Northern Services Corridor
Water Corporation
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Phase 1 Route Selection Report

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Prepared for

Water Corporation

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Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
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B	27-Aug-2012	Draft for Submission	Abra DeKlerk Technical Director	
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Executive Summary

The Water Corporation has identified a need to restructure its Integrated Water Supply System's (IWSS's) Bulk Water Transfer System and that bulk water transfer between reservoirs in the northern suburbs needs to be conducted through a dedicated trunk main pipeline network. Therefore, they are proposing to progressively construct this dedicated bulk water transfer system north of Perth to cater for the development of further water sources north of Perth and to integrate the Northern Sources System (NSS) into the IWSS with a planning horizon of 2050.

In order to progress the project, the Water Corporation engaged AECOM to undertake a series of studies, beginning with selection of preferred potential routes for the eventual construction of the required trunk main. The route selection was carried out in a series of steps that have included:

1) desktop assessment for data relating to environmental, physical, infrastructure and planned development values
2) the application of risk (constraint) and benefit (opportunity) ratings to each data layer and the categories within these (if applicable)
3) the preparation of a "Heat Map" showing the spatial extent of areas of risk and benefit
4) preliminary route selection, in relation to avoiding risk and utilising benefit and in accordance with general principles of constructability and likely ease of land acquisitions
5) selection of three preferred routes via the application of a Multi Criteria Assessment.

Through this process, three preferred routes were selected which were subsequently optimised through more detailed consideration including a site visit.

AECOM, in partnership with the Water Corporation are now progressing into the second and third phases of the project. Phase 2 involves the commencement of the environmental assessment process. The Water Corporation are seeking to have the proposal assessed as a Strategic Environmental Assessment (SEA) by the Environmental Protection Authority (EPA). Once environmental approvals have been obtained, Water Corporation can then seek to secure the corridors through land acquisition.

Progression of the SEA document, submission and responding to public comments will be carried out as Phase 4.

Phase 3 is the detailed assessment stage and will include flora and fauna assessments, as well as a contamination review within the preferred corridors. The information gathered from these studies will contribute to the SEA.

Ultimately, the Water Corporation hopes to obtain strategic approval for the project, to enable the process of securing the corridors for their intended potential future use.

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1.0 Introduction

1.1 Purpose of Route Selection Report

AECOM was commissioned by the Water Corporation in April 2012 to assist with the planning for the future Northern Corridor of the Perth metropolitan Bulk Water Transfer System. This Route Selection Report is the conclusion to Phase 1 of the four-phase study illustrated in Figure 1.

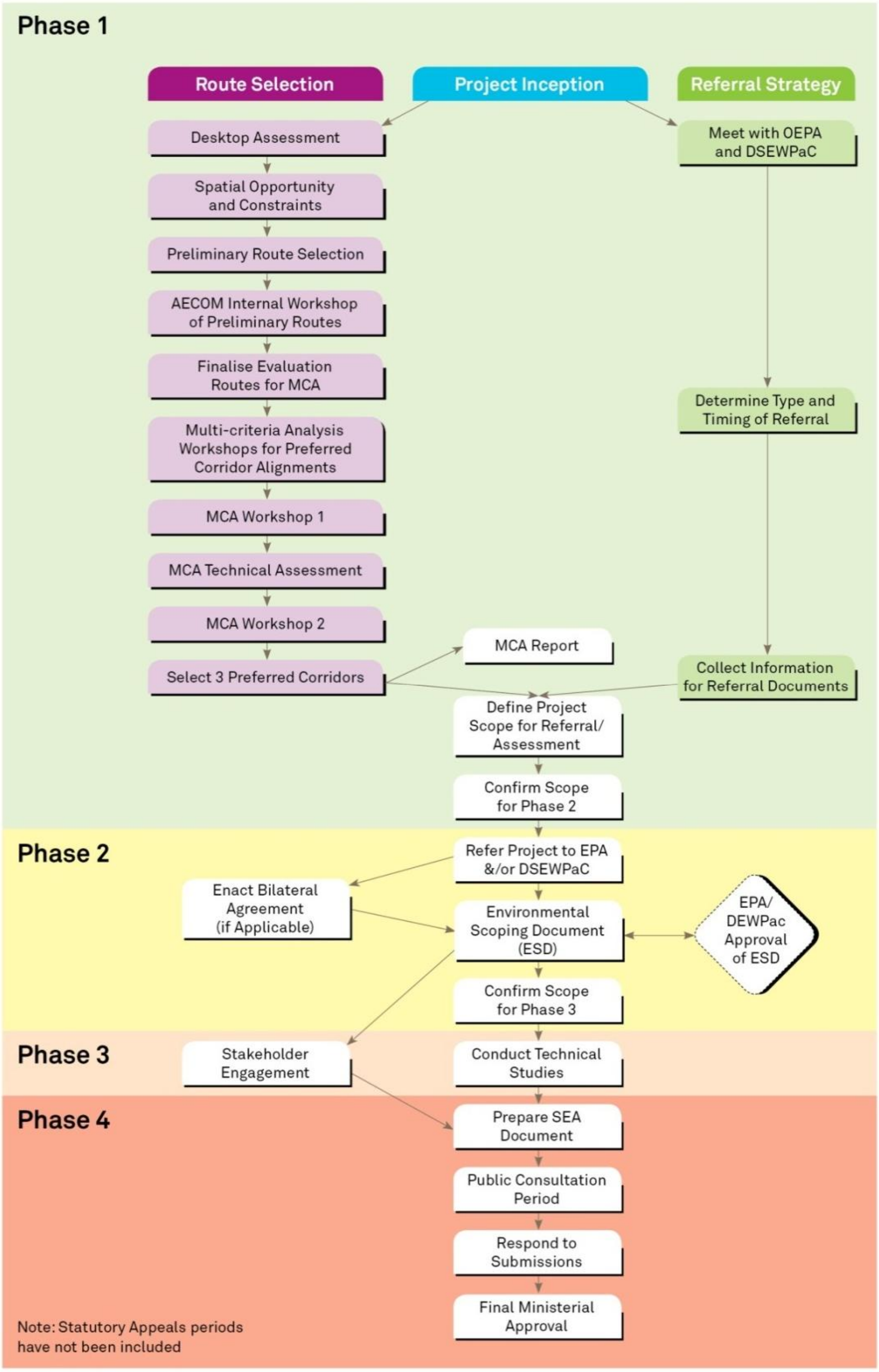


Figure 1 Project Approach

Phase 1 of the project has involved two parallel tasks:

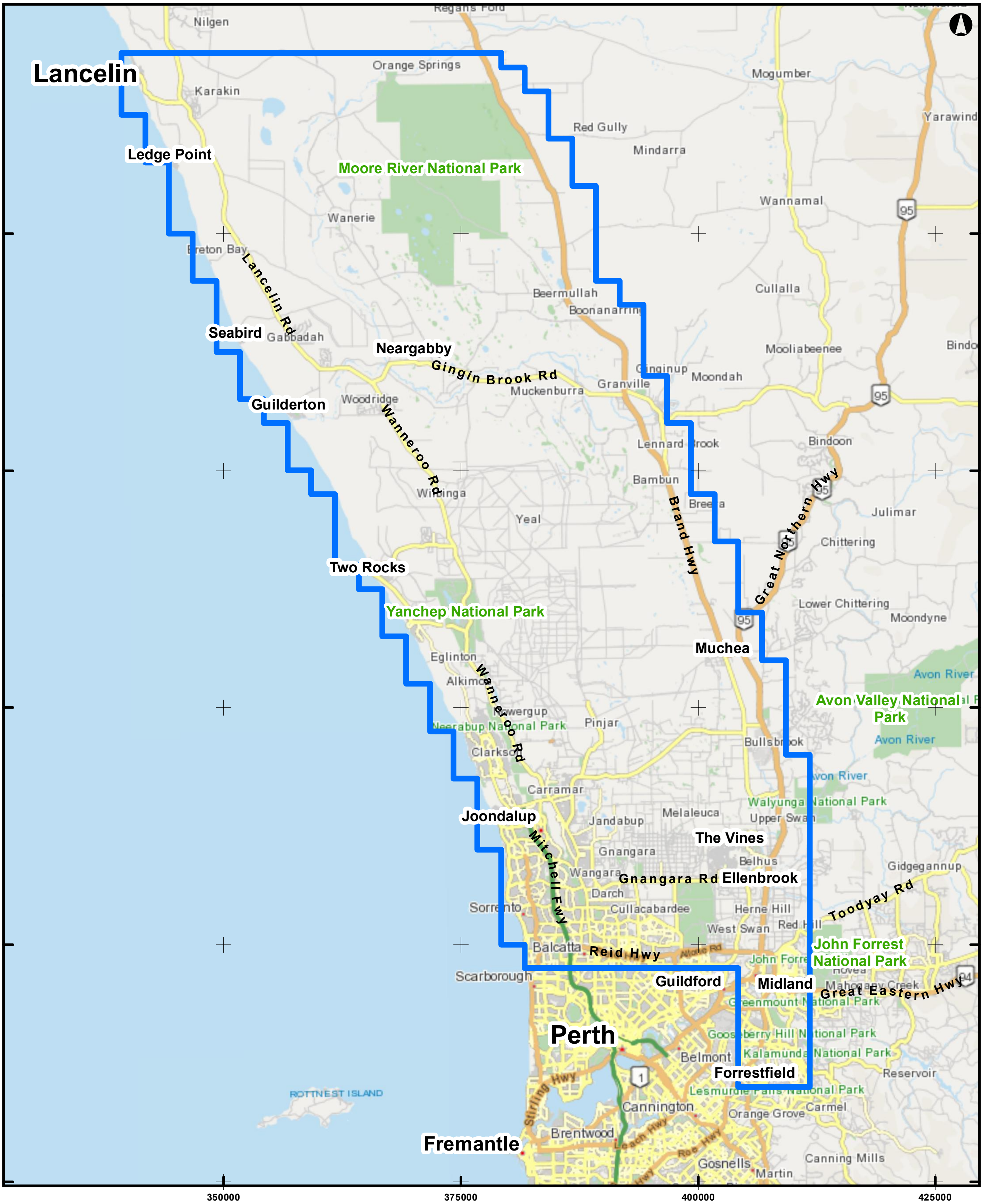
1) Ascertaining the environmental, heritage, social and engineering opportunities and constraints within the general area proposed (via a high level desktop assessment, spatial constraints analysis and Multi-Criteria Analysis (MCA)) for the Northern Corridor and, from this, and in conjunction with Water Corporation representatives, determining three preferred routes for further detail assessment.

2) Undertaking initial consultation with regulatory agencies and stakeholders to identify any major constraints and formulate a referral strategy.

This report details the outcomes of only the first task.

1.2 Study Area

The study area for the project is shown in Figure 2, bound by the NSS trunk main network between the Forrestfield Reservoir in Perth's foothills (south) and Lancelin in the north.



Study Area

Figure 2

Coordinate System: GDA 1994 MGA Zone 50

0 5 10 15 20

Kilometres

1:550,000 (A4)

LEGEND

Study Area

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2.0 Spatial Benefit and Risk Analysis Methodology

2.1 Overview

AECOM has a well-established methodology for Spatial Benefit and Risk Analysis through the use of a Geographic Information System (GIS), which has been used successfully for previous Water Corporation applications. The methodology combines many, often complex, spatial datasets and displays the information in an easy-to-interpret “heat map”. The heat map shows the combined Benefit and Risk level for the Project Area and allows team members to quickly and easily decipher the information presented and make decisions as required. For this project, the heat map was used by the engineering and environmental teams to choose the most opportunistic location for the initial six proposed pipeline routes.

The Spatial Analysis methodology is broken into four defined steps:

1) Data Collection

2) Risk Assessment

3) GIS Analysis

4) Mapping.

Each of these steps is described in detail below.

2.2 Desktop Data Collection

2.2.1 Approach

The first step in the Spatial Analysis methodology was to collect relevant and available spatial data within the project area. The list of spatial datasets selected for the project (listed in 2.2.2) was based on previous similar Spatial Benefit and Risk Analyses undertaken by AECOM as well as any additional data AECOM understood would be beneficial to the project. It is important to note that each dataset considered for the analysis needs to be defined as either a risk or a benefit/opportunity to the project, with varying levels. Therefore, if a spatial dataset could not be classified as a risk or a benefit, there was no need for the dataset to be used.

2.2.2 Data Selection

The GIS team within AECOM have a strong understanding of what spatial data is available within Western Australia, who the custodian of the data is, and how to source the data. Data for this project was collected from both the Water Corporation and other publically available data sources. The majority of data was supplied by the Water Corporation GIS team, who provided extracts of their corporate data. When data could not be sourced from the Water Corporation, AECOM sought other avenues to obtain the necessary data required for the analysis.

Spatial data received from the Water Corporation included:

- Aerial Imagery
- Linear Hydrography
- Transmission Power Lines
- Gas Pipelines
- Road and Rail Network
- Water and Sewerage Network
- Water Corporation Assets
- Cadastral Boundaries & Tenure
- Metropolitan Regional Scheme
- Declared Rare Flora and Threatened Fauna
- Threatened & Priority Ecological Communities
- Bush Forever

- Groundwater Contours
- Remnant Vegetation.

Spatial data which AECOM sourced from other publically available data sources, included:

- Acid Sulphate Soils
- Geomorphic Wetlands
- EPP Wetlands
- DEC Managed Lands
- Public Drinking Water Source Areas
- Register of the National Estate
- European Heritage Sites
- Aboriginal Heritages Sites
- Bridge Locations.

There were two spatial datasets required for the analysis that were unable to be sourced; communications infrastructure (Telstra and Optus cables, inclusive of fibre optic cables), and flood plain data. Flood plain data was available for the Metropolitan area, however as the dataset did not cover the whole project area it was decided it would not be used as input into the analysis.

After the spatial datasets were compiled, the dataset list was reviewed in consultation with the engineering and environmental science teams to ensure all relevant spatial information had been accounted for. With the exception of the two datasets that were unable to be sourced, the spatial data selected for this project is considered to be a true and representative collection of the constraints (risks) and opportunities (benefits) present within the project area.

2.3 Risk and Benefit Assessment

2.3.1 Purpose and Approach

After the relevant spatial datasets were collated, the next process was to assess each spatial dataset and identify risk or benefit weightings of each, and decide whether a buffer was required to best represent the feature.

The benefit and risk values were assigned using the flowing ranking scale:

1	2	3	4	5	6
High Benefit	**Medium Benefit**	**Low Benefit**	**Low Risk**	**Medium Risk**	**High Risk**

The applied rating indicates the relative risk (i.e. constraint) or benefit (i.e. opportunity) of a dataset in relation to the project's objective and the physical project area.

The ratings were initially defined by the GIS team based on Risk and Benefit Spatial Analyses previously undertaken by AECOM on similar projects. This list of ratings was then provided to the project team to further refine and comment on. A few iterations took place before all members of the team were satisfied that the risk and benefit ratings were indicative of factors driving the project including environmental approvals, constructability and social impact.

It should be noted that within each spatial dataset, it is often necessary to separate different categories of data that have a different level of risk or benefit. For example, within the Geomorphic Wetlands dataset, there are several different categories: Resource Enhancement, Multiple Use and Conservation Category. Conservation Category wetlands have an associated High Risk compared to Resource Enhancement and Multiple Use which have an associated Low Risk rating. Therefore, within the one spatial dataset, Geomorphic Wetlands, there are actually three individual datasets which are used as input into the spatial analysis, one for each wetland category. In other instances, the same Risk or Benefit ranking can be applied to the whole dataset. For example, the Bush Forever dataset is classed entirely as Medium Risk as there are no distinguishable categories of data.

After the Risk and Benefit ratings were defined, it was then decided whether or not a buffer should be applied to best represent the data. There are two instances when a buffer should be applied. Firstly, a buffer might be required to include areas of land within close proximity of certain spatial features into the analysis. For example, for this project, watercourses had a 100m buffer applied to them. The justification for this is that the complex hydrological nature of watercourses means that simply because the spatial data defines the edge of a watercourse in a certain location ‘on the ground’ does not mean there is no environmental risk beyond this edge. Another example is Conservation Category wetlands (High Risk) and EPP Lakes (High Risk) which both require a 100m buffer to satisfy the conditions for environmental approvals.

The second reason for applying buffers arises when the input spatial datasets are point or polyline. The spatial analysis requires all input datasets be an area (i.e. a polygon). If a point or polyline is buffered, the resulting feature is a polygon. Rare flora locations are represented by point data and high voltage transmission lines are represented by a polyline. Therefore, all point and polyline features must be buffered by an amount which best represents them.

