HYDRO FUTURE CONSULTING

NORTH TERRACE DRAINAGE DESIGN

DETAILED DESIGN BRIEF

6th May 2015

PROJECT MANGEMENT TEAM

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Wednesday, 5 May 2015

Tim Kerby, Faisal Ahammed
Tonkin Consulting
2/66 Rundle Street
Kent Town SA 5067

RE: Detailed Design Brief to undertake the Detailed Design for the North Terrace Drainage Upgrade.

Dear Tim and Faisal,

Hydro-Future Consulting would like to formally extend their interest in undertaking the Detailed Design for the upgrade of the North Terrace Drainage System.

Having extensive experience of the project area, as we produced the feasibility study, we believe we are in the ideal position to conduct the Detailed Design and that our company will continue to deliver outstanding results as per our proven track record. Furthermore, specialising in Civil Engineering with extensive experience we are supremely confident that a solution can be provided that exceeds all expectations.

After a thorough investigation of the required scope of the work, taking into account all considerations and potential issues that may become apparent during the project, Hydro-Future have determined that the value of the detailed Design for the upgrade of North Terrace Drainage System to be:

$325,500 (GST included)

This value is based on an extensive review of the information provided. It is valid for a period of three months from submission. On behalf of Hydro-Future, I would like to thank the clients for the consideration of our application, and in the event that further information is required please do not hesitate to contact us.

Yours sincerely,

Hugh Burger

Project Manager

Hydro-Future Consulting

Declaration

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Hydro-Future Consulting Pty. Ltd.

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Declaration Statement:

Hydro-Future declares this Design Brief document is accurate at the time of printing.

Hugh Burger	Signed:
Project Manager	Date: 5th May 2014
David Argent	Signed:
Assistant Project Manager/ Quality Manager	Date: 5th May 2014

Executive Summary

This report presents the Detailed Design Brief for the North Terrace Drainage Upgrade, located between Hackney Road and College Road, Kent Town. Hydro-Future Consulting has conducted a thorough feasibility study on the project area and has identified one solution utilising a combination of traditional stormwater management methods and water sensitive urban design (WSUD).

The main purpose of the detailed design is to alleviate significant flooding to the project area after heavy rainfall events. It aims to improve the quality of the stormwater entering the receiving environment, provide improved visual amenity, provide water harvesting options, as well as being cost effective.

Information within this design brief provides an outline of the direction Hydro-Future will take in conducting the Detailed Design, clarifying key issues and providing information that is directly relevant to the design in order to allow for a smooth transition to the design phase.

The fundamental objectives of the detailed design phase include:

1. Conventional Stormwater Management Design
2. Gross Pollutant Trap Design
3. Bio-Retention Basin
4. Water Harvesting
5. Environmental Management Plan
6. Traffic Management Plan
7. Protect Culture and Heritage
8. Social acceptability
9. Community consultation
10. Retaining wall design
11. Structural analysis of a sandstone arch culvert
12. Safety
13. Construction and operation Issues
14. Detailed costing of the entire project
15. Detailed drawings of relevant aspects of the project
16. Detailed recreational amenities
17. Technical specifications
18. Construction of a project website

Version Number	Purpose/Change	Name	Date
0.1	Draft Compilation	David Argent	03/05/2015
0.2	Addition of Costing	David Argent	03/05/2015
0.3	For Review by PM	David Argent	05/05/2015
0.4	Final review/editing	Hugh Burger	05/05/2015

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1. Scope for Detailed Design

The Detailed Design will require certain items to be supplied upon completion. These will form the core of the Detailed Design and will contain all the necessary information. The following documents will be provided in both soft copy and hard copy forms as per the convenience of the client.

1. Detailed Design Report
2. Environmental Management Plan
3. Quality Management System

Contained within these documents the following information will be outlined in the appropriate manner.

1. Design calculations
2. CAD drawings
3. Contract documents
4. Technical specifications
5. Project Website

1.1. Organisational Structure

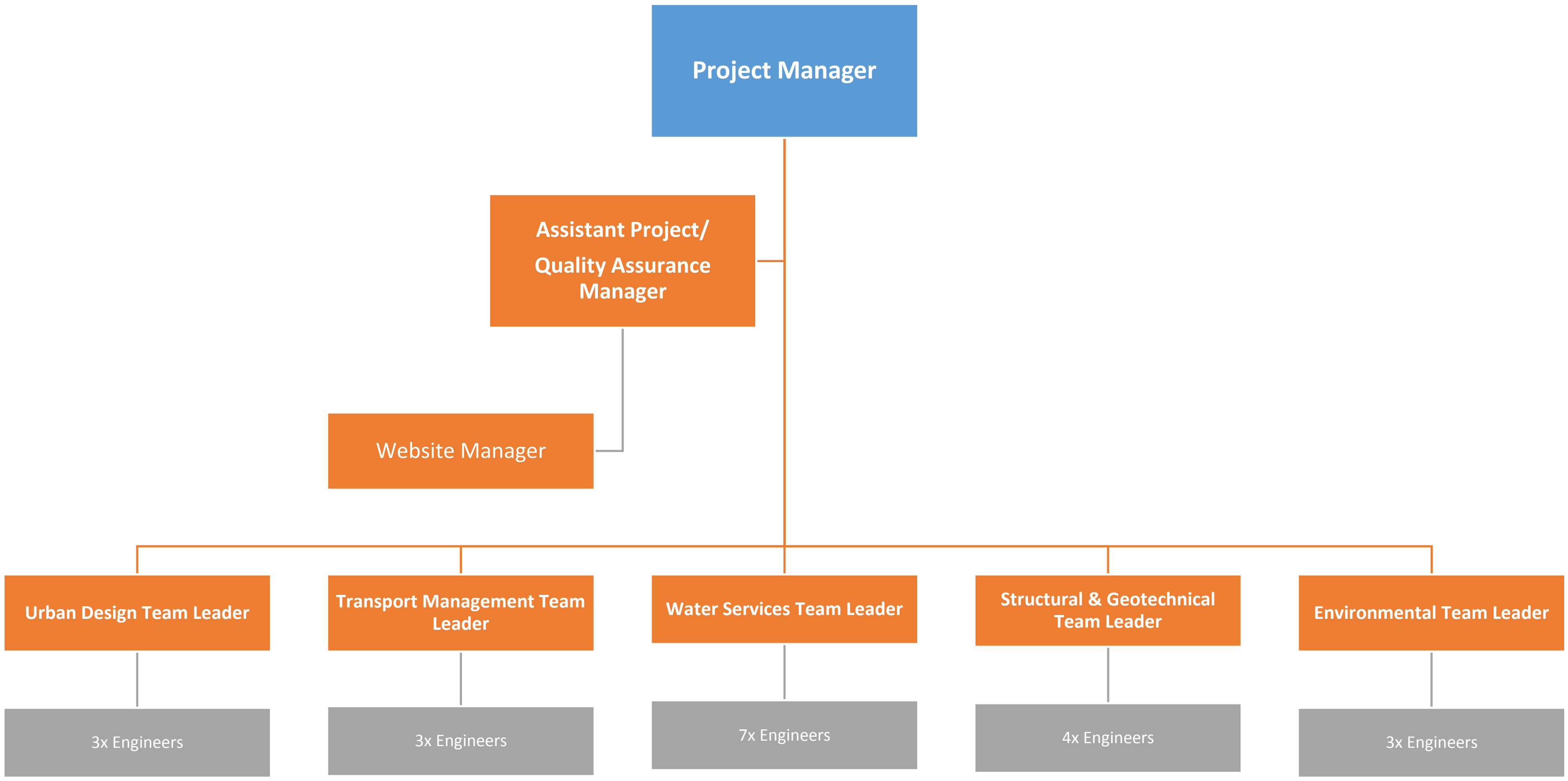


Figure 1: Organisational Structure for Detailed Design

2. Water Considerations

2.1. Introduction

The City of Norwood Payneham and St. Peters is a metropolitan council, covering an area of 15.1km^2, east of Adelaide's CBD. One of the primary services that the council provides for the 34,000 residents is the stormwater drainage network. The drainage network allows for the effective collection of surface water in the area and provides flood protection throughout the city. The majority of the system comprises of stormwater pipes, pits, junction boxes and culverts, the stormwater makes its way to First Creek, the River Torrens and ultimately Gulf St Vincent.

Over the years it has become apparent that as a result of heavy rainfall events, North Terrace Kent Town has suffered significant flooding from College Road through to the Royal Hotel. The council would like to develop a stormwater solution to resolve these flooding events and future proof the existing system against any heavy rain events that may occur. The new solution aims to include water sensitive urban design (WSUD) technologies, be cost effective and to improve the quality of the water before it exits the system into First Creek.

North Terrace is a major arterial road on the outskirts of the CBD and has for many years experienced flooding issues as a result of major storm events, particularly between Hackney Road and College Road, as is shown in Figure 3. The existing infrastructure has proven to be inefficient in providing quality flood mitigation along North Terrace and as a result requires an update in terms of new infrastructure and drainage solution options.

A feasibility study has been conducted, and a combined drainage solution was considered to be the most feasible (as shown in Figure 2) and will be analysed in greater detail during detailed design. It will consist of;

- updating the conventional storm water system
  - Incorporating Gross Pollutant Traps (GPTs)
- Implementing water sensitive urban design (WSUD) measures;
  - A bio-retention basin, and;
  - A series of rain water tanks to collect storm water.

Figure 2: Image highlighting the potential locations of the combined drainage option (Hydro-Future, 2015)

