Report

Hospital Prince of Wales Reservoir - Preliminary Design Report

Prepared for Wellington City Council (Client)

By CH2M Beca Ltd (Beca)

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Volume 1 of 2

Revision History

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1 Introduction

1.1 Background

Wellington City Council (WCC) are seeking to construct a completely buried 35,000m3 concrete reservoir within the Town Belt and above the Upper Prince of Wales Park in Mount Cook (refer Figures 1.1 and 1.2) to service the Wellington Regional Hospital and Central Business District. The facility will have a special post disaster function to supply water for the Wellington Regional Hospital and therefore is required to have an equivalent operational continuity limit state design seismic return period event as the Wellington Regional Hospital (1000 year return period).

The form and location of the selected reservoir needs to recognise the sensitivity of undertaking the required construction works within the Town Belt including environmental considerations.

The WCC programme is to design, construct and commission the new facility, including connections to the existing water reticulation system by approximately the middle of 2017.

CH2M Beca Limited (Beca) has been commissioned by WCC under the Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir (WCC, 1 February 2012) (the Brief).

A number of alternative concepts for both the reservoir and the associated services tunnel were considered in the Conceptual Design Options Report and a preferred single combined reservoir and tunnel arrangement has been identified for advancing to Preliminary Design.

Similarly, a number of alternatives for utilising the Upper Park for temporary storage of excavated material, and for subsequently upgrading the park, have been considered in a Park and Surplus Material Options Assessment Report and a preferred approach has been identified by Capacity Infrastructure Services (Capacity) for advancing to Preliminary Design.

1.2 Project Objective

The Preliminary Design has been based on the assumption that the key WCC objectives are to:

- Build a 35,000 cu m reservoir which has a high degree of reliability and serviceability both in normal service and after an ULS earthquake and with high level of detailing to minimise risk of leakage and minimise maintenance requirements;
- Consider and address the location of the reservoir in the Town Belt and accordingly to construct a completely buried reservoir and landscape the site on completion in an appropriate manner;
- Complete the consultation and consenting without controversy;
- Adopt a design and construction methodology to reflect the Town Belt location and access through a residential area; and
- Complete construction without controversy or consent non-compliance.

The above is based on Beca's interpretation of the requirements of the Brief.

1.3 Site Location

The general location and existing features of the reservoir site are shown in Figures 1.1 and 1.2 and Drawing 6517439-GS-101 shows the existing topography.

Figure 1.1: Proposed Reservoir Site Location

Figure 1.2 Aerial View of Prince of Wales Park

1.4 Purpose and Scope of Report

The purpose and scope of this report is to:

- Describe the Preliminary Design of the selected combined reservoir and services tunnel option and the upgrading of the Upper Park sports field;
- Identify the basis of and identify specific aspects to be addressed at detail design stage;
- Describe in general terms the consenting and consultation strategies to be implemented during Stage 2 of the Project; and
- Describe how these strategies will be recognised and allowed for in the detailed design.

1.5 Associated and Referenced Reports

This report references and draws on information and conclusions from the following documents:

- Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir (WCC, February 2012);
- Hospital Prince of Wales Reservoir Park and Surplus Material Options Assessment Report (Beca, July 2012);
- Hospital Prince of Wales Reservoir Conceptual Design Options Report (Beca, February 2013);
- Seismic Hazard Assessment for the Hospital Prince of Wales Reservoir (Beca, December 2012);
- Hospital Prince of Wales Reservoir Geotechnical Report (Beca, October 2012);
- Hospital Prince of Wales Reservoir Geotechnical Report - Addendum (Beca, January 2013); and
- Hospital Prince of Wales Reservoir (Stage 1 to 3) Risk Analysis (Beca August 2012).

2 Selected Arrangement

2.1 Introduction

In accordance with the Capacity letter of 1 March 2013, this report considers only the preferred reservoir Option R1.0 identified in the Conceptual Design Options Report and the Upper Park Option P1.

2.2 Site Layout

Drawing 6517439-CE-K31 shows the extent and shape of the excavation required to construct the reservoir and tunnel. The excavation profiles have been based on the recommendations in the Hospital Prince of Wales Reservoir Geotechnical Report (Beca, October 2012).

Drawing 6517439-CE-K32 shows the final contours and extent of backfilling on completion of the reservoir

2.3 Reservoir Structure

The reservoir Option R1.0 selected in the Conceptual Design Options Report was a circular and centrally located reservoir with a conventional roof with minimal slope to affect roof drainage. Subsequently the roof arrangement has been modified to a truncated cone with a 10m diameter generally flat section, but with a nominal drainage fall, and a 10H:1V slope out to the top of the walls. This modification was made to improve the resulting contour of the landform over the roof of the reservoir. The reservoir is located in the position shown on Drawing 6517439-CE-K31 and has an internal diameter of 67.0m and wall eaves height of approximately 12m. The subgrade level for the excavation is assumed as 81.0m. Water depth is nominally 10.0m. Refer Drawing 6517439-CE-K18.

2.4 Tunnel Structure

The tunnel structure option selected in the Conceptual Design Options Report is a single tunnel with 6.25m internal clear width located below the floor level of the reservoir orientated towards Rolleston St and fitted with an access door on the side of the tunnel. This arrangement is shown on Drawings 6517439-NM-201 to 205 inclusive.

2.5 Reservoir Pipework

Preliminary definition of the piping configuration for the reservoir has been provided by WCC and includes high and low pressure inlets, outlets, overflow, scour and a ducted air vent from inside the reservoir. The pipe tunnel will also include electrical switchboards and instrumentation and control equipment.

A Piping and Instrumentation Diagram (P & ID) included in the Mechanical Basis of Design Report in Appendix B has been developed by WCC and Beca to define the preferred solution for the reservoir piping control and operational requirements

2.6 Service Connections

The inlet and outlet pipes cross the Upper Park to the end of Hargreaves Street is as indicated in Drawing 6517439-NM-201.

The overflow/scour drain from the reservoir itself will connect to the upgraded Rolleston Street drain. The overflow from the reservoir is sized to allow 1200L/s which will exceed the capacity of the Rolleston Street storm water drain. It is proposed that the resulting overflow would spill to ground in a controlled manner via a scruffy dome manhole located in the south-western corner of the Upper Park. This will have a surrounding apron of rock rip rap to protect from scour. Flow would then be routed via surface contouring onto Rolleston Street as required by the Brief.

The 400 L/s scour flow from the reservoir will discharge into existing storm-water drainage along Rolleston Street which will be upgraded to accommodate it. The Preliminary Design concepts include the installation of a new a 600mm diameter RCRRJ storm water pipe down Rolleston Street.

2.7 Access and Parking

Drawing 6517439-CE-K32 shows the final access road to the door of the tunnel. This road will cross the western margin of the Upper Park playing field and in that area the access road will be available for use by park users.

Otherwise no specific consideration has been made in the Preliminary Design for the provision of enhanced car parking on or adjacent to the Upper Park. Capacity has noted that consideration will need to be given in the detailed design phase. Factors and issues to be considered are set out in Section 6.9.

2.8 Landscaping Arrangements

Drawing 6517439-LS-001 shows potential landscape treatment of the site following construction of the selected reservoir. The key factors that were taken into consideration in preparing the preliminary landscape concept are presented in the Landscape Report included in Appendix D.

An indicative species list, footpaths and seating areas have been included on the Preliminary Landscape Concept plan. It is anticipated that refinement of these elements will occur during detailed design development including the input resulting from consultation.

2.9 Temporary and Permanent Works on Upper Park

2.9.1 Temporary Material Storage

The Preliminary Design and associated estimating is based on temporary storage of excavated material on the Upper Park. The assessment of this quantity has been undertaken based on the following assumptions which have been revised from those discussed in the Park and Surplus Material Options Assessment Report as a result of the additional geotechnical information becoming available on the stability of the Upper Park embankments:

- Generally a 5m clear zone is allowed along the north, east and south sides of the Upper Park except this zone width is increased to 15m at the northwest corner due to the poorly constructed adjacent embankment. This is to avoid significant surcharge loading to the adjacent embankments and the zone of in-ground services to the south, and provides space for the contractor's sediment and erosion control systems particularly at the eastern end;
- A 10m clear zone along the west side adjacent Rolleston Street for access to the site;
- Temporary side slopes of 1V:1.5H to the stock pile; and
- A maximum height of stored fill of 8.5m above the Upper Park level with the existing top soil removed.

Based on these assumptions a perspective view of the temporary stock pile is shown in Figure 2.1 and a typical Cross Section in Figure 2.2.

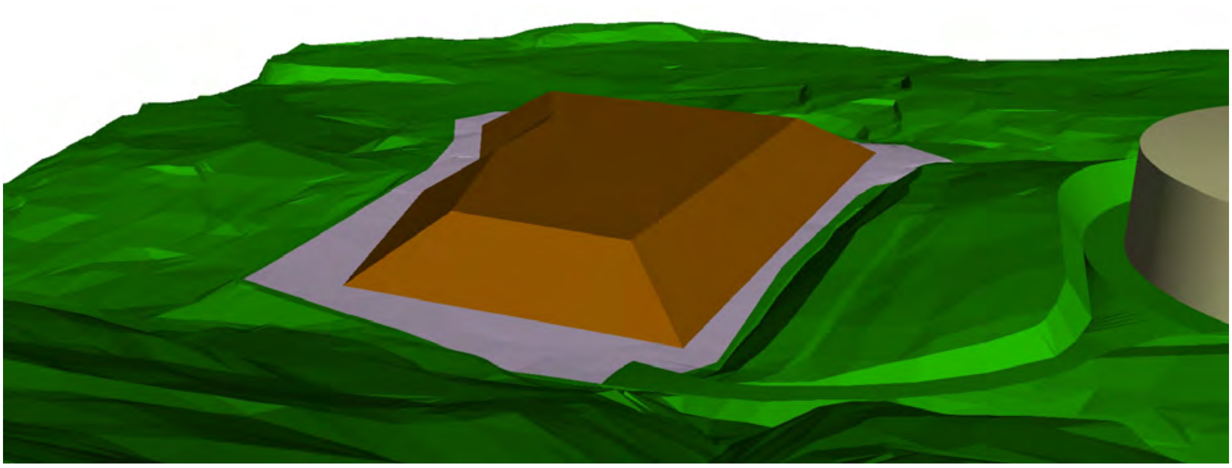

Figure 2.1: Stock Pile Excavated Material, Upper Park

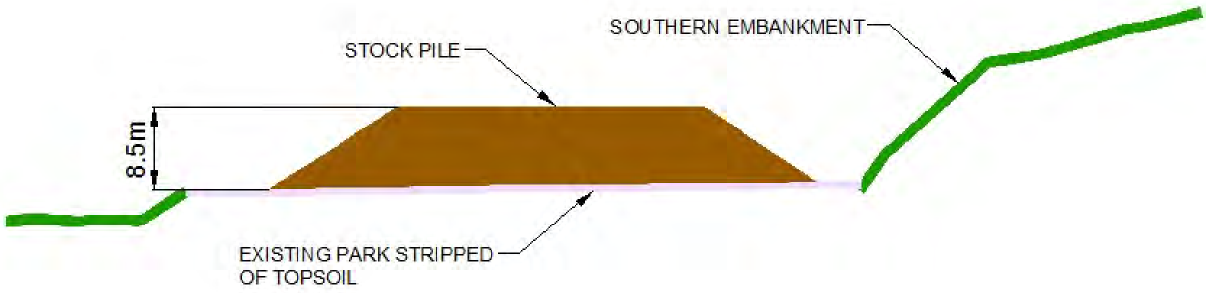

Figure 2.2: Cross Section – Stock Pile Excavated Material, Upper Park (north/south)

2.9.2 Permanent Arrangements

The Park and Surplus Material Options Assessment Report considered a number of options for the final surface of the Upper Park after removal of temporary stored material. Options P1 and P2 were preferred and considered as being comparable, but with different advantages and disadvantages. Capacity selected Option P1 that was effectively for the same cost as Option P2 and without the additional risks associated with new retaining walls and filling over existing services. This involves raising the field the minimum necessary to achieve a desirable surface shape from a drainage perspective. This option has a central generally level crown and surface cross fall at 1:70 to side drains with drainage sumps (both sides). With this arrangement the cover over water mains and power cables remains approximately as existing, no significant edge retaining walls are required and the location of the chain netting fence remains unchanged.

As part of the Option P1 selection, Capacity also requested use of:

- Concrete rather than grass swale side drains, the cost of which is now considered to be included in the cost estimate, and
- In-field irrigation in lieu of use of travelling irrigators.

The detail extent of this irrigation is unclear at this stage and therefore the cost estimate allows for the use of travelling irrigators as scoped in the Park and Surplus Materials Options Assessment Report.

3 Site Factors

3.1 Introduction

The following sections identify factors that have been taken into account in the Preliminary Design or have been identified for action during the consenting and detailed design phases

3.2 Geotechnical Conditions

The Geotechnical Report and the Addendum to the Geotechnical Report describe site conditions as indicated in the design and geotechnical factors requiring consideration in the design.

3.3 Site Seismicity

The Geotechnical Report has advised that no active faults cross or are close to the site and site disruption by faulting does not need to be considered.

The conclusions and recommendations of the Site Specific Seismic Hazard assessment have been taken into account in the Preliminary Design.

3.4 Local Street Connections

All construction and operational / maintenance access will be from Rolleston Street and the high level of construction traffic will require detailed consideration during preparation for the Resource Consent application. Drawing 6517439-CE-K32 shows an area of surface paving on the western end of the sports field in the final arrangement and noting that limited space will be available next to the western facing access doors to the reservoir tunnel structure. This will enable vehicles associated with maintenance and operation to be parked off Rolleston Street.

3.5 Town Belt Access Paths

Existing access paths through the site are shown in Drawing 6517439-CE-K30 and the wider distribution of access paths is shown in Figure 3.1.

Figure 3.1 Existing Walking Paths in Vicinity of Reservoir

4 Environmental Factors

4.1 Location in Town Belt

4.1.1 General

In undertaking the Preliminary Design we have recognised the conditions within Section 5.2 of the Brief Reference 23 that:

- *"The impacts of the proposed reservoir on Town Belt shall be minimised.*
- *The proposed reservoir shall be placed underground, fully buried with existing landform matched as closely as practicable.*
- *It shall be sited to minimise interference with existing features, facilities and plants.*
- *On completion, the proposed reservoir will not affect or change the recreational use of the area.*
- *Any disturbance of the existing site during installation of the proposed reservoir shall be made good immediately after completion."*

4.1.2 Access Through Town Belt

It is implicit in the Brief that the paths through the Town Belt on completion of the reservoir will be at least equivalent to the existing arrangements. This is achievable and is illustrated on the Preliminary Landscape Concept plan (refer Drawing 6517439-LS-001).

In addition to these 'end use' connections, Section 3.4.5 of the Brief also requires proposals for pedestrian access around the construction site connecting Dorking Road, Rolleston Street, Hargreaves Street, the track to the Bell Road reservoir site from the top of Rolleston Street, and the Lower Park.

As discussed in Section 5.14.4 there would be significant difficulties in providing passage between Dorking Road and Rolleston Street immediately adjacent to the site during construction, and the proposal is that during construction pedestrian access from Dorking Street to Hargreaves Street and Rolleston Street would be via the existing paved pedestrian path passing the existing reservoir adjacent Bell Road.

4.2 Visual Effects

4.2.1 General

Section 3.4.5 of the Brief requires landscape drawings for the site and proposed development to be prepared including *"before construction, construction and post construction visual impact sketches and amended photographs".* Drawing 6517439-CE-K30 shows existing site features and vegetation. Drawing 6517439-CE-K31 shows the extent of the construction footprint and vegetation/ landform disturbance. Drawing 6517439-LS-001 shows the preliminary landscape concept for the post-construction treatment for the site.

At this stage 'visual impact sketches and amended photographs' have not been prepared. The main reason for this is that there is insufficient detail at this stage of the project to ensure a suitable degree of accuracy in preparing such imagery. Also as discussed in Section 7.5, it is considered more appropriate to wait until consultation has been progressed with key stakeholders before deciding whether and what, visual impact sketches and amended photographs, should be prepared.

This approach will also allow amendments to the landscape concept plan and illustrative material in conjunction with the preparation of a more detailed landscape and visual effects assessment, which is to be carried out during Stage 2 of the Project.

Without pre-empting this detailed assessment the following general points represent the likely issues around potential visual effects of the proposed reservoir development. The key consideration at this stage is that the degree of visual effect associated with the construction phase and post-construction timeframes will vary considerably.

4.2.2 Construction Phase

Given the elevation of the site and the overall construction footprint (refer Drawing 6517439-CE-K31) it is likely that visual effects will require detail consideration during this phase. The combination of vegetation removal, excavation and temporary fill material storage will result in a highly modified and 'raw' look for the full construction period.

It is likely that during this period the construction works will be visible (to a greater or lesser extent) from various locations across the local and broader landscape. The 8.5m maximum height stockpiled material on the Upper Park will be visible from houses on the western side of Rolleston Street and at the end of Hargreaves Street and possibly also from points on the eastern side of the Newtown Valley.

The large portion of well-established vegetation to be removed from the site will mean that the only existing mitigating factors will be distance, elevation, and complexity of the view from a particular location.

For those houses and public viewpoints that are oriented towards, and have unobstructed views to the site, the construction works will be highly visible and will be a noticeable contrast to the adjacent Town Belt backdrop and surrounding residential matrix.

The existing residential amenity for houses that are located in close proximity will also be adversely affected by the storing and transporting of materials to and from the site. Other environmental effects like dust and noise may also affect existing residential and open space/ Town Belt amenity during the construction period.

In addition to visual effects, the Upper Park sports field will not be available for a period approaching two years. Also whilst temporary pedestrian access around the construction works may be achievable, the ability for users to use the area as they currently do will be temporarily restricted.

Given the nature and extent of the proposed works it is unlikely that additional mitigation measures will significantly reduce effects resulting from construction works. The only option is to ensure that regular hydroseeding of exposed cut faces, fill batters and storage mounds is undertaken to 'soften' the overall appearance of the site.

4.2.3 Post Construction

Although the shape of the ground surface over the reservoir will be noticeable immediately following the construction of the reservoir the quick establishment of grass cover and on-going (re)establishment of vegetation overtime, will mean that the visual effects of the proposed reservoir will be short term.

The change in topography will not be noticeable from locations outside of the Park itself after ground cover is established. Users of the Park and access tracks will notice the change in land form the most but it is anticipated that effects on these users will be minor once access is reinstated and additional vegetation establishes in the medium to long term.

4.3 Urban Design Issues

The key urban design issues associated with the site relate to safe accessibility and connectivity to the wider pedestrian/ street network. The Preliminary Landscape plan takes these issues into account through the provision of:

- Reinstatement of existing paths. Similar to the existing paths, the reinstated paths will be steep in certain areas due to the existing site topography. In addition the introduction of the new reservoir will increase the vertical change in level in some areas and the constrained area available to install pathways will also present challenges to establishing walk ways. The potential to create a gentler graded pathway through the site through 'zig-zag' pathways up the slope will be explored further during the detailed design phase. Paths are proposed to be a minimum of 1.8m in width;
- Introduction of additional paths to increase accessibility across the site;
- Suggested formation of paved or gravel pathways to promote all-weather access and thoroughfare;
- Provision of bench seats, rest areas, signage and information boards as an opportunity for enhancement of amenity and way-finding; and
- Introduction of additional vegetation to reinstate and enhance the existing characteristics of the site. Consideration of safety, keeping open views and clears lines of sight along pathways. When planting close to paths keep the vegetation immediately adjacent the pathway low and below eye height.

4.4 Cultural Issues

As noted in Section 3.4.5 of the Brief, consultation will be undertaken with iwi as part of Stage 2 of the Project. At this stage Beca are not aware of any cultural issues associated with the sites.

4.5 Archaeological

As noted in Section 3.4.7 of the Brief, archaeological work to date has not identified any sites in the area of the reservoir. However, consultations with NZHPT will be required to obtain agreement to an *"accidental Discovery Protocol"* which will be included in the construction documentation prepared at detailed design stage.

4.6 Ecological Impact

Photo 4.1 shows an oblique aerial photograph taken in 1947 indicating the clearance of land west of the reservoir site and the commencement of regeneration in the slope immediately west of the site.

Photo 4.1 Oblique Aerial of Site Area
Brooklyn, Wellington. Whites Aviation Ltd: Photographs Ref: WA-11409-F. Alexander Turnball Library, Wellington New Zealand, December 1947

Drawing 6517439-CE-K30 indicates the vegetation currently on the reservoir site and its assessed ecological value as determined in discussions with WCC Parks and Gardens staff. In the gully to the west of the reservoir there is some 1st order regenerating native bush (typical as a result of the original burn offs across the Wellington region in the 19th century) which is of high value. The remainder of the site is covered by pasture grasses and low to moderate value vegetation, however is not considered to be ecologically significant. With the selected Option R1.0 it is expected to be possible to design the reservoir and the temporary working areas without significant impacts on this area.

Photos of Prince of Wales Park in the 1920's are shown in Photo 4.2.


Photo 4.2 Historical Photos of Prince of Wales Park (from WCC archives, Lower Park)

Photos 4.3 to 4.6 indicate typical examples of the classes of vegetation shown on Drawing 6517439-CE-K30.