2.3.2 Risk Ratings

The datasets used as input into the spatial analysis along with the applied risk/benefit ratings and buffer amounts are listed below:

Category	Dataset Name	Buffer (m)	Rank (1-6)
Environmental	Threatened Flora	50	6
	Geomorphic Wetlands (Conservation Category)	100	6
	DEC Managed Land (Conservation Park)	0	6
	DEC Managed Land (National Park)	0	6
	DEC Managed Land (Nature Reserve)	0	6
	EPP Lakes	100	6
	Threatened/Priority Ecological Communities	0	5
	Priority Flora (P1)	50	5
	Bush Forever	0	5
	DEC Managed Land (Marine Park)	0	5
	Watercourse - Non-perennial - Major	100	5
	Watercourse - Perennial - Major	100	5
	Watercourse - Estuarine	100	5
	Watercourse - Mainstream	100	5
	Watercourse - Major River	100	5
	Watercourse - Major Tributary	100	5
	Reigster of National Estate	0	5
	Native Vegetation	0	5
	Environmentally Sensitive Areas	0	5
	Declared Threatened Fauna - Critical	50	5
	Declared Threatened Fauna - Endangered	50	5
	Declared Threatened Fauna - Vulnerable	50	5
	Priority Fauna (P1)	50	5
	Acid Sulphate Soils (High Risk)	0	4
	Acid Sulphate Soils (Moderate to Low Risk)	0	4
	Priority Flora (P2)	50	4
	Geomorphic Wetlands (Multiple Use)	0	4
	Geomorphic Wetlands (Resource Enhancement)	0	4
	DEC Managed Land (5(1)(g) Reserve)	0	4
	DEC Managed Land (5(1)(h) Reserve)	0	4
	DEC Managed Land (Crown Freehold - Dec list)	0	4
	DEC Managed Land (Miscellaneous Reserve)	0	4
	DEC Managed Land (State Forest)	0	4
	Watercourse - Non-perennial - Minor	50	4
	Watercourse - Minor River	50	4
	Watercourse - Significant Stream	100	4
	Public Drinking Water Source Areas	0	4
	Priority Flora (P3)	20	4
	Priority Flora (P4)	20	4
	Priority Fauna (P3)	50	4
	Priority Fauna (P4)	50	4
	Priority Fauna (P5)	50	4
	Other Specially Protected Fauna (P4)	50	4
	Other Specially Protected Fauna	50	4
Heritage	Aboriginal Heritage Sites	0	5
	European Heritage Sites	20	5
Infrastructure	Petroleum Pipelines	100	6
	High Pressure Gas Pipelines	100	6
	Tranmission Overhead Power Lines (within 100m)	100	6
	Railways	30	5
	Tranmission Overhead Power Lines (within 500m)	500	5
	Tranmission Overhead Power Lines (within 2500m)	2500	4
	Water Pipeline (Bore)	25	2
	Sewer Pressure Mains	10	1
	Water Pump Stations	100	1
	Water Tank/Reservoir Locations	100	1
	Water Pipeline (Trunk)	25	1
	Water Pipeline (Distribution)	25	1
	Bridge Locations	100	1
Planning	Freehold Land	0	5
	Tenements - Live	0	5
	Tenements - Pending	0	4
	Land Matters - WC Land - Easements	0	1
	Crown Land	0	1
	Road Reserve	0	1

Key	
6	High Risk
5	Medium Risk
4	Low Risk
3	Low Benefit
2	Medium Benefit
1	High Benefit

In total, 65 datasets were used as input into the spatial analysis. Of these, 54 (or 83%) were classified as 'Risk' and 11 (or 17%) were classified as 'Benefit'. Coincidently, there was no classification of Low Benefit.

2.4 GIS Analysis and Mapping

2.4.1 Methodology

After the ‘Analysis Layers’ have had a risk/benefit rating applied and a buffer (if required), the next step is to run the analysis. The methodology, developed by AECOM, aims to clearly show the cumulative risk or benefit across the project area in an easy to understand, repeatable and transparent manner.

Firstly, the ‘Analysis Layers’ are overlaid and combined together through the use of a UNION operator. The output is a single layer, called the ‘Union Result’, which contains the spatial and non-spatial (or attribute) data of all the Analysis Layers used as input into the UNION. For example, if there are five spatial features overlaid in a particular area, the UNION result for that area will be a spatial accumulation of the five spatial features, maintaining all information about the five datasets. The use of a UNION operator means that the original Analysis Layers can be interrogated and/or identified within the Union Result layer.

The next step in the spatial analysis is to run calculations on the Union Result layer to determine the cumulative risk and benefit for all areas within the project area. This is achieved through the use of additional calculation fields appended onto the Union Result layer.

2.4.1.1 Calculation Steps

The calculation steps are described as follows:

1) Firstly, six fields are appended to the Union Result layer, one for each of the six risk/benefit rankings:
   - ‘Count1’ refers to the total count of High Benefit
   - ‘Count2’ refers to the total count of Medium Benefit
   - ‘Count3’ refers to the total count of Low Benefit
   - ‘Count4’ refers to the total count of Low Risk
   - ‘Count5’ refers to the total count of Medium Risk
   - ‘Count6’ refers to the total count of High Risk.

The total count of each ranking is calculated for each feature (i.e. row) in the Union Result layer and assigned to the relevant ‘Count’ column.

In the example below, the first feature of the Union Result attribute table has **six** overlapping High Benefit Analysis Layers, **two** overlapping Medium Benefit Analysis Layer and **one** Low Risk Analysis Layer for that feature. There are **no** (i.e. **zero**) Low Benefit Analysis Layers, Medium Risk Analysis Layers and High Risk Analysis Layers. Based on these counts, it can be assumed there are nine Analysis Layers in total which overlap for that particular feature (i.e. 6 + 2 + 1 = 9).

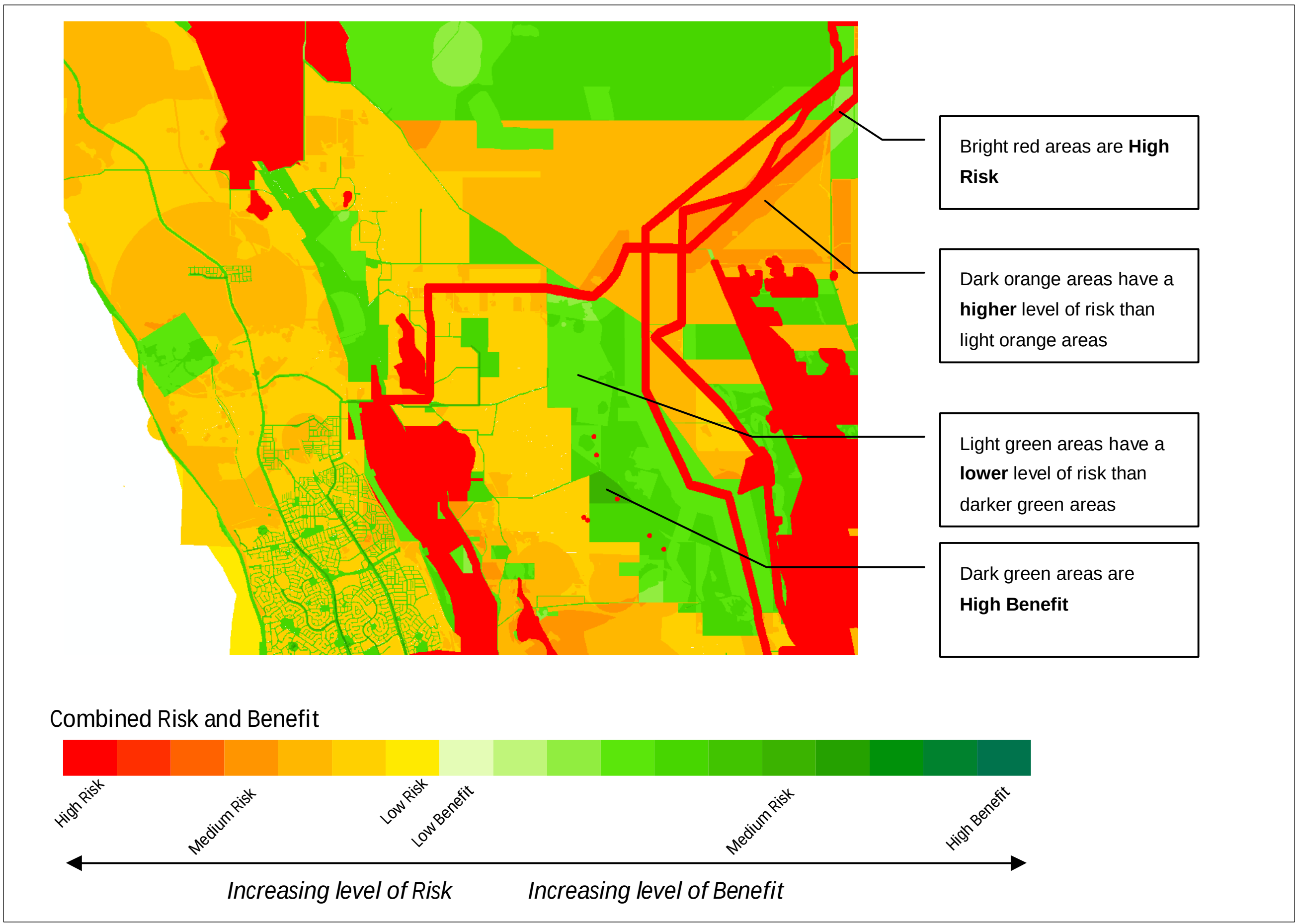
FAUNA_OPF__	BRIDGES_ALL	SEWER_PM	Count1	Count2	Count3	Count4	Count5	Count6
0	0	1	6	2	0	1	0	0
0	0	0	6	1	0	0	0	0
0	0	0	6	1	0	0	1	0
0	0	0	6	1	0	0	1	0
0	0	0	6	0	0	0	2	0
0	0	0	5	2	0	2	1	1

2) Two more fields are then added, ‘Total Benefit’ and ‘Total Risk’, which provide a score of the total *combined* Benefit or Risk, respectively, for each feature/row. The Count fields discussed above are used for calculating these two fields. ‘Count1, ‘Count2’ and ‘Count3’ are used to calculate the combined Benefit for the ‘Total Benefit’ field and fields ‘Count4’, ‘Count5’ and ‘Count6’ are used to calculate the combined Risk for the ‘Total Risk’ field.

3) Lastly, a field called ‘Total Count’ is then added, and a calculation is carried out which combines the score of ‘Total Benefit’ and ‘Total Risk’ weightings in such a way that the accumulation of Risk and Benefit is derived.

2.4.1.2 Mapping

The 'Total Count' field in the Union Result layer is used to display the result of the spatial analysis through the use of a Heat Map. The Heat Map displays the combined Risk and Benefit calculated for each feature in the Union Result layer by displaying a colour-graded red (High Risk) to green (High Benefit). The colour shown in the Heat Map for any one area is determined by the result in the 'Total Count' field for each feature. The more negative the number in the 'Total Count' field, the more Risk is present, and the more positive the number, the more Benefit is present.

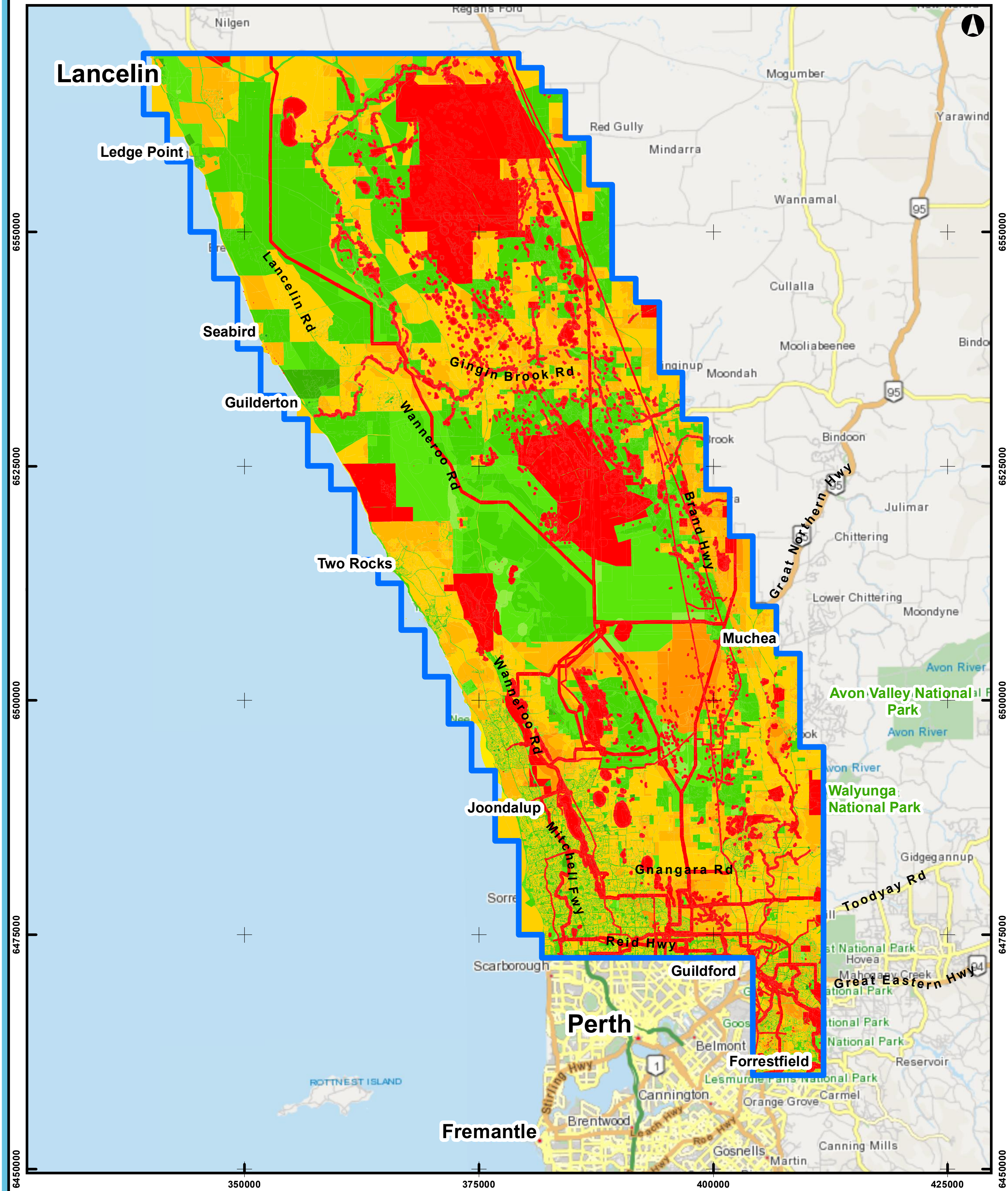


The methodology applied for this project was deliberately exaggerated and increased weighting to High Risk areas, in order to ensure that appropriate attention was given to the environmental values, as this was the primary objective of the assessment. Such areas are of particular importance from an environmental point of view (i.e. wetlands, national parks etc.) as well as from constructability and safety points of view (i.e. gas pipelines and overhead powerlines). Any feature with High Risk is always displayed as High Risk even if overlapping areas might contain one or many 'Benefit' Analysis Layers.

The resulting Heat Map was uploaded to AECOM's online mapping website, which was used by the engineering and environment teams to delineate and decide on the most opportunistic alignment for the six initially proposed pipeline routes.

2.4.2 Results

The key result of the Desktop Assessment and Spatial Constraints Analysis, as discussed, was the Heat Map. This Heat Map was then used for the Preliminary Route Selection. The Heat Map is presented in Figure 3.



Heat Map

Result of the Risk/Benefit Spatial Analysis

Figure 3

Coordinate System: GDA 1994 MGA Zone 50

0 5 10 15 20
Kilometres
1:550,000 (A4)

LEGEND

Study Area

Combined Risk and Benefit

High Risk ← *Increasing Risk* | *Increasing Benefit* → *High Benefit*

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3.0 Preliminary Route Selection

3.1 Approach

The objective of the project was to identify several possible route alignments for the Northern Corridor to join specified start (Forrestfield) and end (Lancelin) points and to pass in close proximity of critical existing or proposed reservoir and tank sites along the alignment.

The straight line distance from Lancelin to Forrestfield is 146km. However the distance along any the preliminary routes identified is in the region of 160-190km. The requirement to link the corridor to some of the reservoirs increased this distance.

The pipeline corridor can be divided into two sections, based on two broad main categories of land use, Rural and Urban. The area south of Gnangara Road and to the west of Joondalup Drive can be considered to be the Urban. Area. The remainder of the project area can generally be considered to be Rural.

The length of corridor in the Rural (north) section is between 100 and 120 depending on the route option. The length of the same in the Urban (southern) section is between 35 and 50km depending on the route option.

In order to select a number of possible route options within the project area, linking the Forrestfield location to the Lancelin location and passing in close proximity with the critical nodes (current and future reservoirs and tanks), the primary guide was the risk and benefit mapping in the heat Map. The secondary guide drew on past experience and technical knowledge in planning and design of water supply infrastructure. In addition to environmental and other risk and benefits mapped in the Heat Map, existing reserves, cadastral boundaries, tenure, easements and existing and planned infrastructure were major considerations during this task.

The challenges in identifying suitable corridors in the Rural section differed with challenges faced in the Urban section. There is an abundance of road reserves in the Urban section, however many of these do not offer the availability of a 100m wide corridor, whereas only one major road, Lancelin Road/Indian Ocean Drive is available in the Rural section. There are plenty of large private lots, and vacant land with no apparent physical development other than plantations and farms in the Rural section. However these areas may present challenges in terms of land acquisitions.

3.1.1 Selection Criteria

A total of six possible routes were selected based on the following broad principals/criteria. Where possible:

- Follow cadastral boundaries and road reserves
- Follow high benefit areas as much as possible
- Avoid high risk areas
- For river and rail crossings, utilise existing road bridges
- Consider potential for trenchless techniques such as Horizontal Directional Drilling when crossing major roads, rivers and rail lines, if road bridges are not available
- Minimise crossing trunk roads and railway lines
- Minimise passing through built up areas.

Local knowledge of road reserves, potential conflicts with existing land users and constructability were also used to select the alignments of routes.