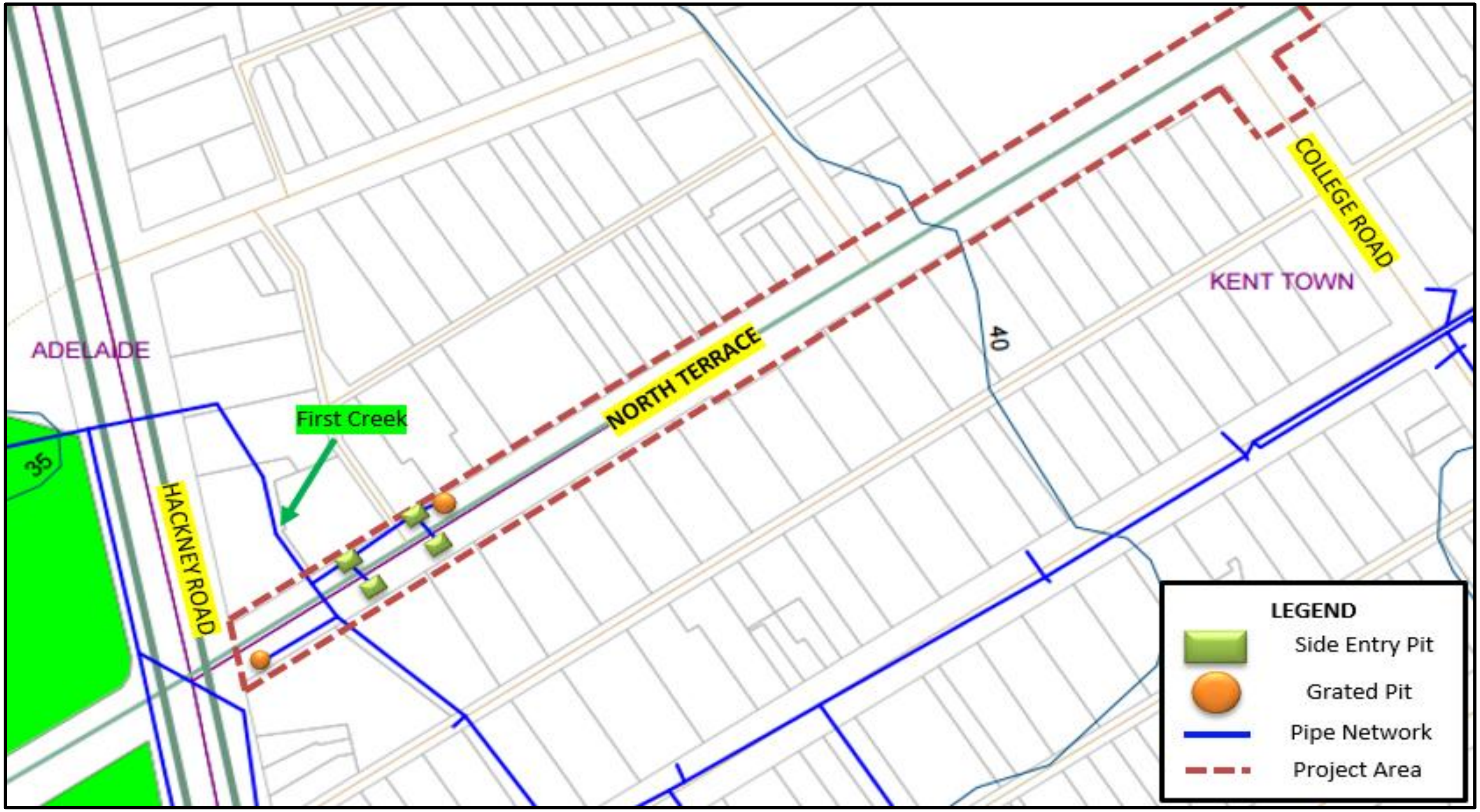


Figure 3- Diagram of project area and its existing respective infrastructure (Hydro-Future Consulting, 2015)

2.2. Design flow

The preliminary calculations presented in Sections 2.1.1 and 3.4.1.5.1 of the feasibility study will be further refined during detailed design.

2.2.1. Conventional Storm water Design Flow

During the detailed design the following points will need to be addressed in regards to the conventional storm water design:

- The catchment will be divided into more sub-catchments, equal to the number of pits that will be used.
- The time of concentration for each catchment needs to be accurately calculated.
- Average Recurrence Interval (ARI) of 1:20 year for the entire project area.
- The combined drainage option will subtract the area of roof that is draining into designed rain water tanks from catchment areas and disregard water captured by the bio-retention basin.
  - Stormwater system will capture all design flow, with a reduction in catchment area due to rainwater tanks.

Therefore, the conventional storm water system has to be designed for the difference between the total conventional runoff and the runoff that will be captured via the rain water tanks.

2.2.2. WSUD Design Flow

The design flow required for design of the bio-retention basin WSUD option was included in Section 3.4.1.5.1 of the Feasibility Study, this will be further refined for detailed design.

2.2.3. New Stormwater Drainage Infrastructure

During the detailed design stage an update to the existing stormwater system in terms of new infrastructure is required to be designed. As per the decision in the Section 3.5 of the Feasibility Study, the conventional storm water system will be combined with WSUD and water harvesting options. In Section 3.2 of the Feasibility Study, preliminary calculations for the conventional storm water system were calculated, however these findings need to be calculated more accurately in the detailed design stage. The following considerations were made as a result of the preliminary calculations and investigations which have to be addressed in more depth in the detail design stage.

2.2.4. Drainage System Extension

Section 3.2 of the Feasibility Study considers an extension to the existing storm water infrastructure of 700m along North Terrace from the stretch of road between First Creek and College Road. The system extension length was found using a conceptual DRAINS model.

Therefore, the suggested extension length can be reduced in the detailed design according to the accurate run off volumes with the new combined option and more accurate sub-catchment areas which will need to be calculated. Figure 48 in the Feasibility Study represents the proposed storm water infrastructure addition and their respective locations. This preliminary location and the inlet numbers may require alteration during the detailed design depending on final findings and results.

2.2.4.1. Pits

The suggested number of pit and pit types are depicted in Section 3.2.1 of the Feasibility Study. A number of requirements to be considered during detailed design include:

- Sag/Grated pits have to be located within the trapped low point (sag area) in North Terrace near Hackney Road. However, the exact location and the span of the sag area is required to be identified in the detail design stage.
- The maximum spacing between two pits has to be in accordance with WSA Codes (100 metres).
- The pit types have to be confirmed according to the City of Norwood, Payneham and St Peter's Council Standards.
- Blockage factors for both pits have to be considered in the design.
- Pit material

2.2.4.2. Pipes

Section 3.2.2 of the Feasibility study conveys the preliminary calculations and results for the required pipe sizes for the new storm water infrastructure. A number of requirements to be considered during detailed design include:

- The pipe sizes for the new infrastructure are to be designed according to the results of the conceptual DRAINS model and the Council standards.
- The minimum slope between the pipes has to be higher than the standard minimum value of 0.5 %. However the slope must be changed to achieve the required flow velocities as per WSA code.
- A minimum of 600mm cover has to be used for the pipes under the road (WSA Code).
- Pipe material

2.2.4.3. Drains Model

In the detail design stage an accurate DRAINS model has to be set up with smaller sub-catchments, accurate travel times and invert levels. In dividing sub catchments every pit (excepting those in close proximity) should have its own sub-catchment to make the total run off enter the system.

During the analysis the blockage factors of 0.2 and 0.5 for on grade and sag pits respectively have to be used to obtain a more accurate design. The over flow routes can be used in the DRAINS model for effective analysis but the final design should consist with zero over flow. Further use of both rational and ILSAX model also will help to obtain more accurate design.

2.2.4.4. Services

The services have to be checked with the new storm water system design to avoid any conflicts and to obtain minimum spacing between the services and the pipes according to the council's standards and WSA codes. If necessary, temporary relocation of the services during the construction period of the new system also has to be addressed in the detailed design stage, though should be avoided if possible as per client requirements. The services have been located approximately as reported in the feasibility study.

2.2.4.5. Gross pollutant Traps

Gross pollutant traps will be considered for detailed design, these will be located at the end of the storm water system, as to capture the pollutants before stormwater enters the first creek.

Detailed design will consider the type, size, location, cost, number and maintenance requirements for the Gross Pollutant Traps, this is undertaken by the environmental team.

2.2.4.6. Cost

Table 21 in the Feasibility Study report stipulates the material costs for the conventional storm water system upgrade. During detailed design, a detailed cost analysis will be conducted, to gain a greater appreciation of the total construction cost. This will ensure that the detailed design comes within the project's budgetary requirements of $600,000-800,000, with an upper limit of $1,000,000 (with client's permission).

2.3. Bio-Retention Basin

Part of the final design for the North Terrace Drainage Design Project includes incorporating water sensitive urban design (WSUD) features. A feature that was highlighted in the Feasibility Study, as beneficial for use, was the implementation of a bio-retention basin. The Detailed Design will include clear and precise engineering drawings displaying the final design dimensions as well as a technical specification as required for construction.

Bio-retention basins usually consist of a vegetated layer, filtration layer, transition layer, drainage layer, perforated pipe system and bypass system. A typical cross section is shown in Figure 4 which identifies the layers within the bio-retention system and their effective depths.

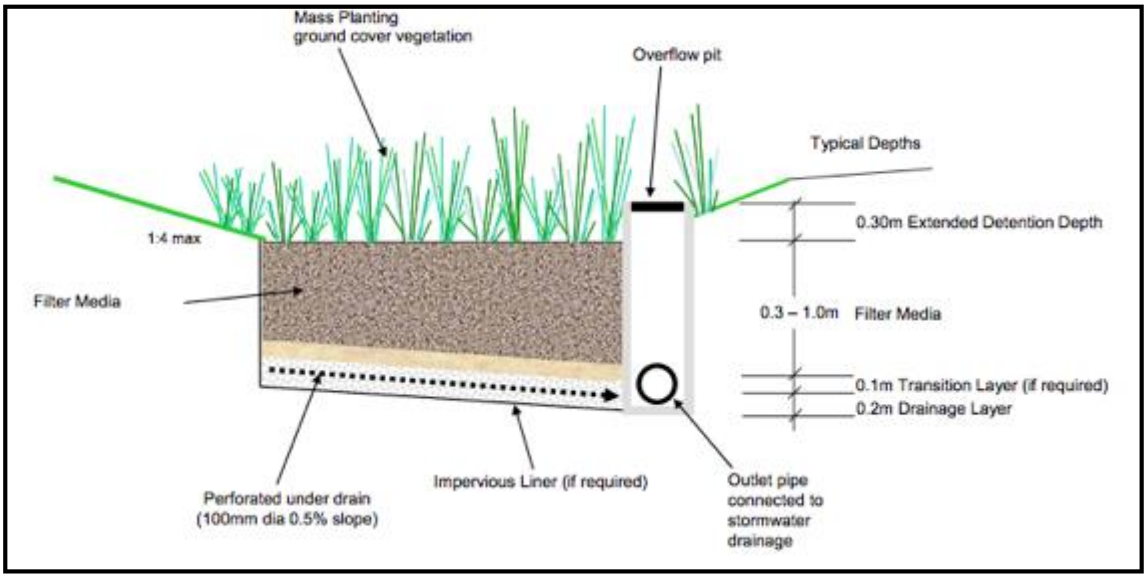


Figure 4: Bio-Retention System Layers (Hydro-Future, 2015)

2.3.1. Approximate Dimensions

The approximate dimensions of the required basin were calculated in Section 3.4.1.5 of the Feasibility study. These preliminary dimensions should be used in the detailed design to decide on an appropriate final design size. The approximate area of the basin is also depicted in the Feasibility Study, based on the treatment meeting particular water quality measures (see Figures 62-64).

2.3.2. Proposed Locations

Two potential locations for the bio-retention basin were considered in the Feasibility Study. The first proposed location is on a low point within the catchment area (Figure 5). Currently this area contains vegetation, which sits adjacent to the Clark Rubber car park and footpath. In the detailed design stage, the excavation and removal of required land will need to be carefully considered to reduce any potential negative impacts to the existing landscape.

The second proposed location is located outside St Peter's College (Figure 6). This is currently a vegetated area, which, again, sides the footpath and school car park area. A combination of the two will be used in detailed design.

The area shown in Figure 5 is approximately 100m^2; whereas the area in Figure 6 is much bigger, approximately 400m^2.