Photo 4.3 Bush High Value Regenerating Natural Bush

Photo 4.4 Moderate Value Mixed Planting

Photo 4.5 Low Value Exotics (right hand side)

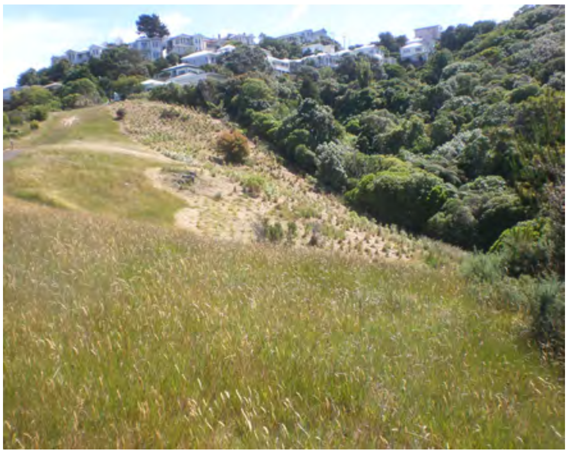

Photo 4.6 Recent Planting

4.7 Construction Impacts

There will be a large number of potential construction aspects that will require management and some of which may be the subject of specific consent conditions beyond the general requirements of the District Plan. These impacts include:

- Need to exclude the public, and particularly children, from the construction site;
- Management of large volumes of heavy trucks and other construction traffic on Rolleston Street and passing through the Rolleston Street – Wallace Street intersection;
- Noise from the construction site and on Rolleston Street;
- Dust from the construction site and from spillage of soil on Rolleston Street; and
- Water run off and sediment control from opened earthworks and site areas.

4.8 Demolition of Superseded Facilities

As noted in Section 3.4.5 of the Brief the redundant 'Meter Hut' (shown on Drawing 6517439-CE-K30) will be removed and the area reinstated. The decision to either abandon the diverted 1954 water main across the Upper Park or excavate and remove the pipe will be made during the detailed design phase.

5 Preliminary Design

5.1 Introduction

The following sections document the design philosophies and assumptions made during the Preliminary Design. These have formed the basis of option consideration and the preliminary cost estimate. It should be noted that Preliminary Design has established the general form of structure and dimensions. These will be further developed in the detailed design. Components that do not influence the form and dimensions or have a significant effect on the cost estimate are not included, and will be developed as part of the detailed design.

As a Preliminary Design, all locations and details presented in this report are to be considered indicative and subject to review and refinement in the detailed design phase.

Preliminary Design Drawings are presented in Appendix H.

5.2 Consultation

As agreed with Capacity, consultation to this stage has been limited to discussions with WCC Parks and Gardens.

5.3 Hydraulic Design Criteria

Hydraulic design criteria as required by the Brief for the reservoir and pipework are summarised in Table 5.1 below.

Table 5.1: Hydraulic Design Criteria

Element	Characteristic
Reservoir	
Storage Volume	35,000m^3
Top Water Level	RL92.00m
Overflow Level	RL92.075m
Pipework	**Max Flow Rate**
Primary Inlet	700l/s
Secondary Inlet	120l/s
Outlet	800l/s
Overflow	1,200l/s
Scour	400l/s

5.4 Reservoir Structure

The Preliminary Design has been undertaken assuming Option R1.0 of the Conceptual Design Options Report and taking into account the requirements of Section 3.4.18 of the Brief and others sections of the Brief where noted. An Importance Level 4 has been adopted as the basis of design.

The reservoir has been designed as a single cell tank without internal walls.

5.4.1 Structural Basis of Design

The structural basis of design is included at Appendix A.

It has been updated from that presented in the Conceptual Design Options Report to include the confirmation in the Capacity letter dated 1 March 2013 to adopt a 100 year design life and a 1000 year return period earthquake for Serviceability Limit State 2 (SLS2) load case.

5.4.2 Reservoir Dimensions and Levels

The internal dimensions and floor and roof levels have been determined from the requirements of Sections 3.4.14 and 3.4.18 of the Brief, and the requirement that the structure will be constructed in an excavation and backfilled to provide a minimum of 500mm earth cover.

5.4.3 Structural System

The structural system comprises of walls which following circumferential post-tensioning are then ~~tin~~ connected to the floor slab. The walls act primarily in hoop tension but vertical bending movements are induced due to pinning of the base.

A wall to roof connection allowing limited thermal movement is provided with a down standing perimeter beam.

Seismic loads from the roof are transferred via bearing of the perimeter down stand beam against the top of the wall. The roof seismic load and the horizontal seismic load due to the contents are transferred down through the walls to a shear connection between the base of the walls and the floor slab.

Key reference Drawings are 6517439-CE-K18, K19 and K23.

5.4.4 Watertightness from Within

The principles used in the design for each reservoir element are as follows:

- A doubly reinforced insitu concrete floor slab designed to limit crack widths to 0.2mm. The slab has a flush soffit and is laid on a double layer of polythene to minimise frictional resistance to shrinkage.
- An infill annular floor slab section at the wall base poured after due to allowance for main slab shrinkage and after wall stressing is complete;
- Floor construction joints comprising a central hydrophilic waterstop and a PVC backstop type waterstop provides two lines of defence against leakage. The base of the wall joint comprises a sealant in a surface rebate and two lines of hydrophilic waterstops;
- Vertically pretensioned and circumferentially post-tensioned walls with insitu concrete infills between panels. Watertightness across these joints is achieved via the post-tensioning and hydrophilic waterstops, the latter being continuous with the horizontal hydrophilic waterstops at the base of the wall;
- A continuous rubber bearing strip on top of the wall kept in compression by a tie down between the roof perimeter beam and the wall. This will prevent leakage during earthquake sloshing; and
- Puddle flanges with hydrophilic waterstops at all pipe penetrations.

5.4.5 Watertightness from Without

A key design assumption is that the reservoir, particularly the underside of the floor, will not be subject to water pressure from without. This is achieved through the provision of a gravity subsoil draining network under the floor.

Watertightness is achieved as follows:

- Backstop PVC waterstops to the underside of floor joints, and a central hydrophilic waterstop;
- A double line of hydrophilic waterstops at the base of the wall joints;
- Draining to the rear of the walls and a bituminous emulsion applied to the outside of the walls. The post-tensioned walls and hydrophilic waterstops at panel infills also contribute to the watertightness from without.
- A membrane applied over the roof and the perimeter beam. A purpose designed and fabricated angle section continuous seal between the underside of the perimeter beam of the wall. This seal laps with the roof membrane and the wall bituminous emulsion.
- A drainage layer above the protective site concrete over the roof membrane and around the perimeter of the reservoir walls, refer drawings 6517439-CE-K23 and K26.

5.5 Reservoir Circulation and Mixing Provisions

Mixing and turnover are important to maintain water quality within the reservoir. The aim of mixing is to provide a uniform distribution of water to avoid pockets of stagnant water that may allow loss of chlorine residual and the risk of microbiological regrowth. Turnover reduces the amount of time that all of the water stays in the reservoir thus maintaining chlorine residual and water quality.

Several options exist to provide and/or increase turnover.

5.5.1 Baffles

Baffles can be provided to avoid short circuiting between the inlet and outlet. For a circular reservoir, a vertical baffle could be provided from the wall through the centre of the tank. The inlet and outlet would be placed on the same side of the reservoir, either side of the baffle wall. The baffle could either be rigid and part of the structure, or it could be a flexible curtain.

However, for a storage reservoir, short-circuiting is not so much of an issue as stagnant areas. Without very elaborate baffling, dead areas can still form near corners and will not be uniformly mixed. With a simple single radius baffle, any mixing provided by the velocity from the inlet pipe would be prevented from providing mixing on the other side of the baffle.

In addition baffles can add significant structural and operational complications, and create difficulties during cleaning.

5.5.2 Separate Fill and Draw

One method commonly used is to have regular cycles where the reservoir is drawn down to a low level and refilled. As one of the primary functions of the reservoir is to provide emergency storage, the amount the reservoir can be drawn down is limited. However, the reservoir should be operated to draw the level down to minimum operating level on a regular basis.

5.5.3 Inlet and Outlet Configurations

Inlet and Outlet Locations

Without baffling, to avoid short circuiting between the main inlet and outlet, they should be placed at opposite sides of the reservoir. This arrangement will result in good turnover through the centre of the tank.

Low Level vs High Level Inlets

A high level inlet can aerate the water as it plunges from the discharge to the water level. A low level inlet avoids this. A high level inlet will provide a stable discharge head that may assist with the control of the system.

High Level Inlet with Top Discharge Point

A simple arrangement is to provide a vertical riser that discharges from the top of the pipe. As mentioned above, with the inlet and outlet at separate sides of the tank, good turnover will occur through the centre. However, there could be areas which do not experience as high a turnover around the sides of the tank.

Low Level Inlet with Angled Discharge

The inlet pipe can be placed at an angle (30º-45º from vertical) and discharge near the bottom of the tank. This will create a swirl pattern within the tank. Although this will move water around the tank and avoid stagnant water at the sides, this type of arrangement is not particularly effective at achieving uniform mixing, especially vertical mixing and moving water near the centre of the tank.

Low Level Inlet with Discharge Ports

Tideflex manufacture rubber duck bill non-return valves. They have a mixing system based on these valves (which they call Tideflex Mixing System). The advantage of these valves is that they will provide higher velocities at lower flows leading to more consistent mixing in the reservoir. An enquiry was sent to them for a mixing arrangement for the reservoir. They proposed a low level inlet with 3 pairs of discharge ports that discharge at an angle. They stated that this system would result in better mixing than a vertical inlet. Computational Fluid Dynamics (CFD) analysis results were also provided which show complete mixing can be achieved if the inlet flow is maintained for 2.1 hours at the maximum inflow. This equates to a 1.5m level change in the reservoir. If this is achieved it would result in a 7.4 day water age. Greater level changes would result in lower water ages. Details are provided in the Appendix ~~G~~ E attached.

Note that the system put forward by Tideflex also includes non-return valves to allow the inlet pipe to function as an outlet. As this is not required, these valves would be omitted. This does not affect the analysis carried out.

Tideflex provided an indicative cost of about $66,000 for the system. This includes final sizing, pipework drawings and supply of valves. This does not include the reservoir pipework. This cost is subject to confirmation.

High Level Inlet with Discharge Ports

To encourage greater mixing throughout the reservoir, the inlet can have horizontal discharge ports on a vertical riser pipe. This pattern will encourage a circular flow path with greater vertical mixing. Multiple ports would be provided on the inlet riser to distribute the incoming flow across different levels. The ports would be directed towards the wall (away from the outlet) and to the sides. The size of the ports will need to be small enough to generate a reasonable velocity. Duck bills could also be considered for the ports.

Tideflex can also provide a mixing system based on a vertical inlet. This is usually used on reservoirs where the depth is greater than the diameter. However, this could also be applied to te this reservoir if it was preferred.

5.5.4 Mechanical Mixing

Mechanical mixing can provide the most consistent mixing in a tank, but mixers are not routinely used in water supply service reservoirs. It would require regular maintenance which would be complicated by the fact the reservoir is buried. Access to the mixers would only be possible by draining the reservoir and entering through the access in the floor, or creating an access shaft above each mixer location. Mechanical mixing would also have an on-going power cost, although this would not be large.

Mechanical mixing options include propeller mixers, recirculation pumps, aeration and draft tube mixers. All options will require regular maintenance. In addition, aeration could be a source of contamination if the air quality is not appropriate.

Draft tube mixers (eg WEARS) have been successfully used in large open water reservoirs to promote mixing. These mixers have very low energy inputs and could be cost-effective for the large capacity of this reservoir.

5.5.5 System Adopted

At this stage the system adopted for Preliminary Design comprises of a high level inlet on the opposite sides of the reservoir to the outlet. Mixing enhancement increases as described above could be further considered if Capacity would like to pursue such an option.

5.6 Tunnel Structure

The Preliminary Design has been undertaken assuming the Option 1 layout as identified in the Conceptual Design Options report. An Importance Level 4 has been adopted as the basis for design.

The reinforced concrete structure will be constructed in an excavation and backfilled. Where the tunnel is beneath the reservoir the excavation will be steep sided with reinforcement and the excavation will be backfilled with low strength concrete or cement stabilised basecourse. Beyond the reservoir footprint influence a conventional free standing excavation may be used and backfilled to provide a minimum of 500mm earth cover

The Preliminary Design provides access for both regular maintenance/inspection and in an emergency. Access includes vehicle access to the door of the reservoir to allow delivery of heavy valves or other components.

5.7 Reservoir Pipework

Details of the reservoir pipework developed in the Preliminary Design are shown on Drawings 6517439-NM-201 and 202.

The Preliminary Design has assumed the reservoir will be fitted with an air vent discharging via the end of the pipework tunnel. The pipe tunnel is also assumed to have provision for a floor drainage system capable of removing water at the full inlet flow rate of the reservoir (1,200 l/s). This is to direct a potential uncontrolled flow into the pipe tunnel to Rolleston Street in the event that a pipeline rupture occurs inside the tunnel.

5.8 Existing Utility Services

5.8.1 General Services

A number of services including the existing 375mm and 450mm water mains are located adjacent to the southern side of the sports field and a 375 water main crosses the park. Locations and details of pothole investigations are shown on Drawings 6517439-GS-103 and 104. There is also an existing stormwater pipe from the toe of the bank across the western margin of the park to an existing manhole M27-030 in the upper section of Rolleston St. Locations are indicated in Drawings 65174390-NM-201 and 202.

The very limited amount of additional fill that can be placed over these services has been taken into account in the design of the modifications to the sports field and in determining the extent of the temporary stockpile.

Specific design will be required in the detailed design phase where the reservoir services cross these utility services. Refer to Drawing 6517439-CE-K24.

The invert levels and details of the existing services are shown on Drawings 6517439-GS-102 and 104:

5.8.2 Power Services

Wellington Electricity (WE) HV power cables are located underground along the southern side of the Upper Park and immediately north of the embankment to the reservoir site, refer Drawings 6517439-GS-103 and 6517439-NM-201. The selected Upper Park Option P1 does not involve any significant increase in soil cover over the existing power cables.

Also while the Upper Park is being used for the temporary storage of excavated material, the storage area (refer Section 2.9.1) has been arranged clear of the existing power cables and therefore does not provide surcharge loading over the power cables.

Proceeding to construction, it is expected that the following requirements would be included in any construction contract:

- Prior to any work being carried out, the power cables would need to be accurately located with the involvement of WE;
- No work will be permitted within the vicinity of the power cables without the presence of WE;
- Construction of the reservoir access road over the power cables would be in accordance with WE requirements, a protection slab or ducting may be required; and
- The use of the area by the contractor immediately above the cables would be subject to WE being able to obtain direct access to the power cables at any time should urgent maintenance work be required.

5.9 Modifications to Existing Services

Because of its inability to accept further surcharge loading the existing (1934) 375mm nominal bore cast iron water main across the park will be replaced by a 400mm nominal bore concrete line steel pipe adjacent to the toe of the bank. Each end will connect into the existing pipe.

New 300mm nominal bore uPVC stormwater pipes will be installed on both sides of the Upper Park.

5.10 Service Connections to the Reservoir

The service connections from the reservoir pass through the tunnel and then cross the Upper Park as indicated in Drawing 6517439-NM-201. The combined 750mm scour and overflow pipe will connected to a new stormwater drain at the upper end of Rolleston Street (also refer 5.11.1 below).

5.11 Drainage

5.11.1 Stormwater and Scour Flow Collection

The Preliminary Design and cost estimate have been based on the assumption that a new 600mm diameter RCRRJ pipe will be laid down Rolleston Street adjacent to the existing pipe and the existing pipe abandoned/blocked off where necessary. This pipe will collect both overland flows and in a seismic event scour flows arising from partial failure of connections as discussed in Section 5.11.4.

A standard precast headwall with a galvanised steel debris grill will be provided on the inlet from the catchment upstream of Rolleston Street. Rock rip rap to provide a stabilised inlet for protection from scour and erosion will be provided.

5.11.2 Secondary Flow Paths

It has been reported that surface flows that occur in flood events from the catchment around the reservoir site currently do not flow to Rolleston Street but flow across the Upper Park. The provision of the new stormwater drain in Rolleston Street recognises the requirement in the Brief that overland flows in the area of the reservoir are to be directed by contouring to Rolleston Street which is a change from the current overland flow patterns.

Such a change is normally an issue that requires inclusion in a resource consent process.

5.11.3 Sports Field Drainage

The project involves modifications to the sports field surface levels and directions of fall and (as required in the Brief) draining it to Rolleston Street whereas currently the eastern corners of the sports field drain to the east away from Rolleston Street. This will result in some relatively minor changes to existing flow paths and catchments.

The Preliminary Design has assumed the new drainage will be sized to a 1 in 2 year return period in accordance with WCC standards, and the arrangements assumed comprise concrete swales along the north and south edges of the sports field. These swales will be drained by sumps into collector drains. A manhole at each end will be provided for maintenance access and the depths and sizes of manholes have been estimated as 1350mm in diameter and 2.4m deep. Details will be refined during the detailed design including fine turning the surface levels of the Upper Park to ensure the secondary flow path is via Rolleston Street and not as existing which directs flows to the Lower Park.

If the manholes cannot be located sufficiently clear of the playing areas then the manholes will be buried so as not to impact on the use of the field. In order to minimise the number of manholes in or around the sports field, uPVC pipes have been used allowing two of the sumps to be connected by junctions.

5.11.4 Scour Flow from Reservoir in Seismic Event

The effects of the overflow or a seismic failure at the reservoir would result in secondary flow down Rolleston Street. An assessment of the likely failure modes of the reservoir and piping after a significant seismic event has been carried out as part of the concept design.

As there is assessed to be negligible risk of failures initiated by geotechnical events such as fault rupture or slope instability, pipe failure, particularly at a flanged joint position or flexible bellows within the pipe tunnel is expected to be the most likely scenario to generate an uncontrolled discharge of any significance. Provisions to provide flexibility for pipe rotation or isolation of pipeline thrust will be included in the pipe design. These have finite capacity to absorb rotation and thrust however, and will likely rupture before failure of the steel pipe sections. The likelihood of a full pipe bore failure (900mm open cross section) was considered very unlikely with partial bore failure with significant less cross sectional area being a more probable scenario.

Mitigating measures to prevent uncontrolled discharge from the piping in the tunnel include:

- Providing an actuated valve as the second fitting on the reservoir pipelines within the tunnel with seismic trigger to automatically close at a Serviceability Limit State 1 (SLS1) level earthquake (25 year return period) acceleration or greater;
- Additional manually operated valves upstream of the actuated values to provide double block and bleed (tell tale indication) functionality of failure to close of the actuated valves;
- Locating pipe bellows or other flexible joints downstream of the pipeline valves;
- The new pipeline will be fabricated from cement lined steel with fully welded joints; and
- The pipe tunnel floor drainage system will be designed to channel the equivalent overflow discharge of 1200 l/s via a separate pipeline to the overflow manhole located in the access way from Rolleston Street to the playing field. A grated cover will allow controlled overflow to the street. Personnel access should be able to the tunnel if a pipe rupture has occurred to check the closure of valves and manually operate the secondary shut off valves.

5.12 Reservoir Cover Earthworks

On completion the reservoir is to be buried which will involve placing between 0.5 and 1.0m of fill over the roof of the reservoir comprising a minimum of 200mm of drainage material and a minimum of 300 mm of topsoil.

Allowance has been made for the weight of fill placed on the roof for both static and seismic loading.

The minimum fill cover over the reservoir roof (0.5m) will be adopted around the reservoir roof perimeter. Within the reservoir area the thickness of fill may be increased up to 1m for landscape purposes.

5.13 Earthworks Surrounding the Reservoir

Drawing 6517439-CE-K32 shows the proposed finished earthworks contours at the site and Drawings 6517439-CE-K33 the cross-sections. These contours have been derived on the following assumptions:

- The target slope for the finished ground surface beyond the reservoir walls is 2H:1V. This slope would not be mowable by conventional means, so would be planted or alternatively grassed with the expectation this is only maintained by occasional “weed eating”.
- Steeper finished ground slopes could be adopted in areas where required to:
  - tie into existing slopes to avoid a thin covering of fill over existing slopes; or
  - avoid filling over existing ecologically valuable areas;

  but provided that the form of landscape treatment is planting which removes any form of grass maintenance requirement and public access considerations;
- The design philosophy adopted with regard to the filling against the walls extending above the top of the excavation is such that the:
  - fill is being provided for landscaping purposes only;
  - reservoir performance is not affected by the presence or absence of the fill or by any failures of the fill;
  - fill should remain in place during and after the SLS1 (1/25 year return period) earthquakes;
  - fill may slump away from the reservoir walls during an SLS2 (1/1000 year return period) earthquake and repairs to the fill slopes may be necessary;
- The expectation to be confirmed in the detailed design is that greywacke fill at a slope:
  - of 2H:1V will meet the design philosophy without reinforcement;
  - of up to 1.7H:1V may meet the design philosophy without reinforcement;
  - steeper than 1.7H:1V will require reinforcement with grid or similar to achieve the design philosophy.

  Figure 5.1 shows the ground slope categories as:

  Category A - Higher ground tie in (Brown).

  Category B - Lower ground tie in at 2H:1V (Yellow).

  Category C - Lower ground tie in with slope flatter than 1.7H:1V but steeper than 2H:1V (Blue).

  Category D - Lower ground tie in with slope steeper than 1.7H;1V (Red).