Publicly available aerial imagery, spatially aligned with data obtained during the desktop assessment and with the Heat Map was used to determine the extent of current development, locations of roads, intersections, water courses and other physical features.

Reservoir locations were supplied by the Water Corporation and corrected to actual location based on aerial images. The reservoirs to be serviced are:

- Yanchep Reservoir – south of Reef Break Drive, Yanchep
- Carabooda Reservoir – off Carabooda Road
- Nowergup Proposed reservoir – off Wattle Avenue

- Neerabup Reservoir - off Burns Beach Road
- Wanneroo Reservoir - off Belgrade Road
- Gnangara proposed Reservoir - off Gaskell Road in Melaleuca
- Greenmount Reservoir - off Scott Street in Helena Valley (a corridor has already been identified by Water Corporation and therefore a new corridor may not be required)
- Foothills Reservoir - off Hawtin Road.

Water Corporation also indicated that it would be preferable for the corridor to pass in close proximity to the Ellenbrook Pump Station on Gnangara Road so that it may be used for a future sewage pumping main to Alkimos.

Once a selection of route alignments had been drafted and plotted using GIS technology, a comparison of the routes using Multi Criteria Assessment (MCA) was then to be carried out.

3.2 Assumptions

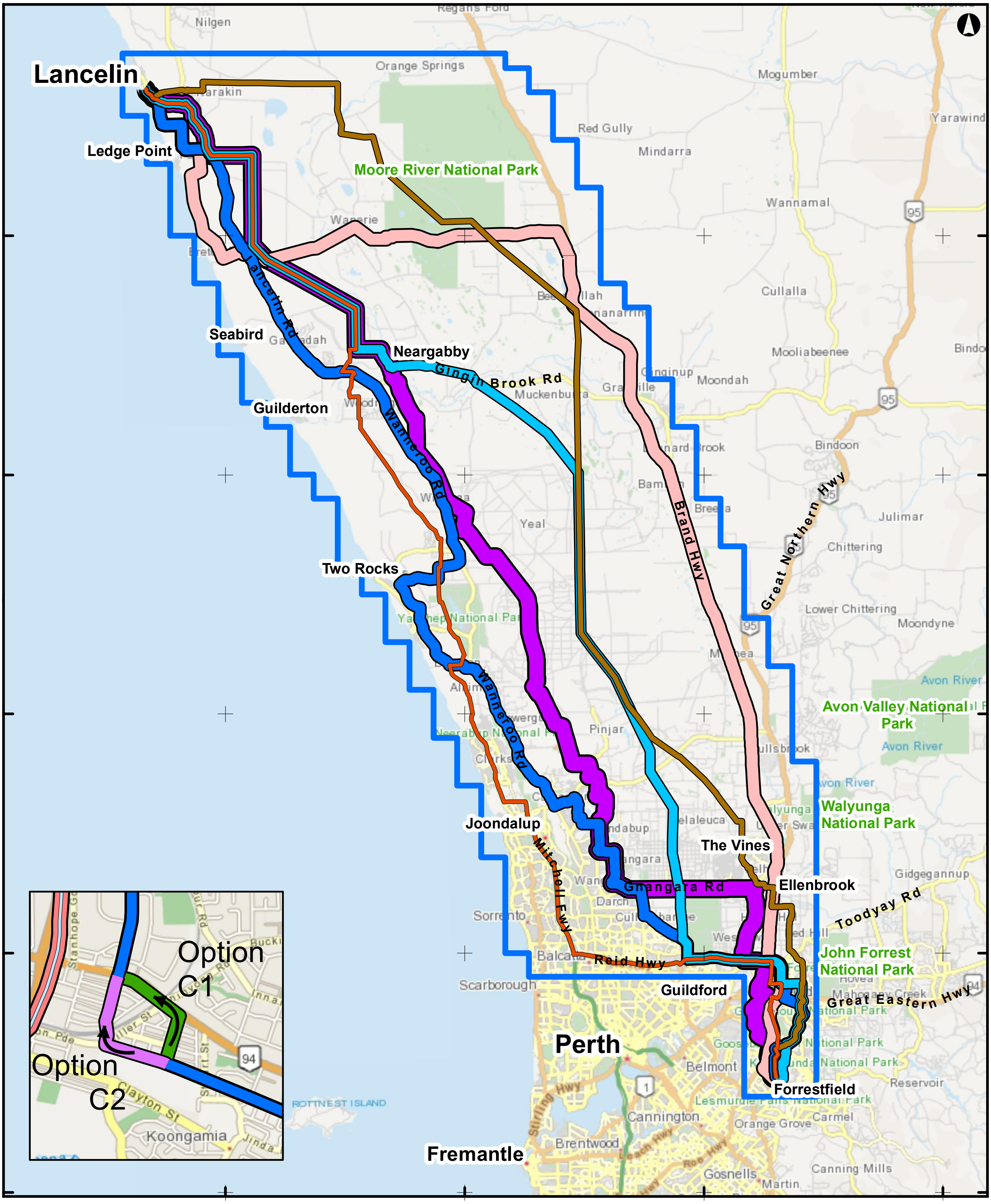
The following assumptions were made when selecting preliminary routes for consideration:

- No assessment was made on the availability within the road reserves for new pipelines or consideration of other existing buried services in the same road reserve
- The accuracy of the visible constraints was limited to the currency (date) of aerial imagery used
- Minimum construction corridor for a 1,400 diameter steel pipe in trench is 30m plus an access road
- No consideration has been made of the presence of existing buried services in the same road reserve, however avoided sharing the same corridor with high pressure gas mains and high voltage power lines.
- Crossing of high pressure gas mains, fibre optic communication cables and high voltage power lines is acceptable
- The accuracy of the visible constraints was limited to the currency (date) of aerial imagery used and the drive past field inspection in some of the critical sections
- No allowance has been made for future planned development other than that shown in the data sets received
- We have avoided following the same alignment in two pipe route options except in short sections
- Following order of preference was adopted in selecting the corridors:
    - In built up areas: 1. Unbuilt public land, 2. Wide road reserves, 3.Private properties
    - In open areas: 1. Shortest distance following cadastral boundaries, 2. Undeveloped land, 3. State forest or crown land
- Rail, major road and river crossings were assumed to be undertaken using Horizontal Directional drilling or Thrust Boring. Availability of space and access for such techniques was considered in locating crossings.
- Pipe bridges over water courses were assumed to be feasible only if located adjacent to an existing road bridge
- All pipe will be below ground in trench.

3.3 Preliminary Routes

A total of six preliminary routes were identified, with the aim of narrowing this down to the three most preferred, through MCA.

The six routes are shown below in Figure 4 and described in the following sections.



Preliminary Routes

Figure 4

Coordinate System: GDA 1994 MGA Zone 50

0 5 10 15 20

Kilometres

1:550,000 (A4)

LEGEND

- Study Area

Preliminary Route Options

- Option A
- Option B
- Option C
- Option D
- Option E
- Option F
- (Option C1)
- (Option C2)

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3.3.1 Route A

In general, Route A aligns along the following course; along Lancelin Road/Indian Ocean Drive/Wanneroo Road, then traversing east, north of Yanchep National Park, through Yanchep and east of Joondalup and Wanneroo, then onto Gnangara Road, east to West Swan Road, following this south onto Roe Highway to Forrestfield.

The alignment of Route A is described in more detail in Table 1.

Table 1 Description of Route A

Route Section	Section Description
1	From Lancelin, follow Lancelin Road, Indian Ocean Drive, then turn east to beyond the Ledge Point turn off. Follow 66kV overhead power line over 60km.
2	Proposed thrust bore under Moore River and Gingin Brook. Cross the road bridge by way of a pipe bridge attached to the road bridge. The route is now inland, east of Guilderton.
3	The route leaves the power line corridor just north of Yanchep Reserve at Military Road and Hydro Road. The alignment utilises land inside the pine plantation. A branch line is provided to the west following road corridors to Yanchep reservoir.
4	The trunk line follows various road reserves such as Aqua Road almost up to Carabooda, where it also serves Carabooda Reservoir.
5	The route then turns south east past Pinjar and a further branch line is provided to serve Nowergup Reservoir.
6	Another branch line is provided just south of Joondalup Drive north of Wanneroo, to serve Neerabup Reservoir. The trunk line continues south along Franklin Road. Wanneroo reservoir is also served by a short branch.
7	The route passes along the western side of the Joondalup Lake.
8	The route continues south past Badgerup up to Gnangara Road up to Ocean Reef Road.
9	The route is aligned with the verge of Gnangara road for 16km until it meets West Swan Road. Along the way it serves Gnangara Reservoir which is located about 6km north of Gnangara Road.
10	The route follows the reserve of West Swan Road all the way south up to Reid Highway.
11	Turning south at Great Northern Highway towards Midland, the route moves between the western and eastern verges to avoid interaction with the High Pressure Gas Main.
12	The route must pass the Midland Town Centre, possibly requiring some thrust boring, mostly utilising low value land uses and open spaces such as at-grade car parks and service areas of shopping centres.
13	Proposed thrust bore under the railway lines along the alignment of Helena Street where there are no other thrust bored services.
14	The route continues east on Foundry Road and then is attached to Clayton Bridge over the Roe Highway up to Greenmount Reservoir if required.
15	The trunk main then turns south along Lloyd Street, passing across Helena River with the pipe bored under the river bed. There it is a dry bed in this locality with pedestrian access.
16	The route then follows Vale Road and Abernethy Road, will be bored under Great Eastern Bypass and Kalamunda Road. The route must then pass under Roe Highway near the intersection with Kalamunda Road.
17	Finally, the route follows the Roe Highway verge up to Maida Vale Road and then uses Brewer Road to get to Forrestfield reservoir.

3.3.2 Route B

In general, Route B aligns along the following course; along Lancelin Road then east of the coastal dunes east of Ledge Point, and further east across the powerlines to Brand Highway and to just north of Muchea, then south along Great Northern Highway to Roe Highway, then to Forrestfield via Helena Valley Road.

The alignment of Route B is described in more detail in Table 2.

Table 2 Description of Route B

Route Section	Section Description
1	From Lancelin, the route follows Lancelin Road up to the Golf Course entrance, then follow the southern boundary of new south Lancelin development and Old Ledge Point Road.
2	The route then passes east of Ledge Point township. Following farm tracks the route traverses south through vacant land east of the coastal dunes.
3	The route then follows the Greenwood Coast Road, crossed Lancelin Road (proposed thrust bore). The route then heads eastward past the first 66kV Over Head power line up to the second 66kV Over Head power line corridor close to Brand Highway at Beermulla north of Gingin.
4	The route then follows the Brand Highway reserve almost up to Muchea. There is a proposed branch line to the west just south of the Gingin airstrip through open land to serve Yanchep Reservoir.
5	The trunk line continues south following Muchea South Road parallel to the railway line.
6	A branch line is provided to the west onto Ellenbrook Drive at Upper Swan and other minor road reserves to service reservoirs at Carabooda, Nowergup, Neerabup and Wanneroo.
7	The trunk line proceeds south following Great Northern Highway reserve up to Roe Highway and then follows the Roe Highway reserve.
8	A branch line is provided on Helena Valley Road to service Greenmount reservoir if required.
9	The trunk line continues south along Roe Highway up to Sultana Road to service Forrestfield Reservoir.

3.3.3 Route C

In general, Route C aligns along the following course; along Lancelin Road to Indian Ocean Drive at Ledge Point and to Yanchep National Park, then west along Vidago Road and along minor roads to the Mitchell Freeway to Two Rocks. The route then joins Wanneroo Road at Eglinton via minor roads and south to Joondalup Drive, then to Reid Highway via Gnangara Road and Alexander Drive to Roe Highway and then Great Northern Highway.

The alignment of Route C is described in more detail in Table 3.

Table 3 Description of Route C

Route Section	Section Description
1	The route follows Lancelin Road up to the golf course and then continues along the same alignment as Route B up to Indian Ocean Drive at Ledge Point.
2	Route C then continues south along Lancelin Road / Indian Ocean Drive reserve over 70km all the way to just north of Yanchep Park.
3	The route then turns west along Vidago Road and follows the reserve of minor roads and future Mitchell Freeway extension corridor up to Two Rocks, branching off on the way to service Yanchep Reservoir.
4	Proceeding south, the route follows Toreopango and Marmion Avenue, past Yanchep Beach Road up to Eglinton, where it turns east on to Pipidinny Road up to Wanneroo Road at Carabooda.
5	At this point the Carabooda Reservoir is served. The route then proceeds south to Joondalup Drive where, serving Nowergup and Neerabup reservoirs along the way.
6	The route proceeds east along Joondalup Drive up to Pinjar Road, then southwards to serve Wanneroo reservoir.

Route Section	Section Description
7	Continuing south, the route follows Badgerup Road up to Ocean Reef Road and then a short distance along Gnangara Road up to Alexander Drive.
8	A long branch line along Gnangara Road serves Gnangara Reservoir. This branch also travels past Ellenbrook sewage pump station.
9	The trunk line turns east to follow road reserves of Hepburn Avenue, Beechboro Road, meeting Reid Highway south of Whiteman Park.
10	The route then proceeds along Reid Highway and Roe Highway road reserves up to Morrison Road. Great Northern Highway, Toodyay Road and Morrison Road crossings will be thrust bored.
11	At Midvale a short section of Option C is subdivided into C1 and C2. C1 is a proposed thrust bore under the railway at the same location as a water main; C2 is a proposed overpass of the railway with a pipe bridge attached to Great Eastern Highway overpass at Midvale.
12	Finally, the route follows the reserve for other water mains along the Railway Heritage Trail, serving Greenmount Reservoir if required.

3.3.4 Route D

In general, Route D aligns along the following course; Lancelin Road/Indian Ocean Drive, then traversing east, following farm tracks up to the second over head power line corridor, then following this corridor south up to Gnangara Road. Then south along Beechboro Road to Reid Highway and along Roe Highway to Morrison Road, then to Great Eastern Highway via minor roads and to the Forrestfield Reservoir.

The alignment of Route D is described in more detail in Table 4.

Table 4 Description of Route D

Route Section	Section Description
1	Route D follows the same route selected for Route A up to Moore River crossing east of Guilderton.
2	The route then proceeds east following farm tracks up to the second over head power line corridor, then following this corridor south up to Gnangara Road. This corridor is midway between Routes A and B.
3	Route D then has several branch lines; one to the west at Kestral Road to serve Yanchep and Carabooda, Nowergup and Neerabup reservoirs; another to the east at Tick Road following bore main corridors to serve Gnangara Reservoir.
4	The trunk line then proceeds south along Beechboro Road up to Reid Highway and continues east along Roe Highway, on the same corridor selected for Option C up to Morrison Road.
5	It is proposed the route be thrust bored under the railway lines across Morrison Road.
6	The route then turns south to Amhurst Road and utilises other minor road reserves up to Great Eastern Highway. There is a water main crossing at the same place under Great Eastern Highway. The corridor runs adjacent to existing water mains almost all the way.
7	Finally, Route D follows existing water main corridors pass Greenmount Reservoir and utilises road reserves such as Ridgehill Road and Scenic Drive up to Forrestfield Reservoir.

3.3.5 Route E

In general, Route E aligns along the following course; along Lancelin Road and through Seaview Estate, across Moore River and open pasture to the second overhead power line, south to east of Pinjar and across West Swan Road to Great Northern Highway to Padbury and under the railway to along Talbot Road and on to Forrestfield.

The alignment of Route E is described in more detail in Table 5.

Table 5 Description of Route E

Route Section	Section Description
1	Route E follows Lancelin Road up to the Lancelin Wastewater ponds and continues east through open land past Seaview Estate for about 24km.
2	The route then turns south at Cowalla Road, crossing Moore Rover via a pipe bridge attached to Cowalla Road bridge.
3	Turning south east, the route continues across open land and through the southern part of Moore River National Park up to the second 66kV Over Head power line corridor.
4	The route then proceeds south up to the east of Pinjar and a branch line extends from this point to serve Nowergup, Carabooda, Neerabup and Wanneroo reservoirs.
5	The trunk line continues south east past Neaves Road.
6	Another branch line is provided westward from The Vines to serve Gnangara Reservoir. The trunk line continues south across West Swan Road up to Great Northern Highway.
7	Following the Great Northern Highway, the route reaches Padbury Road at Herne Hill. A thrust bore is proposed under the railway.
8	The route proceeds south along minor back roads in the Swan Valley area, including Moore Road and a thrust bore is proposed under Toodyay Road opposite Jane Brook.
9	Passing through Jane Brook, the route keeps to the reserve of Talbot Road through to Midvale. It then passes under Morrison Road and Great Eastern Highway.
10	Following a route similar to Option C and D, Route E passes Greenmount reservoir up to Forrestfield reservoir.

3.3.6 Route F

In general, Route F aligns along the following course; from Lancelin Road crosses Moore River on the bridge then south through vacant land to the Two Rocks area and west of Yanchep National Park, the along minor roads to the future Mitchell Freeway corridor where it turns south to the Mitchell Freeway, then east along Reid Highway and Roe Highway and south along minor roads to Morrison Road then to Roe Highway reserve and along Bushmead Road to the Forrestfield site.

The alignment of Route F is described in more detail in Table 6.

