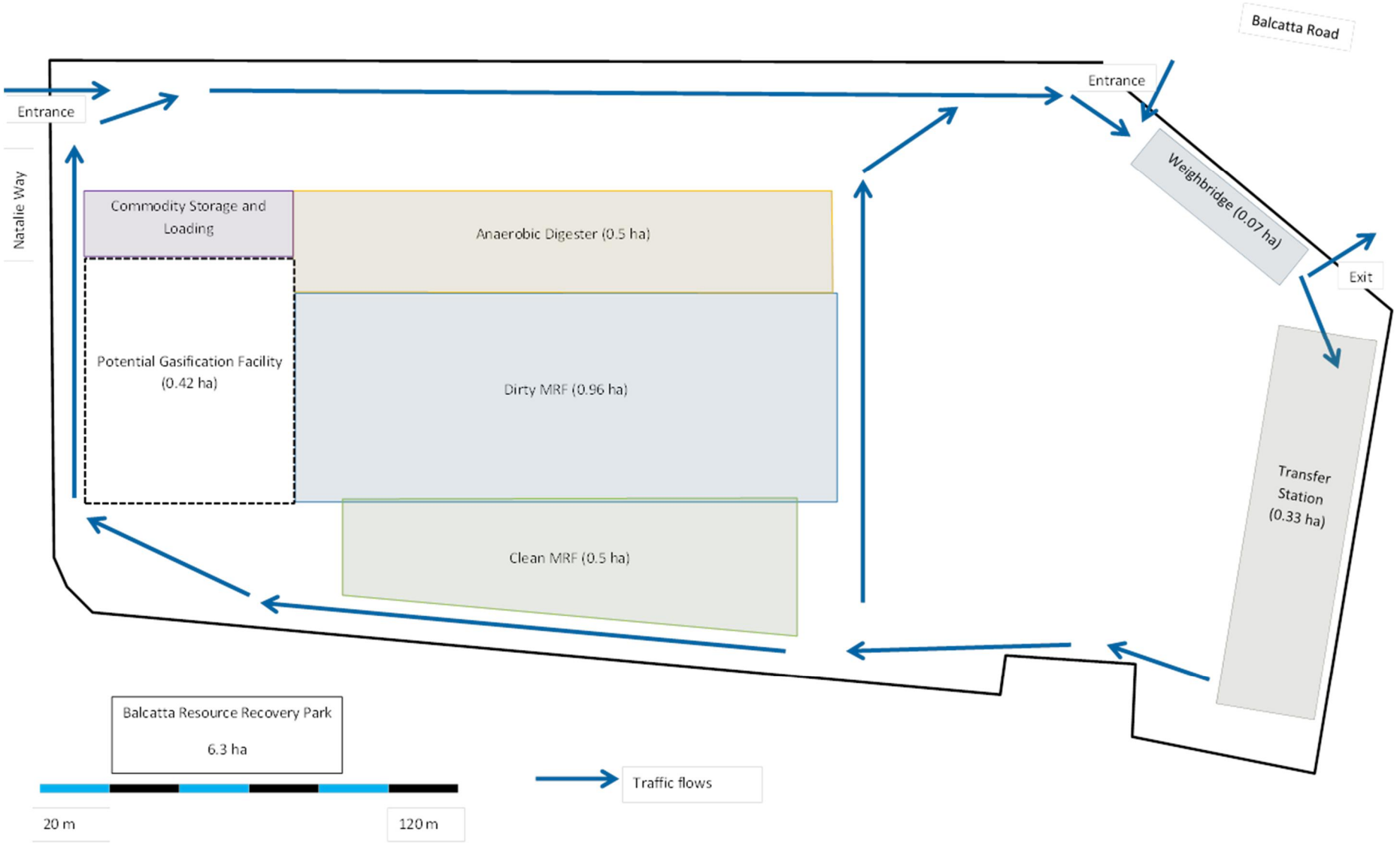
This option shows the waste processing facilities on the western side of the site. Other vehicles accessing the processing areas would bypass the transfer station and access the other facilities using the internal roads, then leave the site also through the Balcatta Road exit after recrossing the weighbridge.