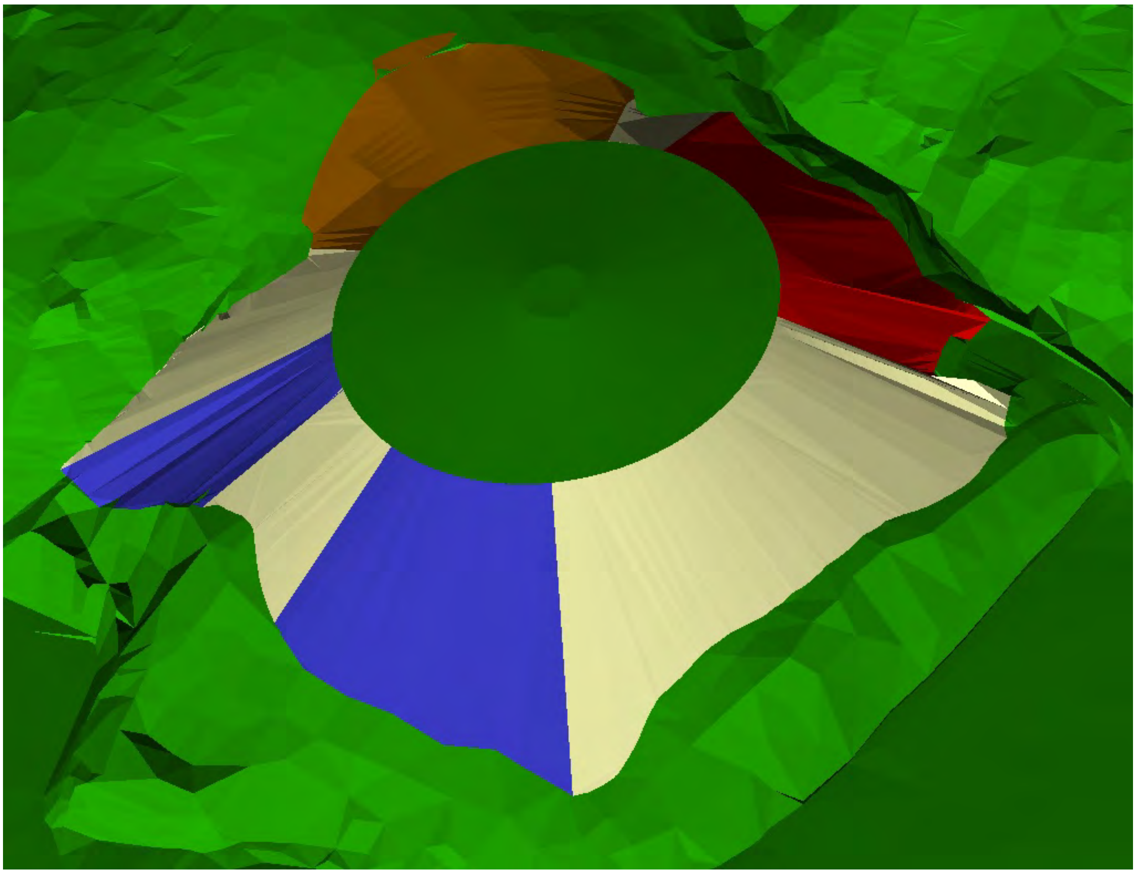

Figure 5.1: Fill Slope Categories

As shown the landscape plan Drawing 6517439-LS-001 areas in Categories C and D will be planted with native re-vegetation planting.

Consideration was given in the Category D area to using a mechanically stabilised block retaining wall to allow flatter fill slope as indicated schematically in Figure 5.1. The conclusion, which will be re-visited at detailed design stage, is that the mechanically stabilised block is likely to be more expensive and should only be considered if the consultations with WCC Parks and Gardens and others indicate the steeper (maximum 1.4H:1V) fill slope is unacceptable.

5.14 Landscaping and Access Arrangements

5.14.1 Landscaping

The Conceptual Design Options Report (Section 1.2) noted that a landscaping plan remained to be prepared and would be presented as part of this report. A landscape plan for the completed project is presented in Drawing 6517439-LS-001 and a Landscape Report which sets out the rationale for the Preliminary Landscape Concept plan is included in Appendix D.

Planting arrangements will be finalised in the detailed design phase in liaison with WCC Parks and Gardens.

5.14.2 Urban Design Furniture

Urban design furniture including signage, park benches, and possibly an information board explaining the presence and function of the reservoir. Indicative locations for seating have been identified on the landscape concept plan, however this will be considered further as part of the detailed design.

5.14.3 Construction Access

A significant quantity of excavated material will be surplus and will need to be taken off site. As part of the Parks and Surplus Material Options Assessment Report a review was made of potential site access options for truck and trailer units and it appears using Rolleston Street is the only practical access available. Extending the Bells Road Reservoir access track through the Town Belt to the reservoir site was investigated but it was concluded that due to the steep contour of the land, installing a temporary access track for trucks would result in an excessive amount of disruption to the existing bush which would be unacceptable.

5.14.4 Construction Phase Public Walkways

The Brief requires that the Landscape Report present proposals for pedestrian access around the construction site connecting Dorking Road, Rolleston Street, Hargreaves Street the Lower Park and the track to Bell Road reservoir site. The Preliminary Design proposal for the construction phase access is shown on Drawings 6517439-CE-K34 and CE-K31.

Walkway options considered not acceptable

The options for the direct connection past the reservoir site between Dorking Road and Rolleston Street were considered based on a 2m wide footpath with 1H:1V cut slopes and 1.5H:1V fill slopes. Two options were identified, both of which had a uniform steep (1 in 4) grade and involve major fills which would enter into the area of regenerating native bush in the western gully. One option would have discharged near the construction site access which is undesirable from a safety perspective and the other option connected to the top of the steps leading to the Bell Road Reservoir, avoiding the construction site access but requiring a major track through regenerating natural bush of the gully.

A uniform 1 in 4 gradient was considered unlikely to be acceptable, in which case consideration would need to be given to constructing the footpath as an elevated wooden walkway with a combination of stairs and ramps to provide lengths with flatter grades. A wooden walkway would also reduce the impact on existing vegetation but would be an expensive temporary construction.

Proposed walkway option

Having considered the above options, the proposed construction phase walkway is that people wishing to walk between Dorking Road and Rolleston Street should do so via the existing paved pedestrian path passing the existing reservoir adjacent to Bell Road as indicated on Drawing 6517439-CE-K34.

5.15 Temporary and Permanent Works on Upper Park

Investigations and slope stability analyses have been undertaken to determine the acceptable footprint for the temporary fill and the retaining wall requirements around the park perimeter for the alternative arrangements for permanent reinstatement of the park. These are reported in the Hospital Prince of Walls Reservoir Geotechnical Report-Addendum and also refer Section 2.9.

For the selected permanent park Option P1, only minor retaining walls are required.

5.16 Summary of Scope of Works

To allow an understanding of the scale of the project the following are some key approximate statistics:

- Excavation from reservoir to stockpile on Upper Park — 25,000m³ (insitu)
- Excavation from reservoir to disposal off site — 31,000m³ (insitu)
- Place general fill to reservoir from stockpile — 25,000m³ (insitu)
- Import and place earth/rock materials to reservoir from off site — 5,500m³ (insitu)
- Insitu reinforced concrete — 1,700m³
- Precast roof and wall panels (666 with maximum weight of 55 tonne) — 3,300m³

5.17 Contract Strategy

5.17.1 Construction Activities

The Brief requests consideration be given to arranging a separate contract for the earthworks in order to potentially *"expedite construction and provide cost advantages".*

After considering the different construction processes involved and their interaction we have concluded that it is not appropriate or in the interests of the Client to adopt a contracting strategy with a separate earthworks contract.

In giving consideration to the above, there are particularly unique aspects on this project that need to be recognised. These are:

- The extent of excavation on the early stages of construction will be dependent on construction of the access road to the reservoir site, inlet and outlet pipework and the tunnel structure;
- Coordinating with the first bullet point above and the ongoing works, excavation of the reservoir site and stockpiling on the Upper Park or disposing of to waste will proceed;
- The sequence for excavation will impact on the contractor's site areas and it is expected that the top of the stockpile will be required as a site area while the structural works are being constructed;
- Significant coordination will be required to manage the environmental conditions such as noise, dust, sediment and erosion, public access around the site areas, aesthetics, transportation to and from the site, etc. These conditions will generally apply to all stages of the construction activities;
- The timing of carrying out earthworks activities will depend on the construction sequence of the project works and the need to minimise double handling of the earthworks materials; and
- The excavation slopes are extensive in height and if any unexpected instability of the excavated slope was to occur it would impact on the progress of the structural work of the reservoir.

5.17.2 Conclusion

We consider it is not appropriate or in the interests of the Client to adopt a contracting strategy with a separate earthworks contract as:

- It will be too difficult to arrange for the earthworks to be undertaken under a separate contract without exposing the Client to work scope interface risks between the contracts which could result in contractual claims including time delays; and

- Due to the nature of the works it is considered the best outcome for cost and time will be achieved by one party being generally in control of the construction sequence and methodology i.e. earthworks not being controlled by another party under a separate contract.

Due to the extent of precast concrete componentry and its specialist nature on this project, the manufacture could be considered to be undertaken under a separate contract. However, for this project requiring a high quality of finish for the precast concrete componentry for use in a buried water retaining structure with low maintenance, we consider the responsibility for manufacture for such componentry should remain under the control of the contracting party constructing and testing the reservoir.

5.18 Construction Control

5.18.1 Contractor's Site Area

The Preliminary Design for the reservoir has been based on initially providing an area encompassing the extent of temporary excavation shown in 6517439-CE-K31 plus a 3m buffer area. For the Upper Park stockpile area the contractor's working area shall extend to 1.5m from the existing fence on the northern and eastern sides. The contractor will be expected to construct a continuous solid timber fence 1.8m high around the complete perimeter of the working area with gates at each entrance controlled by a gateman.

5.18.2 Site Access and Traffic control

The Preliminary Design and cost estimate have been based on the contractor having access only via Rolleston Street and being required to provide a traffic management plan for the approval by WCC and demonstrating how traffic will access and leave the site and traverse Rolleston Street safely.

The volumes of the major material to be taken to and from the site along Rolleston Street are indicated in Section 5.16. The contractor will have the option of either pre-casting units off site or establishing a pre-casting facility on site. The number of transport movements along Rolleston Street for major materials will be of the order of:

- 2500 truck and trailer unit (16m^3 bulked) return journeys during excavation stage;
- 750 truck and trailer unit (16m^3 for earth/rock and 20m^3 for top soil bulked) return journeys during earth/rock backfill stage; and
- 350 return journeys by 5m^3 concrete transit mixers for insitu concrete.

For precast units either:

- 650 return journeys by 5m^3 concrete transit mixers if all panels cast on site; or
- 165 return journeys for 50 tonne capacity articulated truck if all panels cast off site; or
- A mix if only some panels cast off site.

During the consultation phase detailed discussions will be held with the WCC Road Protection Team (WCCRPT) to establish the requirements that will be included in the construction contract specification with regard to truck movements and temporary traffic management. Based on preliminary discussions with Mr Peter Dodge of the WCCRPT. It is anticipated that it may be necessary to:

- Restrict and reorganise kerb side parking to clear park cars from one side of the road to enable two way lanes to operate;

- Ease the top corner in Rolleston Street;
- Install cameras along Rolleston Street;
- Install VMS boards;
- Have traffic controllers at the top and bottom of Rolleston Street to avoid conflicts between arriving and leaving trucks;
- Undertake traffic modelling to determine whether it will be necessary to signalise the intersection of Wallace Street and Rolleston Street and/or other adjoining intersections along Wallace Street for the duration of construction; and
- Restrict the movement of some long/large vehicles onto the site to periods of low traffic (early morning hours) with later unloading during the normal working hours.

It is also expected that it will be necessary for the requirements agreed with the WCCRPT to be presented to the residents of Rolleston Street during consultation and to make any subsequent modifications arising from those consultations.

5.18.3 Hours of Work

The Preliminary Design and cost estimate have been based on the contractor being constrained to working hours set out in the District Plan

5.18.4 Public Relations

The Preliminary Design and cost estimate have been based on the contractor being required to have a public relations management plan which will include:

- Details of the staff who will manage public relations;
- The processes for keeping local residents and the general public informed;
- The processes that the contractor will publicly disseminate for members of the public to raise issues and concerns with the contractor; and
- The procedures for responding to those matters.

5.18.5 Noise

The Preliminary Design and cost estimate has been based on the requirement of the contractor to comply with the requirements of the District Plan and the quoted relevant NZ Standards. The contractor will be expected to arrange random noise measurements by an independent consultant to confirm compliance.

5.18.6 Dust

The Preliminary Design and cost estimate have been based on the requirement of the contractor to comply with the requirements of the Regional and District Plans and to prepare a dust management plan which shall include:

- The contractor's management procedures relating to dust management;
- The processes, such as suppression by water spray, that will be used to manage dust emission; and
- The procedures for responding to complaints from residents should dust generation become an issue.

5.18.7 Environmental Management

The Preliminary Design and cost estimate have been based on the requirement that the contractor will be required to prepare and implement an Environmental Management Plan which will include:

- The identification of a manager responsible for environmental compliance;
- The procedures for regular meetings with the Regulatory Authorities including site inspections;
- The procedures for responding to any Abatement or Non Compliance Notices;
- A Water and Soil Discharge Management Plan including details of control methods to comply with the requirements of District and Regional Plans and any specific project consent conditions;
- Procedures for vehicle refuelling and handling and storage of hazardous chemicals including procedures for responding to accidental spillages;
- Procedures for cleaning vehicles leaving the site;
- The preparation of an environmental effects register;
- The provision of a complaints register and notification records;
- A traffic management plan and compliance monitoring procedure;
- Procedures to be followed in the event of discovering taonga or koiwi; and
- Protocol for archaeological accidental discovery.

5.19 Construction Sequence

The Preliminary Design and cost estimate have been based on an initial partial construction sequence. The sequence has sought to minimise costs through maximising the opportunities available for the storage on site of excavated materials for later use in the works. The sequence developed was as follows:

- As excavated material from the reservoir site is needed later for backfilling around the reservoir when it is fully constructed, the Upper Park will need to be used to its fullest extent for temporary stock piling of such material (no other site areas available).
- Strip top soil from the Upper Park to provide space for temporary storage of excavated material. As the temporary storage will be required for much longer than the 9 months (period nominated in the Brief) no adequate storage arrangements for the Upper Park top soil has been identified and thence the excavated top soil will be removed from site for other uses and new top soil will be sourced when required. The construction contractor may choose to use some of the existing Upper Park top soil as part of their sediment and erosion control system.
- Stockpile top soil recovered from the reservoir site area, on areas adjacent to the reservoir excavation.
- Construct access road to the reservoir, commence excavation of the reservoir site and directly place and compact material on Upper Park to raise its permanent level if appropriate for Option P1 or excavate to waste off site.
- Excavate for pipe tunnel. Excavated material for subsequent backfilling around the tunnel can be stock piled nearby or on the Upper Park. Construct tunnel and install reservoir pipework interacting with the Upper Park. These activities need to be undertaken prior to major reservoir construction as:
  - Pipe tunnel excavation is below, and extends under, the reservoir floor level; and
  - Upper Park is used for storage of excavated material required for later backfilling around the reservoir after water testing. Storage will be required for some considerable time.
- Major reservoir tank construction can then proceed. Excavated material stockpiled on Upper Park for reuse or disposed of off site to waste;

- Proceed with construction of the concrete reservoir, on completion of testing backfill and reinstate around the reservoir;
- Completion of landscaping works to the reservoir site; and
- Once the temporary stock pile has been used then the Upper Park can be completed including placing of the new top soil and seeding, etc.

5.20 Preliminary Project Programme

A preliminary project programme from the commencement of the detail design and consenting phases has been prepared which is included in Appendix F and on A3 sized version included in Volume 2 of the Preliminary Design Report entitled – Drawing/Sundry Information. This programme is based around obtaining the Client's approval to proceed with Stage 2 of the Project at the beginning of July 2013 and not granting an accepted construction contractor possession of the site until 1 July 2015 at the earliest.

The key matters that are incorporated in the programme are as follows:

- A resource consent process over 11 months assuming this will result in the resource consents being obtained by the beginning of June 2014. This assumes a comfortable period for the consultation process but assumes no major opposition and the resource consents are obtained without the need to go through an appeal process;
- With construction not permitted to commence until July 2015, this allows a period of 5 months to be allowed should appeals result from the resource consent process.
- A construction contract period of 23 months and this includes a 1 month period for potential contractual extensions of time; and
- The construction period allows the major excavation works to be carried out over the desirable weather period for earthworks between late 2015 and early 2016. Further, the major backfilling operation can be undertaken over the early part of 2017 which would also include for the preparation of the critical Upper Park surface and at the most desirable time for top soiling and grassing, etc.

While certain periods have been allowed associated with the resource consent process, in order to minimise potential risks of on-going delays disrupting the design and procurement process, the project team will need to be managed to ensure the consultation process is commenced and the consent applications are lodged, at the earliest opportunities.

5.21 Construction Cost Estimate

The detailed construction cost estimate of $17.9M as presented in Appendix G is the Preliminary Design Estimate with a Lower Bound of $17.0M and an Upper Bound of $19.7M all plus GST. That estimate is for design to a serviceability limits state (SLS2) in a 1000 year return period event which is consistent with the advice in the Capacity letter of 1 March 2013.

There have been a number of changes during the Preliminary Design process from the concept design. However, these are considered to be relatively minor and can be accommodated within the estimate amounts. These changes include:

- Change from travelling irrigator to potential in-field irrigation system on the Upper Park details of which can be agreed during the detailed design stage;
- Provision of concrete swales rather than grass swales on the Upper Park;
- Nominal increase in earthwork quantities as a result of fine tuning the finished earthworks profiles; and

- Refinement of reservoir shape from concept design has resulted in no net changes of structure quantities.

Full details of the estimate are provided in the Conceptual Design Options Report.

5.22 Risk Register

In the early part of Stage 1 of the services, a risk workshop was held to identify potential risks for the Project, but excluding those associated with construction. Attendees included the WCC, Capacity, WCC Parks and Gardens and Beca.

This risk workshop identified risks into categories such as Schedule, Consenting, Commercial, Reputation, HSE, Operations and Fitness for Purpose. Each risk was then assessed and a risk priority rating assigned, From this, a risk management plan could then be developed for subsequent monitoring during the execution of the services.

This risk analysis was expected to be updated as appropriate during the carrying out of the services as new circumstances developed and as new risks are identified.

The Risk Analysis summary is included in Volume 2 of the Preliminary Design Report entitled – Drawings/Sundry Information. As discussed with Capacity, it is expected that the current Risk Analysis summary should be reassessed following the Client's decision to proceed with Stage 2 of the Project.

6 Detailed Design Considerations

6.1 Introduction

The following sections set out particular aspects that are expected to require further consideration at the detailed design stage.

6.2 Safety in Design

A "Safety in Design" philosophy will take the existing Preliminary Design concepts and further develop them in the detail design methodology with the objective of identifying means by which potential safety risks during construction, maintenance and operation can be eliminated, isolated or minimised.

6.3 Temporary Excavations for Construction

The current proposed temporary excavations as shown on Drawing 6517439-CE-K31 assume that the area over the scour and service connections will be cut down to facilitate trenching. This will result in the clearance of some moderate value trees which the landscape architects have indicated should ideally be retained to provide screening. During the detailed design consideration will be given to the feasibility of construction methodologies which would allow installation of those services with minimised impact on the vegetation. It is expected that those considerations may be influenced by feedback received in the consultation phase.

6.4 Drainage

The details proposed in Section 5.11 as part of the Preliminary Design will require further analysis and confirmation. In particular it is anticipated that quantification of the changes in overland flow patterns from the reservoir and Upper Park areas may be a requirement for resource consent applications.

A check is also expected to be required to confirm the Preliminary Design assessment that the flow changes to Rolleston Street resulting from changes in overland flow routes may be similar to the flows that might be expected in a maximum reservoir overflow scenario which are also to be directed down Rolleston Street.

6.5 Reservoir Structure

Detailed structural design will be undertaken in accordance with the Structural Basis of Design included as Appendix A taking into account the Geotechnical Basis of Design included as Appendix C.

The final shape is as shown on the Drawings which was determined in consultation with the landscape designers and WCC Parks and Gardens.

6.6 Tunnel Structure

Detailed structural design will be undertaken in accordance with the Structural Basis of Design included as Appendix A taking into account the Geotechnical Basis of Design included as Appendix C.

Reservoir access hatch provisions from the tunnel will need to be agreed with WCC.

6.7 Reservoir Pipework

The detailed design of the reservoir pipework will be undertaken in accordance with the Mechanical Basis of Design included in Appendix B and will be based on the general arrangements determined in the Preliminary Design and presented in Drawings 6517439-NM 201 to 205.

Specific aspects to be addressed at detailed design will include:

- WCC also suggested that the modulating flow control plug valves could be reduced in diameter in order to allow more reliable flow control at lower flow rates. This would require reducers either side of the valves which increases the overall length of the pipe tunnel. WCC have now confirmed that plug valves are to be 600mm diameter. Hence reducers will not be required on the 600mm diameter low pressure inlet and outlet pipeines.
- Detailing the piping in the tunnel to incorporate flexibility to allow for movement of the reservoir structure during a seismic event without putting excessive load onto the reservoir floor pipe penetrations. It is expected this seismic isolation of the pipework to the reservoir structure will be achieved by flexible couplings in the piping at either end of the tunnel. These couplings will be designed to allow movement of the pipework sections inside the tunnel relative to both the reservoir and the buried pipework outside the tunnel. There will also be a seismically triggered isolation valve on reservoir pipework immediately adjacent the reservoir to preserve reservoir contents in event of an earthquake.

6.8 Electrical and Control Systems

Electrical and control systems will be installed in accordance with GWRC Standards. Note that aerials will be required above the tunnel entrance which will be a resource consent consideration.

6.9 Landscaping and Access Arrangements

It is expected that consultation will result in requirements to evaluate alternatives suggested by others and where appropriate modify the design accordingly.

6.9.1 Landscape Plan

Details of the preliminary landscape plan and urban design hardware proposals are expected to require modification after the consultations.

6.9.2 Construction Phase Walkways

The temporary direct connection between Dorking Road and Rolleston Street considered in the Preliminary Design is acknowledged as being not ideal (in terms of grade and extent of earthworks required) and the use of the existing path adjacent Bell Road has been proposed. It is suggested this could be further considered during the detailed design.

6.9.3 Access and Parking Arrangements for Servicing Reservoir

The proposed Preliminary Design arrangements involve an area of surface paving on the western end of the Upper Park sports field, refer Drawing 6517439-CE-K32. While this detail is in accordance with the requirements of the Brief it is possible that this aspect may be raised in consultation and need to be reconsidered.