Table 6 Description of Route F

Route Section	Section Description
1	From Lancelin, Route F follows the same route as Route A up to the Guilderton area. Then it moves west on to Indian Ocean Drive (Lancelin Road) and crosses Moore River with a pipe bridge attached to the road bridge.
2	Route F proceeds south through open land about 2-3 km west of Lancelin Road up to the vicinity of Two Rocks before entering road reserves.
3	With a short branch west to serve Yanchep reservoir, the trunk line passes through open land along the western boundary of Yanchep National Park.
4	At Eglinton the route follows Pipidinny Road westwards, joining Marmion Avenue and proceeding south past Clarkson up to Kinross. On the way a branch line is provided at Alkimos to the east to service Carabooda and Nowergup reservoirs.
5	The high pressure gas main on Marmion Avenue is located further south.
6	The corridor passes adjacent to the new Alkimos Sewage treatment plant.
7	At Kinross the route turns east, thrust bored under Connolly Drive and reaches the future Mitchell Freeway corridor where it turns south.

Route Section	Section Description
8	An eastern branch line is provided to service Neerabup, Wanneroo and Gnangara reservoirs, thrust bored under the Transperth Railway lines and following various road reserves similar to other route options.
9	The trunk line follows the western verge of Mitchell Freeway and passes next to the sewage treatment plant in Craigie/Woodvale.
10	Route F then turns east along Reid Highway and Roe Highway passing Great Northern Highway intersection and then turn south along minor roads up to Morrison Road and then rejoins the Roe Highway reserve.
11	The line is thrust bored under Great Eastern Highway and the railway lines. It crosses Roe Highway with a pipe bridge attached to Bushmead Road bridge and then follows minor roads to the Forrestfield tank.

4.0 Multi Criteria Assessment Workshop

4.1 Purpose and Approach

The purpose of using a Multi-Criteria Assessment (MCA) is to fairly judge the merits of each option (in this case a corridor) against an agreed set of selection priorities. Example priorities might be ease of corridor attainment, avoiding major environmental constraints, or the cost of infrastructure provision.

Our approach to undertaking a MCA includes the following stages:

- Identify and obtain agreement from the Water Corporation on approximately 10 assessment criteria. Care is taken to ensure criteria do not contradict one another or double count any single issue.
- Define a realistic measure for each criterion, which can either be quantitative or qualitative.
- Prepare an in-house MCA spreadsheet tool for the workshop.
- Hold a workshop with appropriate stakeholders to verify the approach, apply weightings to the criteria, run the MCA, undertake sensitivity analysis to test the robustness of the MCA outputs and determine the overall results (three preferred routes).

Typically, criteria for the MCA are identified using a Triple Bottom Line (TBL) approach. The three components included in a TBL approach are generically social, environmental and economic, in order to evaluate the alignments determined during the preliminary selection of potential routes. However, based on discussions with the Water Corporation, it was agreed that detailed consideration of the economic component would be excluded from the assessment, due to the fact that the route selection was undertaken early in the process. However, economic considerations for the route options were agreed to be addressed to some extent indirectly through assessment of items such as land tenure and acquisitions required and route length.

The intention of the workshop was to identify, at a high level, the three most viable route options that will form the basis for detailed studies, the approvals process, and remainder of the project.

The MCA was carried out on 21 June 2012 at AECOM's offices in collaboration with Water Corporation representatives in a workshop format. The workshop was facilitated by Abra DeKlerk, who originally devised the in-house AECOM MCA tool and who has carried out this process with the Water Corporation on a number of previous projects.

4.2 Attendance

The workshop was attended by the following individuals:

- Water Corporation:
  - Jeffrey White – Project Manager, Conveyance Group
  - Lorna McGuire – Environmental Scientist (Approvals)
  - Graeme Hughes – Infrastructure Planning
  - Bernice Nolan – Community Engagement
- AECOM:
  - Abra DeKlerk – Technical Director – Workshop Facilitator
  - Shona Gatenby – MCA Development
  - Kellie Honczar – Project Manager
  - John Braid – Environmental Scientist
  - David Klap – GIS Oversight
  - Kathryn Jones – GIS Analyst
  - Prem Mirihagalla – Principal Water Engineer
  - Nicola Kingdon – Graduate Environmental Scientist - Minutes.

4.3 Process

Notes from the MCA workshop can be found at **Appendix A**. The format and agenda of the workshop was as follows:

- Explanation of Multi Criteria Analysis (MCA) and Constraints Mapping
- Summary of work completed to date
- Stakeholder agreement to the criteria and weightings applied to each
- Overview of the Planning Balance Sheet (data set)
- Running the MCA program
- Undertaking Sensitivity Testing of the weightings and criteria
- Results of sensitivity analysis
- Overall results.

4.3.1 Identifying and Selecting Assessment Criteria

For each of the preliminary alignments, the workshop team prepared a “planning balance” in the form of a spreadsheet containing relevant technical data pertaining to each criterion. This data formed the basis against which the different alignments were assessed. The criteria were based on the route selection design priorities, with the aim to select criteria that clarify the advantages and disadvantages of each alignment used for comparison.

The criteria selected and agreed upon for the initial MCA are listed in Table 7. Additional criteria considered in subsequent sensitivity analyses are listed in Table 8.

Table 7 Initial Assessment Criteria

Assessment Criterion	Criterion Description	Positive or Negative Value	Measure	Comments
1	Total length of route (trunk main only)	Longer distances will be a negative value.	Metres	Length is an indicator of costs
2	Total length of branch lines	Longer distances will be a negative value.	Metres	Length is an indicator of costs
3	Overall Benefit	Benefit areas will be a positive value.	Proportion of route length where benefits outweigh risks	Based on results of combined risk / benefit mapping exercise
4	Environmental Constraint Interaction – High Risk	Interaction with risk areas will be a negative value.	Quantity – hectares	Based on risks identified in mapping
5	Environmental Constraint Interaction – Medium Risk	Interaction with risk areas will be a negative value.	Quantity – hectares	Based on risks identified in mapping
6	Environmental Constraint Interaction – Low Risk	Interaction with risk areas will be a negative value.	Quantity – hectares	Based on risks identified in mapping
7	Infrastructure Constraint Interaction – High Risk	Interaction with risk areas will be a negative value.	Quantity – occurrence	Gas Pipelines
8	Infrastructure Constraint Interaction – Medium Risk	Interaction with risk areas will be a negative value.	Quantity – occurrence	Road and rail crossings, transmission lines.

Assessment Criterion	Criterion Description	Positive or Negative Value	Measure	Comments
9	Quality of Access	Availability of access from public roads will be a positive value.	Proportion of route accessible by public road.	Access to the alignment will affect ease of construction and maintenance. Proportion expressed as a percentage.
10	Use of Crown Land	Use of crown land will be a positive value.	Proportion of route in crown land.	Expressed as a percentage.
11	Geological Karst Formation	Interaction with limestone caves will be a negative value.	Quantity - hectares	Based on risks identified in mapping.
12	European and Aboriginal Heritage	Interaction with risk areas will be a negative value.	Quantity - hectares	Based on risks identified in mapping.

Table 8 Successive Assessment Criteria

Assessment Criterion	Criterion Description	Positive or Negative Value	Measure	Comments
13	Longitudinal Clash with Transmission Lines	Interaction with risk areas will be a negative value.	Qualitative – Impact	Based on risks identified in mapping.
14	Conflict with Urban Development	Interaction with risk areas will be a negative value.	Qualitative – Impact	Based on risks identified in mapping.

During the MCA workshop (detailed over the page), the introduction of the successive criteria detailed in Table 8 coincided with the removal of two original criteria list in Table 7: Criterion 3; “overall benefit” and Criterion 11; “geological karst formation” which were agreed to have less relevance to the overall assessment.

4.3.2 Planning Balance Sheet – Data Input

Quantitative data was available to measure the original 12 criteria selected for the assessment. The data utilised in the MCA is shown in Table 9 and also illustrated in Figure 5 – Figure 16.

Table 9 Measures Used for Initial Criteria

Criteria		Route						
No.	Description	A	B	Ci	Cii	D	E	F
1	Total length of route (trunk main only) - metres	158,001	158,915	158,905	158,920	151,643	155,360	155,458
2	Total length of branch lines - metres	30,415	94,752	24,259	24,316	68,302	69,046	47,655
3	Overall Benefit – proportion (%) of route length where benefits outweigh risks	85	73	73	73	75	70	84
4	Environmental Constraint Interaction – High Risk - hectares	0	3.06	0.28	0.28	0.64	0.26	0.17
5	Environmental Constraint Interaction – Medium Risk - hectares	226	163	175	175	215	200	187

Criteria		Route						
No.	Description	A	B	Ci	Cii	D	E	F
6	Environmental Constraint Interaction – Low Risk – hectares	209	181	140	140	218	171	192
7	Infrastructure Constraint Interaction – High Risk - number of occurrences	9	5	7	7	6	5	7
8	Infrastructure Constraint Interaction – Medium Risk - number of occurrences	47	28	37	37	38	34	66
9	Quality of Access - proportion of route length with access to public road network	49	64	90	90	31	25	55
10	Use of Crown Land - proportion of route length on crown land	48	36	16	16	51	53	41
11	Geological Karst Formation - hectares	89	168	90	90	99	96	118
12	Heritage (European and Aboriginal) - Medium Risk - hectares	17	6	39	39	8	9	55

The total length of the trunk main was measured to rate overall implementation cost; the shorter routes are best.

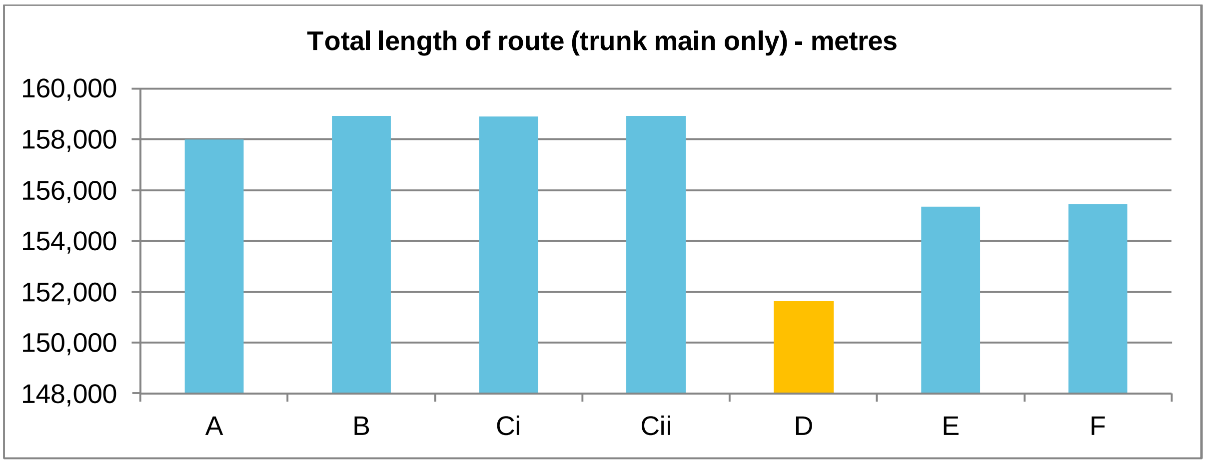


Figure 5 **Criterion 1 Route Data**

The total length of branch lines was also measured as a way of rating implementation costs, although this infrastructure was purposely kept separate from the trunk line as the infrastructure and implementation costs would be different. Again, the shortest distance would be the best outcome.

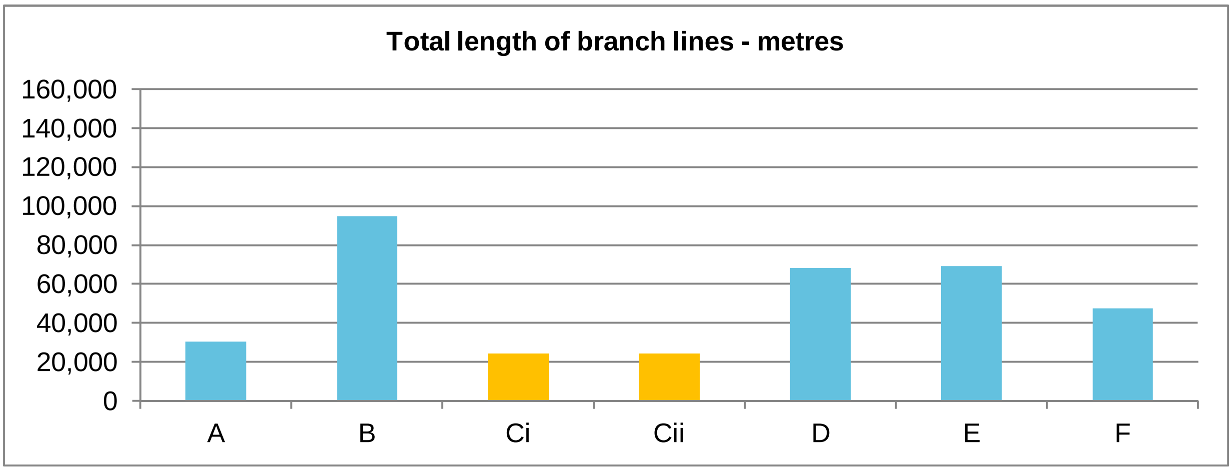


Figure 6 **Criterion 2 Route Data**

The overall benefit was taken from the composite output of the risk and benefit mapping analysis. The measure is a proportion of route length so results are not biased. Larger proportions are the best outcome, however it can be seen in Figure 11 that the results are very similar across all routes, which reflects the intent of the preliminary route selection process. As a result, Criterion 3 does not add as much value to the assessment as originally anticipated and was removed from the final MCA.

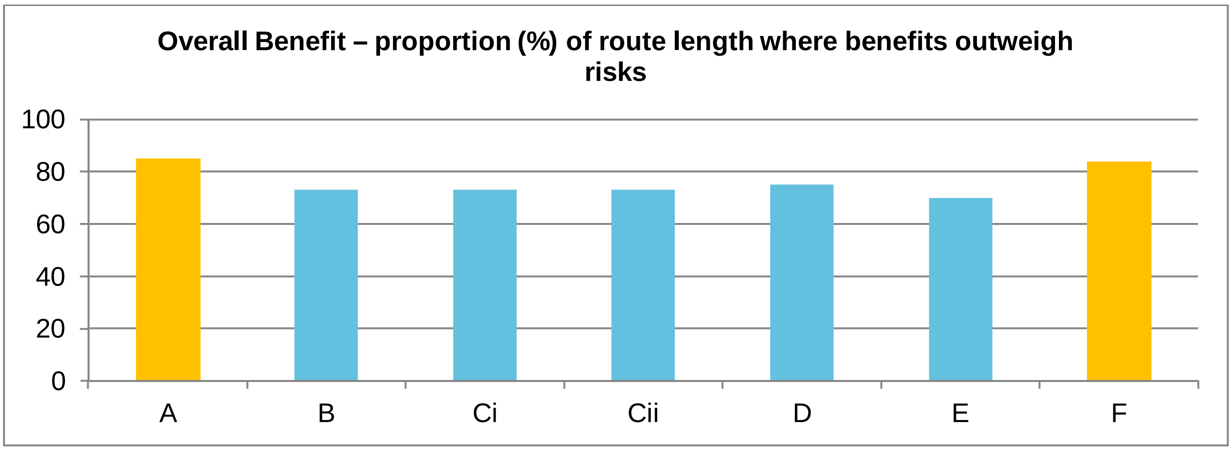


Figure 7 **Criterion 3 Route Data**

High risk environmental constraints were identified through the mapping process and included only one major constraint type: threatened flora. The lower the number, the better the result. The results are shown in hectares to reflect the length and width of corridor area which interacts with the constraint.

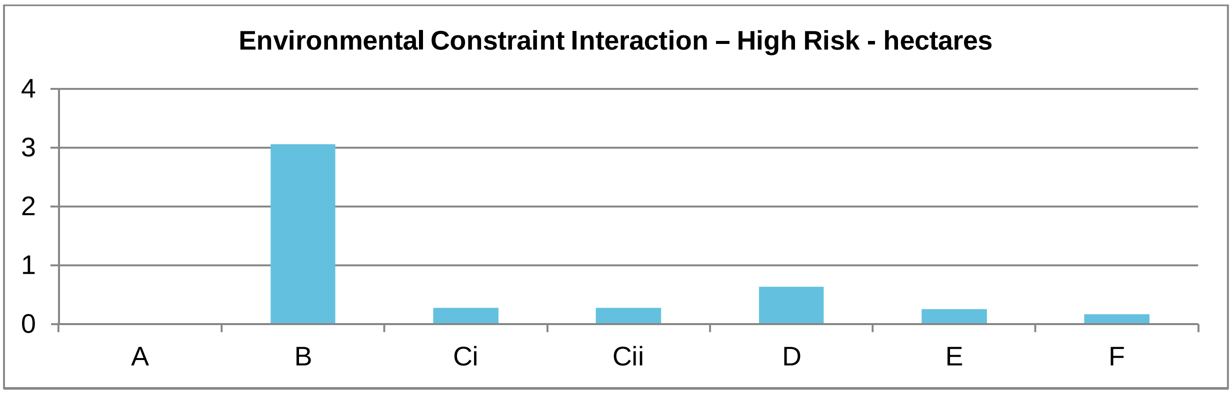


Figure 8 **Criterion 4 Route Data**

Medium risk environmental constraints were identified through the mapping process and included 22 constraint types including DEC managed land, watercourses and declared threatened fauna. The lower the number, the better the result. The results are shown in hectares to reflect the length and width of corridor area which interacts with the constraint.