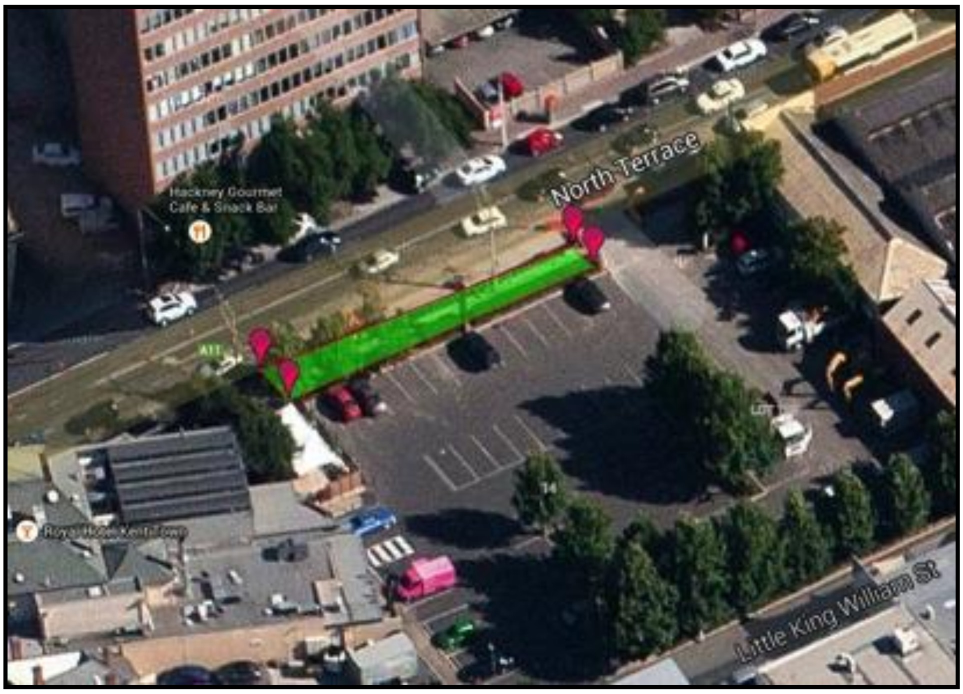


Figure 5: Area that could be used for bio-retention basin (lot 103)

Figure 6: Area that could be used for bio-retention basin (in front of St Peter's College)

2.3.3. Land Acquisition

The two possible locations for the bio-retention basin will require land acquisition of either the Clark Rubber Car Park or the shoulder of St Peter's College. The Urban Planning team will consider this requirement in detailed design, this is outlined further in the urban planning section of this brief.

2.3.4. Considerations in Detailed Design

The approximate size and location of the bio-retention basin were calculated as part of the feasibility study but more details are required to be clarified in the detailed design. These include:

- Maximum infiltration rate
- Inlet details
- Vegetation scour velocity
- Size of slotted collection pipe and respective material
- Exact location
- Depth and material of each layer
- Vegetation species type and quantity
- Dimensions of overflow pit/bypass system
- Accurate cost

2.4. Rainwater Tanks

Section 3.5 of the Feasibility Study depicts the water harvesting option and its respective preliminary design. A thorough detailed design will utilise simulation software and thorough research is required for the inputs in order to provide the most accurate result as possible. The design team must also be aware that the main stress of this option falls in the successful negotiation with properties owners and other stakeholders as the design outcome (locations, number of tanks) is limited by how accepting the stakeholders are in installing rainwater tanks. Therefore, it is important that the team has to be able to adequately communicate the necessity of the system to stakeholders.

2.4.1. Rainwater tank design

Preliminary sizes of the required rainwater tanks have been calculated in Section 3.5.4 of the Feasibility Study. Final tank sizes are required to be determined using Rain Tank Analyser (UniSA, 2015). The detailed design of this option will be based on the following variables:

- Concerned properties' daily demands
- Exact area and types of irrigated vegetation. Example: 40 m^2 of turf
- Types of irrigation method. For example: sprinklers, etc.
- Concerned properties' roof sizes
- First flush for the designed area.
- Concerned properties' roof materials. For example: concrete, brick, etc.
- Soil Type. For example: sandy, clay, etc.

It is important to note that the number of required tanks may change with more accurate input.

2.4.2. Location of rainwater tanks

The location of the required rainwater tanks was highlighted in Section 3.6 of the Feasibility Study (Figure 7). The exact locations of all tanks are subjected to change based on:

- Permission of property owner(s): negotiate and explain with property owner(s) the benefit of re-use scheme and importance of installing rainwater tanks to minimise flooding.
- Appropriateness or availability of land: the tank should not obstruct any driveways, pedestrian paths.
- Concerned properties' roof sizes: the total captured rainwater volume of corresponding tank sizes should meet designed requirements.
- Cost of land use and excavation.
- Location of irrigation area: the location of tanks should be as close as possible to the irrigated sites.

Figure 7: Proposed Rainwater tank locations (Hydro-Future, 2015)

2.4.3. Installation of rainwater tanks

Assuming the permission was granted by property owner(s), the following details are to be determined prior to the installation of rainwater tanks and communicated to the stakeholders:

- Types of tanks (Plastic, Steel or concrete) as negotiated with property owner(s) and with consideration given to relative cost.
- Dimension of tanks.
- Above ground or underground as negotiated with stakeholders.
- Period of installation: date, time, duration.
- Any obstruction to surrounding business due to installation process.
- Transportation and parking area.
- Construction of foundation of rainwater tank: type and structure of soil, dimensions and types of foundation.
- Properties of roof: height, slope, types.
- Properties of gutter and drain: materials, slope, length, diameter.

- Properties of pump and connectors for irrigation and household use: location, dimensions, power, coverage.
- Properties of first flush design device: dimension, position, and outlet.
- Properties of overflow device: dimension, position, outlet.
- Properties of pipes (dimensions, lengths, etc.).
- Listing of all required equipment, materials and specialised vehicles including their provider.
- Detailed engineering drawings of the system.
- Total cost including labour and materials.

2.5. Conclusive Considerations

In order to guarantee proper functionality of the final design option, a number of considerations have to be adhered to. Taking into account these considerations before and during the Detailed Design stage will ensure the option meets the design requirements and fulfils the project scope. Some of these conclusive considerations include:

- Clear communication with not only the teams within the company but also those directly and in-directly related to the project such as contractors and stakeholders.
- No contradiction in plans between teams within the company
- Direct correlation between all three sub-options that make up the combined drainage option to ensure they are no conflicts between options and lead to a successful drainage network as a whole.
- Over-estimating rather than under-estimating, to introduce a factor of safety into design.
- Taking into account future requirements, for example increased storm event duration.
- A Gantt chart should be compiled during the first week and sent out to all team members to provide an understanding of due dates and in particular, the timeline of events and milestones, which must be adhered to.
- Quality control processes need to be implemented during the Detailed Design study to ensure the combined drainage option is designed to the best standard possible to increase the company's goodwill and reduce the risk of any negative impacts that could arise as a result of bad quality control in the future.

3. Structural Considerations

This section of the design brief introduces and illustrates the vital design information required to undertake and complete the structural component for the detailed design phase of the project. All explanations relating to the recommended design option is clearly presented in the following sections.

3.1. Site Visit

The Detailed Design will require a site visit to access the need, if any, for a pedestrian bridge in the vicinity of First Creek. The structural team should pay particular attention to access paths between attractions in the area including the Botanic Gardens, National Wine Centre of Australia and Linear Trail along the River Torrens.

3.2. Chosen Design Options

3.2.1. Sandstone Arch Culvert

The proposed stormwater system along North Terrace will be designed to transport the respective runoff of the catchment area into first creek. This will be achieved by connecting the proposed drainage pipe directly into the sandstone arch culvert which runs underneath North Terrace. Figure 8 below shows the preliminary design drawing of the chosen feasibility option for the design phase of the project. The culvert will need to be evaluated regarding the change in its structural stability and a connection between the drainage pipe and the culvert will need to be designed. Hydro-future recommends integrating the drainage pipe and the sandstone culvert together through a reinforced concrete plate.

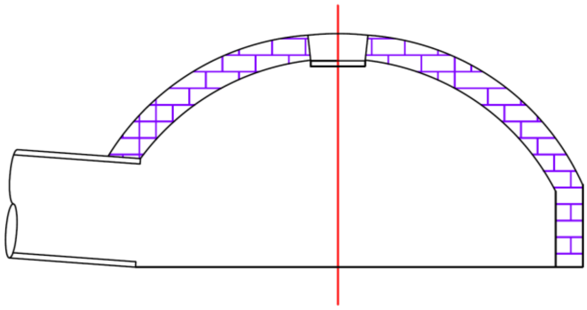


Figure 8 – Drainage Pipe to Sandstone Arch Connection (Hydro-Future, 2015)

3.2.2. Temporary Construction Frame

A temporary construction frame provides the support necessary to keep the culvert structure from collapsing and will be required during the construction phase of this project. After all associated construction has been completed, the temporary support system is removed. The following preliminary design drawings for the temporary support system have been created and are shown in Figure 9 to Figure 10.

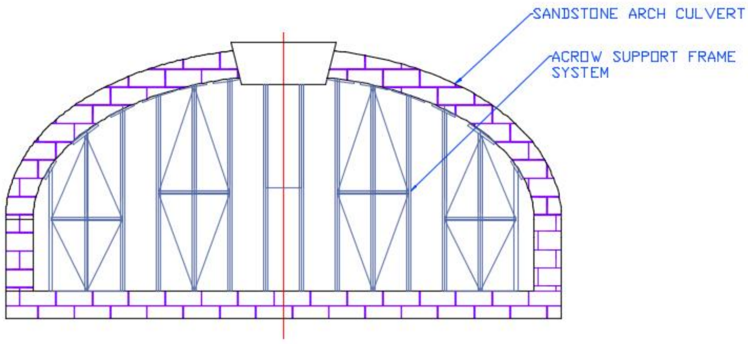


Figure 9 – Acrow type support system (Hydro-Future, 2015)

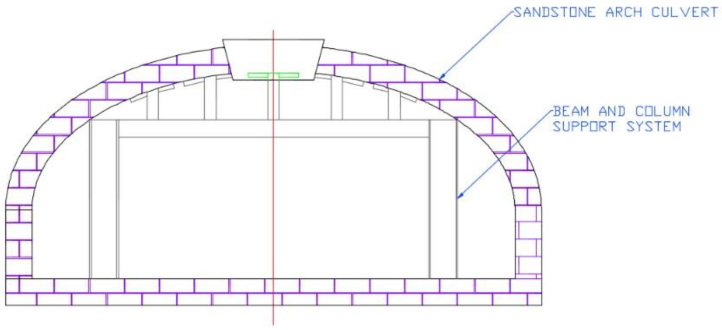


Figure 10 – Beam and purlin support system (Hydro-Future, 2015)

3.3. Dimensions

Several important design dimensions will need to be investigated in the detail design phase which were not established in the feasibility stage.

3.3.1. Sandstone Arch Culvert

- The final dimensions of the drainage pipe which will ultimately create the void in the brick arch culvert needs to be identified to allow proper analysis;
- The dimensions of the reinforced concrete plate used to integrate the culvert and pipe together, these dimensions include but are not limited to the width, breadth and height of the concrete section;
- The cross-sectional dimensions of the brick arch at the location of the drainage pipe connection point. It was established in the feasibility study site visit that there may be dimensional tolerances along the culvert which need to be verified.

3.3.2. Temporary Construction Frame

- The size of each required structural member within the temporary construction frame will need to be established which includes the length, width and breadth.
- The length and width which the temporary construction frame will span throughout the sandstone arch culvert.

3.3.3. Rainwater Harvesting Tanks

- The size of each tank(s) including the height and diameter for a circular tank or the height, width and breadth for a rectangular tank.
- The desired level of the tanks, in terms of above ground or below ground.

3.3.4. Structural Pipe Design

- The material and detailed design will be performed for the underground stormwater pipe

3.4. Design Loads & Analysis

The design loads acting on the sandstone culvert, reinforced concrete plate, stormwater pipe, temporary construction frame and rainwater harvesting tanks will need to be calculated which predominantly include, where appropriate:

- Earth Pressures (Dead Load)
- Traffic Loads (Live Load)
- Hydrological Pressures (Live Load)
- Wind Loads (factored Live Load)

The subsequent deflection and bending, tensile and compressive stresses as a result of the above live and dead loads will need to be determined. Further details regarding the design loadings of the sandstone arch culvert are illustrated in the feasibility study.