6.9.4 Access and Parking Arrangements for Upper Park

It is expected that as a consequence of the consultation it will be necessary to consider refinement to the access and parking arrangements for the Upper Park playing field from Rolleston Street. Potential options available were discussed in Section 4.4 of the Park and Surplus Material Options Assessment Report. Particular attention will be needed to:

- Avoiding excessive encroachment on the western end of the sports field;
- Avoiding a need for major retaining structures to support any parking areas; and
- Determining the extent to which the access and parking provisions for the tunnel entrance can be made available for public use.

Also consideration could be given to using the area adjacent to the top of Hargreaves Street and increasing this area by nominally relocating the Upper Park northern fence into the park area.

6.10 Construction Preliminary and General Specification

A preliminary and general specification will be prepared including the issues identified in Section 5 relating to the management of construction activities, and taking into account the outcomes of consultation and the requirements of any specific project Resource Consent Conditions.

7 RMA Consenting and Consultation

7.1 Consenting Process

Consents under the Resource Management Act, Reserves Act and Town Belt Deed are required. These need to be applied for via either Wellington City Council (WCC) or the Greater Wellington Regional Council (GWRC).

Due to the nature of these consents it is anticipated that the consenting process will involve the notification of the consent applications, a decision by the councils for the appointment of commissioners jointly by WCC and GWRC to hear the applications is likely, and there will be invitation for submissions and the holding of a hearing.

As noted in Section 3.4.6 of the Brief, in addition to consents required under the WCC District Plan (and in particular for structures in Open Space C) separate approvals may be required under requirements of the Town Belt Deed and the Reserves Act 1977. Our view is that those approvals should be obtained before applications are lodged for approvals under the RMA.

In particular the Town Belt Management Plan requires that the Town Belt Trustees to approve the designs within the Town Belt prior to submitting the consent applications. While WCC has obtained agreement in principle from the Trustees it will be necessary to obtain a formal endorsement from the Trustees of the final proposed design to support the consent applications.

7.2 Consent Requirements

A number of consents are required in order to undertake the physical works. The current assessment is that the consents required for the selected reservoir Option R1.0 and Upper Park Option P1 are as set out in the list below. The site is located within the Open Space C zone under the Council District Plan and there are a number of land use consents required from the Council under the District Plan, including (but not limited to):

- Earthworks;
- Vegetation removal (over 100m^2); and
- Structures in Open Space C.

Several of these consents are restricted discretionary or discretionary activities. This allows the Council a greater level of discretion when considering these consent applications.

No additional regional council consents are required for discharge of sediment provided all discharges go to the stormwater system. Any discharges to water bodies will require discharge permits.

Matters for which consents appear likely to be required are:

Greater Wellington Regional Council

- Bulk earthwork – over 10,000m2 on slopes over 28º;
- Discharge permit to discharge sediment to water; and
- Discharge permit to discharge sediment and chemical flocculant to water, and to land where it may enter water.

Wellington City Council

- Earthworks;
- Planting in the Town Belt;
- Carparking & access routes;
- Vegetation removal over 100m^2;
- Structures in Open Space C;
- Utility Structures in Open Space C land; and
- Hazardous substances (viewed as unlikely but needs to be confirmed).

7.3 Consultation to Date

Initial consultation with WCC Parks and Gardens has been carried out to outline the extent of disturbance for each reservoir option and obtain input on the key vegetated areas on site to assist with the attribute scoring of the various options.

This consultation is reported in the Conceptual Design Options Report which included a marked up survey plan indicating the key current vegetated areas on the site. These areas of vegetation have been classified as high-value, moderate value and low-value based on discussions on site between WCC Parks and Gardens and Beca.

7.4 Consenting Strategy and Activities

The following is the proposed sequence of activities to take place in the consenting and detail design phases of the Project. Details of the strategy and the roles in the consultations will need to be established at the commencement of this phase. The sequence proposed is:

- Hold discussions with WCC and GWRC regulatory officers to confirm the consents required and consenting process (we are recommending a joint hearing of all consent applications by commissioners);
- Develop, in collaboration with WCC Parks and Gardens, detail design to a stage where the visual appearance (contours, vegetation, urban design hardware, location of pedestrian paths etc.) at all stages of the project can be defined with confidence;
- Undertake assessment of visual, ecological, and recreational use impacts and landscaping issues and prepare the relevant sections of the Assessment of Environmental Effects (AEE);
- Develop material (visual impact plans, indicative photomontages, etc) as appropriate to assist with the consultation process;
- Prepare sections of the construction drawings showing the extent of the contractor's working area and access and all sections of the specification relating to the contractor's hours of work, site security, public health and safety, public relations obligations and the management of environmental impacts during construction;
- Present the third, fourth and fifth bullet points to the WCC Parks and Gardens officers and obtain endorsement of the proposal (with any amendments agreed with them);
- Present third, fourth and fifth bullet points to the Town Belt Trustees and obtain their endorsement of these (with any amendments agreed with them) as a basis for wider consultation;
- Undertake targeted consultation with iwi, local residents, interest groups etc., undertaking modifications to details progressively and providing feedback to reflect responses to matters raised in the consultation;
- Provide opportunities for general public input to consultation through media, information on local public notice boards, open houses etc. as appropriate. Undertake modifications to details progressively and provide feedback to reflect responses to matters raised in the consultation;
- Complete the AEE and the consent applications required for the Project;
- Present proposed documentation to Town Belt Trustees and WCC Parks and Gardens and obtain supportive written endorsement from them in a form that can be appended to the applications; and
- Lodge applications.

7.5 Consultation Material on Visual Impact

An important aspect of the consultation process is the material provided at the beginning and through the process, and the need to clearly differentiate between:

i. Graphic representations intended to define the extent and relative positions of components of the Project; and

ii. Presentation material intended to demonstrate the visual form and visual impact of the Project.

For i. it is often necessary to use exaggerated scales or artificial perspectives, such as “birds eye” views, to allow all components to be seen in a single presentation. The view of the Upper Park shown in Figure 2.1 is an example of this form of information.

The Brief and proposal for this Preliminary Design Report included the development of “indicative photomontages” which involves taking photographs from a selected viewpoint and then superimposing the proposed landscape change on the photo based on an educated interpretation of the proposed plans. These would provide an “artists impression”.

It has been agreed with Capacity that these “indicative photomontages” should not be prepared at this stage because of:

- The expectation that the major visible component, the planting, will change after further discussions with WCC Parks and Gardens; and
- The inability at this time to identify the most relevant viewpoints as no consultation has been undertaken to allow this.

It is proposed that initial consultation on visual impacts from adjoining sections of the Town Belt and residential areas be undertaken using the landscaping plan. As the consultation progresses, it will become possible to identify the degree of concern of those consulted with regard to visual impact and the viewpoints of concern. After that is known it will be possible to determine what “indicative photomontages” should be prepared. The consultation may indicate no need to prepare “indicative photomontages”, in which case they should not be prepared as to present such material may indicate a concern or encourage a concern that is not held by the project team or those consulted.

7.6 Objective of Project and Consideration of Alternatives

The RMA requires that applicants to set out in the AEE the objective of a Project and demonstrate that consideration has been given to alternatives and to the available reasonable means of avoiding, remedying or mitigating environmental impacts. These areas are often used by submitters and appellants objecting to applications.

In this Project the Conceptual Design Options Report and its multi criteria assessment will provide the evidence of consideration of alternatives.

Appendix A

Structural Basis of Design

Basis of Structural Design

Hospital Prince of Wales Reservoir Structural Basis of Design

Prepared for Wellington City Council (WCC)

By CH2M Beca Limited (Beca)

31 May 2013

Revision History

Revision Nº	Prepared By	Description	Date
A	Juvenal Verano	For Client Review	05.10.12
B	Juvenal Verano	Updated for CDOR	01/02/2013
C	Juvenal Verano	Updated for PDR	19/04/2013
D	Juvenal Verano	Updated for PDR	31/05/2013

Document Acceptance

Action	Name	Signed	Date
Prepared by	Juvenal Verano		19/04/2013
Reviewed by	Simon Edmonds		19/04/2013
Approved by	Dennis Hunt/Mark Sneddon		19/04/2013
on behalf of	CH2M Beca Limited		

Table of Contents

1 Introduction

This document describes the basis of structural design for **The Hospital Prince of Wales Reservoir Project** located in upper Prince of Wales Park at Mount Cook, Wellington City**.**

The project includes a reservoir and the associated earthworks and pipelines. The reservoir is fully buried below ground level and will store 35,000m³ volume of water. It will supply water to Wellington Hospital and to the Central Business District (CBD). CH2M Beca (Beca) has been commissioned by Wellington City Council (WCC) to supply engineering services for the development of the new reservoir.

2 Objectives

The principal objective of this document is to establish a basis that shall be used for the structural design and documentation works of the reservoir and pipe tunnel and to:

- Comply with client requirements
- Comply with statutory requirements
- Adopt a sound design philosophy
- Utilise the relevant experience and skills of the design team members
- Adopt the latest engineering technology
- Enable close coordination with other design disciplines
- Permit construction sequencing to be undertaken in accordance with the client's agreed programme

3 Definitions

Unless the context requires otherwise the following abbreviations and their meanings are used within this document:

B2	Exposure Classification
CBD	Central Business District
Capacity	Capacity Infrastructure
Council	Wellington City Council
CCANZ	Cement and Concrete Association of New Zealand
CoG	Centre of Gravity
DL	Dead load
EL_U	Ultimate limit state earthquake load
EL_S	Serviceability limit state earthquake load
Eu	Ultimate limit state earthquake load.

Fl_p	Fluid pressure loading
Fx	Force in x direction
Fy	Force in y direction
Fz	Force in z direction
G	Dead load
GWRC	Greater Wellington Regional Council
HERA	NZ Heavy Engineering Research Association
HPOW	Hospital Prince of Wales
N.A.	Not applicable
NZBC	New Zealand Building Code
NBS	New Building Standard
LL	Live Load
POW	Prince of Wales Park
Q	Live Load
RFP	Request for Proposal
OSH	Occupational Health and Safety Department of Labour
Sh	Shrinkage effects loading
SLS1	Serviceability limit state for structures of Importance Levels 1, 2 or 3
SLS2	Serviceability limit state for Importance Level 4 – Operational Continuity
SW	Swelling effects loading
TBC	To Be Confirmed
TWL	Top Water Level
UDL	Uniformly Distributed Load
ULS	Ultimate limit state
WCC	Wellington City Council
WE	Wellington Electricity
WL_U	Ultimate limit state wind load
WL_S	Serviceability limit state wind load
yc	Live load combination factor
μ	Ductility factor

ε	Damping factor

4 Scope of Structural Design

Beca will prepare structural design calculation, detailed drawings and specifications to demonstrate compliance with the relevant codes, standards and guidelines outlined in this brief. The scope of structural design work shall cover the reservoir and pipe tunnel including but not limited to the following:

- Foundations
- Floor slabs
- Walls
- Roof support columns
- Roof support beams
- Roof slabs
- Columns
- Reservoir pipe tunnel roof, walls and floor
- Access hatches into the reservoir (roof and floor)
- Pipe supports inside the reservoir and pipe tunnel
- Access stairs and landings
- Access ladders and platforms
- Guard rails and handrails

5 Reference Documents

The following documents are to be referred to in the design of the Hospital Prince of Wales Reservoir.

This document shall be read in conjunction with the following documents:

- Hospital Prince of Wales Reservoir Geotechnical Basis of Design (Beca, Rev B dated 1 February 2013)
- Hospital Prince of Wales Reservoir Mechanical Basis of Design (Beca, Rev 1 dated 1 February 2013)
- Hospital Prince of Wales Reservoir Geotechnical Report (Beca, Rev B 'Final' dated 3 October 2012)
- Hospital Prince of Wales Reservoir Geotechnical Report Addendum (Beca, Rev 1 dated 14 January 2013)
- Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir (2012).

6 Specific WCC Requirements

The following WCC requirements are specified in the RFP document and are listed below for the purpose of outlining the general and structural requirements which are deemed critical for the structural design.

6.1 General Requirements

- Reservoir is to be located in the Upper Prince of Wales Park, Mt Cook, Wellington.
- The required reservoir capacity is 35,000m^3 to be stored below the TWL of 92.00m (New City Datum).
- Reservoir to be fully buried.
- Have roof hatches (non-venting) in all four quadrants of the reservoir adjacent pipework discharge points (overflow, primary inlet, high pressure inlet and the fourth quadrant) with an access ladder and platforms below at least one of the roof hatches.
- Incorporate a continuous membrane across the reservoir roof.
- Incorporate a bitumen emulsion or equivalent membrane product on the external face of the reservoir walls.
- Completed a successful reservoir water tightness test prior to backfilling the reservoir or sealing the external face of the reservoir walls.

6.2 Structural Requirements

- Reservoir Design Life to be 100 years (as contained by Capacity letter dated 1 March 2013).
- The reservoir shall be designed for SLS2 seismic loads equivalent to a 1000 year return period event (as confirmed by Capacity letter dated 1 March 2013). This is to provide equivalence or exceed the seismic design standards for the Wellington Regional Hospital to provide operational continuity within six hours of a 1000 year return period earthquake.
- Allowance for excavation around any point of the perimeter of the reservoir in the future.
- A minimum of four sumps shall be positioned in the floor located opposite to inlets. Sumps to have grates and connect to the sewer pipe system.
- The reservoir structure shall be designed to withstand a water pressure of at least one meter above the top level of the reservoir walls.
- The roof shall be designed to take the required loading from landscaping activities, tractor mowing and use of an excavator (at least 10 tonnes) for future maintenance.
- A minimum of 300mm of turf including top soil over 200mm of drainage material shall be provided over the roof of the reservoir above the level of a site concrete layer protecting the waterproofing membrane layer below.
- The reservoir walls shall be either cast in-situ, pre-stressed or precast concrete panels.
- The lowest roof beam must be 300mm above TWL or 50mm above the maximum water level when the reservoir is discharging via the overflow system at a flow rate of 1200L/s (250mm above TWL). Freebound in excess of this is to be provided if necessary to accommodate sloshing during a seismic event.
- The minimum level of the roof slab shall be at least 450mm above the TWL.
- Pipe tunnel/gallery to have at least 2.2m clear internal height.

7 Reservoir Structural Description

7.1 Structural System

7.2 Roof

- Minimum reservoir floor and roof grades are to be 1 in 100.

Either an orthogonal column and beam layout or a circumferential column and beam layout will be adopted depending on selected option. Reservoir Option R1.0 could have either an orthogonal or circumferential roof structure layout.

7.3 Floor Slab

- Nominally 250 thick slab. Either conventionally reinforced or post tensioned construction.

7.4 Walls

Nominally 425 thick (based on SLS2 1000 year earthquake return period), prestressed vertically and post tensioned horizontally. 10 No. Pilasters; circumferential stressing in four overlapping tendons around reservoir.

7.5 Foundations

- Continuous strip foundations normally two metres wide below reservoir wall. Local slab thickenings 500mm deep at column positions.

8 Design Standards & Guidelines

The following standards (and manual) shall be used in the design of the structures stated in this document.

AS/NZS1170.0	General Principles
AS/NZS1170.1	Permanent, Imposed and other Actions
AS/NZS1170.2	Wind Actions
AS/NZS1170.3	Snow and Ice Actions
NZS1170.5	Earthquake Actions - New Zealand
NZS3106	Design of Liquid Retaining Structures
AS4678:2002	Earth-retaining Structures
NZS3101.1	Concrete Structures Standard
NZS3404.1	Steel Structures Standard
NZS 3109	Concrete Construction
NZS 3121	Water and aggregate for concrete
NZS 3114	Concrete surface finishes
NZS 3104	Specification for concrete production
NZS 3122	Specification for Portland and blended cements
AS/NZS 4671	Steel Reinforcing Material
AS/NZS 4672	Steel prestressing materials
AS 1310	Steel wire for tendons in prestressed concrete
AS1311	Steel tendons for prestressed concrete

AS 3678	Hot-rolled structural steel plates, floorplates and slabs
AS 3679.1	Hot-rolled structural steel bars and sections
AS 3679.2	Welded Sections
AS/NZS 1252	High Strength Bolts for Structural Engineering
AS/NZS 2451	Bolts, screws and nuts
AS/NZS 1553.1	Covered Electrodes for Welding
AS/NZS 1554.1	Welding of Steel Structures
AS/NZS 1554.2	Welding of Stainless Steel Structures

CCANZ Publication TM 34 Tilt-up Technical Manual

Transit New Zealand (TNZ) Bridge Manual

RRU 83 – Seismic Design of Bridge Abutments

New Zealand Building Act 2004

New Zealand Standard Act 1988

9 Material Properties

The following material properties shall be used in the design of the structural elements including components and connections.

9.1 Reinforced Concrete

9.1.1 Concrete

The minimum compressive strength of concrete to be used in design of ordinary reinforced concrete element shall be:

- Reservoir (roof, beam, wall, base-slab, column & foundation) fc' = 40MPa
- Reservoir access hatch upstands fc' = 40MPa
- Pipe tunnel fc' = 40MPa
- Valve chambers fc' = 30MPa
- Pipe encasement fc' = 30MPa
- Stair and platform foundation fc' = 30MPa
- Pipe supports and thrust blocks fc' = 30MPa
- Retaining walls around entrance to pipe tunnel fc' = 30MPa

9.1.2 Reinforcing Steel

The minimum yield strength of reinforcing bar to be used in the design shall be:

- Deformed bar designated 'DH' shall be grade 500E f_y = 500MPa
- Plain round bar designated 'RH' shall be grade 500E f_y = 500MPa
- Plain round bar designated "R" shall be grade 300E f_y = 300MPa

9.2 Prestressed Concrete

If prestressed concrete shall be used in the design of reservoir the following material properties shall be used.

9.2.1 Concrete

The maximum compressive strength of prestressed concrete shall be determined in conjunction with the concrete supplier and precaster but is likely to be no more than 55 MPa. The minimum compressive strength of concrete to be used in design of prestressed concrete element shall be:

- Roof slab, floor slab, roof support beams, walls — fc' = 40MPa

9.2.2 Prestressing Strands

The minimum tensile strength of prestressing strand (tendons) to be used in the design of prestressed concrete shall be:

- VSL Super Grade (or equivalent) — Fp_u = 1840MPa
- Strand diameters shall be either 12.7mm or 15.9mm with appropriate proprietary wedge anchorage systems.

9.3 Structural Steel

The minimum yield strength of steel (mild and stainless) structures, components and connections to be used in the designed shall be:

9.3.1 Steel Sections

- Hot rolled plates — f_y = 250MPa
- Hot rolled structural sections (UB, UC, PFC, EA) — f_y =300MPa
- Hot rolled structural sections (RHS, SHS & CHS) — f_y =350MPa

9.3.2 Stainless Steel Sections

- Plates — (TBC)
- Sections — (TBC)

9.3.3 Bolts & Nuts & Washers

- High strength bolts grade 8.8 — f_u = 830MPa
- Mild steel bolts grade 4.6 — f_u = 460MPa
- Stainless steel bolts grade 316 — (TBC)

9.3.4 Welding Consumables

- E48XX electrodes shall be specified for all welds — f_{uw} =410MPa

10 Design Criteria and Loads

The following criteria and loadings shall be used in the design of the reservoir structure and the associated structures stated in this brief.

10.1 General

As stated in Clause 3.4.4e of RFP, WCC requires that for design purposes the reservoir shall be considered as a significant post disaster storage facility which structural performance during and after major earthquake event are expected to exceed the requirements of Importance Level (IL) 4 structures with a special post disaster function. Associated structures are also expected to perform similar to the reservoir structure during and after a major seismic event.

10.1.1 Design Life

WCC's requirement for the new reservoir including the associated structures shall be designed for a ~~minimum~~ design life of 100 years. ~~(HOLD – Capacity to confirm design working life as 100 or 150 years).~~

10.1.2 Importance Level

For seismic loading calculation, as specified in the AS/NZS 1170.0 Table 3.3, for 100 years design life the corresponding IL to which a structure must be designed is 4. The reservoir shall be designed assuming importance level (IL) 4 and with due consideration that its performance will meet the requirement mentioned in Clause 10.1 above.

10.2 Permanent Loads, G

Dead loads include the self-weight of all structural elements including fixed equipment. The following material densities were used throughout the design process.

- Concrete 25kN/m^3
- Steel 79kN/m^3
- Fresh Water 10kN/m^3
- Soil 20kN/m^3

10.3 Imposed Loads, Q

Generally, the reservoir shall be designed for the loading specified in NZS 3106:2009 and NZS 1170.1. During the normal operating condition the roof shall be designed assuming the following imposed load:

- Uniform roof live load 3.0kPa
- Excavator or mower 10.0 Tonnes (TBC)

10.4 Earth Pressure, F_e

The reservoir shall be fully buried below ground level. The earth pressure due to retained soil to be used in the design shall be:

- Unit weight of soil (Refer Geotechnical Basis of Design)
- Coefficient of friction angle (Refer Geotechnical Basis of Design)

The increase in soil pressure due to seismic loading shall be calculated using either NZS 3106; Mononobe-Okabe principle or equivalent principle or RRU 83 Seismic Design of Bridge Abutments.

10.5 Hydrostatic Pressure, Fl

The hydrostatic pressure due to retained fresh water to be used in design shall be based on the maximum height of retained water assuming the water level to be a minimum of one meter above the top of the reservoir wall. Refer Clause 6.2 of this brief for the specific client requirements. If a permanently submerged roof design is adopted then the maximum height of retained water above the top of the walls will be used.

10.6 Ground Water, Gw

Hydrostatic pressure due to ground water shall be considered in the design of the reservoir including associated underground structures. The water table gradient shall be based on the highest piezometer water level recorded on site reducing to an effective residual pressure at the reservoir wall. This is based on the assumption that a drainage system is installed around the external perimeter of the reservoir.

10.7 Earthquake Loads, E

The following seismic parameters shall be used for the calculation of earthquake loads. The height of retained water to be used in the designed shall be one meter above the top of reservoir wall. Refer Clause 6.2 of this brief for the specific client requirements.