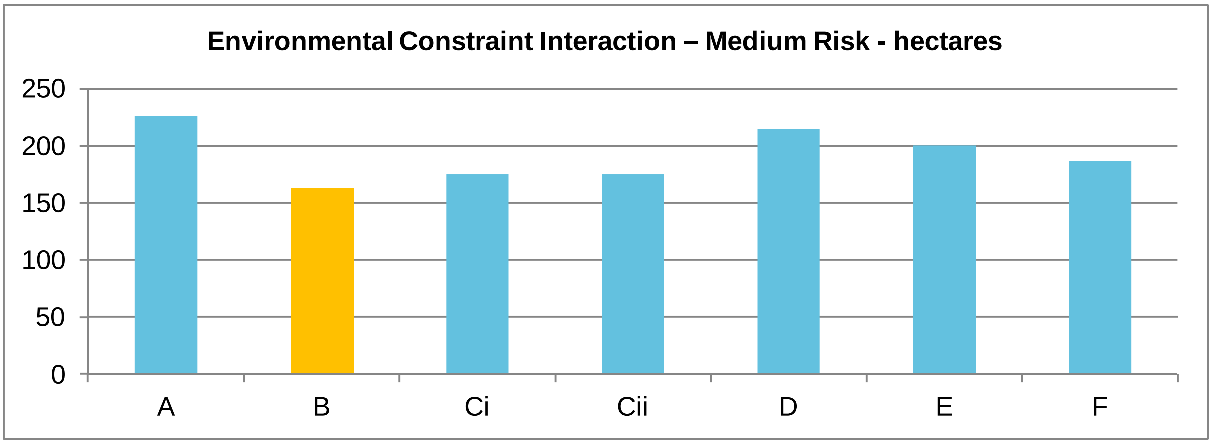


Figure 9 Criterion 5 Route Data

Low risk environmental constraints were identified through the mapping process and included 21 constraint types including Acid Sulphate Soils, geomorphic wetlands, and priority flora and fauna. It is important to register that "low risk" is not the same as "no risk". The lower the number, the better the result. The results are shown in hectares to reflect the length and width of corridor area which interacts with the constraint.

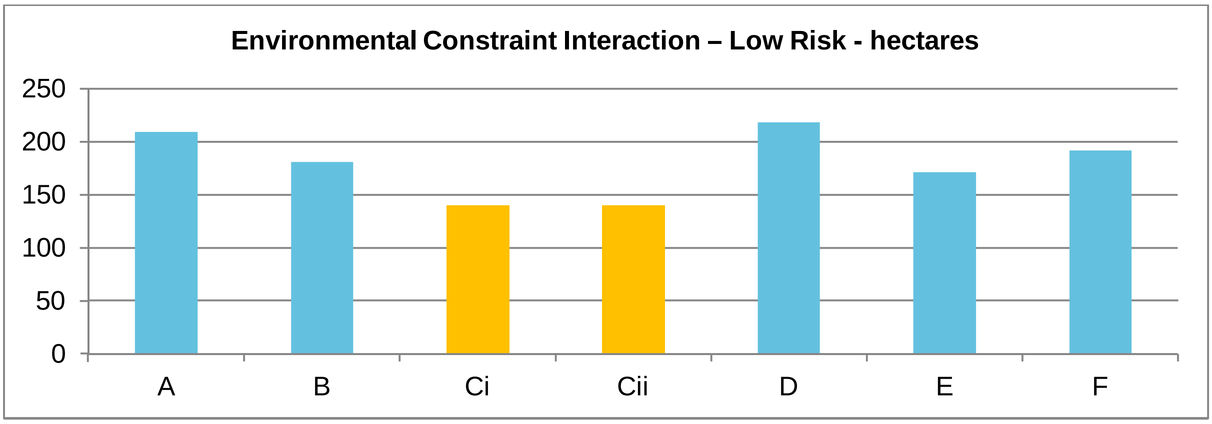


Figure 10 Criterion 6 Route Data

High risk infrastructure constraints were identified through the mapping process and included only one major constraint type: high pressure gas mains. The lower the number, the better the result.

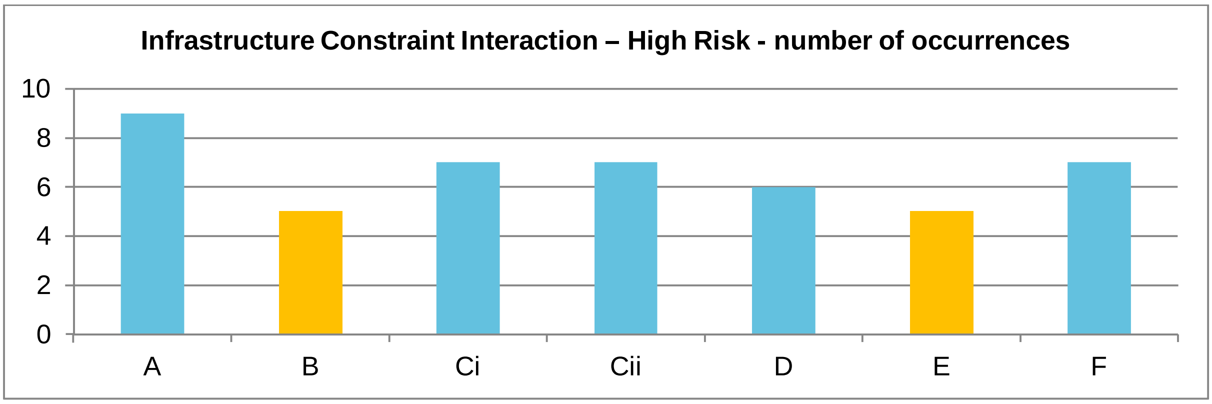


Figure 11 Criterion 7 Route Data

Medium risk infrastructure constraints were identified through the mapping process and included 3 constraint types: railway crossings, road crossing, and transmission line crossings. The lower the number, the better the result.

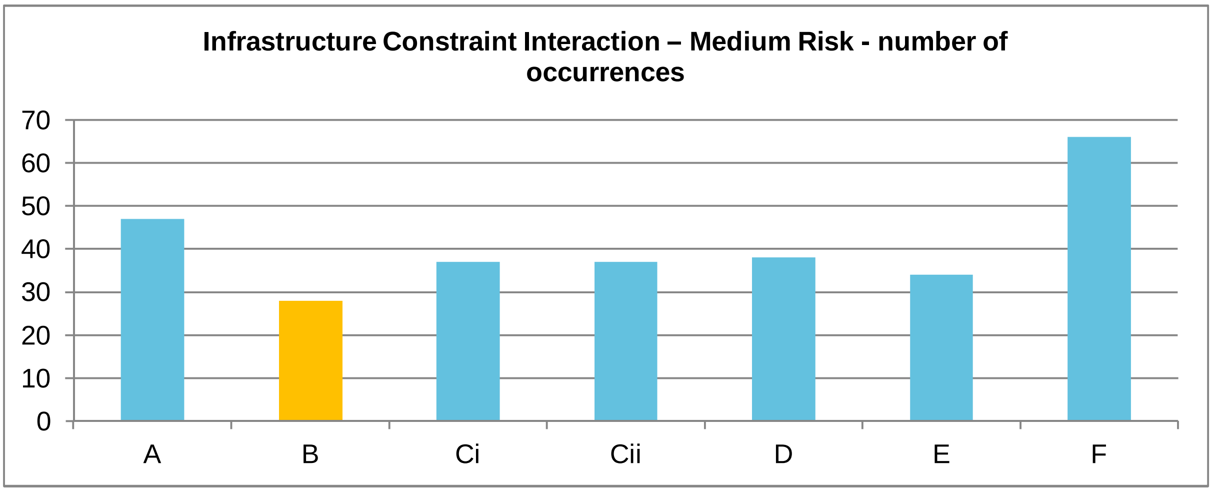


Figure 12 Criterion 8 Route Data

Quality of access was adopted as a criterion to measure the relative ease of construction and maintenance of the pipeline. The measure demonstrates the proportion of the route which can be easily accessed from the public road network. The higher the number the better the result.

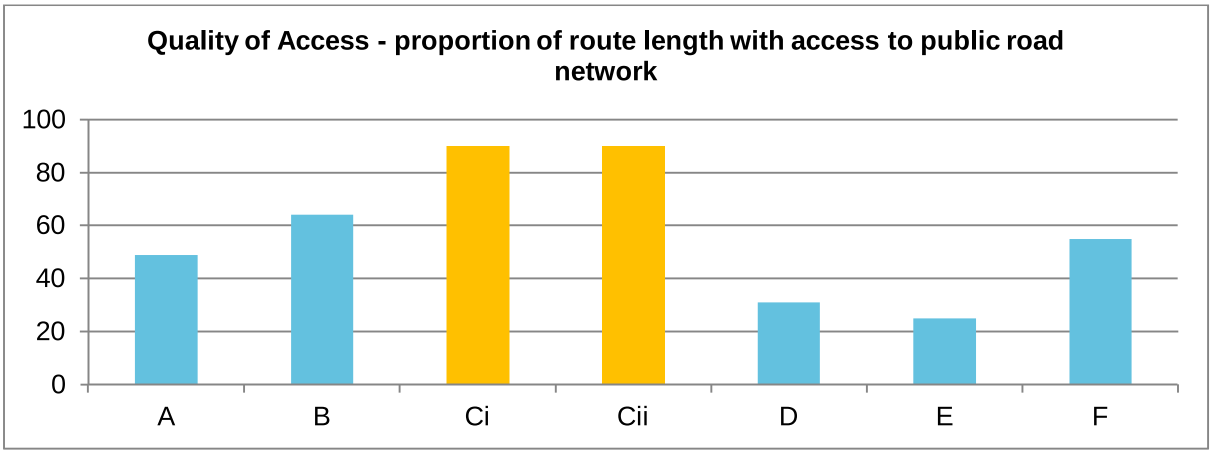


Figure 13 Criterion 9 Route Data

The use of crown land was measured to highlight areas where corridor reservation and construction of the pipeline will be easier than in other privately owned locations. The higher the number, the better the result.

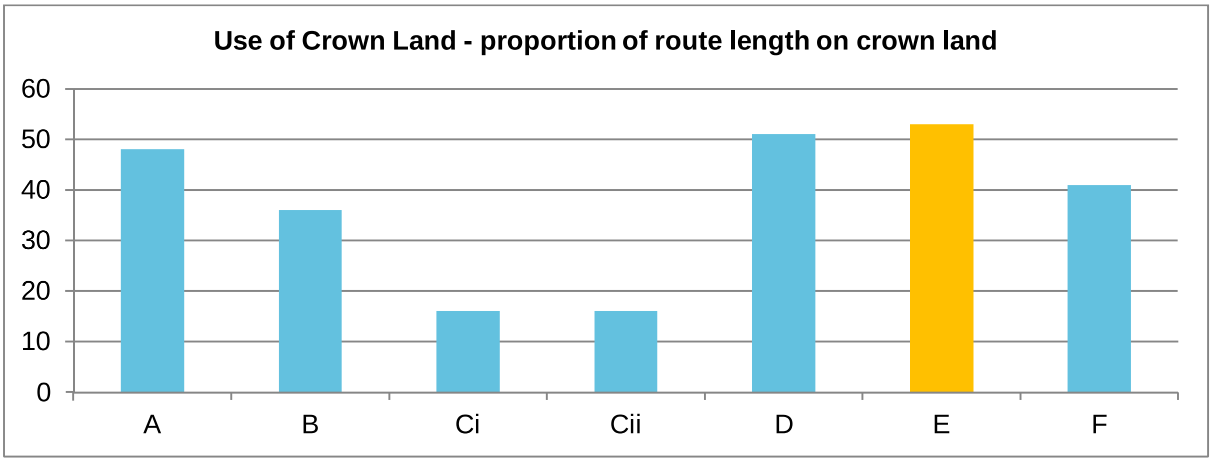


Figure 14 Criterion 10 Route Data

Geological kart formations in the form of underground caves can be a risk to construction. The lower the number the better the result. This criterion was removed from subsequent analysis as the workshop attendees agree the risk was not sufficiently significant to merit inclusion in the MCA. The results are shown in hectares to reflect the length and width of corridor area which interacts with the constraint.

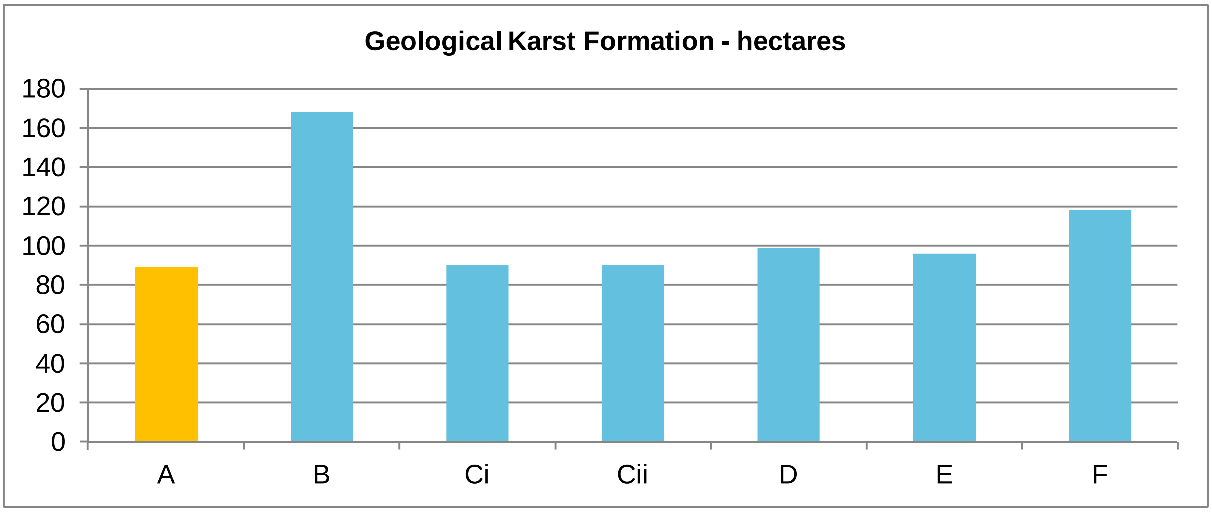


Figure 15 Criterion 11 Route Data

Heritage constraints were identified through the mapping process and included two major constraint types: aboriginal heritage areas and European heritage sites. The lower the number, the better the result. The results are shown in hectares to reflect the length and width of corridor area which interacts with the constraint.

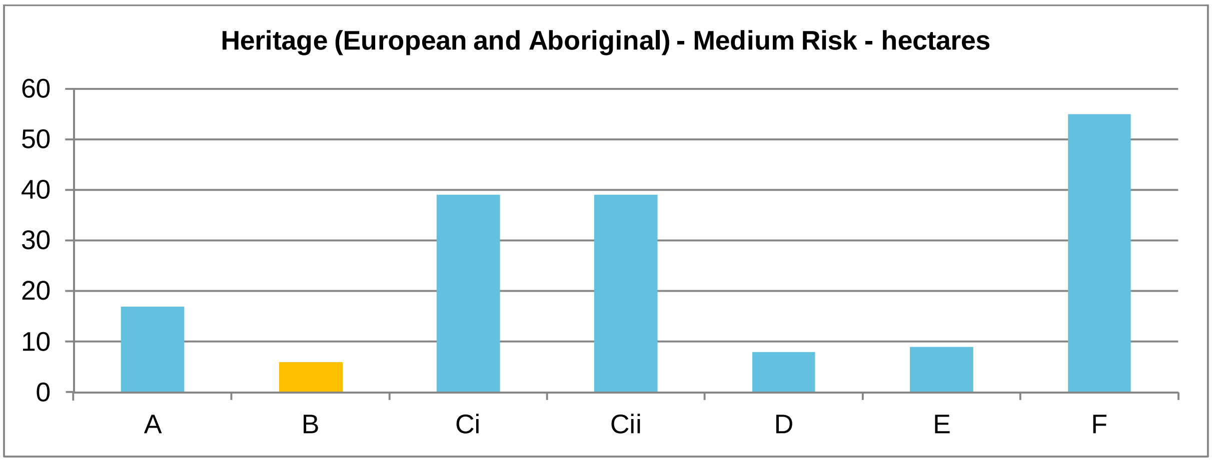


Figure 16 Criterion 12 Route Data

The two additional criteria selected during the MCA workshop process were measured using a qualitative assessment methodology as quantitative data was not immediately available. The qualitative process requires agreement within the stakeholder group on a descriptive score. The scores range from poor through to good, or low through to high and reflect the degree of impact made by the route upon the assessment criteria. The agreed rates are detailed in Table 10, where good and low are better scores than poor or high.

The Water Corporation identified the use of high voltage power line corridors as a risk to route selection due to the pipe corrosion which can be inflicted by stray electrical current if not adequately mitigated. Potential use of the HV corridors had originally been viewed as a benefit due to the availability of land and existing environmental approvals within the corridor for the placement of infrastructure.

The Water Corporation also raised concerns about the degree of conflict anticipated in the urban area closest to Forrestfield. The preferred corridor width of 100 metres will not be attainable in existing developed areas, where a 5 metre corridor may be the largest achievable.