3.5. Materials

Materials for the temporary construction frame will need to be established. These materials will be required to comply and withstand the construction loads and corrosion from the influence of stormwater. Hydro-future recommends using steel or treated wood for the temporary construction frame.

The type of material to be used for the rainwater tanks will be decided during detailed design taking into consideration strength, durability, cost and availability. These materials will need to withstand the live and dead loads and have a high tolerance to corrosion. Hydro-future recommends steel, plastic and/or concrete for the rainwater harvesting tanks.

The connection between the drainage pipe and the sandstone arch culvert will require materials which are durable, flexible and structural sound. It has been recognised that the design of a reinforced concrete plate will be required to integrate the drainage pipe to the culvert. Hydro-future recommends further materials including proprietary silicon and rubber compounds to allow for movement and waterproofing throughout the joint.

3.6. Technical Specification

This section introduces the technical details for the structural components that will be determined and utilised during the design phase of the project, these include:

- Material strength properties.
- Structural properties of the truss members, reinforced concrete plate and drainage pipe.
- Steel reinforcement cover and detailing.
- Type and size of the connections between the structural members of the temporary construction frame.
- Design of articulation joints within the sandstone culvert to drainage pipe connection.
- Ratio of substances/aggregates used within any concrete, mortar or bonding agents required throughout the project.
- Design of a suitable geotechnical/structural foundation to support the rainwater harvesting tanks.

3.7. OHS&W

All OHS&E requirements will be identified for all structural works.

4. Geotechnical Considerations

Our expert team has identified that many geotechnical issues weren't investigated thoroughly in the feasibility study. For this reason, a site visit will be conducted during detailed design to identify any areas where there is;

- Potential for reduced flow capacity of first creek
- Opportunity for improved pedestrian access over first creek via a pedestrian bridge
- Existing pavement conditions that require improvement

Site photographs, GPS co-ordinates, and crude measurements will be taken to allow proper recording and identification of these issues. Our team will undertake detailed design of these potential problems only after consultation with the client.

4.1. Rainwater Tanks

The geotechnical team will be required to analyse the loadings that will be generated by the installation of water tanks as part of the water harvesting component of the Combined Drainage Option being implemented in the design area. This analysis will include the development of a footing design that will support the rain water tanks being installed in properties as part of the project.

4.2. Trench Stability

Installing the stormwater drainage pipe along North Terrace will require the excavation of a trench. To prevent the trench from collapsing during construction, hydro-future has recommended three design options including slope stability, trench shielding and trench stability. Our experts will investigate these three options and provide a final detailed design based on safety, ease of construction, cost and visual amenity.

4.2.1. Chosen Design options

4.2.1.1. Trench Shielding

As shown in Figure 11, the trench shielding configuration allows a metal box to slide through the length of the trench. Hence providing lateral support against earth pressures and construction loads. The trench shielding method will be considered for deeper excavations where there is not enough room for a stable slope.

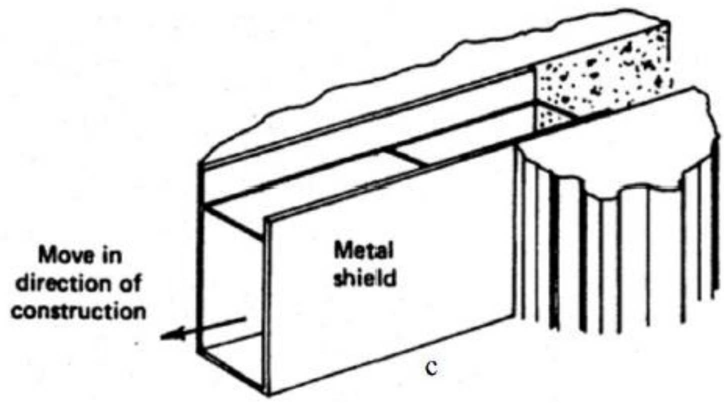


Figure 11: Trench Shielding (Nemati, 2007)

4.2.1.2. Slope and Trench stability

A stable slope design will be considered where there is allowable lateral room along North Terrace. The slope stability method is the preferred method, however there are construction challenges in terms of traffic management. During detailed design if it is found that the width required for excavation with stable slopes is wider than the allowable, trench shoring will be detailed.

Where the depth of the trench is shallow and there is insufficient lateral space for a stable slope a trench stability analysis will be used. This requires analysing the cohesion and stability of the soil to establish a depth where trench shielding or slope stability is not required. Hydro-futures feasibility study outlines the cohesion of soils along with the allowable depths.

4.2.2. Dimensions

4.2.2.1. Trench

The depth and width of the trench will need to be established for the full length of the drainage pipe. The depth and width of the trench will vary depending on the natural surface level, drainage pipe depth and clashes with utilities. The dimensions of the trench will need to be modelled using a long section of North Terrace to ensure the correct trench stability method is assigned. The location of each trench stability method will be included on the long section drawings.

4.2.2.2. Trench Shielding

Where the trench shielding method is required, the dimensions of the box including the height, width and length will need to be designed in conjunction with the trench long section.

4.2.2.3. Stable Slope

The stable slope method will form a trapezoidal trench shape, hence the bottom width, top width and side slopes will need to be established in accordance with the traffic management plan, which will ensure the trench width does not encompass more than one lane along North Terrace.

4.2.2.4. Trench Stability

Where a general trench stability method is required, the maximum safe working height and width of the trench will need to be established.

4.2.3. Design Loads & Analysis

Lateral forces that will occur throughout the trench will be investigated during detailed design. These lateral forces include earth pressures in conjunction with construction machinery and activities as well as traffic loads. The subsequent bending, compressive and tensile forces as a result of the above loads will be generated throughout the trench shielding mechanisms and will need to be accounted for. The Hydro-Future feasibility study further outlines traffic and earth pressures in accordance with Australian Standards and the established site soil profile and geotechnical model.

Operation design loads include frictional and dragging forces which are generated from the movement of the trench shield along the length of the excavated region. These operational loads will need to be accounted for in conjunction with the lateral forces.

4.2.4. Materials

The trench shielding design option will require materials which can withstand the trench lateral forces, frictional and dragging forces during operation and corrosion due to the presence of water. Hydro-Future recommends the use of steel or treated wood to construct the trench shielding box.

4.2.5. Trench Drainage

A trench drainage plan will need to be created during the detailed design stage. The trench drainage plan will state how water is drained or removed from the trench in accordance with safety and environmental regulations. Hydro-Futures feasibility study details the permeability of the soils present along North Terrace which can be used within the trench drainage design.

4.2.6. OHS&W Management plan

All OHS&W requirements will be identified for construction within and around excavated areas.

4.3. Retaining Wall

A retaining wall design will be considered during detailed design, as to reduce the erosion of the creek embankments.

4.3.1. Chosen Design Option

4.3.1.1. Gabion Retaining Wall

The gabion retaining wall was recommended as the most suitable option for the design conditions and location. The gabion retaining wall consists of rocks which are enclosed in a rectangular mesh cage which are stacked according to the required retaining height and width.

4.3.2. Location

The retaining wall will be located and constructed within Botanical Parklands which has been illustrated and documented in the feasibility study and can be seen below in Figure 12.

Figure 12: Retaining Wall Location (Google Earth, 2013)

4.3.3. Dimensions

Several important design dimensions will need to be investigated in detailed design phase which were not established in the feasibility stage:

- Dimensions of the existing creeks cross section along the full length of the retaining wall which include the bed width and embankment slopes.
- Length of retaining wall (approximately 20 meters according to the initial site visit).
- Height of the retaining wall and foundation.
- Width of the retaining wall and foundation.
- Gabion size (width, height and length).
- Stone or Rock size, shape and material.

4.3.4. Design Loads & Analysis

The design loads acting on the retaining wall which comprise of active and passive pressures will need to be calculated which predominantly include:

- Earth Pressures (Dead Load)
- Hydrological Pressures (Live Load)
- Surcharge Loads (Live Load)

The subsequent sliding forces, overturning forces, bending moments, tensile stresses and compressive stresses as a result of the above live and dead loads will need to be considered during the retaining wall design.

The design loads acting on the retaining walls foundation will need to be calculated which predominantly include:

- Self-weight of the structure (Dead Loads)
- Hydrological Pressures (Live Loads)

The subsequent bearing capacity of the foundation will need to be determined and designed for in accordance with the above live and dead loads.

4.3.5. Materials

A material type will need to be defined for the gabion baskets and the retaining walls foundation as well as a rock or stone composition which will fill the gabion baskets. Due to the intensity of the conditions associated with this design the following performance criteria for each material will need to be adhered to which include, but is not limited to the following:

- Aesthetically pleasing.
- Durable.
- Geocomposites (such as: sufficient permeability, sufficient void size, stability, strength, toughness and abrasion resistance)
- Low maintenance and cost.
- Corrosion resistant.

Hydro-Future recommends the use of stainless steel for the gabion baskets and locally sourced rock to fill the gabions baskets and a compacted select fill for the foundation.

4.3.6. Environmental Management

The proposed retaining wall will be constructed within the Botanical Gardens. A detailed environmental policy which the design and construction process will need to comply with will be outlined within the environmental sector of Hydro-Future.

4.3.1. OHS&W Management plan

All OHS&W requirements for construction within and around the region of the retaining wall will be identified.

4.4. Cost estimates

A detailed cost estimate which includes the price of materials, labour, machinery hire and required permits will need to be calculated for each of the following section:

- Drainage pipe to sandstone arch culvert connection
- Temporary construction frame
- Rainwater harvesting tanks
- Trench Stability
- Retaining wall design

4.5. Australian Standards

The following Australian standards will need to be adhered to during the design and construction phases of this project:

- *AS 5047 – 2005 Hydraulic Shoring and Trench Lining Equipment*
- *AS 4744.1 – 2000 Steel Shoring and Trench Lining Equipment*
- *AS 4678 Earth Retaining Structures*
- *AS 1289 Methods of testing soils for engineering purposes*
- *AS 4970 Protection of trees on development sites*
- *AS/NZS 1170.0:2002 Structural design actions - General principles*
- *AS/NZS 1170.1:2002 Structural design actions – Permanent, imposed and other actions*
- *AS3500.3(2003) Plumbing and Drainage – Stormwater Drainage*
- *AS3600 Concrete Structures*
- *AS1289.0 Methods of Testing soils for engineering purposes*
- *AS1289.1 Methods of Testing soils for engineering purposes*
- *AS/NZS 4058 Precast concrete pipes (pressure and non-pressure)*
- *AS/NZS 3725 Design for installation of buried concrete pipes*

5. Environmental Considerations

A summary of the key identified environment impacts have been documented in the following sections. The associated mitigation methods are detailed and can be found in the Environmental Management Plan (EMP) which will be further developed during the design stage of the project. The mitigation methods will be describe in detail with measures on how to implement them during the project.

5.1. Water

The biggest environmental impact in regards to the project will be the quality of the stormwater runoff. As runoff from the catchment area is transported to First Creek and ultimately ends up in the River Torrens, special considerations should be made to improve its quality.

Due to the significant foot and vehicle traffic volumes present within the Adelaide CBD the potential for harmful pollutants and toxins entering the water way is very high. To prevent these pollutants from entering the water system, construction should take place in the summer months. This decreases the risk of pollutants, debris and other materials that may be collected when it rains. Flowing water has the potential to pick up containments from construction equipment, construction waste and other materials that are present during the construction stage.