Option 3 is the same as Option 2 but the processing facilities are on the eastern side of the site. This reduces the distance that vehicles accessing the processing facilities have to travel on-site.

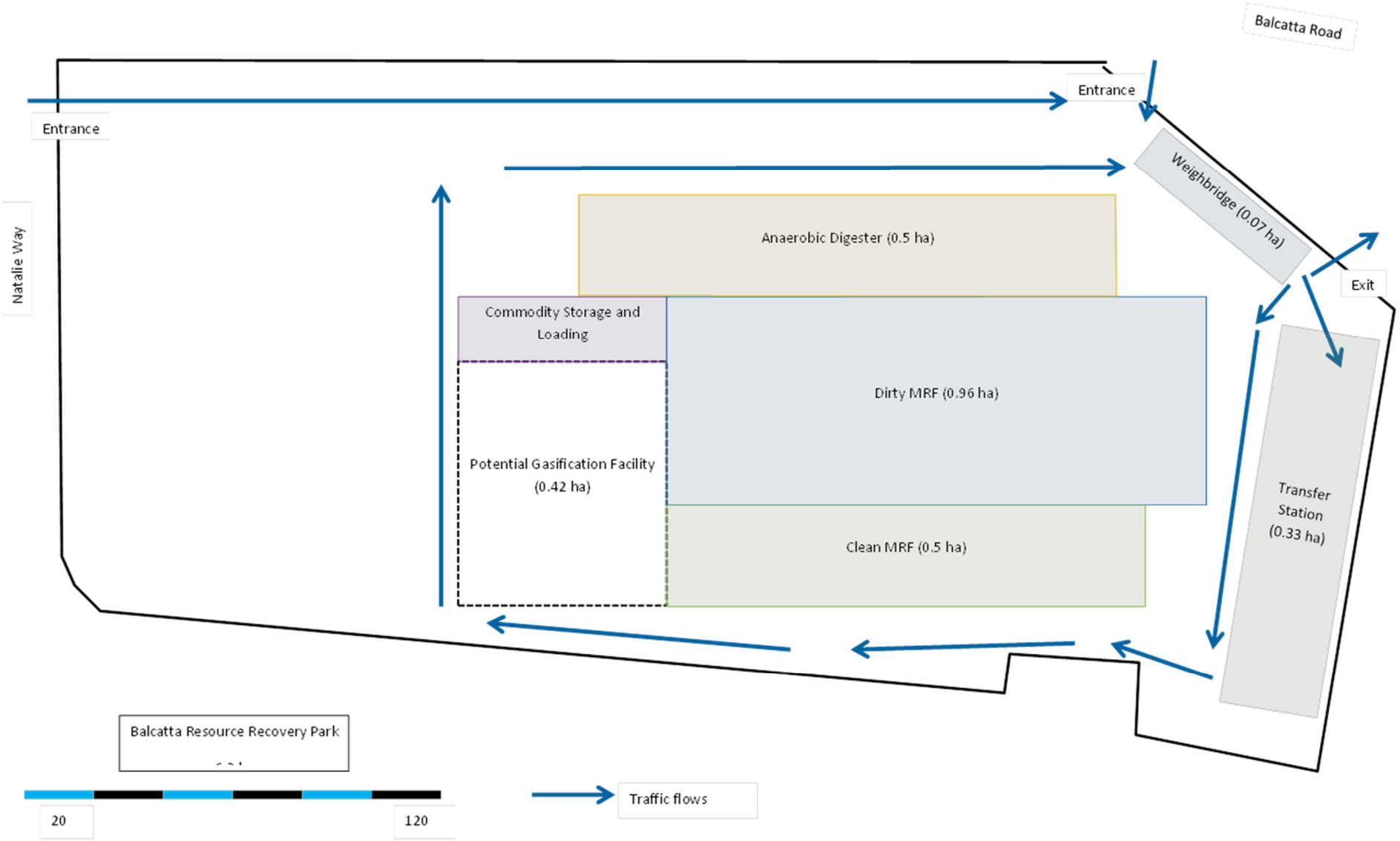
These options are concepts only. The exact final locations of facilities on site will depending on a range of factors not yet explored such as, vehicle turning circles, exact facility footprints and designs, traffic quantities, available area, external traffic issues among others.