Table 10 Measures Used for Successive Criteria

Criteria		Route						
No.	Description	A	B	Ci	Cii	D	E	F
13	Longitudinal Clash with Transmission Lines	Good	Good	Poor/Fair	Poor/Fair	Poor/Fair	Fair	Poor/Fair
14	Conflict with Urban Development	Medium	Low/Med	Med/High	Med/High	Low/Med	Low	High

4.3.3 Weighting of Criteria

The assessment criteria were initially weighted by the workshop stakeholders as shown in Table 11. Criteria given a higher weighting will be given more emphasis in the analysis process than criteria with a lower weighting. The data and differentials associated with higher weighted criteria will count more towards the assessment results than lower weighted criteria. A graph illustrating the initial criteria weightings is shown as Error! Reference source not found..

Table 11 Initial Criteria Weightings

Criteria		Initial Weighting
No.	Description	
1	Total length of route (trunk main only) - metres	Medium/ High
2	Total length of branch lines - metres	Medium
3	Overall Benefit - proportion of route length where benefits outweigh risks	Medium
4	Environmental Constraint Interaction – High Risk - hectares	High
5	Environmental Constraint Interaction – Medium Risk - hectares	High
6	Environmental Constraint Interaction – Low Risk - hectares	Medium
7	Infrastructure Constraint Interaction – High Risk - number of occurrences	Medium/High
8	Infrastructure Constraint Interaction – Medium Risk - number of occurrences	Medium/High
9	Quality of Access - proportion of route length with access to public road network	Low
10	Use of Crown Land - proportion of route length on crown land	Medium
11	Geological Karst Formation - hectares	Low
12	Heritage (European and Aboriginal) - Medium Risk - hectares	High

The stakeholder group applied the highest weightings to environmental and heritage constraints which were considered to be of high or medium level risk to the project. Quality of access and geological kart formations were weighted "low" by the workshop stakeholders as these criteria were not considered to be as relevant to the assessment process. Overall the weightings are evenly distributed across the criteria.

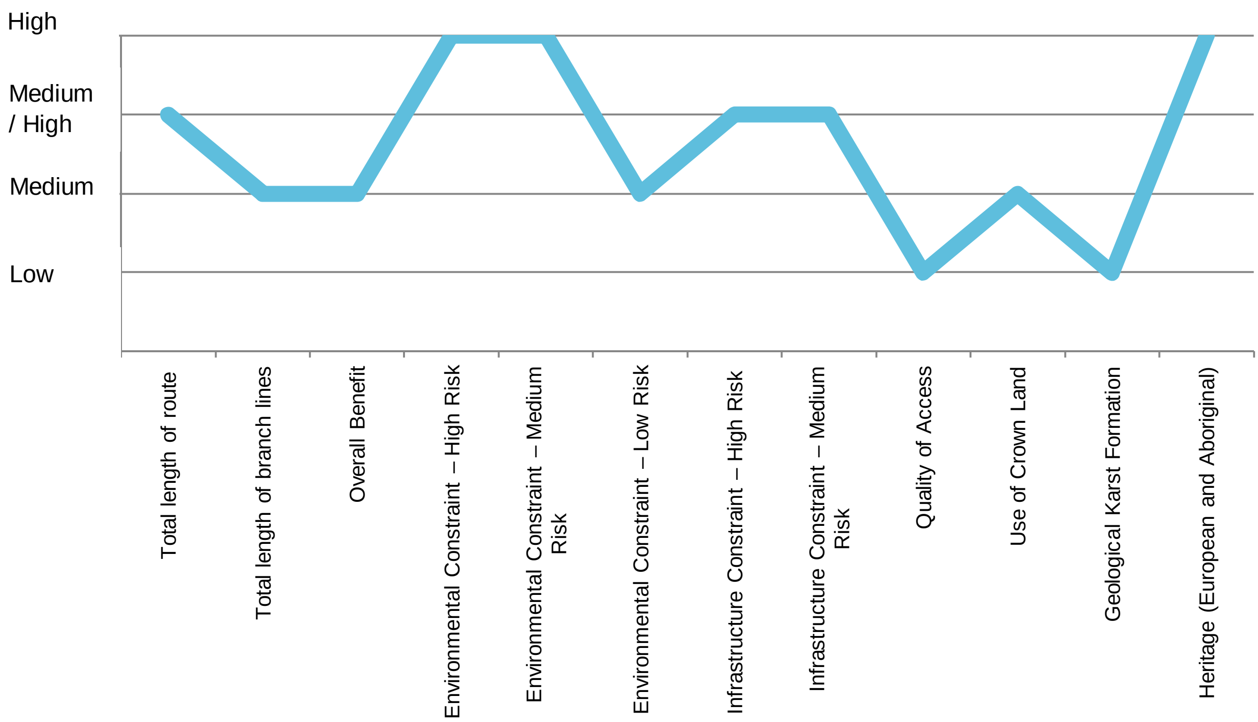


Figure 17 Initial Weightings

4.3.4 Initial MCA Results

The results of the first MCA run are shown in Table 12 and Figure 18.

Table 12 Initial MCA Results

Run	Description	Placing					
		1	2	3	4	5	6
1	Initial Weightings	E	D	A	C	B	F

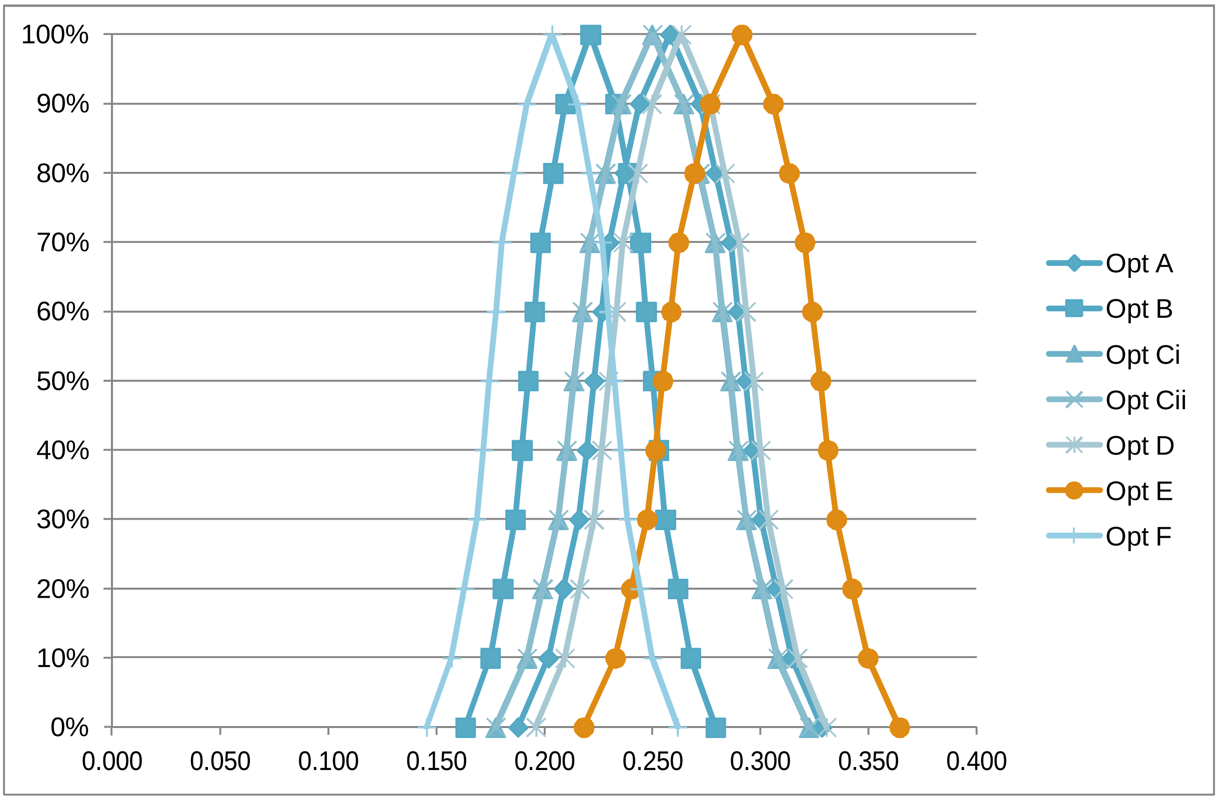


Figure 18 Initial MCA Results Graph

4.3.5 Sensitivity Testing

The initial MCA result were subjected to a series of sensitivity tests whereby the assigned criteria weightings were exaggerated and an additional six MCA configurations runs. The purpose of the sensitivity tests is to ensure minor changes to criteria weightings does not fundamentally impact on the overall result/outcome of the initial MCA. In this case the following ranges of sensitivity tests were carried out:

- Exaggerated “Capitalist” – placing higher weightings in favour of the development, with no concern for environmental aspects but maximum concern for cost and ease of land acquisitions.
- Exaggerated “Environmentalist” – placing higher weightings on the environmental values, with no concern about cost and ease of land acquisitions.
- “No Weightings”: - all criteria applied with a “Medium” weighting to test regular and exaggerated sensitivities.

The sensitivity tests are summarised below in Table 13.

Table 13 Sensitivity Testing

Criteria		Initial Weighting	Successive Weighting			
No.	Description		Minor Change	Exaggerated: "Capitalist"	Exaggerated "Environment -alist"	No Weightings
1	Total length of route (trunk main only) - metres	Medium/ High	Medium/ High	High	Low	Medium
2	Total length of branch lines - metres	Medium	Medium	High	Low	Medium
3	Overall Benefit - proportion of route length where benefits outweigh risks	Medium	Medium	Medium	Medium	Medium
4	Environmental Constraint Interaction – High Risk - hectares	High	High	Low	High	Medium
5	Environmental Constraint Interaction – Medium Risk - hectares	High	High	Low	High	Medium
6	Environmental Constraint Interaction – Low Risk - hectares	Medium	Medium/ High	Low	High	Medium
7	Infrastructure Constraint Interaction – High Risk - number of occurrences	Medium/ High	Medium/ High	High	Low	Medium
8	Infrastructure Constraint Interaction – Medium Risk - number of occurrences	Medium/ High	Medium/ High	High	Low	Medium
9	Quality of Access - proportion of route length with access to public road network	Low	Low	Medium/ High	Low	Medium
10	Use of Crown Land - proportion of route length on crown land	Medium	Medium	Medium	Medium	Medium
11	Geological Karst Formation - hectares	Low	Low	Low	High	Medium
12	Heritage (European and Aboriginal) - Medium Risk - hectares	High	Medium/ High	Low	High	Medium

The graphical results of the sensitivity testing are presented in Figure 19 to Figure 21.

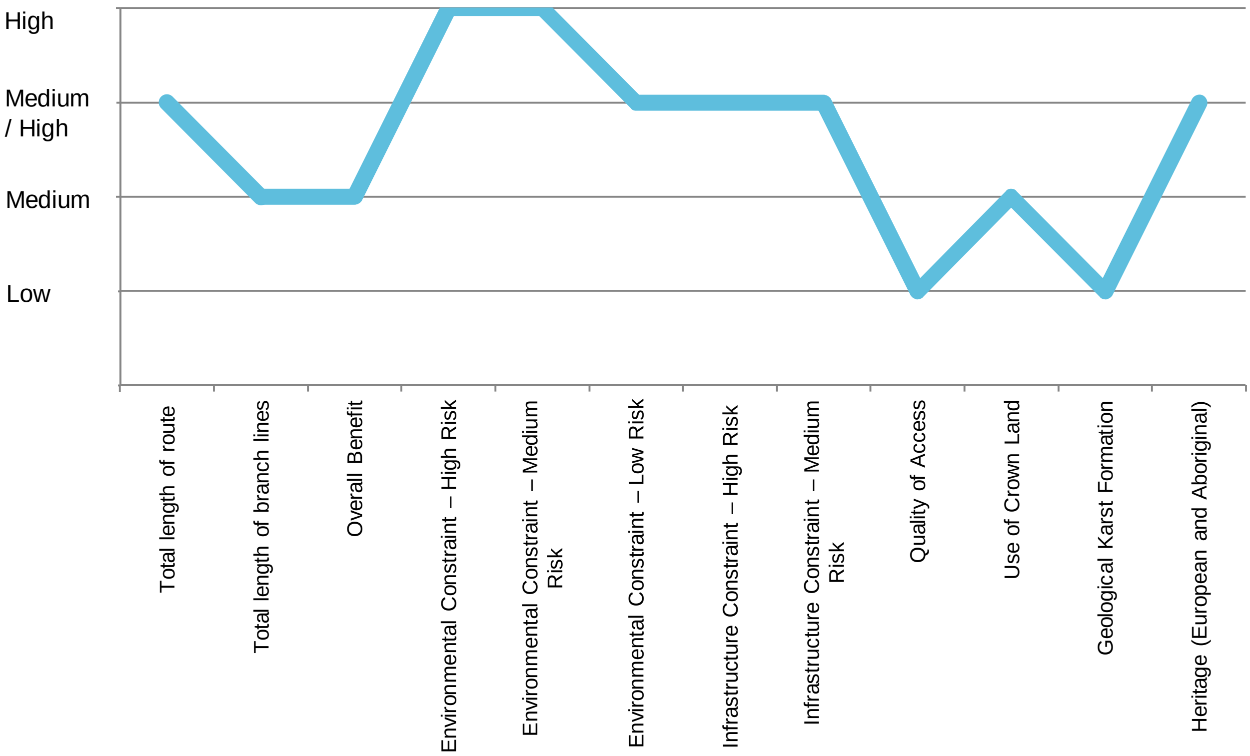


Figure 19 Sensitivity Testing – Initial Weightings

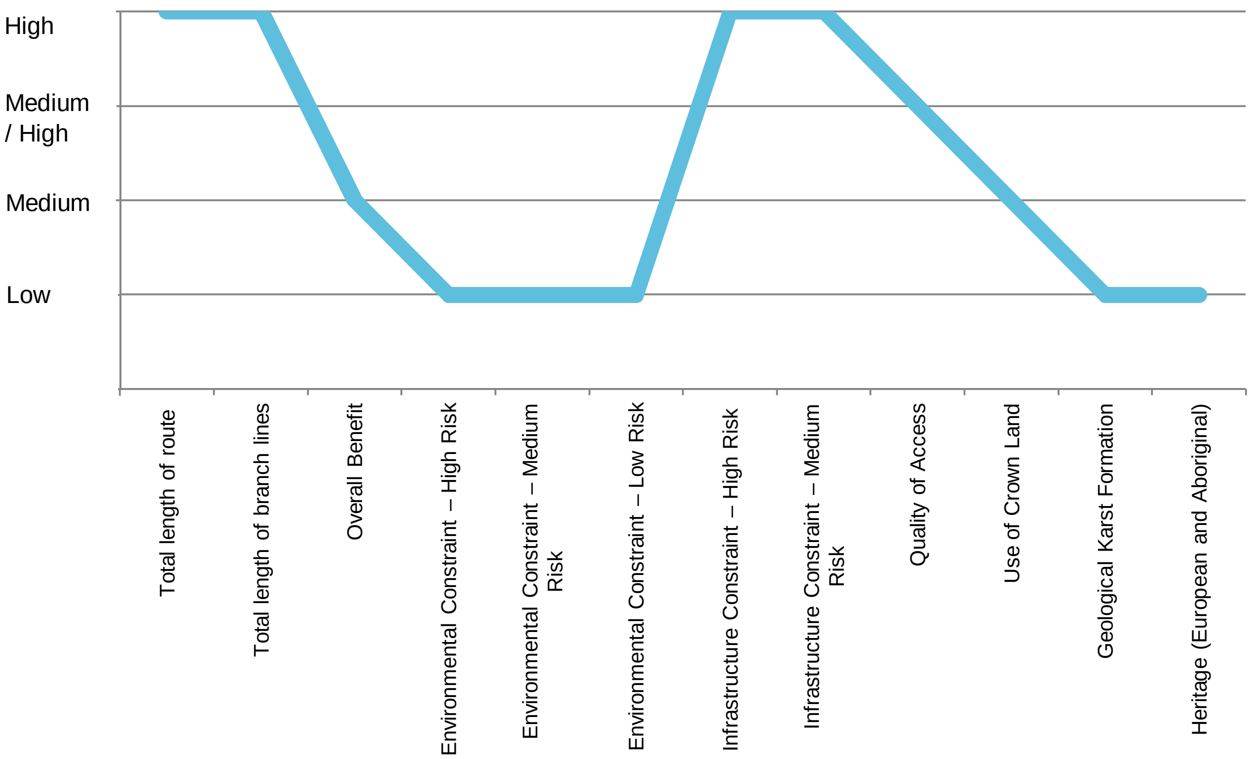


Figure 20 Exaggerated Weightings to Test Robustness of MCA – "The Capitalist"