In the detailed design stage mitigation strategies such as sediment control structures, use of spill kits and stormwater diversion controls will need to be described in detail in order to control water quality.

5.2. Heritage

A key design concern is the 150 year old arch culvert. The arch culvert is a heritage listed structure and can be found on the Councils Heritage Register. Special care needs to be taken in the analysis of the structure to determine its strength and the amount of flow able to pass through it safely.

Reinforcement practices such as shotcreting will need to be assessed for their environmental friendliness to make sure no additional pollutants will be leaked into the waterway.

Figure 13 depicts the degradation of the mortar between the sandstone blocks that make up the structure. Figure 14 shows where previous attempts to repair the structure but have been ineffective. Record of these repairs should be noted in order to find more effective solutions.

Figure 13 - Degradation of the mortar between the sandstone blocks

Figure 14 - Previous attempts to repair structure

Any works to be conducted on Aboriginal land will first need the approval from the Minister for Aboriginal Affairs and Reconciliation. Likewise any artefacts found need to be reported and acted on in accordance with the Heritage Places Act 1993. Due to the project area being in a built up urbanised area it's unlikely that these factors will be an issue but will still need to be investigated.

5.3. Air Quality and Greenhouse Gas Emissions

During any large construction work, air quality will diminish due to the increase of dust that enters the air as a result of construction activities and from vehicle emissions from the construction vehicles in the area.

A reduction in air quality can pose a hazardous risk to human health and should be mitigated where possible. Mitigation measures such as wetting down of dirt piles, quick stabilisation of disturbed areas, maintaining equipment and machinery to ensure optimal operation and the removal of any excess soil that may cause additional dust generation should be implemented and will need to be outlined in detail in the environmental management plan.

5.4. Noise & Vibration

Similarly to other projects involving the use of machinery for construction works, it's expected that there will be substantial noise during the construction stage that cannot be avoided.

To mitigate against the impact of additional noise, it's recommended that all machinery are fitted with noise suppression devices, hammering construction activities should not be continuous over long periods of time, acoustic barriers will be used, construction works will take place during less sensitive times of the day and there will be regular monitoring of noise and vibration levels to make sure they don't exceed standards.

5.5. Fire

The possibility on a fire on site is a serious risk. Construction activates such as welding, grinding and flame cutting should be carefully considered and planned for. To mitigate against the risk of a fire starting during the construction phase all possible measures will be implemented for the avoidance of ignition sources on site and for the accidental lighting of fires, no smoking policies will be enforced, all works will be carried out under strict compliance to the South Australian Fire and Emergency Services Act 2005, all hot work activities will require permits issued by the Project Manager and activities that pose a fire risk won't take place on high risk weather days.

5.6. Dangerous Goods

The Contractor will be required to manage waste in accordance with the environmental performance criteria for the project. The waste must also be managed in accordance with the Environment Protection (Waste Management) Policy 1994, and South Australia's Waste Strategy 2005-2010.

This Policy provides that a person who transports waste on or in a vehicle must take all reasonable and practicable steps to cover, contain or secure the waste to ensure that it remains on or in the vehicle throughout the course of transportation. To prevent further waste pollutants from entering into the system, post construction, a Gross Pollution Trap will be installed at the end of the stormwater pipe exiting at First Creek as well as the already installed trash racks along North Terrace which require regular maintenance.

5.7. Utilities & Services

The relatively high volumes of excavation involved will impact the air quality, noise and vibration levels, water quality as well as have a social impact on the surrounding area. One of the main design concerns is the potential impact on underground utilities and services due to earthworks operations.

Impacting live systems including electricity, gas, and sewers can cause significant service disruption and environmental damage. Hence, these services need to have their exact location confirmed via potholing and through consultation with the relevant utility companies.

Locations of the existing services in the vicinity of the project will need to be established prior to commencement of excavation. A detailed assessment will provide the exact location of the services and the possible impacts associated with the excavation. Mitigation strategies to address these impacts will need to be described in detail during the detailed design stage.

5.8. Soil Contamination & Pollution

Excavation machinery used in the project area and irresponsible disposal of waste has the potential to pollute the soil profile. This added pollution can be hazardous to the environment and may cause instability in the local ecological system. Furthermore, contaminants in the soil can affect human health when they come into contact, are ingested or inhaled.

Seepage and leakage, erosion, slope instability and groundwater flow can cause contaminants to travel long distances and become wide spread. A detailed assessment of the negative impacts associated with the geotechnical engineering perspective of the project is required and mitigation strategies on soil contamination will need to be investigated further.

5.9. Social Impact

As the project will have a substantial effect on the surrounding environment, social impacts should be considered thoroughly. As the project area consists of residential and commercial dwellings, the occupants will be directly affected during the construction phase of the project.

Air quality, noise pollution, access restrictions, traffic disturbances and the aesthetic impact on the area will be the key issues that will cause discomfort for local residents, business owners, customers and members of St. Peter's school. Mitigation strategies against these impacts will need to be described in detail during the detailed design stage.

5.10. Aesthetics

Aesthetic impacts are expected in the North Terrace Drainage Design upgrade, from pre-construction up until project completion. The impacts involve urban design, landscape character and views. In this project, there are businesses on the north and south side of North Terrace, as well as residential areas and St Peter College Junior School along the northern side of the road.

Through effective mitigation strategies the negative influence on the environment will need to be limited. A detailed aesthetics management plan will need to be developed in regards to the overall design appearance, and to reduce the overall impact on the environment.

5.11. Property Access

North Terrace is one of the main arterial roads to the city centre. As such, there is a high density of properties, and a high level of both traffic and pedestrian flow in the area. An assessment of the construction impacts on the road network and property access will need to be developed and presented during different stages.

A management plan for property access detailing temporary access locations, car park locations, notification and signage and how local residents and businesses will be notified on these issues will need to be detailed. All traffic management plans will need to be developed in accordance with the Real Property Act, 1886 (SA) and the Land & Business (Sale & Conveyancing) Act 1994.

5.12. Land Acquisition

In the project, the acquisition of land would be required for areas adjacent to North Terrace to incorporate the Water Sensitive Urban Design options. A plan for land acquisition is needed to minimise the impacts on the surrounding environment, economy and community. Land acquisition for the project needs to be undertaken in accordance with the Land Acquisition

Information Guide (Roads and Maritime 2012) and the Land Acquisition (Just Terms Compensation) Act 1991.

It is necessary to review urban planning and contact Adelaide Land Division Services to find out if there is any reserved land available that can be used for the project temporarily within the subject area. All businesses and residents affected by land acquisition for the project will be appropriately compensated.

5.13. Waste Management

The Contractor will be required to manage waste in accordance with the environmental performance criteria for the project. The waste must also be managed in accordance with the Environment Protection (Waste Management) Policy 1994, and South Australia's Waste Strategy 2005-2010. Relevantly, the Policy provides that a person who transports waste on or in a vehicle must take all reasonable and practicable steps to cover, contain or secure the waste to ensure that it remains on or in the vehicle throughout the course of transportation.

To prevent further waste pollutants from entering into the system, post construction, a Gross Pollutant Trap will be installed at the end of the stormwater pipe exiting at First Creek in addition to trash racks in pits along North Terrace, which require regular maintenance.

5.14. Flora and Fauna

A small amount of vegetation is present on both sides of North Terrace which consists of mature and adolescence trees with no other types of vegetation located along this section of road. Shrubs are located on the perimeter of the Royal Hotel car park as well as within the property boundaries of a number of residential buildings within the project area.

The mature trees provide habitat for native birds and wildlife in the area but is minimal due to the minimal amount of vegetation that is present. The site does not appear to be the habitat of any endangered flora or fauna and does not contain any significant or regulated trees. During construction specific pathways will be allocated to machinery that will prevent the damage of existing flora and fauna and storage areas for materials will be specified to avoid the compaction of soils surrounding vegetation that may prevent future growth. No removal of native vegetation will occur unless authorised in accordance with the Native Vegetation Act 1991.

5.15. Gross Pollutant Trap

The Environmental team is required to design a Gross Pollutant Trap (GPT) to be installed to capture all large rubbish that enters the stormwater system. Consideration during design must be given to the need to both the required size of the GPT as well as the need to regularly and safely access the GPT to perform cleaning and maintenance.

6. Transportation Considerations

6.1. Introduction

Within the Feasibility Study the current traffic conditions were analysed, which included considering the use of motorists, heavy vehicles, pedestrians, cyclists and public transport (buses in this area). For each of the proposed options the transportation team investigated these current conditions in order to determine the potential impacts these proposed options may cause.

The main issue was the impact on general traffic flows within North Terrace and ways to minimize these negative impacts, although many of the proposed options involved areas away from North Terrace. The transportation team looked at using general traffic management strategies to create a traffic management plan. This was required as all the proposed options would need to include some form of conventional storm water pipe, and therefore roadworks would be required. This included using traffic management devices and strategies such as signs, detours, temporary traffic lights, altering traffic single timings, lane closures, altering speed limits, using traffic directors, managing construction times as well as any other required traffic management impact mitigation strategies.

The Detailed Design will require more specific traffic management strategies to be evaluated for the proposed water considerations. This will include an exact plan that will and can be implanted during the construction phase.

6.2. Traffic Management Plan

6.2.1. Construction timing

The transportation team will analyse the needs and activities of all stakeholders in the area to develop a construction timing plan that ensures minimal disruption to businesses, residences and St Peter's College.

6.2.2. Public Transport

It was found during feasibility that there are 4 bus stops within the project area, with large numbers of people using this route for their commute. A school is also located within the project area, thus during detailed design the team will consider which stops are effected and when in order to detail solutions for this problem.

The transportation team will consider the use of a temporary potential bus stops, with a location identified during feasibility in Section 7.3.3. (Figure 136). The Urban Planning team will develop detailed solutions for notifying public transport users on bus stop closures or bus detour times and locations. These measures will be performed in collaboration with Adelaide Metro as to assess whether these potential changes are suitable.

6.2.3. Signage & Devices

During the Feasibility Study the transportation team estimated the required number and cost of roadwork signs and traffic devices, this included caution signs, detour signs, notification signs, traffic cones, barriers, speed limit signs, temporary traffic lights and traffic directors.

Detailed Design will refine this further as the water engineering options have now been decided. This will result in a detailed Traffic Management Plan and Technical Specification as required for construction.

Feasibility considered only the purchase of signage, during detailed design detailed cost analysis will be performed to ascertain whether or not it is more economical to purchase or hire the required traffic management devices.

6.2.4. Detours

The Feasibility Study looked at two potential detours for all road users of North Terrace. One for vehicles (heavy vehicles, motorist and buses) and one for pedestrians, both can be found within Section 7.5.1. of the Feasibility Study.

During the Detailed Design the transportation team will re-assess both of these detours and ensure they are appropriate and effective; if not, new solutions will be detailed.

6.2.4.1. Pedestrian Detour

The Feasibility study didn't go into sufficient detail and detailed design will consider the actual detour route for pedestrians for all stages of the project.

6.2.4.2. Heavy Vehicle, Bus, Motorist Detour

An illustration of the detour for all vehicles can be found in figure 140 within the Feasibility Study. This nominated detour by the transportation team involves temporary traffic lights at Fullarton Rd and Rundle St intersection, possible traffic light timing alterations and killing the traffic lights while using traffic directors to allow vehicles to turn right from North Terrace onto Dequetteville Tce.