- Hazard factor — Z = 0.4 For Wellington City
- Site sub-soil class — Soil Class A/B (Refer SSSHA)
- Annual probability of exceedance — P = 1/5000 for ULS
- Annual probability of exceedance — P = 1/1000 for SLS_2 (Operational continuity)
- Return period factor — Ru for ULS (Refer SSSHA recommendations)
- Return period factor — Rs = 1.3 For SLS_2 (Operational continuity)
- Return period factor — Rs = 1.0 For SLS_2 (Code requirement)
- Near fault factor — N(Ti,D) = (Refer SSSHA recommendations)
- Structural performance factor — Sp = 1.0 for ULS & SLS_2 (for reservoir)
- Structural performance factor — Sp = 0.925 for ULS (for pipe tunnel structure)
- Structural performance factor — Sp = 0.7 for SLS (for pipe tunnel structure)
- Ductility factor — μ = 1.25 for ULS
- Ductility factor — μ = 1.0 for SLS
- Damping factor — ε = 5% for ULS
- Damping factor — ε = 0.5% for SLS

The increase in liquid pressure (hydrodynamic) due to seismic accelerations shall be calculated as per Appendix A of NZS3106:2009.

10.8 Swelling, Sw

The effect due to swelling shall be considered in the design of the reservoir structure. In the absence of a rational analysis, the minimum effects due to moisture variation shall be determined considering the swelling strains specified in Table 2, Clause 4.2.4 of NZS 3106:2009

10.9 Shrinkage, Sh

The effect due to shrinkage shall be considered in the design of the reservoir structure. In the absence of a rational analysis, the minimum effects due to moisture variation shall be determined considering the shrinkage strains specified in Table 2, Clause 4.2.4 of NZS 3106:2009

10.10 Temperature, T

The effect due to increase or decrease in temperature and due to differential temperature gradient shall be considered in the design of the reservoir for the walls for load cases prior to backfilling. The following changes in temperature and temperature gradient as per Clause 4.2.3 of NZS 3106:2009 shall be used in the design:

- Roof ±20º Celsius
- Roof temperature gradient is 5º Celsius per 100mm
- Wall ±30º Celsius
- Wall temperature gradient as per in NZS 3106:2009

The coefficient of thermal expansion of concrete used in design was 11 x 10^{-6} / º Celsius

10.11 Construction Load

Allowance for load during construction shall be considered in the design. The roof and its immediate supports shall be designed assuming a minimum construction live load of 2.0kPa (TBC).

11 Load Combinations

In general, the load combinations specified in NZS3106:2009 shall be used in the design of reservoir structure. The load combinations specified in AS/NZS 1170.1 shall be used in the design of the associated structures (pipe tunnel). The following load combinations shall be used:

11.1 Roof slab, beams and columns

The roof slab of the reservoir including its immediate support shall be designed considering the load combinations specified Transit New Zealand (TNZ) Bridge Manual.

11.1.1 Maintenance Condition

Design Standard: TNZ Bridge Design Manual

- 1.35G + 1.35(1.67LLxI) At ULS Where: I = 1.3 Dynamic amplification factor
- 1.0G + 1.35LLxI At SLS

11.1.2 Operating Condition

Design Standard: NZS 3106:2009

- 1.35G At ULS
- 1.2G + 1.5Q At ULS
- G + Flp + Sh SLS – Group A
- G + T + 0.7Sh SLS – Group B1
- G + Flp + Es_1 SLS – Group B2

11.2 Floor slab, Wall and Wall Joints

The following load combinations shall be used in the design of floor slabs, walls and wall joints.

11.2.1 Serviceability

- G+ Flp + 0.5Sw Group A

■ G + Flp + T	Group B
■ G +Flp + Es1	Group B
■ G +T + 0.7Sh	Group B

11.2.2 Ultimate

- 1.35G
- 1.2G + 1.5Q
- 1.0G + 1.0Eu

11.3 Foundation

The following load combinations shall be used in the design of foundations.

11.3.1 Serviceability

- G+ Flp + 0.5Sw
- G + Flp + T
- G +Flp + Es1
- G +T + 0.7Sh
- G + Q + ycQ

11.3.2 Ultimate

- 1.35G
- 1.2G + 1.5Q
- 1.0G + 1.0Eu

11.4 Associated Structures

The following load combinations shall be used in the design of other structures.

11.4.1 Serviceability

- G + Q
- G + Ws + yc Q
- G + Es

11.4.2 Ultimate

- 1.35G
- 1.2G + 1.5Q
- 1.0G + 1.0Eu

11.5 Stability

The load combinations specified in AS/NZS 1170.1 shall be used for the global stability checked against overturning and sliding of the reservoir.

- 0.9G + 1.0Eu

12 Allowable Deflections

The following deflection criteria shall be used in the design of structural elements:

- Roof slab L/360
- Roof beams L/360
- Cantilever retaining wall H/150
- Column lateral deflection H/400

13 Durability Requirements

The following design criteria for concrete durability shall be used in the design of reservoir.

- Minimum intended life span 100 years
- External exposure classification B2
- Internal exposure classification B2
- Minimum concrete cover for walls -60mm for outside surface
- Minimum concrete cover for walls 60mm for inside surface
- Minimum concrete cover for roof slab 50mm for top bars (covered by membrane)
- Minimum concrete cover for roof slab 35mm for bottom bars
- Minimum concrete cover for ground slab 60mm for top bars
- Minimum concrete cover for ground slab 50mm for bottom bars (with site concrete)
- Minimum concrete cover for foundation 50mm for bottom bars (with site concrete)
- Minimum concrete cover for foundation 60mm for bottom bars
- Other structure not part of reservoir 60mm

Note the above specification is applicable for a 100 years durability in accordance with NZS3101:2006 except concrete covers have been increased by 10mm beyond NZS3101:2006 requirements.

14 Water Tightness Requirements

The reservoir walls shall be classified as water-tight liquid retaining structure having a Tightness Class 3 as per Table 3 Clause 5.1.1 of NZS3106:2009. The reservoir floor shall be classified as having a Tightness Class of 2.

The floor slab shall be designed to either; limit the width of cracks due to combined flexural stresses and secondary stresses (temperature, swelling and shrinkage) by limiting the tensile stress of the reinforcing steel to 240 MPa. This requirement is as per clause 5.2.5 of NZS3106:2009 or by the application of post tensioning to the slab in segments and between segments to resist combined tensile flexural and secondary stresses by the application of compression stress across the full concrete section.

14.1 Floor Slab Waterstops

At specified locations joints in the floor slab will be constructed. These will be to limit concrete pour size and optimise the geometry of slab segments. Waterstops to be provided at floor slab joints include synthetic rubber hydrophilic waterstops within the depth of the slab section and PVC external waterstops at the underside of the slab. Formed recesses will be provided for the hydrophilic sealants in the surface of the precast panels. In general polyurethane sealants will be provided around pipe penetrations, floor access hatches and at the junction of the wall to the floor slab.

Column foundations are to be constructed integrally with the floor slab with floor slab joints located away from column positions. Reinforcing starter bars will be provided through the floor for columns above. Waterstops are not proposed at the construction joint positions between the top of floor slab and base of column sections.

14.2 Wall Section Waterstops

Only vertical construction joints shall be used for the reservoir walls. Waterstops at the wall infill sections between precast concrete panels will be synthetic rubber hydrophilic waterstops within the depth of the wall section. Formed recesses will be provided for the hydrophilic waterstops in the surface of the precast panels. Roughened concrete surface finish will be provided for the balance of the precast panel construction joint surface.

Continuity will be provided between the vertical wall hydrophilic waterstops in the wall joints and the horizontal hydrophilic waterstops between the wall and floor slab.

14.3 Roof Slab Water Tightness

The roof slab shall be covered with a waterproof membrane.

15 Geotechnical Information

Applicable geotechnical information for the structural design of the reservoir is included in the Beca document Hospital Prince of Wales Reservoir – Geotechnical Basis of Design (Beca 2012).

Appendix B

Mechanical Basis of Design

Basis of Design

Hospital Prince of Wales Reservoir Mechanical Basis of Design

Prepared for Wellington City Council (Client)

By CH2M Beca Limited

31 May 2013

Revision History

Revision Nº	Prepared By	Description	Date
A	Mike Yarrall	For Client Review	17/07/2012
0	Mike Yarrall	For Use	12/09/2012
1	Mike Yarrall	Updated for CDOR	01/02/2013
2	Brian Smith	Final PD Report	31/05/2013

Document Acceptance

Action	Name	Signed	Date
Prepared by	Mike Yarrall		01/02/2013
Reviewed by	Darren Hewett	p.l.	01/02/2013
Approved by	Simon Edmonds		01/02/2013
on behalf of	CH2M Beca Limited		

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Appendices

1 Introduction

This document describes the basis of design for the mechanical components for the **Hospital Prince of Wales Reservoir Project** located in upper Prince of Wales Park at Mount Cook, Wellington City.

The project includes a reservoir and the associated earthworks and pipelines. The reservoir is fully buried below ground level and will store 35,000m³ volume of fresh water. It will supply water to Wellington Hospital and to the Central Business District (CBD). CH2M Beca (Beca) has been commissioned by Wellington City Council (WCC) to supply engineering services for the development of the new reservoir.

2 Objectives

The principal objective of this document is to establish a basis that shall be used for the design and documentation works of all aspects of the reservoir mechanical and piping components and to:

- Comply with client requirements
- Comply with statutory requirements
- Address whole of life operation, inspection and component replacement requirements
- Utilise the relevant experience and skills of the design team members
- Incorporate consideration of recent engineering technology developments
- Enable close coordination with other design disciplines
- Permit construction sequencing to be undertaken in accordance with the client's agreed programme

3 Definitions

Unless the context requires otherwise the following abbreviations and their meanings are used within this document:

CBD	Central Business District
Capacity	Capacity Infrastructure
Council	Wellington City Council
GW	Greater Wellington regional Council
HPOW	Hospital Prince of Wales
RFT	Request for Tender
TBC	To Be Confirmed
TWL	Top Water Level
WCC	Wellington City Council
WE	Wellington Electricity

4 Process Description

The HPOW reservoir will be part of the 'Low Level Zone'. This includes the following reservoirs: Macalister, Carmichael and Mt Albert. The reservoirs in this zone are hydraulically connected through the reticulation system with the larger reservoirs having a Top Water Level (TWL) of 92m. The HPOW reservoir is filled from the new 800 NB inlet main on Hargreaves St and the Bell Rd Reservoir. The outlets are both to the Carmichael Reservoir and the new 900 NB outlet main on Hargreaves St.

In a seismic event the reservoir will automatically be isolated from the reticulation network. Flow control valves also serve to allow control over the filling rate of the reservoir as well as controlling the flow out of the reservoir.

5 Scope of Mechanical Design

The following areas are covered by the mechanical design:

- Above ground pipework, valves and fittings inside the tunnel and reservoir.
- Underground pipelines, valves and fittings from the tunnel to the connection to the new streetworks pipelines.
- Underground pipework, valves and fittings from the tunnel to the existing mains.
- Underground overflow and scour pipework, valves and fittings from the tunnel to the stormwater system.

Pipelines associated with the reservoir:

- Outlet pipeline 900 NB to Hargreaves Street.
- Primary inlet pipeline 800 NB from Hargreaves Street.
- Scour and overflow pipeline.
- Secondary inlet pipeline 300NB that connects to the existing high pressure inlet pipeline, 450 NB existing installed in 1954 from Bell Road reservoir
- Secondary outlet pipeline 300 NB that feeds the existing 375 NB that supplies Carmichael Reservoir.

Pipeline design will include, where necessary: manual valves, automated actuated valves, air valves, scour valves and pressure reducing valves.

6 Reference Documents

The following documents are to be referred to in the design of the Hospital Prince of Wales Reservoir:

- Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir 1 February 2012
- Capacity Infrastructure Services Approved Products Register 2011.04.01 (2011)
- Regional Standard for Water Services. Capacity Infrastructure Services. Rev A [DRAFT] – May 2012.
- Wellington City Council Pipe Networks requirements checklist for as-built drawings (2011)
- Wellington City Council Water Supply Specification 7th Edition (2004)

The following standards shall be used in the design of the Hospital Prince of Wales Reservoir:

■ AS/NZS2280:2004	Ductile iron pipes and fittings
■ AS/NZS2451:1998	Bolts, screws and nuts with British Standard Whitworth threads (rationalized series)
■ AS/NZS2566.1:1998	Buried flexible pipelines Part 1: Structural Design
■ AS/NZS2566.2:2002	Buried flexible pipelines Part 2: Installation
■ AS/NZS2638.2:2003	Gate valves for waterworks purposes – Resilient seated
■ AS/NZS4020:2005	Testing of products for use in contact with drinking water
■ AS/NZS4058:2007	Precast concrete pipes (pressure and non-pressure)
■ AS/NZS4087:2011	Metallic flanges for waterworks purposes
■ AS/NZS4130:2009	Polyethylene (PE) Pipes for Pressure Applications
■ AS/NZS4158:2003	Thermal-bonded polymeric coatings on valves and fittings for water industry purposes
■ AS/NZS4331:1995	Metallic Flanges (HOLD)
■ AS/NZS4442:1998	Welded steel pipes and fittings for water, sewage, and medium pressure gas
■ AS/NZS:4998:2009	Bolted unrestrained mechanical couplings for waterworks purposes
■ AS2129:2000	Flanges for pipes, valve and fittings
■ AS3897.3:2002	Site Testing of Protective Coatings
■ AS4041:2006	Pressure Piping
■ BS EN 1092-1:2007	Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated – Part 1: steel flanges
■ NZS1170.5:2004	Earthquake Actions - New Zealand

- Seismic Hazard Assessment for the Hospital Prince of Wales Park Reservoir (Beca, 2012)

7 Mechanical Design Criteria

The pipework arrangement will be designed to allow the same functionality as shown in the "Proposed Pipe Work and Fittings" drawing (approved 13/10/2011) issued by Capacity Infrastructure Services. This functionality is to be confirmed by preparation of a P&ID by Beca and subsequent review by Capacity and amendment by Beca to an agreed process flow.

Pipework and valves within the pipe tunnel are to be configured to allow the inspection (internal and external) and removal and replacement of pipe spools and fittings.

The design life for the pipelines is to be at least 100 years with maintenance.

7.1 Flows and Hydraulics

The inlet and outlet pipework will separately connect the reservoir to the Central Zone via the streetworks pipelines (primary connection) and to the Kaitoke main via Bell Road reservoir (secondary connection). There will be two separate inlets into the reservoir, and one outlet that will split to the two lines. A cross connection will link the secondary inlet to the outlets via a PRV. An overflow and scour will also be provided.

7.1.1 Primary Inlet

Design Flowrate:	700 L/s (maximum peak value)
Proposed diameter:	600 NB inside tunnel, 800 NB below ground

Nominal velocity:	2.5 m/s (at maximum peak flowrate)
Level of rim:	90.000 NCD

7.1.2 Secondary Inlet

Design Flowrate:	120 L/s (maximum peak value)
Proposed diameter:	300 NB inside tunnel and below ground
Nominal velocity:	1.7 m/s (at maximum peak flowrate)
Level of rim:	Bent down to below normal water level; inlet pipe high point at 92.000 NCD

7.1.3 Outlet

Design Flowrate:	800 L/s (maximum peak value)
Proposed diameter:	600 NB inside tunnel, 900 NB below ground
Nominal velocity:	2.8 m/s (at maximum peak flowrate)

Below floor level at 45°, with grill (stainless steel handrailing to be considered in subsequent design stages) and vortex preventer.

7.1.4 Secondary Outlet

Design Flowrate:	Not provided
Proposed diameter:	300 NB inside tunnel and below ground

Branches from primary outlet in tunnel.

7.1.5 Overflow Pipework

Design Flowrate:	1,200 L/s (maximum peak value)
Level of rim:	92.075 NCD
Allowable head:	250mm above rim (92.325 NCD)

Pipe provided to be 600 NB, this would give a velocity of 4.2 m/s at the maximum peak design flowrate. Although this velocity is high the discharge at this rate would be for short periods only hence CLMS could be considered suitable. As an alternative epoxy lined pipe could be used subject to agreement from Capacity. The headloss in the overflow pipe is expected to be about 5m. As the overflow is expected to be more than 20m above the discharge point, there is plenty of head available. A vortex inhibitor is to be provided at the bellmouth to prevent vortices in the event that the overflow inlet becomes submerged.

7.1.6 Scour Pipework

Design Flowrate:	400 L/s (nominal over a period of 24 hours)

The minimum pipe diameter will be approximately 500mm prior to connection into the overflow line.

7.1.7 Test Pressure

The test pressure for all pipework shall be 100m, which is the minimum specified in the RFT. This will be significantly in excess of the expected operating pressure. However, it will be less than the 1.3 x minimum pipe pressure rating as specified in the WCC Water Supply Specification.

7.2 Valves

7.2.1 Below Ground Valves

Below ground valves up to and including 300mm diameter will be flanged resilient seated gate valves.

Below ground valves larger than 300mm diameter will be resilient seated double flanged butterfly valves. Although the WCC Code of Practice for Land Development requires butterfly valves to be approved by the Council, the RFT indicates that most valves will be butterfly valves. For larger diameters, butterfly valves will offer a significant space, weight and cost saving over gate valves.

7.2.2 Above Ground Valves

Isolating:

All valves isolating lines of 50mm diameter or less will be ball valves.

All above-ground manual valves isolating lines of greater than 50mm diameter will be butterfly valves. These valves will be double flanged which enables them to still isolate when pipework on one side is removed.

Although the RFT shows bypass valves on large diameter valves Capacity has advised that no bypass valves should be provided as there is no requirement to maintain water supply while operating valves (e.g. for testing purposes).

Control:

As specified in the RFT, all control valves will be plug valves and the type is to be agreed with Capacity. Manufacturers such as Valmatic and Dezurik will be considered. Rotork actuators with battery backup will be used for the shut-off valves. Limit switches will be required.

Flow control on the reservoir inlet and outlet valves is required to balance operation of the reservoir with the other low level zone reservoirs and ensure turnover of the reservoir contents.

The valves will be specified to be controlled so that the final part of the closure happens slowly enough to mitigate the risk of problematic surge pressures in the pipeline.

Pressure Reducing Valve:

A hydraulically actuated control valve is proposed. This will be sourced from Capacity approved suppliers Claval or Bermad. These valves generally require at least 10m upstream pressure to operate, but we understand this will be available from the Kaitoke main.

Non Return Valves:

A non-return valve will be installed on the 300mm diameter outlet. This could be a swing-check type of valve or a wafer type twin plate sprung non-return valve. Capacity to confirm their preference.

Flap valves will be provided where the open channel tunnel drain discharges to the stormwater manhole.

Air Valves:

Air valves will be required to vent air that accumulates at high points and bends in the pipeline, and to assist when filling the pipe. They will also be required to let air in to the pipe to prevent negative pressure from occurring in the event of sudden valve closure.

The exact location of air valves will be confirmed once the pipework arrangement is finalised.

The recommended air valve type is the Vent-O-Mat RBX. Capacity to confirm their preference.

Standpipes will not be considered as they are not preferred by Capacity.

7.3 Flexible Couplings

Bellows will be provided as the first flexible coupling outside of the reservoir after the isolation valves hard piped to the reservoir structure. A flexible coupling will also be provided at the end of the tunnel arrangement. Where the pipework exits the tunnel the pipe penetration will be configured to allow a degree of movement to accommodate seismic movement and differential settlement.

All pipework in the tunnel will be restrained, with thrust taken up outside the tunnel. However pipe supports could also provide thrust restraint if required. Flexible couplings/bellows may need to have tie bolts installed to allow partial dismantling of piping which is in service to deal with thrust.

Viking Johnson dismantling joints or tied gibaults/flange adaptors will be used to provide the ability to dismantle valves and fittings and to correct alignments during construction.

Earthquake loads on the pipes will be determined as detailed in NZS 1170.5:2004 modified in accordance with the Site Specific Seismic Hazard Assessment (Beca, 2012). The design acceleration recommended by the site specific assessment is 1.56g horizontal.

7.4 Pipe

7.4.1 Below Ground Pipework

Pipe will be installed with a minimum of 1m cover. The design will aim to maintain a maximum cover of 2m. However, the raising of the existing park level will mean the cover for existing pipework may exceed this with agreement from Capacity. A minimum of 0.5m clearance needs to be provided between the 33kV cable and the pipeline, but the design will aim for a larger clearance.

The large diameter below ground pipework (i.e. the 800mm and 900mm diameter pipes) will be concrete lined mild steel to NZS 4442. The pipe wall thickness will be as detailed in column (b) of Table 2 in NZS 4442:1988. The pipe outside diameters will be 345, 426, 508, 610, 813 or 914 mm.

Depending on the pipe supplier, the pipes will be coated with either a Polyken Synergy or Sintakote coating. Hemispherical slip-in joints are proposed.

The structural pipeline design shall allow for HN-HO-72 external loading in areas where heavy traffic loads are expected.

The material for smaller diameter below ground pipework will be determined during subsequent design stages, but could be steel or ductile iron.

Pipework 600mm diameter and above will have 500mm diameter access hatches to provide personnel access to the interior of the pipe. These will be spaced at 200m intervals. We understand Capacity have preferred details for these access points.

7.4.2 Above Ground Pipework

Concrete lined, epoxy coated steel pipework to NZS 4442:1988 is preferred for all pipework in the tunnel. Epoxy lined pipe may be used for short pipe lengths with agreement from Capacity.

All pipework will either be welded, flanged or use gibault/flange adaptor flexible couplings.

7.5 Flanges

All flanges will be tested to a minimum of 10 bar.

Capacity has advised the preferred flange drilling is AS/NZS 4331 PN16. Other patterns may be necessary for compatibility with available valves and fittings.