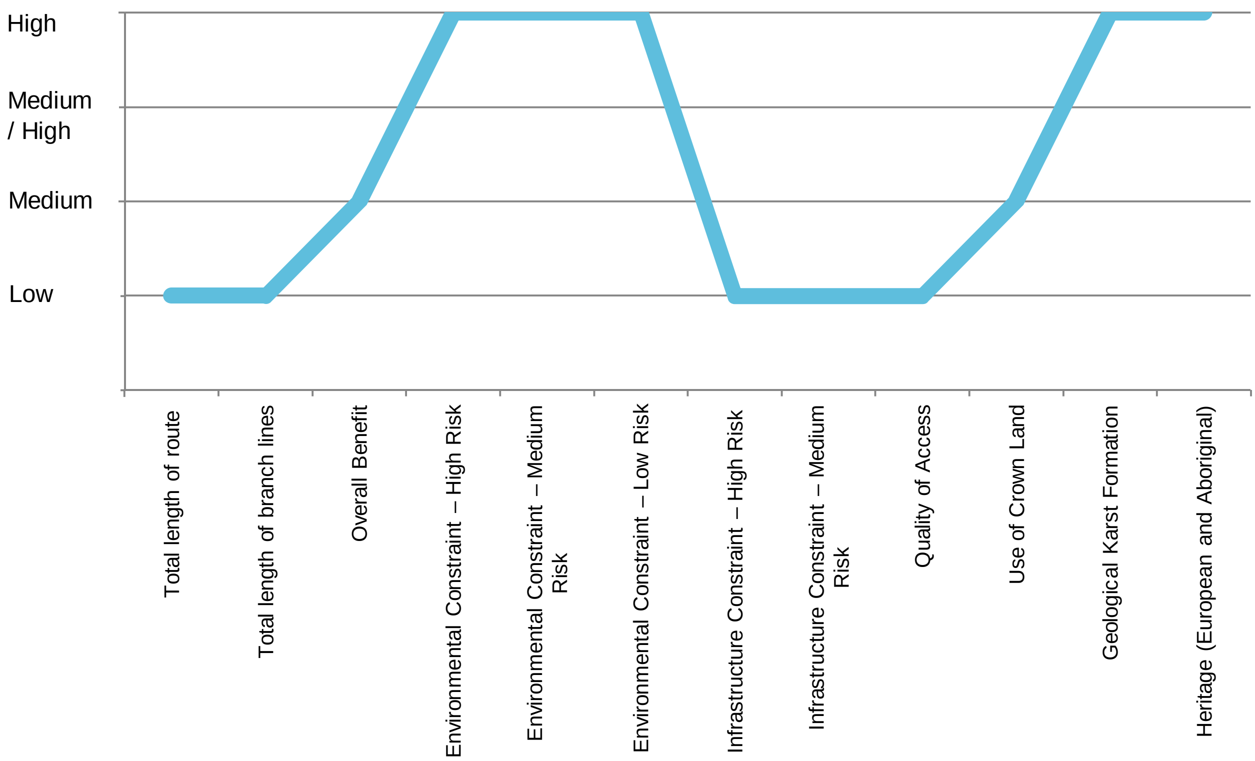


Figure 21 Exaggerated Weightings to Test Robustness of MCA – "The Environmentalist"

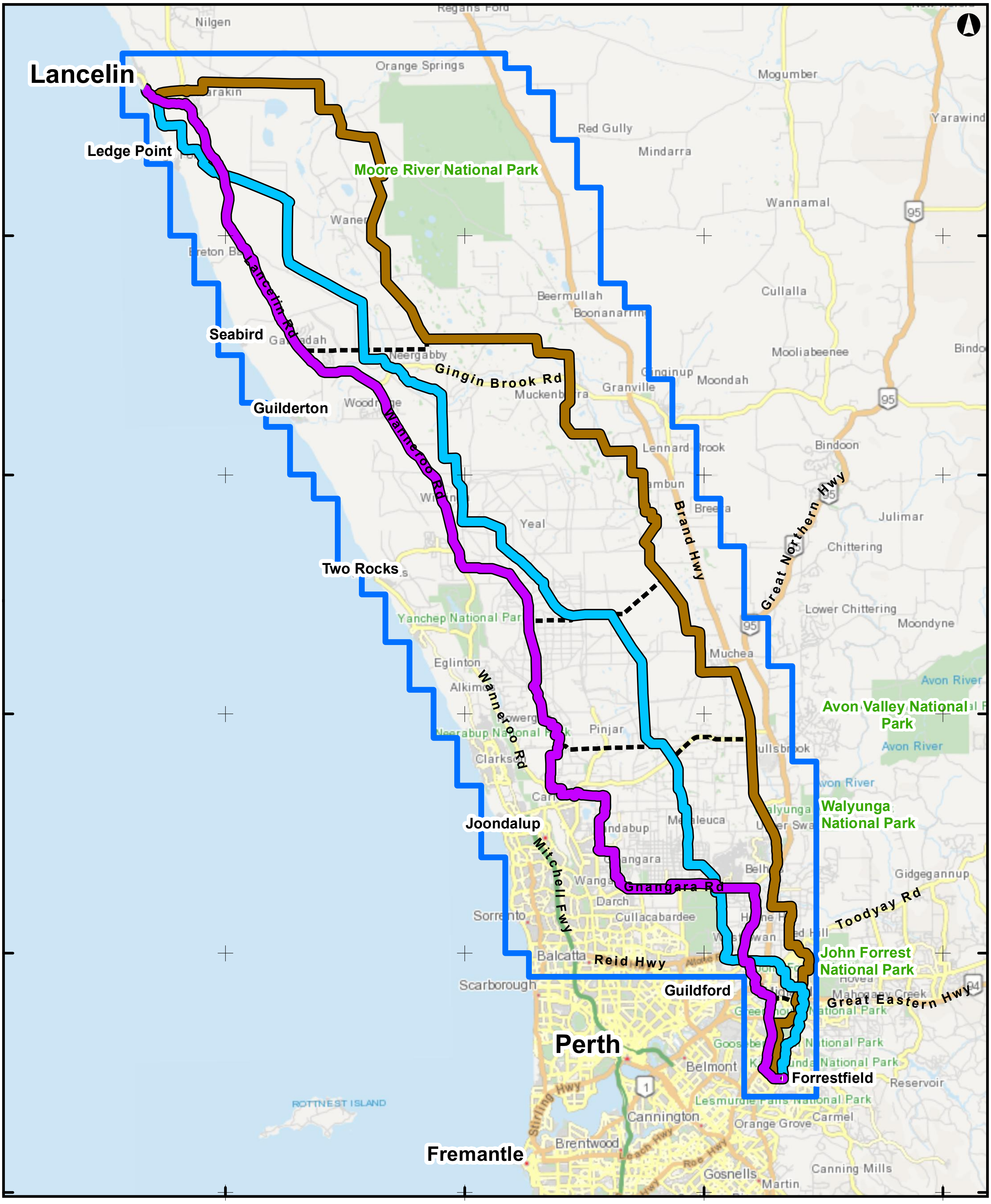
4.4 Results

The scores and placings for the various MCA "runs" are summarised below in Table 14, showing the three initial preferred options colour coded (E, D and A).

Table 14 MCA Results

Run	Description	Placing					
		1	2	3	4	5	6
1	Initial Weightings	E	D	A	C	B	F
2	Revised Weightings	E	C	A	D	F	B
3	Capitalist	C	E	A	D	B	F
4	Environmentalist	E	A	D	C	F	B
5	No Weightings	E	C	A	D	B	F
6	Revised Criteria (using Run 2 Weightings)	E	C	D	A	B	F
7	Changed Criteria (as Run 6+ new criteria: transmission lines/urban conflict)	E	A	B	D	C	F

In summary; the results of the sensitivity testing confirmed that Option E is clearly preferred and Options D and A are sound additional options. These routes are shown in Figure 22.



Three Preferred Routes

Figure 22

Coordinate System: GDA 1994 MGA Zone 50

0 5 10 15 20

Kilometres

1:550,000 (A4)

LEGEND

- Study Area
- Route A
- Route D
- Route E
- Laterals

AECOM does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. AECOM shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

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5.0 Route Optimisation

Subsequent to the initial site selection process and the MCA evaluation, the three preferred route options (Option E, A and D) were reviewed in more detail.

The first stage of this review involved minor adjustments to corridors to minimise traversing high risk areas, that were addressed following the MCA. The reviews concentrated on areas in close proximity to High Voltage power lines that had been identified as High Risk during the MCA process.

The second stage of review included a field visit. The field visit was undertaken over two days including driving along some of the routes between Forrestfield to Midland and Swan Valley on the first day and traversing the remaining section to Lancelin on the second day.

A number of GIS positioned photographs were taken during the visit, along with recording relevant observations to contribute to optimisation of the routes.

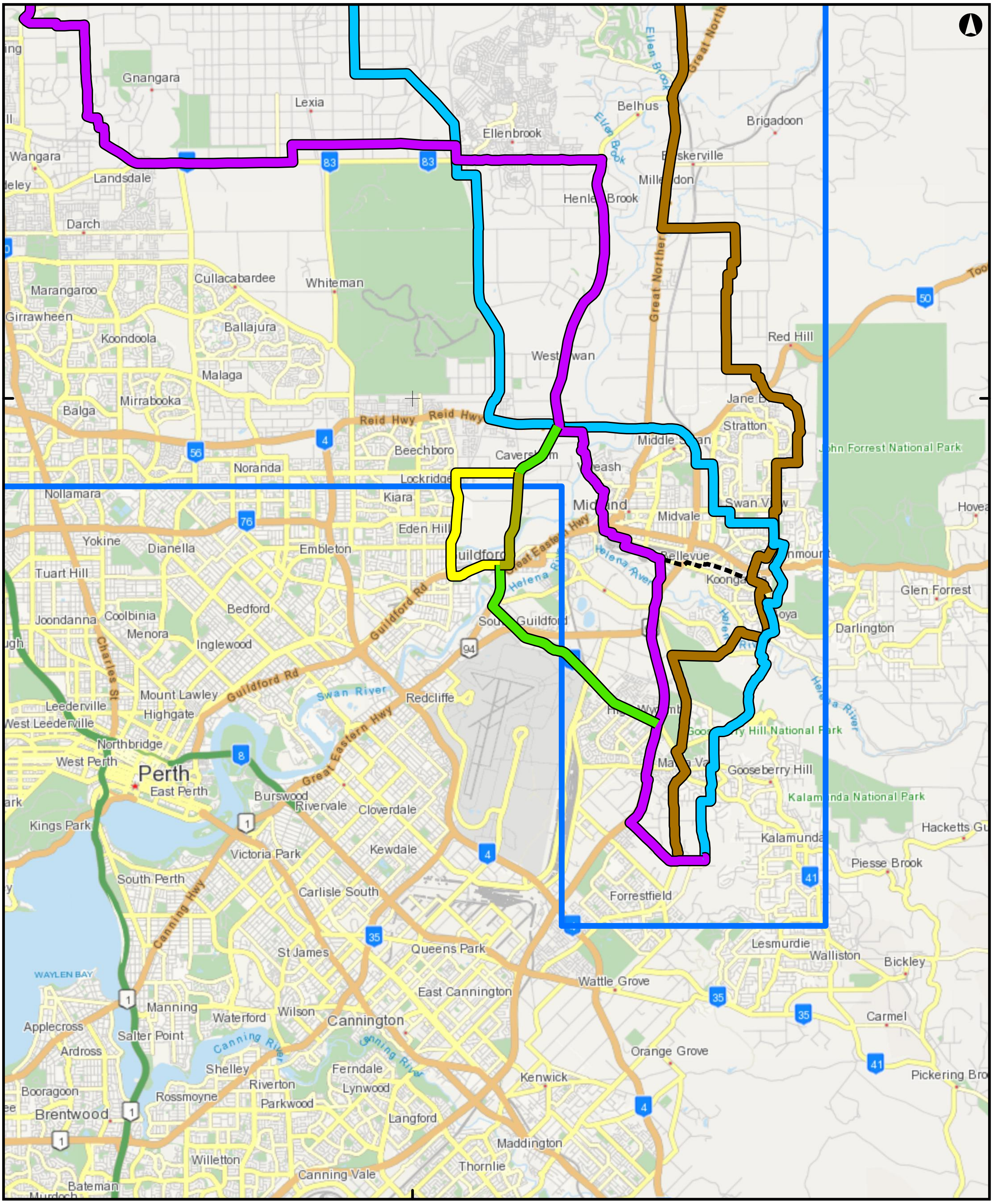
The itinerary of the field visit is detailed in Appendix B.

The field visit identified the following issues within selected corridors, which had not previously been considered:

- Road and land layouts were found to be different on the ground to that observed in aerial imagery.
- There were areas of recent and planned development that were not shown in the aerial imagery.
- In some locations, the available easements were very steep and therefore the opposite side of the road would be preferable.
- Large mature trees would in some locations need to be cut and that could represent environmental impacts.
- Better alternative routes were identified on the ground, which reiterated the benefit of the site visit.

Final optimisation of the routes included consideration of an alternative route that traverses through the township of Guildford, in an attempt to avoid the highly constrained area of Midland. This additional route is shown in Figure 23.

The route optimisation, as well as the addition of the “Guildford alignment”, was not intended to select a different set of preferred routes, because the spatial constraints analysis resulting in the Heat Map and the results of the MCA were definitive. Therefore, the outcomes of this assessment confirmed that Routes A, E and D were still preferred, but resulted in an optimised alignment of these corridors.



Guildford Alignment

Figure 23

Coordinate System: GDA 1994 MGA Zone 50

0 1 2 3 4

Kilometres

1:150,000 (A4)

LEGEND

Study Area	Guildford Option
Route A	Route A1 / A2
Route D	Route A1 only
Route E	Route A2 only
Laterals	

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6.0 Next Steps

As per the project scope agreed with the Water Corporation, now that the three preferred routes have been selected, detailed assessment of the values supported within the 100m wide corridors (where available) will be investigated.

The values to be investigated by AECOM primarily include flora, fauna and contamination, as well as other soil risks such as Acid Sulphate Soils (ASS).

Heritage assessments will be carried out internally by the Water Corporation.

Stakeholder and Community Consultation is underway and includes informing stakeholders of the project and assessment process. Notifications of Entry for landholders whose property supports native vegetation that requires detailed assessment during spring 2012 and possibly beyond is also underway.

Following collection of data relevant to environmental values, a Strategic Environmental Assessment will be carried out to obtain statutory approvals to enable the Water Corporation to secure preferred corridors. This will facilitate long-term planned development of preferred corridors. At the time of preparation of this report, the State Referral were in preparation, in collaboration with the Water Corporation.

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Appendix A

MCA Workshop Minutes

Appendix A MCA Workshop Minutes

AECOM

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Minutes of Meeting

WC Northern Corridor

Subject	MCA Workshop with WC	Page	1
Venue	AECOM, Level 6, Room 6.4	Time	09:30-14:00
Participants	**Water Corporation:** Jeff White- Project Manager, Conveyance Group Lorna Maguire – Environmental Scientist (Approvals) Graeme Hughes – Infrastructure Planning Bernice Nolan – Community Engagement **AECOM:** Abra DeKlerk – Technical Director - Facilitator Shona Gatenby – MCA Development Kellie Honczar – Project Manager Kathryn Jones – GIS Analyst David Klap – GIS Oversight Prem Mirihagalla –Principal Water Engineer John Braid – Environmental Scientist Nicola Kingdon – Note Taker		
Apologies	Anthony McLaughlin, Water Corporation		
File/Ref No.	60265480	Date	21st June 2012
Distribution	As above		

No	Item	Action	Date
1	**Safety Moment – Driver Safety and Fatigue** KH **Housekeeping and Evacuation** KH **Introductions**		
2	**Explanation of Constraints Mapping and MCA** ADK Goal of Constraints Mapping exercise is to identify opportunities, restrictions and constraints, ultimately minimising environmental constraints and impacts in the instance of this project. The mapping utilises a combination of database information and overlays one upon the other. The process identifies fatal flaws – areas to be avoided – which permits removal of any options that could encounter these fatal flaw areas. Overview of example data sets shown on the screen. Example of previous project mapping outputs shown on the		

No	Item	Action	Date
	screen. In-house MCA tool is utilised by AECOM. MCA comprises 4 critical steps: - Definition of criteria - Identify assessment methods - Weight the criteria - Technical scoring of criteria performance Results of the AECOM MCA tool are shown as bell curves in a graph. Refine data and further investigate preferred options.		
3	**Summary of Work Completed – Overview of Spatial Analysis** KJ Collection of spatial data – publically available data sources + information sourced from the WC. Utilised 64 datasets - 45 environmental datasets - 2 heritage - 12 infrastructure (gas, water, road, rail) - 6 planning (land use) Consultation with technical teams within AECOM. Ranking of datasets in risk and benefit categories. Application of ranking and some datasets had buffers applied. E.g. Priority 1 and 2 flora datasets were given a 50 metre buffer to signify the level of importance / risk. Spatial Analysis: all 64 datasets are overlaid one upon another and combined into one composite map. A program is run which calculates total risk, total benefit, and cumulative risk/benefit score. Outputs are shown as heat maps where risks are shown in a tone of red and benefits are in a tone of green. Where risk outweighs benefit the site will be shown as red (and conversely where benefits outweigh risks the area will be shown in green). Anything rated as high risk cannot be outweighed by any level of benefit.		
4	**Overview of Preliminary Route Selection** PM Clarification of start and end points of the corridor. There is a reason for every 100m of corridor selected, however this can only be viewed when zoomed in.		