The transportation team will provide detailed design on this detour, including the timing of road closures, (e.g. night works and no construction during 'Mad March'). It will also require analysis into the problem of not being able to turn right onto Dequetteville Tce from North Terrace, whether the traffic lights will be killed and traffic directors are used or possibly temporary traffic lights being used at this intersection or any other possible solution that is found during Detailed Design.

6.2.5. Lane Closures

Within the Feasibility Study the transportation team looked at four different lane closure options, peak hour mornings, peak hour afternoon and two other times options which could be used outside of peak hour times (middle of day/late afternoon/night). The transportation team during the detailed design will determine whether these lane closure options are first possible, then determine potential speeds limits, delays, waiting times and when exactly these alternate lane closure options will be used.

6.2.5.1. Peak Hour Morning

The peak hour morning lane closure options can be seen in figure 142 within the Feasibility Study. The figure demonstrates two lanes in the primary direction of flow and one in the non-primary direction flow. This will greatly depend on exactly where the storm water pipe is being placed and how much space is need around the stormwater pipe for construction. For instance if the pipe was located two lanes in from the curb this lane closure option would not be possible.

The transportation team will also have to determine speeds limits for this lane closure option. During the feasibility study the transportation team noted that they would try to make this lane closure option have a speed limit of 40km/h to maintain healthy traffic flows but may not be possible and a speed limit of 25km/h may be required due to constructions or changed traffic conditions (more information on reasons for 25km/h speed limit can found within7.4.4. Speed Limit and Regulation).

6.2.5.2. Peak Hour Afternoon

The peak hour afternoon lane closure option is quite similar to peak hour morning lane closure option however with one lane direction switch to maintain two lane in the primary direction and one lane in the non-primary direction, as seen in figure 143 of Feasibility.

In addition to checking what speed limits can be applied to this lane closure option, within the Feasibility Study is was suggest the speed limit could be 40km/h to maintain healthy traffic flows but 25km/h may need to be applied.

6.2.5.3. 1.2.4.3. Other Times

During other times two other lane closure options have been included within the Feasibility Study. One of the options is single lane traffic in both directions as seen in Figure 144 of the feasibility study while the other is a shared single lane for traffic flows with traffic directors assisting vehicles as shown in Figure 145.

Both lane closure options have a currently been allocated a speed limit of 25km/h as maintaining fast traffic flows is less of a concern outside of peak hours. This speed limit will need to be determined and finalised during the Detailed Design by the transportation team. Additionally the transportation team will have to work with the water team to determine when these other time lane closure options will be used during the construction phase.

6.2.5.4. 1.2.4.3. Modelling

Within the Feasibility Study it was noted that the transportation team assumed that these lane closure options would cause little delays. This was due to that fact the project area was quite small in length (approx. 400m) and the construction may even be conducted in segments which would only further reduce the length of the lane closures, this is something the transportation team will determine.

Although this assumption was made, no actual modelling was conducted, this will be conducted during the Detailed Design by the transportation team as outlined in the Feasibility Study.

The Modelling program that will be used during the Detailed Design will be SIDRA. The transportation team will need to effectively model the conditions of each of the proposed lane closure options.

Some inputs for this modelling include relative AADT and lane closures with the desire to produce output that includes but is not limited to the following points below

- Traffic flow speeds during peak/off-peak/night construction phases in both directions
- Wait times at traffic lights during peak/off-peak/night construction phases not only at the lights on North Terrace but surrounding arterial roads
- Wait times at the right hand turn from Fullarton Rd to Rundle Rd with and without the temporary traffic lights
- The increased traffic volume/flow speed/delay on Rundle Rd when being used as a detour
- Required modifications to traffic light timings to accommodate the increased volumes on surrounding roads

6.2.6. Access Plan

Not covered within the Feasibility Study was an access plan for local businesses and schools within the area. During the Detailed Design the transportation will develop strategies to allow access to these facilities. This may involve trying to complete construction during school holidays to minimise the effects access to the school will cause during the construction phase. Additionally it may include temporary footbridges over construction points to allow access to local business within the affected area.

This will be analysed during the Detailed Design, with the transportation team working closely with the urban planning team in order to communicate with the local businesses and schools at finding appropriate solutions and notifying them when access may be limited due to construction.

7. Urban Planning Considerations

7.1. Introduction

The tasks for urban planning team in detailed design involve consideration of safety issues related to construction, maintenance schedule after construction and community consultation procedures. The urban planning team should have a plan to manage the local community to maintain the heritage and cultural value of the City.

7.2. Construction safety management

7.2.1. Service clearance

During the construction, the safety of construction workers and local community residents is the priority for urban planning team, in terms of construction safety management, the public infrastructures will be identified carefully before the construction begins and the clearance of each type of infrastructure will be shown clearly and specifically in the construction manual. A construction supervisor should be in the construction site at all time to supervise the construction progress. The following points will be carefully considered during the detailed design stage:

- Determine the location of public infrastructure that will be effected by the construction
- Determine the specific clearance for each ground surface public infrastructure
- Determine the specific location of the underground service
- Determine the specific clearance for each underground service

Once all the public infrastructure has been located determine, the construction worker should be shown the location of the service pipe lines and cable lines by marking on the ground surface (see Figure 15).

Figure 15 marking the location of underground service

7.2.2. Fencing

To keep the safety of the local community resident from construction equipment and also to keep the safety of construction worker from the traffic on the road, the urban planning design team will design a fence to be used around the construction site. The location and the structure of the fence will be based on the findings of the structural and water considerations.

In the detailed design, the following points will be delivered to the client.

- The location of the fencing around the project area
- The number of fencing required based on the design option
- The cost of fencing

7.3. Maintenance

During the detailed design stage, the urban planning team will design the most efficient and environment friendly maintenance techniques based on the water team design option.

Regular maintenance will maintain the drainage system in its best performance, also the US EPA (2001) reported that regular cleaning of the stormwater drainage network can increase dissolved oxygen levels in stormwater, reduce levels of bacteria, reduce the load of common stormwater pollutants entering receiving waters (e.g. sediment, nutrients, litter, organic matter).

In detailed design, the urban planning team will select one design option and talk more detail about maintenance techniques and frequency. In the detailed design report, the following information will be indicated:

- Identify the main component that require maintenance based on the water team design option
- Identify the maintenance techniques required for the main component
- Determine the maintenance frequency required for the main component

7.4. Heritage building protection and culture protection

The City Plan 2030 had vision “a city which values its heritage, cultural diversity, sense of place and natural environment. A progressive City that is prosperous, sustainable and socially cohesive, with a strong community spirit.” This vision indicates that heritage building and culture protection is the priority of urban planning team.

Along North Terrace, there were 14 buildings that on the local heritage listing and state heritage listing. During the detailed design stage, each of heritage building will carefully analysed in terms of proximity to construction and heritage building management plan should be created that come up with following information:

- Heritage building protection and culture protection plan
- The fencing around heritage building
- The procedures should be undertaken when the construction is in progress around the heritage building

7.5. Community consultation and notification

7.5.1. Liaise with the local community

The urban planning team will come up with a management plan that can make communication between construction team, Hydro-Future and local community more effective; in the Management Plan, the following items will be included:

- Detailed design of a questionnaire survey sheet that contains the problems likely to affect the local community
- Set up a regular meeting time and meeting agenda during the construction period
- Develop contact letter for residents to be approached for rainwater tank installation
- Develop project Facebook® page
- Develop project newsletter to be distributed to residents and businesses in the area, and handed out at community events.
- Develop community poster to promote the project at community events
- Organise community event to promote the project.
- Set up a public office, website, and phone number that can deliver the project information to the public

7.5.2. Access to community area

To find the access to the local community area is a part of traffic team's responsibility, but the urban planning team will communicate with traffic team to find the best solution that has the best benefit for the local community and also is the most convenient solution for the construction team.

7.5.3. Vegetation removal and protection

Along the North Terrace, there are trees that may be affected during construction or may in conflict with the designs. In the detailed design stage, the urban planning team will identify all trees in the project area and modify the design based on minimal disturbance to vegetation. Some of trees along the North Terrace are very old, therefore removal is the last option that should be considered, these trees should preferably be replaced after construction or moved to another location as the preferred option. During the detailed design, the location of each tree will be analysed and compared with water team and structural team's design option to protect the vegetation along the North Terrace, and included in a Vegetation Management Plan.

7.6. Amenities

During the detailed design stage, the location of site offices will be determined, with the number of staff present for construction determined to find the required size of toilets, lunch room and site office. All these facilities will be determined based on the construction team size related to water team and structural team's design option, once the construction size is determined, the urban planning team can determine the size of required facilities based on the Code of Practice for Building and Construction Workplaces.

Also to maintain the environment of construction site, a wash-out basin should be included on the site. A wash-out basin is a plastic lined trench that concrete pumps use to wash out remaining concrete after pumping to keep it out of the environment. The location of wash-out basin will be determine in the Detailed Design.

7.7. Land cost

During the Feasibility Study, the Urban Planning team found the location of all available open space along the North Terrace, as well as a nominal land cost for the area. During the Detailed Design stage, each piece of land that is required will be costed and summarised in the urban planning section, and the urban planning team will calculate the total land cost for the project.

7.8. Information Poster

During detailed design, the urban planning team will come up with a poster that highlights the key project details and key items of the project. This will allow greater community engagement with the project.

8. Project Website

A project website will be developed that contains the project background, company information, a description of each stage of the project and a link to download the Feasibility Study, Quality Management System Manual, Environmental Impact Statement, Detailed Design Brief, Detailed Design Report and drawings and the Environmental Management Plan.

The website will also describe the company structure, contact details and give information about the project team, working on the detailed design report.

9. Project Schedule

With all the aforementioned detailed design considerations, Hydro-Future has identified some key dates throughout the project's lifecycle. These are listed in Table 1, and in Appendix 1 a detailed project schedule, or GANTT chart, is presented that highlighting the key deliverables between the design teams.

Table 1: Key Dates throughout the Project lifecycle

Key Dates	Description
Wednesday May 6th 2015	Award of Contract – Detailed Design begins
Various (See GANTT)	Draft Report Submission
Various (See GANTT)	Draft Report Feedback Given
Friday 5th June 2015, 5pm	Final Report Submission
Tuesday 9th June 2015 5pm	Detailed Design Report Submitted, Website Published, Oral Presentation to Client
Wednesday 17th June 2015 6 to 8:30 pm	Public Presentation; followed by Multi-Cultural Meal

9.1. Proposed structure breakdown

The information outlined in the proposed teams is not all encompassing, there may be additional information required from each team that has to be included. Amendments and more work will be required during the progress of the detailed design stage. The exact number of employees in each department is shown in the chart in Figure 1

9.2. Project Manager

The Project Manager is responsible for oversight of the entire project, ensuring targets and deadlines are met and that the outcomes are to the desired standard. Part of Project Manager task is ensuring that each team has clear and attainable project objectives as well as liaising with the clients in the appropriate manner.

9.3. Assistant Project Manager/Quality Manager

While the main focus of this role is to aid the Project Manager, another focus is the Quality Management System. Ensuring that the Quality Management System is in place and is being correctly used is imperative to having a smoothly run organisation. Furthermore after the original internal audit by Hydro-Future Consulting, the following corrective actions are recommended to be taken:

1. Internal Audit Templates have to be revised to ensure that it covers all of the procedures in the QMS.
2. It will be highly emphasised by the Project Manager and Quality Manager to ensure that drafts submitted have to be proof read by the Team Leaders before submission.
3. The Quality Manager will collect meeting minutes weekly. The Quality Manager will have to ensure that received meeting minutes contains enough details. If not enough details are in the minutes, Team Leaders will be required to complete this work themselves.
4. Project Manager will have the responsibility to ensure deadlines are achievable by each department.