An insulated flanged joint is required on the inlet pipe immediately outside the structure to allow cathodic protection to be applied to the inlet pipe without loss of the impressed current into the structure.

7.6 Instrumentation

7.6.1 Flowmeters

All flowmeters will be ABB Watermaster 24 V DC as specified in the RFT.

Flowmeters will be full bore as the pipework in the tunnel is already a reduced diameter.

As bidirectional flow could occur, at least 5 x diameter straight length will be provided upstream and downstream of the flowmeters.

7.6.2 Other Instrumentation

Tappings for pressure indicators and transmitters will be provided.

Appendix A

Process and Instrumentation Diagram and Legend Sheet

Appendix C

Geotechnical Basis of Design

Report

Hospital Prince of Wales Reservoir Geotechnical Basis of Design

Prepared for Wellington City Council (Client)

By CH2M Beca Limited

1 February 2013

Revision History

Revision N°	Prepared By	Description	Date
A	Jerry Spinks	For Client Review	05/10/12
B	Simon Edmonds	Updated for CDOR	01/02/2013
C	Jerry Spinks	EQ Return Period Confirmed	19/04/2013

Document Acceptance

Action	Name	Signed	Date
Prepared by	Jerry Spinks	J. Spinks	19/04/2013
Reviewed by	Andrew Law	J. Spinks	19/04/2013
Approved by	Brian Smith	Brian Smith	19/04/2013
on behalf of	CH2M Beca Limited		

Table of Contents

1 Introduction

This document describes the basis of design for the geotechnical criteria for the **Hospital Prince of Wales Reservoir Project** located in upper Prince of Wales Park at Mount Cook, Wellington City.

The project includes a reservoir and the associated earthworks and pipelines. The reservoir is fully buried below ground level and will store 35,000m³ volume of fresh water. It will supply water to Wellington Hospital and to Central Business District (CBD). CH2M Beca (Beca) has been commissioned by Wellington City Council (WCC) to supply engineering services for the development of the new reservoir.

2 Objectives

The principal objective of this document is to establish a basis that shall be used for the design and documentation works of all aspects of the reservoir earthworks and foundations and earth pressure loading and to:

- Comply with client requirements
- Comply with statutory requirements
- Utilise the relevant experience and skills of the design team members
- Enable close coordination with other design disciplines
- Permit construction sequencing to be undertaken in accordance with the client's agreed programme

3 Definitions

Unless the context requires otherwise the following abbreviations and their meanings are used within this document:

CBD	Central Business District
Capacity	Capacity Infrastructure
Council	Wellington City Council
GW	Greater Wellington regional Council
HPOW	Hospital Prince of Wales
IL	Importance Level
RFT	Request for Tender
SLS	Serviceability Limit State
TBC	To Be Confirmed
TWL	Top Water Level
WCC	Wellington City Council

WE	Wellington Electricity

4 Scope of Geotechnical Basis of Design

The following items are addressed in the geotechnical basis of design:

- Geotechnical profile
- Groundwater
- Soil parameters
- Lateral seismic earth pressures
- Temporary cut slopes
- Engineered fill slopes
- Foundation bearing pressures
- Earthworks material classification

5 Reference Documents

The following documents are to be referred to in the design of the Hospital Prince of Wales Reservoir:

- Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir 1 February 2012
- NZS1170.5:2004 Earthquake Actions - New Zealand
- Hospital Prince of Wales Reservoir Geotechnical Report (Beca, Rev B 'Final' dated 3 October 2012)
- Hospital Prince of Wales Reservoir Geotechnical Report Addendum (Beca, Rev 1 dated 14 January 2013)
- O'Riley et al, Seismic Performance of the Terrace Tunnel Approach Walls, Wellington. 2006, NZSEE Conference
- MJ Pender, Some Properties of Weathered Greywacke, 1971 Aust NZ Conference in Geomechanics
- MJ Pender, Friction and Cohesion Parameters for Highly and Completely Weathered Wellington Greywacke, 1980, University of Auckland
- Read, S.A.L., Richards, L., and Perrin N.D.(2000): Assessment of New Zealand Greywacke Rock Masses with the Hoek-Brown Failure Criterion. In: C. Haberfield et al., (ed.) Proceedings GeoEng2000, International Conference on Geotechnical & Geological Engineering, Melbourne, 19-24 November 2000, paper SNES0868: Technomic Publishing Company, Lancaster.
- CH2M Beca Ltd, 2012: Seismic Hazard Assessment for the Hospital Prince of Wales Reservoir. Prepared for Capacity Infrastructure Services Limited.
- Duncan C. Wyllie, Foundations on Rock, First Edition (1992)
- BS8004:1986 Code of Practice for Foundations, 1986, British Standards Institute

6 Geotechnical Design Criteria

The new reservoir is expected to provide water for the Wellington Regional Hospital in Newton. This structure has a base isolation system and a design requirement that the building is fully operational within 6 hours after a major earthquake. The return period for this major earthquake has been selected as 1000 years. The propose HPOW reservoir is to match this design requirement by having a design SLS 2 (Operational Continuity) earthquake return period of 1000 years (HOLD – Seismic design standard to be confirmed by Capacity). The design is to meet or exceed the requirements of Importance level 4 (IL4) structures for facilities with a special post disaster function. The backfill around the reservoir does not have to meet the same SLS2 criteria provided slope failure does not affect the integrity of the reservoir.

6.1 Geotechnical Profile

Unit	Description	Depth to top (m)	Thickness (m)
Topsoil	Soft to firm clayey organic SILT; dark brown; medium to high plasticity	0	0.2
Residual soil/ completely weathered GREYWACKE/ ARGILLITE*	Stiff, clayey SILT; orange-brown; low to high plasticity.	0.2	0.2-1.6
	Extremely weak to very weak GREYWACKE/ ARGILLITE.	0.4-1.8	0.3-1.0
Highly weathered GREYWACKE/ ARGILLITE	Weak to very weak GREYWACKE/ ARGILLITE.	0.7-2.5	0.5-5.4
Moderately weathered GREYWACKE/ ARGILLITE	Weak to moderately strong GREYWACKE/ ARGILLITE.	1.2-8.0	1m+

*GREYWACKE/ARGILLITE is subsequently referred to as Greywacke.

6.2 Groundwater

Groundwater monitoring was undertaken within boreholes BH01 and BH02, recording average groundwater RLs of 86.5m and RL 85.8m respectively.

6.3 Soil Parameters

Unit	Bulk Density γ (kN/m³)	Effective cohesion c' (kPa)	Effective Friction Φ (°)
Engineered Fill (reworked Greywacke)	19	0	36
Residual Soil/ Completely Weathered Greywacke	18	10	28
Highly Weathered Greywacke	22	100	45
Moderately Weathered Greywacke	24	100	45

6.4 Lateral Seismic Earth Pressures

Lateral earth pressures will be prepared during detailed design. We recommend that RRU 83 – 'Seismic Design of Bridge Abutments' is used for determination of seismic earth pressures on the reservoir wall. We anticipate that 'rigid' wall loading will be applicable; however this should be confirmed by the structural designers. This method is to be compared with the NZS 3106:2009 method for embedded tanks. Seismic accelerations will be as per the recommendations from the Hospital Prince of Wales Reservoir – Site Specific Seismic Hazard Assessment (Beca, Rev B 'Final' dated 21 December 2012).

6.5 Subgrade Stiffness

During detailed design, the interaction of the reservoir foundations and underlying subgrade will be modelled by providing 'spring stiffness' values for the weathered Greywacke. Representative values will be determined by calculating displacements across a range of foundations.

6.6 Temporary Cut Slopes

Temporary cuts in rock are recommended to be no steeper than 60°, with a 2m to 3m wide intermediate catch benches every 8-10m height, achieving an equivalent overall slope of 1:1V(45°), max slope height in the order of 12m. Should persistent unfavourable defects be identified during the logging of the cut as it progresses, this angle may need to be reduced.

Temporary cuts in the overlying residual soils and completely weathered rock should be cut no steeper than 2H:1V.

For temporary cuts in rock an acceptable alternative to 60º cut slopes is to use either a vertical tied back soldier pile wall or near vertical reinforces shot crete and soil nail wall. This approach is recommended for the pipe tunnel excavation below the reservoir. Backfill between the excavation and pipe tunnel structure should be low strength concrete.

For vertical earth pressure from backfill on top of the pipe tunnel assessment should be in accordance with AS/NZS 3725:2007 Design for Installation of Buried Concrete Pipes, assuming the arrangement acts as 'embankment fill', adopting the scenario of positive projection and a backfill unit weight of 19 KN/m3 for saturated fill.

6.7 Engineered Fill Slopes

For long term stability a fill slope no steeper than 2H:1V, formed of Engineered Fill comprising re-worked Greywacke, is expected to achieve a factor of safety under static conditions of 1.4. With a maximum slope height in the order of 8m.

6.8 Foundations

We recommend a geotechnical ultimate bearing capacity of 1MPa within the moderately weathered Greywacke rock. For limit state structural design (with code factored structural loads), a strength reduction factor of 0.5 shall be applied to this value.

The settlement of shallow footings supported on the weathered Greywacke under sustained loads (e.g. unfactored dead plus live loads) are expected to be in the order of 10mm to 25mm.

6.9 Earthworks

In accordance with TNZ/F1: 1997, Specification for Earthworks Construction, we recommend the majority of the cut material is classified as Type A. This is interpreted as material than can be won by a 16T machine excavator, fitted with a toothed bucket.

The excavation will likely intercept the groundwater table (from below around RL 86m). Therefore, drainage of the reservoir platform will be required during construction, and also in the longer term, including the backfill. Drainage provisions for groundwater around the outside of the reservoir will need to be separate from the reservoir under floor drainage system as per the client requirements.

The excavated material will predominantly comprise highly to moderately weathered, highly fractured greywacke rock. The re-worked material is anticipated to be favourable in terms of its drainage characteristics and resistance to breaking down during re-working and compaction. Compaction criteria, including insitu and laboratory verification testing, will be set during the subsequent phase of design.

Appendix D

Landscape Report

Report

Hospital Prince of Wales Reservoir - Landscape Report

Prepared for Wellington City Council (Client)

By CH2M Beca Ltd (Beca)

31 May 2013

Revision History

Revision Nº	Prepared By	Description	Date
A	Paul Roper-Gee	For Client Review	19 April 2013
B	Brian Smith	Final Issue	31 May 2013

Document Acceptance

Action	Name	Signed	Date
Prepared by	Paul Roper-Gee	Paul Roper-Gee	19 April 2013
Reviewed by	Brian Smith	BJ Smith	19 April 2013
Approved by	Mark Sneddon		19 April 2013
on behalf of	CH2M Beca Ltd		

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Appendices

1 Introduction

Wellington City Council (WCC) are seeking to construct a completely buried 35,000m^3 concrete reservoir within the Upper Prince of Wales Park in Mount Cook to service the Wellington Hospital and Central Business District. The facility will have a special post disaster function to supply water for the Wellington Region.

CH2M Beca Limited (Beca) has been commissioned by WCC under the Capacity Infrastructure Services Request for Tender for the Consultancy Services for the Hospital Prince of Wales Reservoir (WCC, 1 February 2012) (the Brief).

A number of alternative concepts for both the reservoir and the associated services tunnel were considered in the Conceptual Design Options report and a preferred single combined reservoir and tunnel arrangement has been identified for advancing to Preliminary Design.

The form and location of the selected reservoir needs to recognise the sensitivity of undertaking the required construction works within the Town Belt including environmental considerations. A key WCC objective was to consider and address the location of the reservoir in the Town Belt and accordingly to construct a completely buried reservoir and establish appropriate landscaping across the works site on completion.

In undertaking the preliminary design we have recognised the conditions within section 5.2 of the WCC Approval to locate the proposed reservoir in the Town Belt (Prince of Wales Park) (included as Reference 23 of the Brief) that:

- *"The impacts of the proposed reservoir on Town Belt shall be minimised.*
- *The proposed reservoir shall be placed underground, fully buried with existing landform matched as closely as practicable.*
- *It shall be sited to minimise interference with existing features, facilities and plants.*
- *On completion, the proposed reservoir will not affect or change the recreational use of the area.*
- *Any disturbance of the existing site during installation of the proposed reservoir shall be made good immediately after completion."*

Also, it is implicit in the Brief that the future paths through the Town Belt on completion of the reservoir should be where practical at least equivalent to the existing arrangements.

In addition to these 'end use' connections, the final paragraph of Section 3.4.5 of the Brief also requires proposals for pedestrian access around the construction site connecting Dorking Road, Rolleston Street, Hargreaves Street, the Lower Park and the Bell Road reservoir site.

This report presents the background to the development of the landscape plan incorporated in the preliminary design.

2 Site Location and current form

2.1 Location

The general location and features of the reservoir site are shown in Figures 2.1 and 2.2.

Figure 2.1: Site Location - Proposed Reservoir

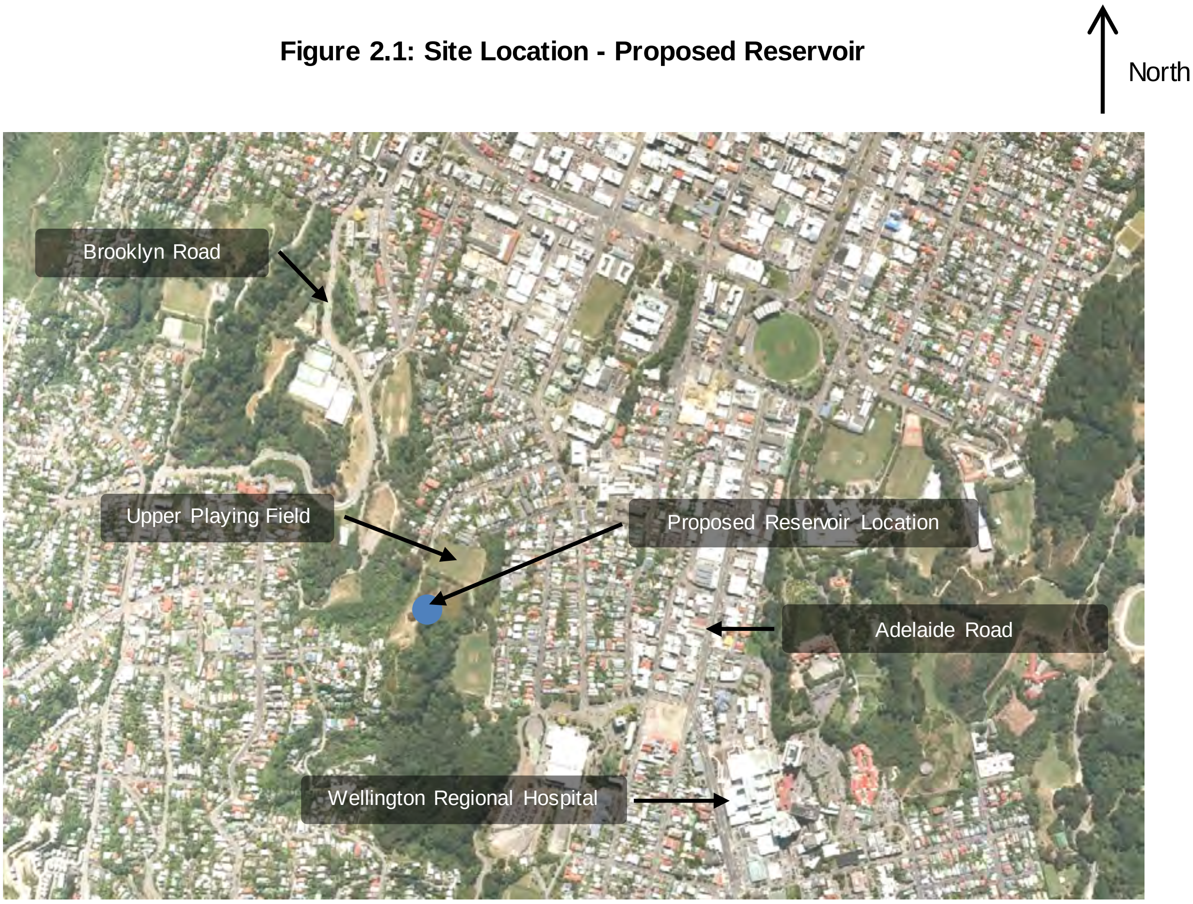


Figure 2-2 Aerial View of Prince of Wales Park

2.2 Existing Topography and Vegetation

The existing topography includes a rounded spur landform aligned generally south west to north east, sloping down from the residential dwellings on Dorking Road to an open rounded knoll at the site of the reservoir.

From this knoll, the site slopes away to the west into a small gully containing an ephemeral waterway. An area of recent community revegetation planting is located on the eastern side of the gully containing a wide range of native tree and shrub species. The western side of the gully is covered with established regenerating native bush containing a range of native tree and shrubs species including tree ferns, cabbage trees, Mahoe, Pittosporum and Coprosma.

The site slopes down to the south and west of the knoll towards the lower playing field. This area contains a range of vegetation but is dominated by exotic planting including large pine trees. Open areas include gorse and bracken fern.

North of the knoll patches of mixed exotic and native vegetation fill the slope down to the upper playing field. The vegetation patches are divided by the existing track network. Species include mature Pohutukawa trees on the cut slope above the upper playing field and Eucalyptus trees which have been observed to provide fodder for native birds.

Drawing 6517439-CE-K30 within Appendix A shows the existing topography and existing vegetation on the reservoir site and its assessed ecological value as determined in discussions with WCC Parks and Gardens staff.

Photos 2.3 to 2.6 below illustrate typical examples of the classes of vegetation shown on Drawing 6517439-CE-K30 and described above.

Photo 2.3 - View from knoll looking west towards high value regenerating native bush

Photo 2.4 - View from existing track network looking west through moderate value mixed exotic and native planting

Photo 2.5 – View from above knoll looking north east towards reservoir site. Low value exotics including pine trees are visible on the right hand side.

Photo 2.6 – View from knoll looking south west showing areas of 'rough' long grass and recent revegetation planting adjacent to existing high value regenerating native bush

2.3 Existing Pathways

Existing paths through the site are shown on Drawing 6517439-CE-K30 and the wider distribution of paths is shown in Figure 2.7 below.

The existing paths range from 'tracks through grass' through to gravelled or paved pathways. In some areas the paths are steeply graded including portions with slopes of approximately 3H:1V and 4H:1V. In other areas the paths are more gently graded.

Figure 2.7 Existing walking paths in vicinity of reservoir

3 Selected Reservoir Arrangement

3.1 Introduction

This report considers only the preferred option R1.0 identified in the Conceptual Design Options Report.

3.2 Site Layout

Drawing 6517439-CE-K31 shows the extent and shape of the excavation required to construct the reservoir and tunnel and the extent of natural vegetation (other than grass) which will be removed in the construction process.

Drawing 6517439-CE-K32 shows the final contours and extent of backfilling on completion of the reservoir with typical sections shown in 6517439-CE-K33

4 Landscaping Arrangements

4.1 Preliminary Landscape Concept

Drawing 6517439-LS-001 shows the proposed landscape treatment of the site following construction of the reservoir. The key factors that were taken into consideration in preparing the preliminary landscape concept include:

- The nature and extent of established vegetation removal as a result of the overall construction footprint;
- The overall construction footprint and degree of landform modification that will occur;
- The final form and visual characteristics of the reservoir; and
- The overall visibility of the site, in the site, local and broader landscape contexts.

Given that all of the considered reservoir options included significant excavation of the existing spur, the primary 'landscape-related' goal during the options phase was the retention of key vegetation and site features and limiting the extent of the overall construction footprint, and fill material in particular.

With this in mind, the Conceptual Design Options and Park and Surplus Materials Option Assessment report considered various backfill options (i.e. both over and around the reservoir) including both un-reinforced fill at a slope of 2H:1V and also steeper slopes with reinforced fill. The selected backfill options had to limit the overall construction footprint on the one hand and establish safe and accessible slopes for pedestrians to access and traverse the park in the future on the other.

The selected arrangement for backfill surrounding the reservoir is generally an unreinforced slope (varies 2 to 1.7H:1V) though steeper reinforced slopes are proposed on the south eastern part of the reservoir to limit the depth and extent of the sidling fill that would be required down the gully compared with the unreinforced slope.

The reservoir roof proposed in the preliminary design has a truncated cone shape with a 10m diameter generally circular flat central area which falls radially 3m at a gradient of 10H:1V to the reservoir edge. The preliminary design assumes a fill depth of between 0.5m (the minimum for turf establishment) to a maximum of 1m. The new landform created by the buried reservoir will be more regular and geometric than the existing natural form. The proposed planting will help to disguise the regular geometric form as it matures, creating its own natural undulation and variable form.

4.2 Planting Arrangements

The planting arrangements shown in Preliminary Landscape Concept plan take into account the existing and future characteristics of the site and suggestions on species selection made by WCC Parks and Gardens.

The landscape planting has been developed with the aim of:

- Establishing a mix of grassed and vegetated areas in keeping with the informal and un-structured nature of the Town Belt in this area;
- Planting the backfilled side flanks of the reservoir to help to integrate the new reservoir into the broader vegetated landscape;
- Providing an open grassy corridor down the centre of the site similar to the existing situation. It is envisaged that grassed areas would be maintained in accordance with existing methods. There will be steep areas that are not conventionally mowable and it is envisaged that these areas would be left as 'rough grass' or occasionally trimmed with a weedeater;
- Improving the biodiversity in the area by providing suitable plants for birds and insects. This may include providing exotic species such as Eucalyptus to provide fast growing bird fodder;
- Long term ecological succession within the planting by including pioneer, secondary colonisers and emergent species within the plant species mix;
- Avoiding interference with underground services and pipework;
- Establishing low shrubs and groundcovers in the vicinity of pathways and seating areas to keep these areas open and visible, reducing the risk of people being able to hide in close proximity to these areas;
- Establishing medium to high native revegetation planting in the western gully area to support the existing regenerating bush on the adjacent slope and improve the quality of planting within the ephemeral waterway at the base of the gully. This planting will replace the area of recent community planting that will be removed during construction;
- Establishing medium to high native revegetation planting on the northern and eastern slopes of the site to replace planting removed during construction, and provide screening to reduce long distance views of the site and help to 'blend' the new reservoir form into the surrounding landscape; and
- Incorporating specimen trees within the design to add character and vegetation height to areas that are otherwise left grassed or in low planting.