Balcatta Layout Option 1



Balcatta Layout Option 2



Balcatta Layout Option 3

Appendix E – Discounted Cash Flow analysis

BaU

| | | |

BaU

| | | |

Trigen / Solar

| | | |

Trigen / Solar

Discount Rate: 7.0%
Inflation Rate: 3.0%
Length of NPV: 50.00

| | | |

Geo / Solar

Discount Rate: 7.0%
Inflation Rate: 3.0%
Length of NPV: 50.00

| | | |

Geo / Solar

Discount Rate: 7.0%
Inflation Rate: 3.0%
Length of NPV: 50.00

				1.00	0.93	0.87	0.82	0.76	0.71	0.67	0.62	0.58	0.54	0.51	0.48	0.44	0.41	0.39	0.36	0.34	0.32	0.30	0.28	0.26	0.24	0.23	0.21	0.20	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03
				Discount Factor																																																			
				Escalation Factor																																																			
				Year																																																			
				Year number																																																			
					0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00	48.00	49.00	50.00
OPERATING COSTS																																																					
Water																																																						
	Potable	Upgrade source / treatment / conveyance	28.709	$2.02	0.025	0.060	0.093	0.156	0.204	0.248	0.299	0.345	0.408	0.450	0.494	0.539	0.583	0.627	0.668	0.706	0.741	0.771	0.796	0.816	0.830	0.839	0.843	0.842	0.837	0.828	0.816	0.802	0.785	0.767	0.747	0.727	0.706	0.685	0.663	0.642	0.621	0.600	0.579	0.559	0.539	0.520	0.501	0.483	0.465	0.448	0.432	0.416	0.401	0.386	0.372
		Upgrade storage																																																					
		Upgrade distribution mains	0.709	$ 0.05	0.001	0.001	0.002	0.004	0.005	0.006	0.007	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.019	0.019	0.018	0.018	0.017	0.017	0.016	0.016	0.015	0.015	0.014	0.014	0.013	0.013	0.012	0.012	0.011	0.011	0.011	0.010	0.010	0.010	0.009
		New & upgraded reticulation	2.292	1.25%	0.029	0.028	0.027	0.026	0.025	0.051	0.049	0.047	0.046	0.044	0.066	0.063	0.061	0.059	0.057	0.071	0.068	0.065	0.063	0.061	0.066	0.063	0.061	0.059	0.057	0.057	0.055	0.053	0.051	0.049	0.049	0.047	0.045	0.043	0.042	0.040	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.026	0.025	0.025	0.024	0.023
		New meters																																																				
	Wastewater	Upgrade WWTP	1.072	$ 0.20	0.001	0.002	0.003	0.006	0.008	0.009	0.011	0.013	0.015	0.017	0.018	0.020	0.022	0.023	0.025	0.026	0.028	0.029	0.030	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.030	0.030	0.029	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.023	0.022	0.022	0.021	0.020	0.019	0.019	0.018	0.017	0.017	0.016	0.016	0.015	0.014	0.014
		Upgrade main sewer - SCC component	1.575	1.25%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.085	0.082	0.079	0.076	0.073	0.070	0.068	0.065	0.063	0.060	0.058	0.056	0.054	0.052	0.050	0.048	0.046	0.044	0.043	0.041	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.030	0.029	0.028	0.027
		Upgrade pump stations																																																				
		Local trunk sewers and rising mains																																																			
		Upgrade local reticulation																																																			
	Drainage	New road drainage																																																			
	Non-drinking water																																																				