5. In the detailed design stage, employees will have to report actual hours of work done.
6. Timesheets will have to be submitted on Mondays during project time.

10. Costing

10.1. Hourly Rates

The cost of this phase is made up entirely of employee wages, with a total of 28 employees each with varying rates. The rates of each employee depend on the level of responsibility to be undertaken for this stage of the project as well as prior experience. Table 2 summarises the hourly rates for each employee.

Table 2: Hourly Rates for all employees

Position	Hourly Base Rate ($)
Project Manager	240
Quality Manager	220
Website Designer	200
Team Leaders	200
Senior Engineer	180
Graduate Engineer	120

10.2. Detailed Costing

The entire detailed costing is provided in Table 3, it has been largely based on a 15 hour work week.

Table 3: Detailed Cost Breakdown for Detailed Design

Department	Position	Rate	No.	Hours per Week	Weeks	Total Cost
Project Management	Project Manager	$240	1	15	5	$18,000
	Quality Manager	$220	1	15	5	$16,500
Water Engineering	Team Leader	$200	1	15	5	$15,000
	Senior Engineer	$180	3	15	5	$40,500
	Graduate	$120	4	15	5	$36,000
Structural/ Geotechnical Engineering	Team Leader	$200	1	15	5	$15,000
	Senior Engineer	$180	2	15	5	$27,000
	Graduate	$120	2	15	5	$18,000
Environmental Engineering	Team Leader	$200	1	15	5	$15,000
	Senior Engineer	$180	1	15	5	$13,500
	Graduate	$120	2	15	5	$18,000
Transport Engineering	Team Leader	$200	1	15	5	$15,000
	Senior Engineer	$180	1	15	5	$13,500
	Graduate	$120	2	15	5	$18,000
Urban Planning	Team Leader	$200	1	15	5	$15,000
	Senior Engineer	$180	1	15	5	$13,500
	Graduate	$120	2	15	5	$18,000
Website	Website Designer	$200	1	15	5	$15,000
					Total	**$325,500**

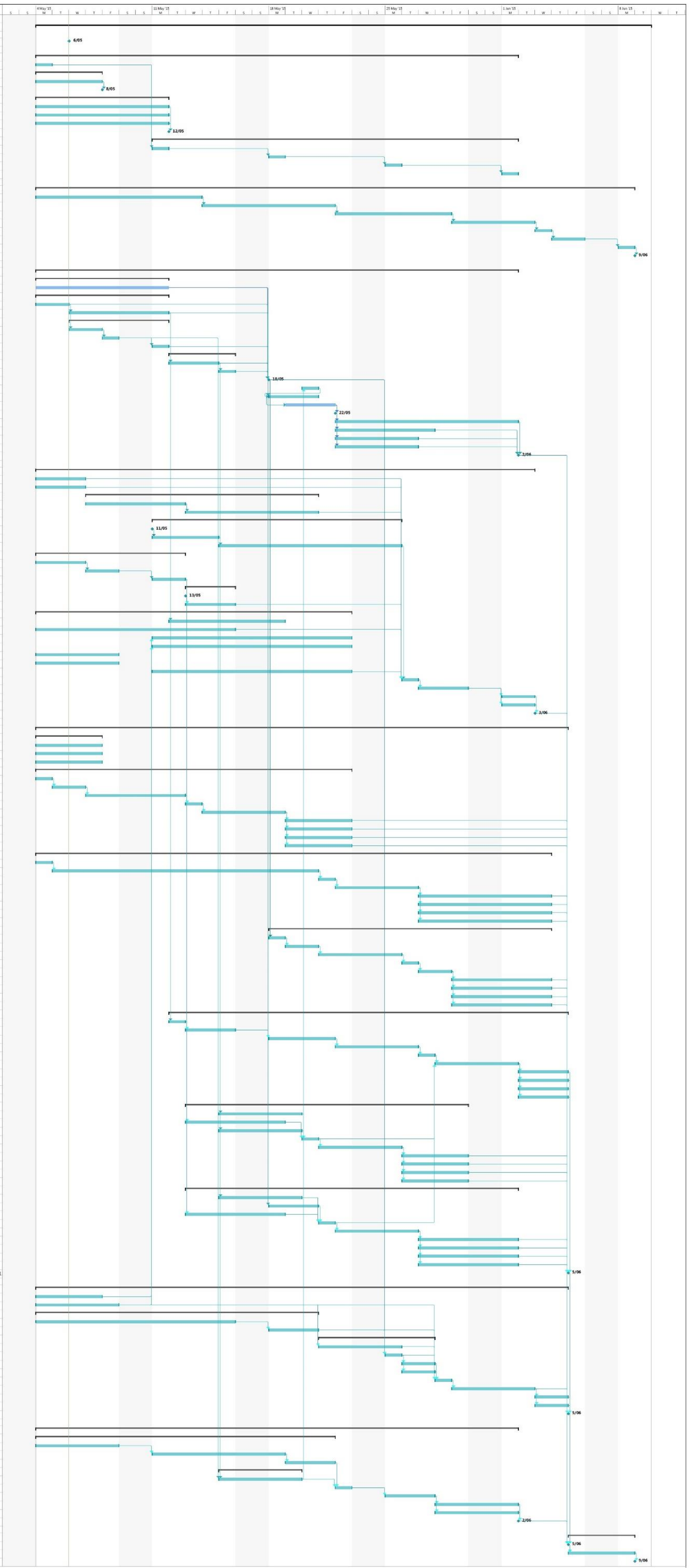
References

Nemati, m.k., 2007, ‘Temporary Structures’, Accessed on 29/04/2015, Available at: http://courses.washington.edu/cm420/Lesson5.pdf

Google Earth 7.1.2.2041, 10/7/2013. *Adelaide South Australia, viewed 28/03/2015, Available at: http://www.google.com/earth/index.html*