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No	Item	Action	Date
	Route A 1. Option A of the Corridor starts from Lancelin, follow Lancelin Rd, Indian Ocean Drive, turn east and go bush just past Ledge Point turn off, follow 66kV overhead power line over 60km. 2. We then thrust bore under Moor River and Gingin Brook with a pipe bridge attached to the road bridge. This is inland, east of Guilderton. 3. Leave the power line corridor just north of Yanchep Reserve at Military Road and Hydro Rd all inside the Pine plantation. 4. Follow various road reserves like Aqua Road almost up to Carabooda. Serve Carabooda reservoir. 5. Then go south east past Pinjar etc and serve Nowergup reservoir. 6. It branches just south of Joondalup Drive north of Wanneroo, one branch goes east to serve Neerabup Reservoir and the other south to serve Wanneroo reservoir. 7. Pass on the western side of the Joondalup Lake and go south past Badgerup up to Gnangara Road where it is supposed to connect to Ocean Reef Road. 8. Sit on the south verge of Gnangara road for 16km until it meets West Swan Road. On the way it serves Gnangara reservoir which is located about 6km north of Gnangara road. 9. Follow the eastern verge of West Swan Road all the way south up to Reid Highway. 10. Turn south at Great Northern Hway towards Midland. We keep to both western and eastern verge to avoid the HP Gas main and go past the Swan District Hospital. 11. Pass the Midland Town centre with some possible thrust boring, using car parks and backyard of shopping centres. 12. Thrust Bore under the railway lines along the alignment of Helena Street where there are no other thrust bored services. 13. Go east on Foundry Road and then attached to Clayton bridge over Roe Highway up to Greenmount Reservoir if required. 14. Otherwise branch off south along Lloyd Street etc, passing across Helena river with thrust boring under river bed. There it is a dry bed with pedestrian access. 15. Follow Vale Road and Abernethy Road, thrust bored under Great Eastern Bypass and then Kalamunda road. Thrust bore under Roe Highway near the intersection with Kalamunda Rd. 16. Follow Roe Highway eastern verge up to Maida vale Road and then use Brewer Road to get to Forrestfield reservoir or Foothills which is very		

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No	Item	Action	Date
	close by. **Route B** 1. Option B starts from Lancelin, follow Lancelin Rd up to the Golf Course entrance, follow the southern boundary of new south Lancelin development and Old Ledge Point Road. 2. Pass east of Ledge Point town following farm tracks traverse south through vacant land east of the coastal dunes. 3. Follow Greenwood coast road, cross Lancelin road (thrust bored) and go eastwards pass the first 66kV OH power line up to the second 66kV OH power line corridor close to Brand Highway at Gingin. 4. Follow Brand Highway reserve almost up to Muchea. Branch off to the west, just south of the Gingin airstrip through open land to serve Yanchep Reservoir 5. Continue south following Muchea South Rd parallel to the railway line. 6. Branch off to the west on to Ellenbrook Drive at Upper Swan and other minor road reserves to service reservoirs at Carabooda, Nowergup, Neerabup and Wanneroo. 7. Proceed south following Great Northern Highway reserve up to Roe Highway and then follow Roe Highway reserve. 8. Branch off on Helena Valley Road to service Greenmount reservoir if required 9. Proceed south along Roe Highway up to Sultana Road to service Forrestfield Reservoir. **Route Ci and Cii** 1. Follow Lancelin Road up to Golf course and then same as Route B up to Indian Ocean Drive at ledge Point. 2. Continue on Lancelin Road/ Wanneroo Road reserve over 70km all the way to just south of Yanchep Park. 3. Follow the reserve of minor roads to the west up to Two Rocks, branching off on the way to service Yanchep Reservoir. 4. Proceed south following Toreopango and Marmion Avenue, past Yanchep Beach Road up to Eglinton. Turn east on to Pipidinny Road and follow this road up to Wanneroo Road at Carabooda. 5. Serve Carabooda Reservoir and proceed south up to Joondalup Drive. Serve Nowergup and Neerabup reservoirs on the way. 6. Proceed east along Joondalup Drive up to Pinjar Road, then southwards to serve Wanneroo reservoir. 7. Proceed south following Badgerup Road up to Ocean Reef Road and then a short distance along		

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No	Item	Action	Date
	Gnangara Road up to Alexandra Drive. 8. Serve Gnangara Reservoir with a long branch along Gnangara Road. 9. Turn east to follow road reserves of Hepburn Avenue, Beechboro Road and meet Reid Highway south of Whiteman Park. 10. Proceed all the way on Reid Highway and Roe Highway road reserve up to Morrison Road. Great Northern Highway, Toodyay Road and Morrison Road crossings will be thrust bored. 11. At Midvale a short section of Option C is subdivided C1 and C2. C1 is to thrust bore under the railway at the same location as a water main and C2 is to pass over the railway with a pipe bridge attached to Great Eastern Highway overpass at Midvale. 12. Follow the reserve for other water mains along Railway Heritage Trail. Pass Greenmount Reservoir if required. 13. Follow narrow road reserves of Ridgehill Road and other minor roads. Follow Hawtin Road to reach Forrestfield reservoir . **Route D** 1. Follow the same route selected for Option A up to Moore River crossing east of Guilderton. 2. Proceed east following farm tracks up to the second OH power line corridor and follow it all the way south up to Gnangara Road. This corridor is midway between Corridors A and B. 3. Branch off to the west at Kestral Road to serve Yanchep and Carabooda, Nowergup and Neerabup reservoirs. Branch off to the east at Tick Road following bore main corridors to serve Gnangara Reservoir. 4. Proceed south along Beechboro Road up to Reid Highway and proceed east and then along Roe Highway, on the same corridor selected for Option C up to Morrison Road. 5. Thrust bore under the railway lines across Morrison Road. 6. Turn south to Amhurst Road and other minor roads up to Great Eastern Highway. There is a water main crossing at the same place under Great Eastern Highway. The corridor runs adjacent to existing water mains almost all the way. 7. Follow existing water main corridors pass Greenmount Reservoir. Follow narrow road reserves such as Ridgehill Road and Scenic Drive up to Forrestfield Reservoir. **Route E** 1. Follow Lancelin Road up to the Lancelin Wastewater ponds and proceed east through 24km of open land past Seaview estate.		

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No	Item	Action	Date
	2. Turn south at Cowalla road, cross Moore Rover with a pipe bridge attached to Cowalla road bridge. 3. Turn south east and continue across open undeveloped land (parkland) up to the second HV OH power line corridor. 4. Proceed south up to east of Nowergup and branch off to Nowergup, Carabooda, Neerabup and Wanneroo reservoirs. 5. Branch off west at The Vines to serve Gnangara Reservoir and proceed south across West Swan Road up to Great Northern Highway. 6. Follow Great Northern Highway up to Padbury Road at Herne Hill. Thrust bore under railway. 7. Proceed south along minor roads in the Swan Valley vines area such as Moore Road and thrust bore under Toodyay Road opposite Jane Brook. 8. Pass through Jane Brook to Midvale. Thrust bore under Morrison Road and Great Eastern Highway. 9. Follow a route similar to Option C and D via Greenmount to Forrestfield reservoirs. **Route F** 1. Starts like Option A to Indian Ocean Drive 2. Cross Moore River at Pipe bridge 3. Follow Indian Ocean Drive 4. Yanchep Reservoir 5. Difference is a diversion along Picadilly Road to reach Marmion. Join Marmion, proceed south past Clarkson. Route is west of all existing tasks. The route is always in a road reserve. 6. Feature – passing very close to Alkimos. 7. Avoiding HPGM in Marmion 8. Kinross, turn east, thrust bore under minor roads to Mitchell Freeway. 9. Follow Mitchell Freeway reserve to Reid Highway. 10. Branch line needs to cross the railway.		
	Points and Questions Utilising the high voltage power line would be considered as a high level risk to the WC. Prefer to be 5km from HV power lines or require voltage mitigation. Cathodic protection is a form of voltage mitigation but is deemed expensive. Overall this is a cost risk and has not been considered in detail in this analysis which focuses upon risk to environmental approvals. Some concerns raised regarding areas on the maps which appear to be beneficial when known constraints are located in these areas. This is a result of the combined mapping, which in itself was based upon agreed risk ratings of each database. Agreed to run through the MCA and then revisit the risk ratings in the mapping if necessary.		
-	Break for Morning Tea		

No	Item	Action	Date
5	**Multi Criteria Assessment** - Review of criteria descriptions and how each criterion is measured. <u>Comments</u> Need to show where a 100m corridor is impossible, for example through current built up areas. Would be good to see where the high, medium and low risk environmental areas occur for each corridor. Concern raised regarding risk associated with planned urban development. Less of an issue if the pipeline corridors are reserved now before this development occurs. Not convinced "quality of access" is particularly important. Believe that Karst formations will be over very low significance for this assessment. MCA could be trialled without these Query about why there are limited social assessment criteria. Request to assess where MRWA roads are used rather than an alternative road reserve (on the basis that MRWA will have sway over whether the reserve can or cannot be utilised). Community and social impacts easier to measure at a more detailed stage of the project, and will be a key differentiator when refining the corridors. - Review of measurement method - Review of Weightings <u>1st Round Agreement:</u> Criterion 1 – Med/High Criterion 2 – Med Criterion 3 – Med Criterion 4 – High Criterion 5 – High Criterion 6 – Med Criterion 7 – Med/High Criterion 8 – Med/High Criterion 9 – Low Criterion 10 – Med Criterion 11 – Low Criterion 12 – High - Review of Planning Balance Sheet The "C" options may be harder to obtain a 100m corridor. Run Results #1: 1 – E 2 – D 3 – A 4 – Ci and Cii 5 – B 6 – F **Sensitivity Testing**		

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No	Item	Action	Date
	Amendment to Weightings <u>2nd Round Agreement:</u> Criterion 1 – Med/High Criterion 2 – Med Criterion 3 – Med Criterion 4 – High Criterion 5 – High Criterion 6 – Med/High Criterion 7 – Med/High Criterion 8 – Med/High Criterion 9 – Low Criterion 10 – Med Criterion 11 – Low Criterion 12 – Med Run Results #2: 1 – E 2 – C 3 – A 4 – D 5 – F 6 – B Amendment to Weightings – Exaggerated (to test robustness of MCA model) *Capitalist Engineer:* 1 – C 2 – E 3 – A 4 – D 5 – B 6 – F *Radical Environmentalist:* 1 – E 2 – A 3 – D 4 – C 5 – F 6 – B *No Weightings:* 1 – E 2 – C 3 – A 4 – D 5 – B / F Revised Criteria (removal of Criterion 2 and 11) 1 – E 2 – C 3 – D 4 – A 5 – B		

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No	Item	Action	Date
	6 – F <u>Discussion Conclusion</u> Remove the alignments out of the HV power line easements. Start with a 5km buffer. **Sensitivity Testing – Revised Criteria** Addition of “Transmission Lines” and “Conflict with Urban Development” as 2 new criteria and continued removal of “overall benefit” and “Karst” criteria. <u>Criterion 11 – Longitudinal Clash with Transmission Lines</u> (Qualitative – Poor / Poor Fair / Fair / Fair Good / Good) - Route A – can be moved – Good - Route B – small length (2-4km), potential to be moved or mitigated – Good - Route C – reasonable length along Wanneroo Road (8km) cannot be relocated – Poor Fair - Route D – reasonable length which can be moved (similar to A) + reasonable length (63km) which cannot be moved – Poor Fair - Route E – reasonable distance which can be moved + reasonable distance (15km) which cannot be moved – Fair - Route F – reasonable length which can be moved + reasonable length (8km) which cannot be moved – Poor Fair <u>Criterion 12 – Conflict with Urban Development (Impact)</u> Route A – 3rd Route B – 2nd Route C – 4th Route D – 2nd Route E – 1st Route F – 5th Results: 1 – E 2 – A 3 – B 4 – D 5 – C 6 – F B is significantly different from the other routes but only scores well in Run 7 due to less impact on transmission lines and conflict in the urban area. D is considered to have the best elements already contained in E and A. **Preferred Routes For Further Investigation**		

No	Item	Action	Date
	1 – E 2 – A 3 – D D is viewed as a combination of Routes E and A (where E and A already score more highly under every analysis). C is knocked out because of conflicts in the urban area. F is knocked out as it scores very badly in every run. B is knocked out because the branch lines are very long and this option will be compromised if cost is considered very important.		

Appendix B

Site Visit Itinerary

Appendix B Site Visit Itinerary

Day 1

1) Forrestfield Tank – Berkshire Road from Roe Highway. Check route to the east – Identify a gap for the corridor. Check out reserve on Hawtin and Sultana Roads.
2) Sultana road east – determine preferred side of road. Location for Directional Drilling under Roe Highway.
3) Roe Highway – Select Left or Right reserve.
4) Passing Kalamunda Road.
5) Passing Great Eastern Highway Bypass.
6) Turn left on Great Eastern Highway Bypass and right to Stirling Crescent, right to Bushmead and left to Military Road.
7) Passing through wetland of Helena River.
8) Railway Roads – any visible constraints.
9) Crossing Roe Highway under bridge.
10) Continue on Clayton Street, turn right at Katherine Stree and right turn at Scott Street, pass the bridge, turn right to Helena Valley Road and turn west just before Samson Sreet. Check land availability.
11) Go round Helena Valley Road and turn left to Midland Road, check other end of open land section just after Talbot Road.
12) Check reserve after Sadler Road.
13) Check intersection with Kalamunda Road.
14) Check easement on Hawtin Road.
15) Proceed north on Hawtin Road up to Maud Road , then right to Holmes and drive 1.2km. Is there a tank here? Is there a clear gap for corridor Option D?
16) Proceed north on Holmes, right to Norwood, left to West Terrace, cross Kalamunda Road, Scenic Drive, Scenic Drive is not continuous. Return and take Watsonia Road, Gooseberry Hill Road, north to Watsonia, right turn to Ridge Hill Road, straight to Maguire Road, right to Ridge Hill Left to Helena Valley Road , right to Scott Street. Check space for construction of a pipe bridge across Helena River.
17) Follow Scott, Marriot, Coulston to Tank site at Greenmount Hill (Check out tank site access at Coulston and Fredder Roads).
18) Check out access along old rail track – just before Coongan Avenue.
19) Take Scott Street to Great Eastern Highway and go west past Roe Highway on to Victoria Sreet and turn left to Helena Street. Check out Rail crossing at Helena Street and warehouse area on Yelverton Drive. Are there any railway workshops here?
20) Return on Helena St and check practicality of running through Midland town centre (Morrison/ Great Northern Highway).
21) Turn right to Morrison, pass Roe Highway and turn right to Farrell Road and first left leading to Park Road and check Rail Crossing on Gladstone Avenue.
22) Return to Farrell Road, turn left, then right to Rothschild to end to see possibility of thrust boring under Roe Highway.
23) Return to Farrell Road, right to Morrison Road, turn left to Talbot Road, all the way past Jane Brook. Check out Pipe Bridge on Talbot Road across Jane Brook.
24) Check out location of Pipe crossing Toodyay Road and open land.
25) Turn left to Toodyay Road and after Roe Highway, turn right to Viveash Road. Turn right to Great Northern, turn left at intersection to Roe Highway, check out the new bridge over Swan River and U turn.

Day 2

1) Proceed north on Great Northern Highway and turn right to Oakover Road, (just after George Road) cross railway and left to Gugeri Road in Swan Valley.

2) Continue north, right to Stock Road, left to Campersic and left to William St, right to Moore Road, left to Padbury Ave. Check out Rail Crossing on Padbury Road Swan Valley.

3) Follow north on Great Northern, left to West Swan,
13A Follow West Swan Road south checking out both sides of the road – which is best?
13B Intersection Reid/West Swan turn right go west on Reid Highway.
13C Turn Right to Lord Street, which reserve is best?
13D Turn right to Gnangara Road and U turn at Henley Brook Circle.

4) Proceed west on Gnangara to Drumpeller Drive,
14A Check out corridor through Pines north of Gnangara road (0.5km from Gnangara Road) for option A
14B Check out open land corridor at a point 1.3km from Gnangara Road.– then make a U turn.

5) Gnangara Road just after Alexander Drive – Check out northern reserve. Is there a wetland risk near the road north of the road?

6) Proposed Ocean Reef Road connection to Gnangara Road – is there any road reserve?

7) Proceed west on Gnangara, turn right to Prestige, left to Ocean Reef, Right to Callaway and right to Badgerup Road and go north.

8) Check out intersection Badgerup Road and Lakelands Drive.

9) Travel North on Badgerup, turn left to Ashby, right to Benmuni and check out corridor through the Park.

10) Go north on Franlklin and left to Belgrade and check out intersection.

11) Wanneroo reservoir entry and proceed west to Wanneroo Road.

12) Turn right on Wanneroo Road, right into Pinjar Road, all the way to Joondalup Drive circle and check out northern verge along the circle.

13) East on Joondalup Drive and photos of circle at Tumbleweed Drive.

14) Straight on to Neaves Road and corridor of Route D located 1.6km from Timely Hostess Mews (just after HV overhead line).

15) Continue east on Neaves Road and turn left to Muchea Road going parallel to railway line.

16) Go north past Muchea on Brand Highway, – pipe turns to Chittering Street.

17) Continue north and turn left to Gin Gin Brook Road.

18) Pipe option E passes 1.35km from Sandringham Road.

19) Continue west and 1.6km past Neergabby where Option D cross the road.

20) Moore River Crossing.

21) West along Gingin Brook Road to Indian Ocean Drive. Another 55+55km (2 hours).
If there is time go to Lancelin, otherwise return to Perth where option D joins at Bennies Road.
Golf course route option, Sewage pond route option.

22) Corridor diverts east along fire break just before Yanchep National park 700m after Military Road.

23) Proceed south just past Yanchep park entrance turn left to Old Yanchep Road. Corridor Option A joins from Aqua Road. No tank at Carabooda site.

24) Proceed south on Old Yanchep/Pinjar Road and turn right to Wesco Road.

25) Check out from 2.5km to 3.7 km on Wesco Road.

26) U Turn and return to Old Yanchep Road. Drive south on Pinjar and turn right on to Wattle Avenue east and check out 1.5km to pipe corridor.

27) Proceed south on Pinjar and right to Pedrick St. Branch line of Option D runs along this road.