		Recycled Water Plant	11.705	$0.85	0.010	0.025	0.038	0.064	0.083	0.101	0.122	0.141	0.166	0.184	0.201	0.220	0.238	0.255	0.272	0.288	0.302	0.314	0.325	0.333	0.338	0.342	0.344	0.343	0.341	0.338	0.333	0.327	0.320	0.313	0.305	0.296	0.288	0.279	0.270	0.262	0.253	0.244	0.236	0.228	0.220	0.212	0.204	0.197	0.190	0.183	0.176	0.170	0.163	0.157	0.152
		RW distribution	2.066	$0.15	0.002	0.004	0.007	0.011	0.015	0.018	0.021	0.025	0.029	0.032	0.036	0.039	0.042	0.045	0.048	0.051	0.053	0.055	0.057	0.059	0.060	0.060	0.061	0.061	0.060	0.060	0.059	0.058	0.056	0.055	0.054	0.052	0.051	0.049	0.048	0.046	0.045	0.043	0.042	0.040	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.030	0.029	0.028	0.027
		RW reticulation																																																				
		RW disposal	0.843	$0.15	0.001	0.002	0.003	0.005	0.006	0.007	0.009	0.010	0.012	0.013	0.015	0.016	0.017	0.018	0.020	0.021	0.022	0.023	0.023	0.024	0.024	0.025	0.025	0.025	0.025	0.024	0.024	0.024	0.023	0.023	0.022	0.021	0.021	0.020	0.019	0.019	0.018	0.018	0.017	0.016	0.016	0.015	0.015	0.014	0.014	0.013	0.013	0.012	0.012	0.011	0.011
Energy																																																					
	Electricity																																																				
		Substation upgrades	4.929	3.50%	0.000	0.000	0.000	0.199	0.191	0.184	0.177	0.171	0.164	0.158	0.152	0.147	0.141	0.136	0.131	0.126	0.121	0.117	0.137	0.131	0.127	0.122	0.117	0.113	0.109	0.105	0.101	0.097	0.093	0.090	0.086	0.083	0.080	0.077	0.074	0.071	0.069	0.066	0.064	0.061	0.059	0.057	0.055	0.053	0.051	0.049	0.047	0.045	0.044	0.042	0.040
		New distribution feeders	0.706	3.50%	0.009	0.008	0.008	0.008	0.008	0.016	0.015	0.015	0.014	0.014	0.020	0.020	0.019	0.018	0.017	0.022	0.021	0.020	0.019	0.019	0.020	0.020	0.019	0.018	0.017	0.018	0.017	0.016	0.016	0.015	0.015	0.014	0.014	0.013	0.013	0.012	0.012	0.011	0.011	0.011	0.010	0.010	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.007	0.007
		LV transformers & switchgear	7.057	3.50%	0.088	0.085	0.082	0.079	0.076	0.158	0.152	0.146	0.141	0.135	0.203	0.195	0.188	0.181	0.174	0.217	0.209	0.201	0.194	0.186	0.203	0.195	0.188	0.181	0.174	0.176	0.170	0.163	0.157	0.151	0.150	0.144	0.139	0.134	0.129	0.124	0.119	0.115	0.110	0.106	0.102	0.099	0.095	0.091	0.088	0.085	0.082	0.078	0.076	0.073	0.070
		Undergrounding and line removal																																																			
	SWIS Generatio	Additional 86 MW required																																																		
		FOM	0.000																																																	
		Fuel	0.000																																																
		Carbon price	0.000																																																
	Local Generation																																																			
		Gas engines	0.000																																																
		Capacity credits	0.000																																															
		Solar PV	11.169	1.50%	0.171	0.165	0.159	0.153	0.147	0.284	0.273	0.263	0.253	0.244	0.339	0.327	0.314	0.303	0.291	0.342	0.329	0.317	0.305	0.294	0.308	0.297	0.286	0.275	0.265	0.263	0.253	0.243	0.234	0.226	0.220	0.212	0.204	0.196	0.189	0.182	0.175	0.169	0.162	0.156	0.151	0.145	0.140	0.134	0.129	0.124	0.120	0.115	0.111	0.107	0.103
		Electrical storage	3.462	3.50%	0.053	0.051	0.049	0.047	0.046	0.088	0.085	0.082	0.079	0.076	0.105	0.101	0.097	0.094	0.090	0.106	0.102	0.098	0.095	0.091	0.096	0.092	0.089	0.085	0.082	0.081	0.078	0.075	0.073	0.070	0.068	0.066	0.063	0.061	0.059	0.056	0.054	0.052	0.050	0.048	0.047	0.045	0.043	0.042	0.040	0.039	0.037	0.036	0.034	0.033	0.032