11. Appendix A Gantt Chart

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1						
2		Project Life	27 days	Mon 4/05/15	Tue 9/06/15	
3						
4		Contract Award	0 days	Wed 6/05/15	Wed 6/05/15	
5						
6		**Project Management**	**21 days**	**Mon 4/05/15**	**Mon 1/06/15**	
7		Preliminary Management meeting	1 day	Mon 4/05/15	Mon 4/05/15	
8		**Develop quality manual**	**4 days**	**Mon 4/05/15**	**Fri 8/05/15**	
9		Address comments	4 days	Mon 4/05/15	Thu 7/05/15	
10		Distribute to teams	0 days	Fri 8/05/15	Fri 8/05/15	9
11		**Templates**	**6 days**	**Mon 4/05/15**	**Tue 12/05/15**	
12		Develop drawing template	6 days	Mon 4/05/15	Mon 11/05/15	
13		Develop document template	6 days	Mon 4/05/15	Mon 11/05/15	
14		Develop reporting template	6 days	Mon 4/05/15	Mon 11/05/15	
15		Distribute templates	0 days	Tue 12/05/15	Tue 12/05/15	12,13,14
16		**Weekly management meetings**	**16 days**	**Mon 11/05/15**	**Mon 1/06/15**	
17		Week 9	1 day	Mon 11/05/15	Mon 11/05/15	7
18		Week 10	1 day	Mon 18/05/15	Mon 18/05/15	17
19		Week 11	1 day	Mon 25/05/15	Mon 25/05/15	18
20		Week 12	1 day	Mon 1/06/15	Mon 1/06/15	19
21						
22		**Website**	**26 days**	**Mon 4/05/15**	**Tue 9/06/15**	
23		Develop template	8 days	Mon 4/05/15	Wed 13/05/15	
24		Insert project information	6 days	Thu 14/05/15	Thu 21/05/15	23
25		Hyperlink cross refences	5 days	Fri 22/05/15	Thu 28/05/15	24
26		Editing & polishing	3 days	Fri 29/05/15	Tue 2/06/15	25
27		Reporting	1 day	Wed 3/06/15	Wed 3/06/15	26
28		Hold Point - Management review [End of reporting]	2 days	Thu 4/06/15	Fri 5/06/15	27
29		Final editing	1 day	Mon 8/06/15	Mon 8/06/15	28
30		Publishing of website	0 days	Tue 9/06/15	Tue 9/06/15	29
31						
32		**Water**	**21 days**	**Mon 4/05/15**	**Tue 2/06/15**	
33		**Bio-retention basin**	**6 days**	**Mon 4/05/15**	**Mon 11/05/15**	
34		Determine size and location	6 days	Mon 4/05/15	Mon 11/05/15	
35		**Rainwater tanks**	**6 days**	**Mon 4/05/15**	**Mon 11/05/15**	
36		Determine tank locations and roof areas	2 days	Mon 4/05/15	Tue 5/05/15	
37		Determine number, size & material of tanks	4 days	Wed 6/05/15	Mon 11/05/15	36
38		**Determine flow rate**	**4 days**	**Wed 6/05/15**	**Mon 11/05/15**	
39		Define accurate catchments	2 days	Wed 6/05/15	Thu 7/05/15	36
40		Define detailed flow rate	1 day	Fri 8/05/15	Fri 8/05/15	39
41		DRAINS model	1 day	Mon 11/05/15	Mon 11/05/15	40
42		**Detailed design of stormwater system**	**4 days**	**Tue 12/05/15**	**Fri 15/05/15**	
43		Define pipe size, material & slope in relation to service conflicts	3 days	Tue 12/05/15	Thu 14/05/15	41
44		Define pit size and location	1 day	Fri 15/05/15	Fri 15/05/15	43
45		Construction locations defined	0 days	Mon 18/05/15	Mon 18/05/15	34,36,43,44
46		Analyse Gross Polloutant Traps in MUSIC	1 day	Wed 20/05/15	Wed 20/05/15	177
47		Reporting	3 days	Mon 18/05/15	Wed 20/05/15	34,37,41,43,44,46
48		Hold Point - Management review [End of reporting]	3 days	Tue 19/05/15	Thu 21/05/15	47SS
49		Distribute design to waiting teams	0 days	Fri 22/05/15	Fri 22/05/15	48
50		Construction Drawings	7 days	Fri 22/05/15	Mon 1/06/15	48
51		Technical Specification	4 days	Fri 22/05/15	Wed 27/05/15	48
52		Identify Safety requirements	3 days	Fri 22/05/15	Tue 26/05/15	48
53		Detailed costing	3 days	Fri 22/05/15	Tue 26/05/15	48
54		Submission to Project Managers	0 days	Tue 2/06/15	Tue 2/06/15	50,51,53,52
55						
56		**Urban Design**	**22 days**	**Mon 4/05/15**	**Wed 3/06/15**	
57		Produce land acquisition model	3 days	Mon 4/05/15	Wed 6/05/15	
58		Develop service clearances detailed design	3 days	Mon 4/05/15	Wed 6/05/15	
59		**Maintenance**	**10 days**	**Thu 7/05/15**	**Wed 20/05/15**	
60		Identify items requring maintenance	4 days	Thu 7/05/15	Tue 12/05/15	
61		Develop maintenance management plan	6 days	Wed 13/05/15	Wed 20/05/15	60
62		**Develop Heritage management plan**	**11 days**	**Mon 11/05/15**	**Mon 25/05/15**	
63		Hold point - need contruction locations from water group	0 days	Mon 11/05/15	Mon 11/05/15	
64		Define heritage properties in conflict with constructions	4 days	Mon 11/05/15	Thu 14/05/15	63
65		Develop individual heritage management plan for each property in conflict	7 days	Fri 15/05/15	Mon 25/05/15	64
66		**Fencing**	**7 days**	**Mon 4/05/15**	**Tue 12/05/15**	
67		Define fencing location and dimensions	3 days	Mon 4/05/15	Wed 6/05/15	
68		Define requried fence type	2 days	Thu 7/05/15	Fri 8/05/15	67
69		Define structural/geo requirements	2 days	Mon 11/05/15	Tue 12/05/15	68
70		**Amenities**	**3 days**	**Wed 13/05/15**	**Fri 15/05/15**	
71		Hold point - need detailed construction information	0 days	Wed 13/05/15	Wed 13/05/15	
72		Define required amenities for construction	3 days	Wed 13/05/15	Fri 15/05/15	71
73		**Community consultation**	**15 days**	**Mon 4/05/15**	**Fri 22/05/15**	
74		Design public contact letter for tank installation	5 days	Tue 12/05/15	Mon 18/05/15	37
75		Design questionnare survey	10 days	Mon 4/05/15	Fri 15/05/15	
76		Create Facebook page	10 days	Mon 11/05/15	Fri 22/05/15	155,156
77		Design Newsletter	10 days	Mon 11/05/15	Fri 22/05/15	155,156
78		Design community poster	5 days	Mon 4/05/15	Fri 8/05/15	
79		Organise community event	5 days	Mon 4/05/15	Fri 8/05/15	
80		Vegetation management plan	10 days	Mon 11/05/15	Fri 22/05/15	
81		Reporting	1 day	Tue 26/05/15	Tue 26/05/15	57,58,61,65,72,80,75
82		Hold Point - Management review & Editing [End of reporting]	3 days	Wed 27/05/15	Fri 29/05/15	81
83		Detailed costing	2 days	Mon 1/06/15	Tue 2/06/15	82
84		Identify Safety requirements	2 days	Mon 1/06/15	Tue 2/06/15	82
85		Submission to Project Managers (5pm)	0 days	Wed 3/06/15	Wed 3/06/15	83,84
86						
87		**Geo/Structural**	**24 days?**	**Mon 4/05/15**	**Fri 5/06/15**	
88		**Site visit**	**4 days**	**Mon 4/05/15**	**Thu 7/05/15**	
89		Determine flow carrying capacity of creek	4 days	Mon 4/05/15	Thu 7/05/15	
90		Determine pavement condition to determine if bike lane is required	4 days	Mon 4/05/15	Thu 7/05/15	
91		Find potential location of pedestrian bridge if requried	4 days	Mon 4/05/15	Thu 7/05/15	
92		**Retaining wall**	**15 days**	**Mon 4/05/15**	**Fri 22/05/15**	
93		Site visit (creek alignment & dim.)	1 day	Mon 4/05/15	Mon 4/05/15	
94		Geotechnical model for retaining wall	2 days	Tue 5/05/15	Wed 6/05/15	93
95		Retaining wall design	4 days	Thu 7/05/15	Tue 12/05/15	94
96		Reporting	1 day	Wed 13/05/15	Wed 13/05/15	95
97		Hold Point - Management review [End of reporting]	3 days	Thu 14/05/15	Mon 18/05/15	96
98		Construction drawings	4 days	Tue 19/05/15	Fri 22/05/15	97
99		Technical specification	4 days	Tue 19/05/15	Fri 22/05/15	97
100		Detailed costing	4 days	Tue 19/05/15	Fri 22/05/15	97
101		Identify safety requirements	4 days	Tue 19/05/15	Fri 22/05/15	97
102		**Arch Culvert**	**23 days**	**Mon 4/05/15**	**Wed 3/06/15**	
103		Site visit	1 day	Mon 4/05/15	Mon 4/05/15	
104		Construction method design	12 days	Tue 5/05/15	Wed 20/05/15	103
105		Reporting	1 day	Thu 21/05/15	Thu 21/05/15	104
106		Hold Point - Management review [End of reporting]	3 days	Fri 22/05/15	Tue 26/05/15	105
107		Construction Drawings	6 days	Wed 27/05/15	Wed 3/06/15	106
108		Technical Specification	6 days	Wed 27/05/15	Wed 3/06/15	106
109		Detailed costing	6 days	Wed 27/05/15	Wed 3/06/15	106
110		Identify safety requirements	6 days	Wed 27/05/15	Wed 3/06/15	106
111		**Excavations**	**13 days?**	**Mon 18/05/15**	**Wed 3/06/15**	
112		Hold Point - Need pipe size from water group	1 day?	Mon 18/05/15	Mon 18/05/15	45
113		Investigate methods	2 days	Tue 19/05/15	Wed 20/05/15	112
114		Trench stability design	3 days	Thu 21/05/15	Mon 25/05/15	113
115		Reporting	1 day	Tue 26/05/15	Tue 26/05/15	114
116		Hold Point - Management review [End of reporting]	2 days	Wed 27/05/15	Thu 28/05/15	115
117		Construction Drawings	4 days	Fri 29/05/15	Wed 3/06/15	116
118		Technical Specification	4 days	Fri 29/05/15	Wed 3/06/15	116
119		Detailed costing	4 days	Fri 29/05/15	Wed 3/06/15	116
120		Identify safety requirements	4 days	Fri 29/05/15	Wed 3/06/15	116
121		**Rainwater Tanks**	**18 days?**	**Tue 12/05/15**	**Thu 4/06/15**	
122		Hold Point (Need tank size & location)	1 day?	Tue 12/05/15	Tue 12/05/15	37
123		Materials research	3 days	Wed 13/05/15	Fri 15/05/15	122
124		Tank design	4 days	Mon 18/05/15	Thu 21/05/15	123
125		Foundation design	3 days	Fri 22/05/15	Tue 26/05/15	124
126		Reporting	1 day	Wed 27/05/15	Wed 27/05/15	125
127		Hold Point - Management review [End of reporting]	3 days	Thu 28/05/15	Mon 1/06/15	126,136,146
128		Construction Drawings	3 days	Tue 2/06/15	Thu 4/06/15	127
129		Technical Specification	3 days	Tue 2/06/15	Thu 4/06/15	127
130		Detailed costing	3 days	Tue 2/06/15	Thu 4/06/15	127
131		Identify safety requirements	3 days	Tue 2/06/15	Thu 4/06/15	127
132		**Structural Analsis**	**13 days**	**Wed 13/05/15**	**Fri 29/05/15**	
133		Pipe design (wait on water, pipe material and size)	3 days	Fri 15/05/15	Tue 19/05/15	43
134		Security fencing analysis	4 days	Wed 13/05/15	Mon 18/05/15	69
135		Heritage buildings (if requried)	3 days	Fri 15/05/15	Tue 19/05/15	64
136		Reporting	1 day	Wed 20/05/15	Wed 20/05/15	135,133,134
137		Hold Point - Management review [End of reporting]	3 days	Thu 21/05/15	Mon 25/05/15	136
138		Construction Drawings	4 days	Tue 26/05/15	Fri 29/05/15	137
139		Technical Specification	4 days	Tue 26/05/15	Fri 29/05/15	137
140		Detailed costing	4 days	Tue 26/05/15	Fri 29/05/15	137
141		Identify safety requirements	4 days	Tue 26/05/15	Fri 29/05/15	137
142		**Geotechnical Analysis**	**14 days**	**Wed 13/05/15**	**Mon 1/06/15**	
143		Pipe Loads	3 days	Fri 15/05/15	Tue 19/05/15	43
144		Pit Loads	3 days	Mon 18/05/15	Wed 20/05/15	44
145		Security fencing analysis	4 days	Wed 13/05/15	Mon 18/05/15	69
146		Reporting	1 day	Thu 21/05/15	Thu 21/05/15	143,144,145
147		Hold Point - Management review [End of reporting]	3 days	Fri 22/05/15	Tue 26/05/15	146
148		Construction Drawings	4 days	Wed 27/05/15	Mon 1/06/15	147
149		Technical Specification	4 days	Wed 27/05/15	Mon 1/06/15	147
150		Detailed costing	4 days	Wed 27/05/15	Mon 1/06/15	147
151		Identify safety requirements	4 days	Wed 27/05/15	Mon 1/06/15	147
152		Submission to Project Managers (5pm)	0 days	Fri 5/06/15	Fri 5/06/15	98,99,107,108,128,129,138,1
153						
154		**Transport**	**24 days**	**Mon 4/05/15**	**Fri 5/06/15**	
155		Determine construction timing	4 days	Mon 4/05/15	Thu 7/05/15	
156		Determine detours	5 days	Mon 4/05/15	Fri 8/05/15	
157		**Traffic model**	**13 days**	**Mon 4/05/15**	**Wed 20/05/15**	
158		Develop traffic model of project area	10 days	Mon 4/05/15	Fri 15/05/15	
159		Derive outcomes from model	3 days	Mon 18/05/15	Wed 20/05/15	158
160		**Develop public transport management plan**	**5 days**	**Thu 21/05/15**	**Wed 27/05/15**	
161		Define required signage and devices	3 days	Thu 21/05/15	Mon 25/05/15	156
162		Define required lane closures	1 day	Mon 25/05/15	Mon 25/05/15	45,159
163		Develop local buisiness access plan	2 days	Tue 26/05/15	Wed 27/05/15	162
164		Develop pedestrian access plan	2 days	Tue 26/05/15	Wed 27/05/15	162
165		Reporting	1 day	Thu 28/05/15	Thu 28/05/15	164,159,161,162,163,156
166		Hold Point - Management review [End of reporting]	3 days	Fri 29/05/15	Tue 2/06/15	165
167		Detailed costing	2 days	Wed 3/06/15	Thu 4/06/15	166
168		Identify safety requirements	2 days	Wed 3/06/15	Thu 4/06/15	166
169		Submission to Project Managers (5pm)	0 days	Fri 5/06/15	Fri 5/06/15	166,167,168
170						
171		**Environment**	**21 days**	**Mon 4/05/15**	**Tue 2/06/15**	
172		**Environmental Management Plan**	**14 days**	**Mon 4/05/15**	**Thu 21/05/15**	
173		Draft environmental management plan	5 days	Mon 4/05/15	Fri 8/05/15	
174		Develop environmental management plan	6 days	Mon 11/05/15	Mon 18/05/15	173
175		Edit environmental management plan	3 days	Tue 19/05/15	Thu 21/05/15	174
176		**Gross Pollutant Traps**	**3 days**	**Fri 15/05/15**	**Tue 19/05/15**	
177		Define location and size of trap	3 days	Fri 15/05/15	Tue 19/05/15	40,43
178		Reporting	1 day	Fri 22/05/15	Fri 22/05/15	175,177
179		Hold Point - Management review [End of reporting]	3 days	Mon 25/05/15	Wed 27/05/15	178
180		Detailed Costing	3 days	Thu 28/05/15	Mon 1/06/15	179
181		Identify safety requirements	3 days	Thu 28/05/15	Mon 1/06/15	179
182		Submission to Project Managers	0 days	Tue 2/06/15	Tue 2/06/15	180,181
183						
184		**Final Report**	**2 days**	**Fri 5/06/15**	**Tue 9/06/15**	
185		Collect final submissions from teams	0 days	Fri 5/06/15	Fri 5/06/15	54,85,152,169,182
186		Compile and edit report	2 days	Fri 5/06/15	Mon 8/06/15	185
187		Submit report	0 days	Tue 9/06/15	Tue 9/06/15	186



Project: Project Gantt Chart 0.2
Date: Wed 6/05/15