Planting arrangements will be finalised in the detailed design phase in liaison with WCC Parks and Gardens. The preliminary list of plant species to be included within the proposed planting is outlined in Table 4.1 below and shown on the Preliminary Landscape Concept plan.

Table 4.1 Preliminary Planting List

Low Planting (0.4m to 1.5m high)	
Anemanthele lessoniana	Wind Grass
Cortaderia fulvida	Toetoe
Dianella nigra	Inkberry
Meuhlenbeckia complexa	Pohuehue
Phormium cookianum	Mountain Flax
Poa cita	Silver Tussock
Mid height Planting (1.5m to 6m high)	
Coprosma propinqua	Mingimingi
Coprosma robusta	Karamu
Cortaderia fulvida	Toetoe
Fuchsia excorticata	Tree Fuchsia
Griselinia littoralis	Broadleaf
Hebe stricta	Koromiko
Kunzea ericoides	Kanuka
Phormium cookianum	Mountain Flax
Phormium tenax	Flax
Pittosporum eudenoides	Lemonwood
Pittosporum tenuifolium	Kohuhu
Pseduopanax arboreus	Five Finger
Sophora microphylla	Kowhai
High Planting (1.5m to 20m high)	
Aristotelia serrata	Wineberry
Beilchmedia tawa	Tawa
Carpodetus serrata	Putaputaweta
Coprosma propinqua	Mingimingi
Coprosma robusta	Karamu
Cortaderia fulvida	Toetoe
Griselinia littoralis	Broadleaf
Hebe stricta	Koromiko
Kunzea ericoides	Kanuka
Metrosideros robusta	Northern Rata

Myoporum laetum	Ngaio
Pennantia corymbosa	Kaikomako
Phormium tenax	Flax
Pittosporum eudenoides	Lemonwood
Pittosporum tenuifolium	Kohuhu
Podocarpus totara	Totara
Prumnopytus taxifolia	Matai
Sophora microphylla	Kowhai
Specimen Trees (minimum of 1.8m high at time of planting)	
Metrosideros excelsa	Pohutakawa

It is envisaged that exotic tree species such as Eucalyptus may also be incorporated to provide fast growing bird fodder, with a long term intent that these are removed when native tree species have established sufficiently to provide an adequate food source for birds.

4.3 Urban Design Issues

The key urban design issues associated with the site relate to safe accessibility and connectivity to the wider pedestrian/ street network. The Preliminary Landscape Plan takes these issues into account through the provision of:

- Reinstatement of existing paths. Similar to the existing paths, the reinstated paths will be steep in certain areas due to the existing site topography. In addition the introduction of the new reservoir will increase the vertical change in level in some areas and the constrained area available to install pathways will also present challenges to establishing walk ways. The potential to create a gentler graded pathway through the site through 'zig-zag' pathways up the slope will be explored further during the next design phases. Paths are proposed to be a minimum of 1.8m in width.
- Introduction of additional paths to increase accessibility across the site;
- Suggested formation of paved or gravel pathways to promote all-weather access and thoroughfare;
- Provision of bench seats, rest areas, signage and information boards as an opportunity for enhancement of amenity and way-finding; and
- Introduction of additional vegetation to reinstate and enhance the existing characteristics of the site. Consideration of safety, keeping open views and clears lines of sight along pathways. When planting close to paths keep the vegetation immediately adjacent the pathway low and below eye height.

4.4 Construction Phase Walkways

The Brief requires that the Landscape Report present proposals for pedestrian access around the construction site connecting Dorking Road, Rolleston Street, Hargreaves Street the Lower Park and the track to Bell Road reservoir site. The Preliminary Design proposal for the construction phase access is shown on Drawings 6517439-CE-K34 and CE-K31.

Walkway options considered not acceptable

Consideration was given to arrangements for connecting Dorking Road directly to the end of Rolleston Street.

The options for the direct connection past the reservoir site between Dorking Road and Rolleston Street were considered based on a 2m wide footpath with 1H:1V cut slopes and 1.5H:1V fill slopes. Two options were identified, both of which had a uniform steep (1 in 4) grade and involve major fills which would enter into the area of regenerating native bush in the western gully. One option would have discharged near the construction site access which is undesirable from a safety perspective and the other option connected to the top of the steps leading to the Bell Road Reservoir, avoiding the construction site access but requiring a major track through regenerating natural bush of the gully.

A uniform 1 in 4 gradient was considered unlikely to be acceptable, in which case consideration would need to be given to constructing the footpath as an elevated wooden walkway with a combination of stairs and ramps to provide lengths with flatter grades. A wooden walkway would also reduce the impact on existing vegetation but would be an expensive temporary construction.

Proposed walkway option

Having considered the above options, the proposed construction phase walkway is that people wishing to walk between Dorking Road and Rolleston Street should do so via the existing paved pedestrian path passing the existing reservoir adjacent Bell Road as noted on drawing 6517439-CE-K34.

5 Detailed Design of Landscaping and Access Arrangements

5.1 Landscape Plan

The preliminary landscape plans will be developed further in the next phases of the project, during the consultation process held in Stage 2 and in detailed design. Particular items that will be developed further and finalised are:

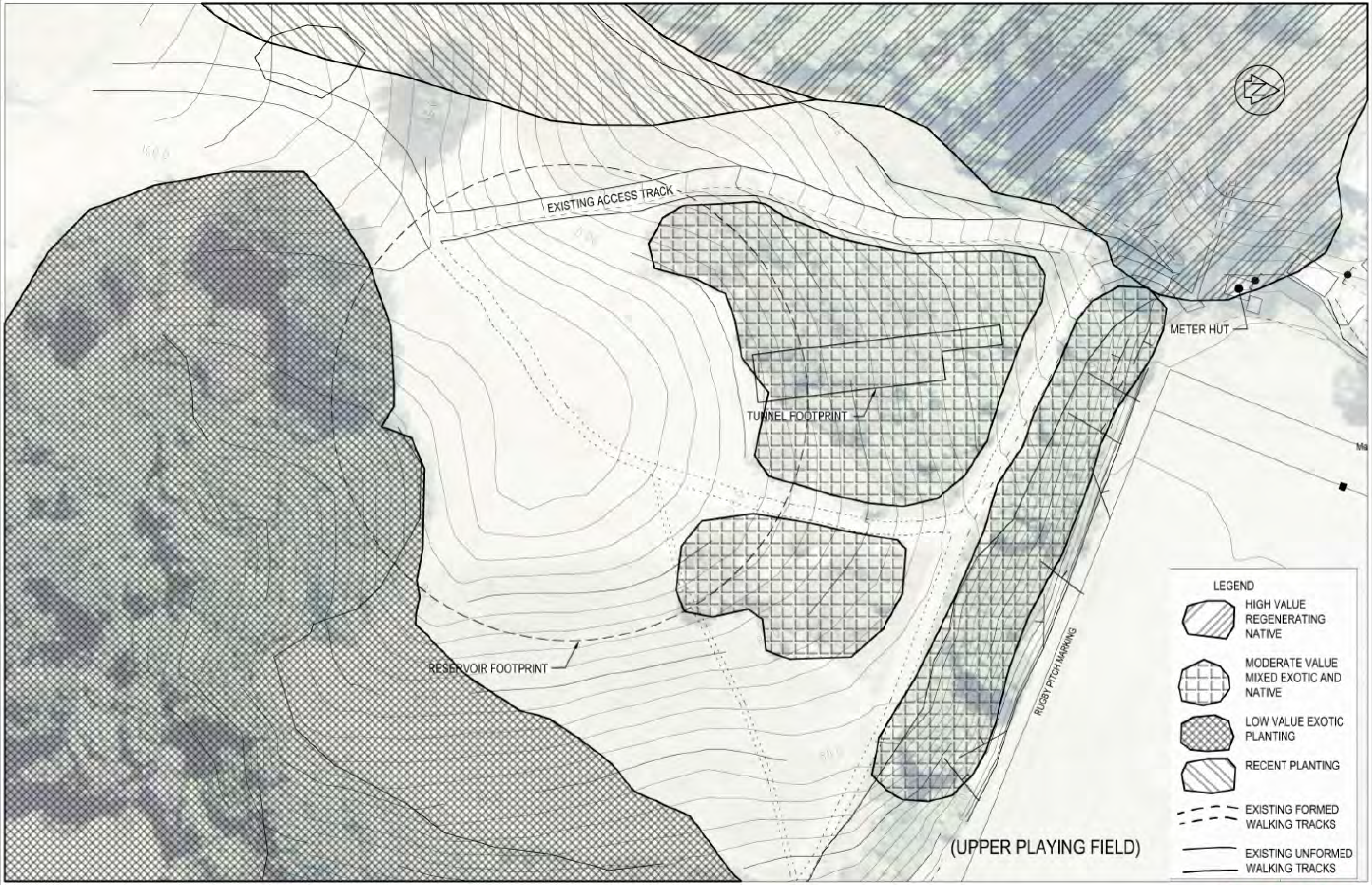
- Final locations and grades of paths through site and construction method;
- Access for tractor operated mower if possible. This may involve widening of access paths.
- Selection and positioning of park furniture such as signage, park benches, and potentially interpretive information boards to explain the presence and function of the reservoir. It is envisaged that these items will be selected from the existing WCC palette of park furniture used within the Town Belt. Indicative locations for seating have been identified on the landscape concept plan, however these will be considered further as part of the detailed design;
- Detail and species selection for planting over reinforced fill slope areas; and
- Planting arrangements including numbers of each plant species, locations and groupings.

Appendix A

Drawings (6517439)

- Existing Site Features, Rev B
  CE-K30
- Reservoir Option-R1.0 Extent of Excavation, Rev B
  CE-K31
- Plan of Reservoir Option–R1.0 Completed Work, Rev B
  CE-K32
- Earthworks Cross Sections, Rev A
  CE-K33
- Construction Phase Pedestrian Routes, Rev B
  CE-K34
- Preliminary Landscape Concept, Rev B
  LS-001

Drawing Plotted: 19 Apr 2013 11:37 a.m.



PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	ISSUED FOR LANDSCAPE DESIGN REPORT	PRG	WR	SAE	19.04.13
A	ISSUED FOR CDOR	HLY	SRW	SAE	01.02.13

Drawing Originator: CH2M Beca | capacity infrastructure services

Original Scale (A1) 500 | Reduced Scale (A3) 1000

Design	JDB		Approved For Issue*
Drawn	HLY	26.07.12	
Checked	JDB	26.06.12	
Dsg Check	SAE	27.06.12	Date

* Refer to Revision 1 for Original Signature

Client: Absolutely Positively Wellington City Council

Project: HOSPITAL PRINCE OF WALES RESERVOIR

Title: EXISTING SITE FEATURES

Discipline: CIVIL

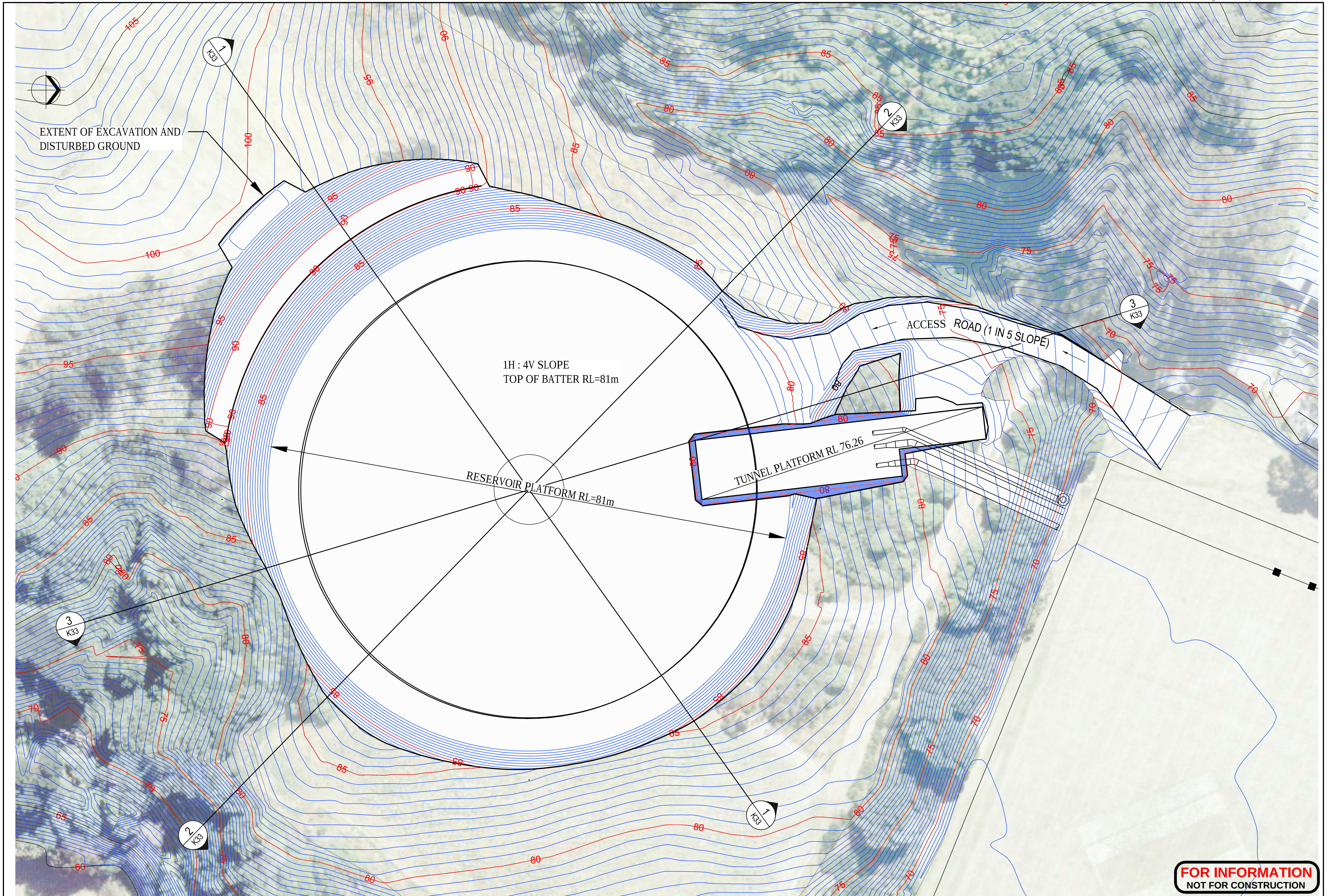
Drawing No. 6517439-CE-K30 | Rev B

DO NOT SCALE

IF IN DOUBT ASK.

Document No. 6517439-CE-K30.DWG

Drawing Plotted: 22 Apr 2013 8:12 a.m.



No.	Revision	By	Chk	Appd	Date
B	ISSUED FOR PDR	AJP	CJM	SAE	18.04.13
A	ISSUED FOR PDR	AJP	CJM	SAE	18.04.13

Drawing Originator: CH2M Beca / capacity infrastructure services

Original Scale (A1) 1:250 (A1)	Designed	CJM	
	Drawn	AJP	09.12
Reduced Scale (A3) 1:500 (A3)	Dsg Verifier	SAE	
	Dwg Check	SAE	

Approved For Construction*

Date

* Refer to Revision 1 for Original Signature

Client: Absolutely Positively Wellington — Me Heke ki Pōneke Wellington City Council

Project: HOSPITAL PRINCE OF WALES RESERVOIR

Title: RESERVOIR OPTION - R.1.0 EXTENT OF EXCAVATIONS

Discipline: ALL DISCIPLINES

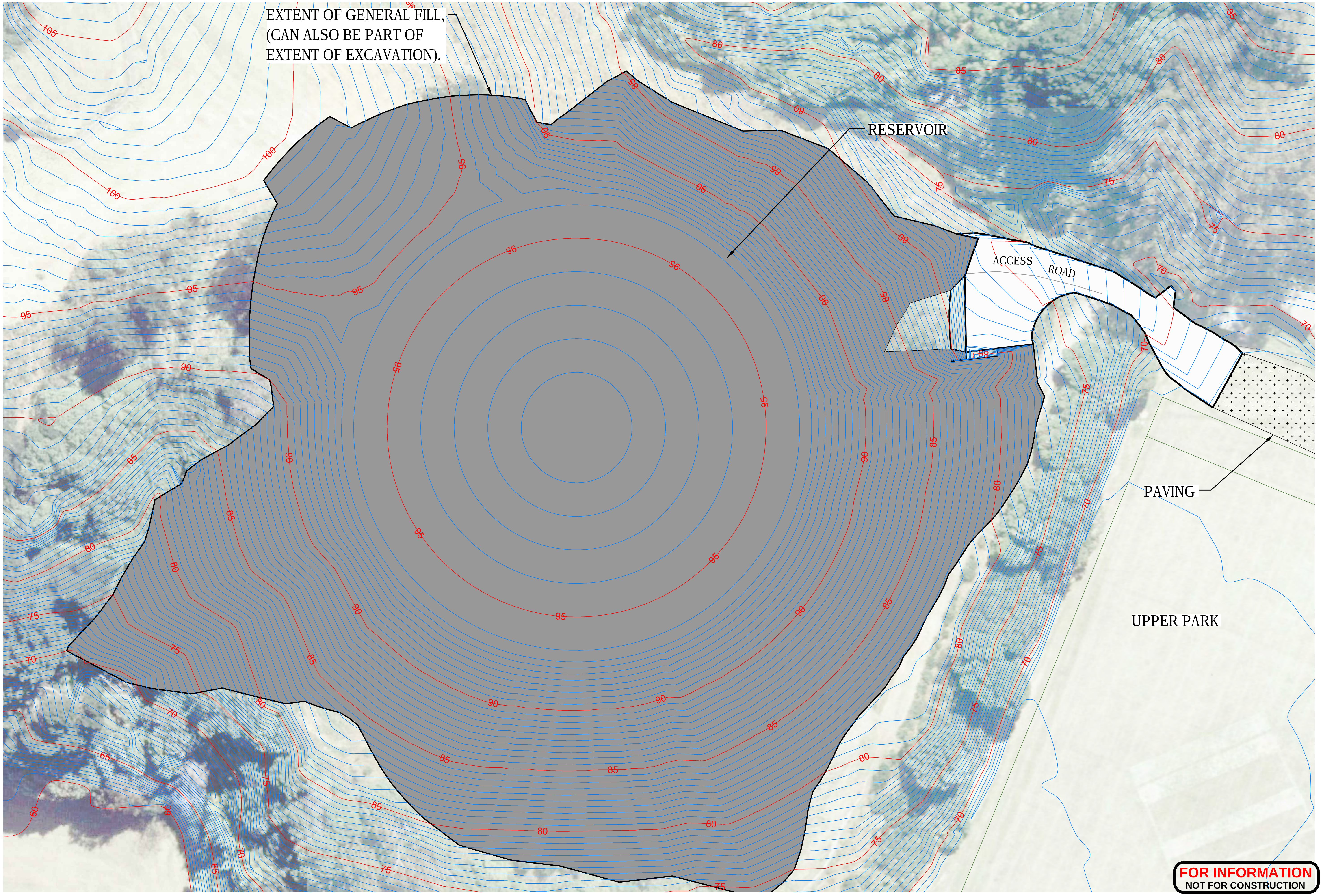
Drawing No.: 6517439-CE-K31

Rev.: B

DO NOT SCALE

IF IN DOUBT ASK.

Drawing Plotted: 22 Apr 2013 8:14 a.m.