	Thermal Network																																																				
		Geothermal bore - doublet	17.188	3.00%	0.750	0.722	0.695	0.669	0.644	0.620	0.597	0.574	0.553	0.532	0.512	0.493	0.475	0.457	0.440	0.424	0.408	0.392	0.378	0.364	0.350	0.337	0.324	0.312	0.301	0.289	0.279	0.268	0.258	0.248	0.239	0.230	0.222	0.213	0.205	0.198	0.190	0.183	0.176	0.170	0.163	0.157	0.151	0.146	0.140	0.135	0.130	0.125	0.120	0.116	0.112
		Absorption chillers	4.763	3.50%	0.060	0.057	0.055	0.053	0.051	0.107	0.103	0.099	0.095	0.091	0.137	0.132	0.127	0.122	0.118	0.147	0.141	0.136	0.131	0.126	0.137	0.132	0.127	0.122	0.118	0.119	0.115	0.110	0.106	0.102	0.101	0.097	0.094	0.090	0.087	0.084	0.080	0.077	0.074	0.072	0.069	0.067	0.064	0.062	0.059	0.057	0.055	0.053	0.051	0.049	0.047
		Electric chillers	2.078	3.50%	0.026	0.025	0.024	0.023	0.022	0.046	0.045	0.043	0.041	0.040	0.060	0.057	0.055	0.053	0.051	0.064	0.062	0.059	0.057	0.055	0.060	0.058	0.055	0.053	0.051	0.052	0.050	0.048	0.046	0.045	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.025	0.024	0.023	0.022	0.021	0.021
		Chilled water storage	2.809	3.50%	0.035	0.034	0.033	0.031	0.030	0.063	0.060	0.058	0.056	0.054	0.081	0.078	0.075	0.072	0.069	0.086	0.083	0.080	0.077	0.074	0.081	0.078	0.075	0.072	0.069	0.070	0.068	0.065	0.063	0.060	0.060	0.057	0.055	0.053	0.051	0.049	0.047	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.032	0.031	0.030	0.029	0.028
		Hot water network	13.710	3.50%	0.171	0.165	0.159	0.153	0.147	0.307	0.295	0.284	0.273	0.263	0.394	0.379	0.365	0.351	0.338	0.422	0.406	0.391	0.376	0.362	0.394	0.380	0.365	0.352	0.339	0.343	0.330	0.318	0.306	0.294	0.291	0.280	0.269	0.259	0.250	0.240	0.231	0.223	0.214	0.206	0.199	0.192	0.185	0.178	0.171	0.165	0.158	0.153	0.147	0.141	0.136
		Chilled water network	16.130	3.50%	0.202	0.194	0.187	0.180	0.173	0.361	0.347	0.334	0.322	0.310	0.464	0.446	0.430	0.413	0.398	0.496	0.478	0.460	0.443	0.426	0.464	0.447	0.430	0.414	0.398	0.403	0.388	0.374	0.360	0.346	0.342	0.329	0.317	0.305	0.294	0.283	0.272	0.262	0.252	0.243	0.234	0.225	0.217	0.209	0.201	0.194	0.186	0.179	0.173	0.166	0.160
		Pits and pumps	0.289	3.50%	0.004	0.003	0.003	0.003	0.003	0.006	0.006	0.006	0.006	0.008	0.008	0.008	0.008	0.007	0.007	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
		Heat rejection	0.840	3.50%	0.011	0.010	0.010	0.009	0.009	0.019	0.018	0.017	0.017	0.016	0.024	0.023	0.022	0.022	0.021	0.026	0.025	0.024	0.023	0.022	0.024	0.023	0.022	0.022	0.021	0.021	0.020	0.019	0.019	0.018	0.018	0.017	0.017	0.016	0.015	0.015	0.014	0.014	0.013	0.013	0.012	0.012	0.011	0.011	0.010	0.010	0.010	0.010	0.009	0.009	0.008
	Gas	Distribution upgrades	0.417	3.50%	0.005	0.005	0.005	0.005	0.004	0.009	0.009	0.009	0.008	0.008	0.012	0.012	0.011	0.011	0.010	0.013	0.012	0.012	0.011	0.011	0.012	0.012	0.011	0.011	0.010	0.010	0.010	0.010	0.009	0.009	0.009	0.009	0.008	0.008	0.008	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004
		Reticulation upgrades	0.706	3.50%	0.009	0.008	0.008	0.008	0.008	0.016	0.015	0.015	0.014	0.014	0.020	0.020	0.019	0.018	0.017	0.022	0.021	0.020	0.019	0.019	0.020	0.020	0.019	0.018	0.017	0.018	0.017	0.016	0.016	0.015	0.015	0.014	0.014	0.013	0.013	0.012	0.012	0.011	0.011	0.011	0.010	0.010	0.009	0.009	0.008	0.008	0.008	0.008	0.007	0.007	0.007
		Syngas main from Balcatta to trigen	0.000																																																			
		Gas consumption	53.778	12.30	0.047	0.113	0.174	0.293	0.382	0.465	0.559	0.646	0.763	0.843	0.925	1.009	1.092	1.174	1.251	1.323	1.388	1.444	1.491	1.528	1.555	1.572	1.579	1.577	1.568	1.551	1.529	1.502	1.471	1.437	1.400	1.362	1.323	1.283	1.242	1.202	1.162	1.123	1.084	1.047	1.010	0.974	0.939	0.905	0.872	0.840	0.809	0.779	0.751	0.723	0.696
		Additional fuel for trigeneration	0.000	12.30																																																	
Waste		Additional operating costs	73.100	$ 0.064	0.064	0.153	0.236	0.398	0.520	0.632	0.760	0.878	1.038	1.146	1.258	1.372	1.485	1.595	1.701	1.799	1.887	1.963	2.027	2.077	2.114	2.136	2.146	2.144	2.131	2.109	2.079	2.042	1.999	1.953	1.903	1.851	1.798	1.743	1.689	1.634	1.580	1.527	1.474	1.423	1.372	1.323	1.276	1.230	1.185	1.142	1.100	1.059	1.020	0.983	0.946
		Vaccum waste system	6.481	1.5%	0.081	0.078	0.075	0.072	0.070	0.145	0.139	0.134	0.129	0.124	0.186	0.179	0.173	0.166	0.160	0.199	0.192	0.185	0.178	0.171	0.186	0.179	0.173	0.166	0.160	0.162	0.156	0.150	0.144	0.139	0.137	0.132	0.127	0.123	0.118	0.114	0.109	0.105	0.101	0.098	0.094	0.091	0.087	0.084	0.081	0.078	0.075	0.072	0.069	0.067	0.064
		Dirty MRF	67.206	$ 0.467	0.840	0.809	0.778	0.749	0.721	1.503	1.447	1.392	1.340	1.290	1.931	1.859	1.790	1.723	1.658	2.067	1.990	1.915	1.844	1.775	1.933	1.861	1.791	1.724	1.660	1.680	1.617	1.557	1.498	1.442	1.426	1.372	1.321	1.272	1.224	1.178	1.134	1.092	1.051	1.012	0.976	0.940	0.904	0.871	0.838	0.807	0.777	0.748	0.720	0.693	0.667
		Clean MRF	13.441	$ 0.140	0.168	0.162	0.156	0.150	0.144	0.301	0.289	0.278	0.268	0.258	0.386	0.372	0.358	0.345	0.332	0.413	0.398	0.383	0.369	0.355	0.387	0.372	0.358	0.345	0.332	0.336	0.323	0.311	0.300	0.288	0.285	0.274	0.264	0.254	0.245	0.236	0.227	0.218	0.210	0.202	0.195	0.188	0.181	0.174	0.168	0.161	0.155	0.150	0.144	0.139	0.133
		Anaerobic digestor	38.404	$ 0.080	0.480	0.462	0.445	0.428	0.412	0.859	0.827	0.796	0.766	0.737	1.104	1.062	1.023	0.984	0.948	1.181	1.137	1.095	1.054	1.014	1.105	1.063	1.024	0.985	0.948	0.960	0.924	0.890	0.856	0.824	0.815	0.784	0.755	0.727	0.699	0.673	0.648	0.624	0.601	0.578	0.558	0.537	0.517	0.498	0.479	0.461	0.444	0.427	0.411	0.396	0.381
		Gasification plant	0.000	$ -																																																	
		Biogas treatment	0.180	$ 0.015	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.004	0.004	0.003	0.005	0.005	0.005	0.005	0.004	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		Syngas treatment	0.000	$ -																																																	
Telecoms		Upgrades / NBN	3.188	$ 0.025	0.040	0.038	0.037	0.036	0.034	0.071	0.069	0.066	0.064	0.061	0.092	0.088	0.085	0.082	0.079	0.098	0.094	0.091	0.087	0.084	0.092	0.088	0.085	0.082	0.079	0.080	0.077	0.074	0.071	0.068	0.068	0.065	0.063	0.060	0.058	0.056	0.054	0.052	0.050	0.048	0.046	0.045	0.043	0.041	0.040	0.038	0.037	0.035	0.034	0.033	0.032
		Total Infrastructure	391.001		3.383	3.473	3.551	4.018	4.190	6.703	6.810	6.900	7.095	7.175	9.261	9.293	9.333	9.374	9.412	10.787	10.749	10.694	10.641	10.540	11.135	10.959	10.760	10.541	10.305	10.286	10.016	9.738	9.454	9.167	8.983	8.692	8.404	8.120	7.841	7.568	7.302	7.042	6.789	6.544	6.312	6.082	5.859	5.644	5.436	5.235	5.041	4.854	4.674	4.500	4.333
Building costs																																																				
		Boilers / Chillers	0.000																																																		
		Improved thermal efficiency																																																		

		Total Infrastructure & Building	391.001		3.383	3.473	3.551	4.018	4.190	6.703	6.810	6.900	7.095	7.175	9.261	9.293	9.333	9.374	9.412	10.787	10.749	10.694	10.641	10.540	11.135	10.959	10.760	10.541	10.305	10.286	10.016	9.738	9.454	9.167	8.983	8.692	8.404	8.120	7.841	7.568	7.302	7.042	6.789	6.544	6.312	6.082	5.859	5.644	5.436	5.235	5.041	4.854	4.674	4.500	4.333

Appendix F – Existing utility charges

Business as usual utility charges

Water Corporation charges (residential)

		Unit rates 2013/14		
Water	Headworks	4031	$/SRE	
	Service charge	205.71	$/connection	
	Consumption	1.381	$/kl less than 150kL pa	
		$ 157.44	pa	(calculated)
Wastewater	Headworks	1352	$/lot	
	Service charge	4.47	$/$GRV	
Drainage	Headworks	477	$/350m2	
	Service charge	$ 92.65	pa	(calculated)

Synergy charges

Tariff L3 – small/medium business tariff (contestable)

Supply charge: 49.9964 cents per day
Electricity charge – cents per unit:
First 1650 units per day: 35.2200
More than 1650 units per day: 32.0206

Tariff A1 – residential electricity

Supply charge: 43.2072 cents per day
Supply charge for additional homes: 33.5485 cents per day
Electricity charge: 25.9052 cents per unit

Alinta charges

Gas Tariffs
Coastal [Metropolitan] Region
Residential Customers

Prices including GST [as at 21 May 2013]
Supply charge
19.73 cents per day
The first 12 units used on average per day
13.61 cents per unit
Over 12 units used on average per day
12.28 cents per unit

Business Customers

Prices including GST [as at 21 May 2013]
Supply charge
17.16 cents per day
The first 100 units used on average per day
12.41 cents per unit
Over 100 units used on average per day
9.94 cents per unit

City of Stirling waste charges

Current charge per hse is $278.00 residential plus $202.00 for extra bin if requested
Current charge per commercial varies to size of bin and frequency of lifts per week

240ltr	= $524.30
240lt paper bin	=$229.50
1.5m3 – ea lift	=$49.66
3m3 – ea lift	=$70.80
4.5m 3 – ea lift	=$100.50

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	W. Grace	T. Eldridge		P. Tilley		28 Nov 2013

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