No.	Revision	By	Chk	Appd	Date
A	ISSUED FOR PDR	LB	CJM	SAE	18.04.13
A	ISSUED FOR PDR	AJP	CJM	SAE	18.04.13

Drawing Originator: CH2M Beca; capacity infrastructure services

Original Scale (A1) 1:250(A1)
Reduced Scale (A3) 1:500(A3)

Designed	CJM	31.07.12
Drawn	AJP	31.07.12
Dsg Verifier	BS	31.07.12
Dwg Check		

Approved For Construction*
Date
* Refer to Revision 1 for Original Signature

Client: Absolutely Positively Wellington — Me Heke ki Pōneke — Wellington City Council

Project: HOSPITAL PRINCE OF WALES RESERVOIR

Title: PLAN OF RESERVOIR OPTION - R1 COMPLETED WORKS

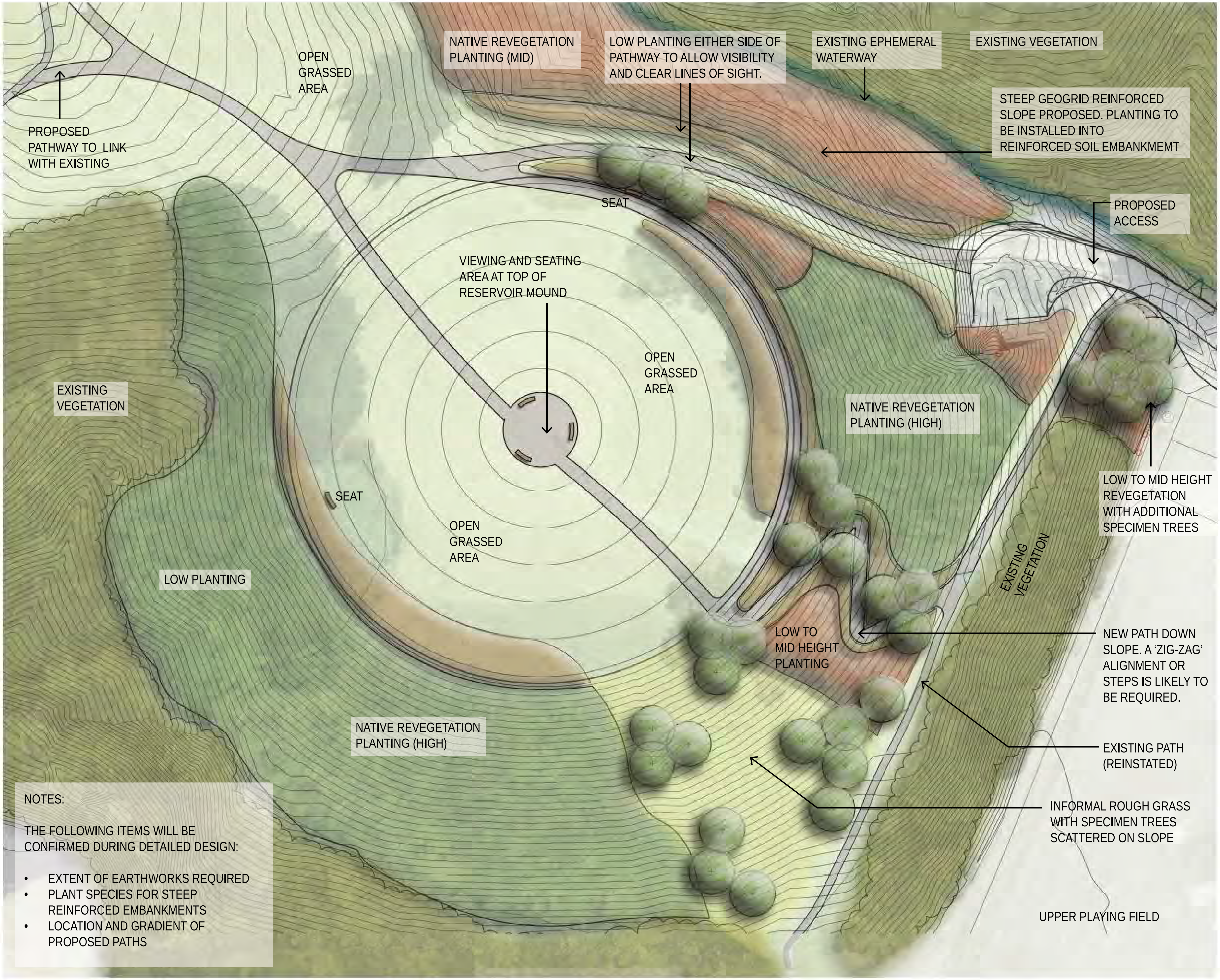
Discipline: CIVIL

Drawing No.: 6517439-CE-K32

Rev.: B

DO NOT SCALE

IF IN DOUBT ASK.



NOTES:

THE FOLLOWING ITEMS WILL BE CONFIRMED DURING DETAILED DESIGN:

- EXTENT OF EARTHWORKS REQUIRED
- PLANT SPECIES FOR STEEP REINFORCED EMBANKMENTS
- LOCATION AND GRADIENT OF PROPOSED PATHS

INDICATIVE PLANT LIST

LOW PLANTING (0m to 1.5m HIGH)

Anemanthele lessoniana	Wind Grass
Cortaderia fulvida	Toetoe
Dianella nigra	Inkberry
Meuhlenbeckia complexa	Pohuehue
Phormium cookianum	Mountain Flax
Poa cita	Silver Tussock

MID HEIGHT PLANTING (1.5m to 6m HIGH)

Coprosma propinqua	Mingimingi
Coprosma robusta	Karamu
Cortaderia fulvida	Toetoe
Fuchsia excorticata	Tree Fuchsia
Griselinia littoralis	Broadleaf
Hebe stricta	Koromiko
Kunzea ericoides	Kanuka
Phormium cookianum	Mountain Flax
Phormium tenax	Flax
Pittosporum eudenoides	Lemonwood
Pittosporum tenuifolium	Kohuhu
Pseduopanax arboreus	Five Finger
Sophora microphylla	Kowhai

HIGH PLANTING (1.5m to 20m HIGH)

Aristotelia serrata	Wineberry
Beilchmedia tawa	Tawa
Carpodetus serrata	Putaputaweta
Coprosma propinqua	Mingimingi
Coprosma robusta	Karamu
Cortaderia fulvida	Toetoe
Griselinia littoralis	Broadleaf
Hebe stricta	Koromiko
Kunzea ericoides	Kanuka
Metrosideros robusta	Northern Rata
Myoporum laetum	Ngaio
Pennantia corymbosa	Kaikomako
Phormium tenax	Flax
Pittosporum eudenoides	Lemonwood
Pittosporum tenuifolium	Kohuhu
Podocarpus totara	Totara
Prumnopytus taxifolia	Matai
Sophora microphylla	Kowhai

SPECIMEN TREES

Metrosideros excelsa	Pohutakawa

Exotic tree species such as Eucalyptus may be incorporated to provide quick growing bird fodder

PRELIMINARY
NOT FOR CONSTRUCTION

Rev	Revision	By	Chk	Appd	Date
B	FOR LANDSCAPE REPORT - REVISED CONTOURS	PRG	WR		02.09.13
A	FOR LANDSCAPE REPORT	PRG	WR		15.12.12

CH2M Beca | capacity

Original Scale (A1) 1:200(A1) | Reduced Scale (A3) 1:500(A3)

HOSPITAL PRINCE OF WALES RESERVOIR

PRELIMINARY LANDSCAPE CONCEPT

LANDSCAPE ARCH

6517439-LS-001 | B

Appendix E

Reservoir Mixing Analysis

TIDEFLEX MIXING SYSTEM (TMS)

PRELIMINARY DESIGN REPORT

Tank Name: HPOW 38,000 m3 (10.0MG) Reservoir

Water Utility/Owner: Wellington, New Zealand

Consultant: Beca

CONTENTS

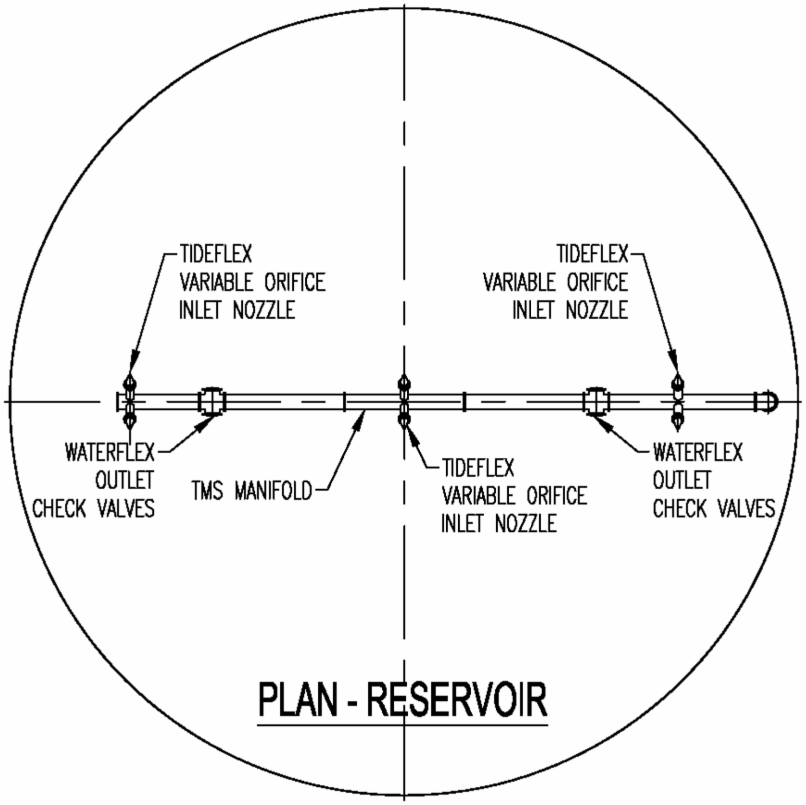
Analysis By:
Michael Duer, P.E.

Tideflex Technologies
A Division of Red Valve Company, Inc.

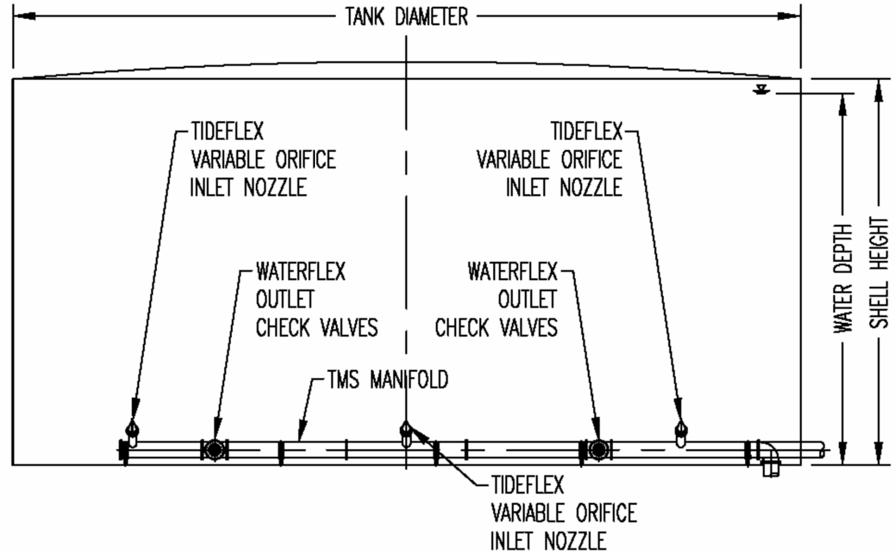
March 5, 2013

CANADIAN PATENT NUMBER: 2,409,009

UNITED STATES PATENT NUMBER: 7,104,279



PLAN - RESERVOIR



ELEVATION - RESERVOIR

NOTES:

1. DO NOT USE THIS DRAWING FOR CONSTRUCTION. DRAWING INTENDED AS A GENERAL REPRESENTATION ONLY.
2. QUANTITY, SIZE, ELEVATIONS, LOCATIONS, AND DISCHARGE ANGLES OF TIDEFLEX INLET NOZZLES AND/ OR OUTLET CHECK VALVES ARE TANK-SPECIFIC BASED ON HYDRAULICS, MIXING AND TURNOVER CRITERIA.
3. CARBON AND STAINLESS PIPE SECTIONS MAY BE SUPPLIED WITH PLAIN ENDS TO BE BUTT WELDED IN THE FIELD.

FINAL MIXING SYSTEM DESIGN AND ALL SUPPORTING CALCULATIONS TO BE SUPPLIED BY RED VALVE COMPANY

S.O.#: QUOTE #:

NOT FOR CONSTRUCTION

REV	BY	DATE	DESCRIPTION
A			

Tideflex Technologies
A Division of Red Valve Company, Inc.

TIDEFLEX TECHNOLOGIES
TIDEFLEX MIXING SYSTEM
700 N. BELL AVENUE
CARNEGIE, PA 15106 USA
PHONE: 412-279-0044
FAX: 412-279-5410
WEBSITE: WWW.TIDEFLEX.COM
EMAIL: INFO@TIDEFLEX.COM

TMS GENERAL ARRANGEMENT FOR GROUND LEVEL CIRCULAR RESERVOIRS

CONSULTANT:

APPLICATION: (TMS) TIDEFLEX MIXING SYSTEM

SCALE: FULL PLOT:

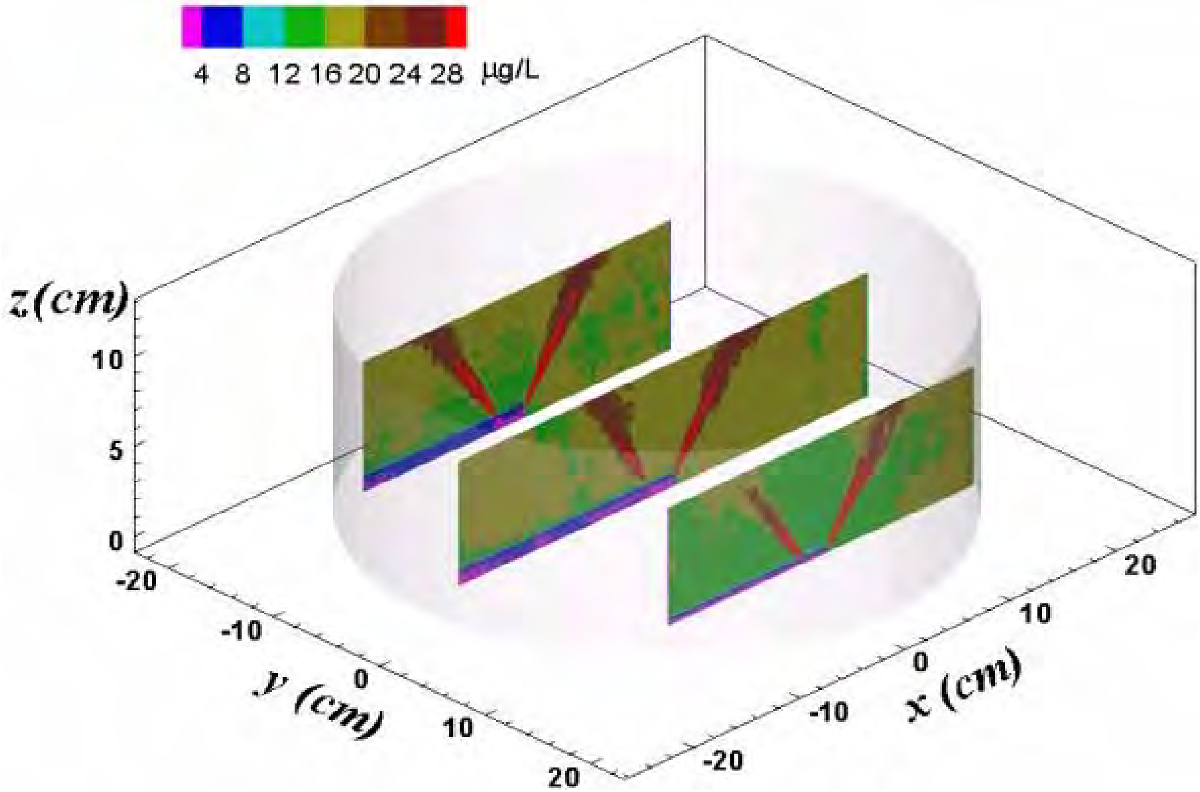
DWG. BY: MJD DATE: 12/13/02

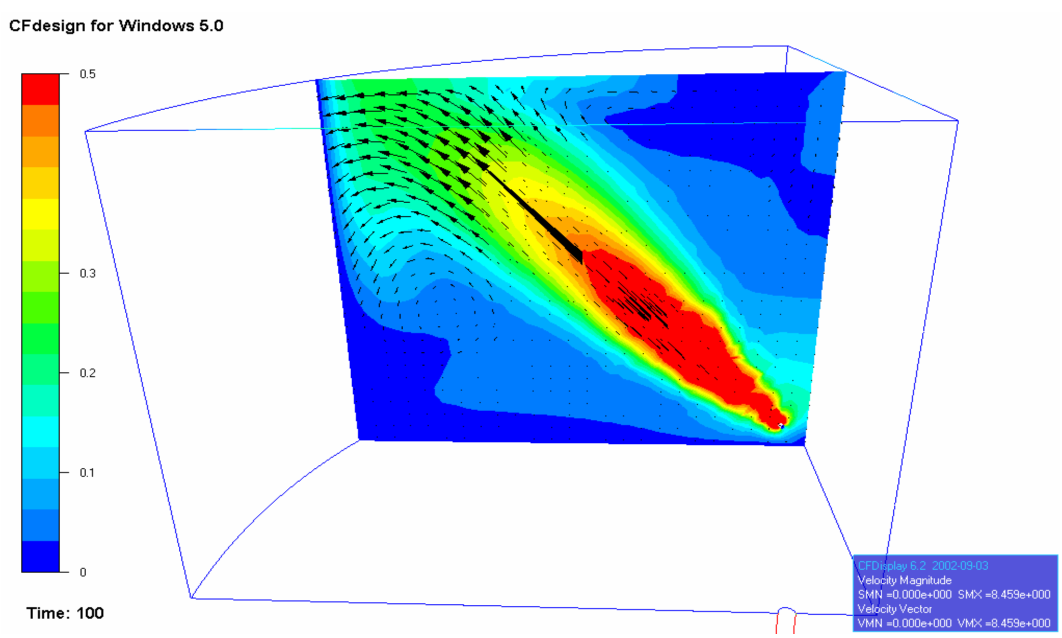
DWG. NO. TMS-CIR12

SHEET 1 OF 1

Computational Fluid Dynamics (CFD) Modeling

Below are CFD and Scale Modeling images showing representative velocity magnitude contour and vector images of this TMS configuration in a circular





Tideflex® Technologies
A Division of Red Valve Company®, Inc.

TIDEFLEX RESERVOIR MIXING ANALYSIS

HPOW 38,000 m3 (10.0MG) Reservoir
Wellington, New Zealand

The Reservoir Mixing Analysis (RMA) is to be supplied to the water utility/owner as it provides guidance on the tank turnover/fluctuation required to ensure complete mixing with the TMS installed. Maintaining water quality in tanks and reservoirs is a combination of achieving complete mixing AND tank turnover to minimize water age. It is critical to achieve complete mixing to prevent a localized increase in water age (and associated water quality problems) due to short-circuiting and dead zones.

The RMA calculates the dependent variables and uses the mixing time formula to calculate the "Theoretical Mixing Time" (MT) at various filling flow rates. The MT is the fill time required to achieve complete mixing. The required drawdown (in feet), % turnover, and the required volume exchange (in gallons) are calculated based on these mixing times. These values are shown in the "Guide to Tank Fluctuation and Turnover" section of the RMA. A slightly greater drawdown/turnover is typically recommended to be conservative.

Within the "Guide to Tank Fluctuation and Turnover" is a "Minimum Tank Fluctuation Target". This is applicable for tanks that operate in fill-then-draw. This is the minimum amount the tank should be drawn down on the draw cycles to ensure complete mixing on the fill cycles. This data is intended to be used by operators in conjunction with SCADA and strip charts (where applicable) to verify adequate tank turnover and to determine "pump on" and "pump off" set points (where applicable). For tanks that operate in simultaneous fill and draw, the "Theoretical Mixing Time" (fill time required to achieve complete mixing) should be used to ensure the minimum fill time required is achieved.

The RMA also provides data on the time required to draw down the tank, at various draw rates, to the required level as determined by the mixing time calculations.

Note, the data provided on the required drawdown, % turnover and volume exchange are to ensure complete mixing of the tank volume to prevent water quality problems associated with short-circuiting, incomplete mixing, and increased water age. A water age evaluation of the entire distribution system may dictate greater tank turnover than provided with the RMA. As long as the actual tank turnover/fluctuation is equal to or greater than that provided with the RMA, the tank will be completely mixed.

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Tideflex Technologies
A Division of Red Valve Company, Inc.

RESERVOIR MIXING ANALYSIS (TMS)

05-Mar-2013

RESERVOIR / TANK NAME: HPOW 38,000 m3 (10.0MG) Reservoir

CONSULTANT: Beca
Contact: Mike Yarrall
Address:
phone
fax
email

UTILITY / OWNER: Wellington, New Zealand
Contact:
Address:
phone
fax
email

RED VALVE REP.: Flotech Controls Pty. Ltd.
Contact:

ANALYSIS BY: Michael Duer, P.E.

** If "Effective" Tank Diameter is shown, the tank diameter is calculated to make the volume compute correctly. Mixing times are based on volume.

RESERVOIR / TANK DATA			INLET / OUTLET PIPES		FILL / DRAW RATES	
Tank Diameter	220	ft	Outlet Dia. = 24 in		Fill Rates (gpm)	Draw Rates (gpm)
Tank Depth (SWD) to HWL	36	ft				
Depth to LWL	29.5	ft	* Effective Diameter of TMS (See Note 1)			
			Effec. Dia (in) =	AT	793	793
			Effec. Dia (in) =	AT	3000	3000
Tank Volume	10,236,924	Gallons	Effec. Dia (in) =	AT	8000	8000
Tank Volume	1,368,478	ft^3	Effec. Dia (in) =	AT	11100	11100
Gallons Per Foot =	284,359					

FILL

INLET FLOW RATES (gpm)	Time to Fill Tank from Empty to H.W.L (Hours)	(Days)	Time to Fill to 1' Depth (Minutes)	(Hours)	Input Fill Time (Hours)	Resulting Increase In Water level (ft)	Volume Change (gallons)
793.00	215.15	8.96	358.59	5.98	4	0.7	190,320.00
3000.00	56.87	2.37	94.79	1.58	3	1.9	540,000.14
8000.00	21.33	0.89	35.54	0.59	2	3.4	959,999.99
11100.00	15.37	0.64	25.62	0.43	1	2.3	666,000.00

GUIDE TO TANK FLUCTUATION AND TURNOVER

FILL

INLET FLOW RATES (gpm)	Jet Velocity (fps)	JV^2 / 2g (feet)	Reynold's Number	Inlet Momentum (ft^4 / min^2)	Velocity Gradient, G (1/sec)	Theoretical Mixing Time (Fill Time Req'd for Complete Mixing) MT = K * V^(2/3) / M^(1/2) (Minutes)	(Hours)	Req'd Drawdown on Previous Draw to Mix on Next Fill (feet) (SEE NOTE 2)	% Turnover Required (%) (SEE NOTE 2)	Volume Exchange Required (gallons) (SEE NOTE 2)
793.00	2.94	0.13	318,264	18,696	0.68	918.6	15.3	2.6	7.1	726,822
3000.00	5.76	0.52	866,330	138,526	2.58	337.5	5.6	3.6	9.9	1,013,455
8000.00	9.55	1.42	1,821,673	612,500	6.98	160.5	2.7	4.5	12.5	1,279,616
11100.00	11.35	2.00	2,339,614	1,010,307	9.78	125.0	2.1	4.9	13.6	1,392,222

SEE NOTE 2

MINIMUM TANK FLUCTUATION TARGET

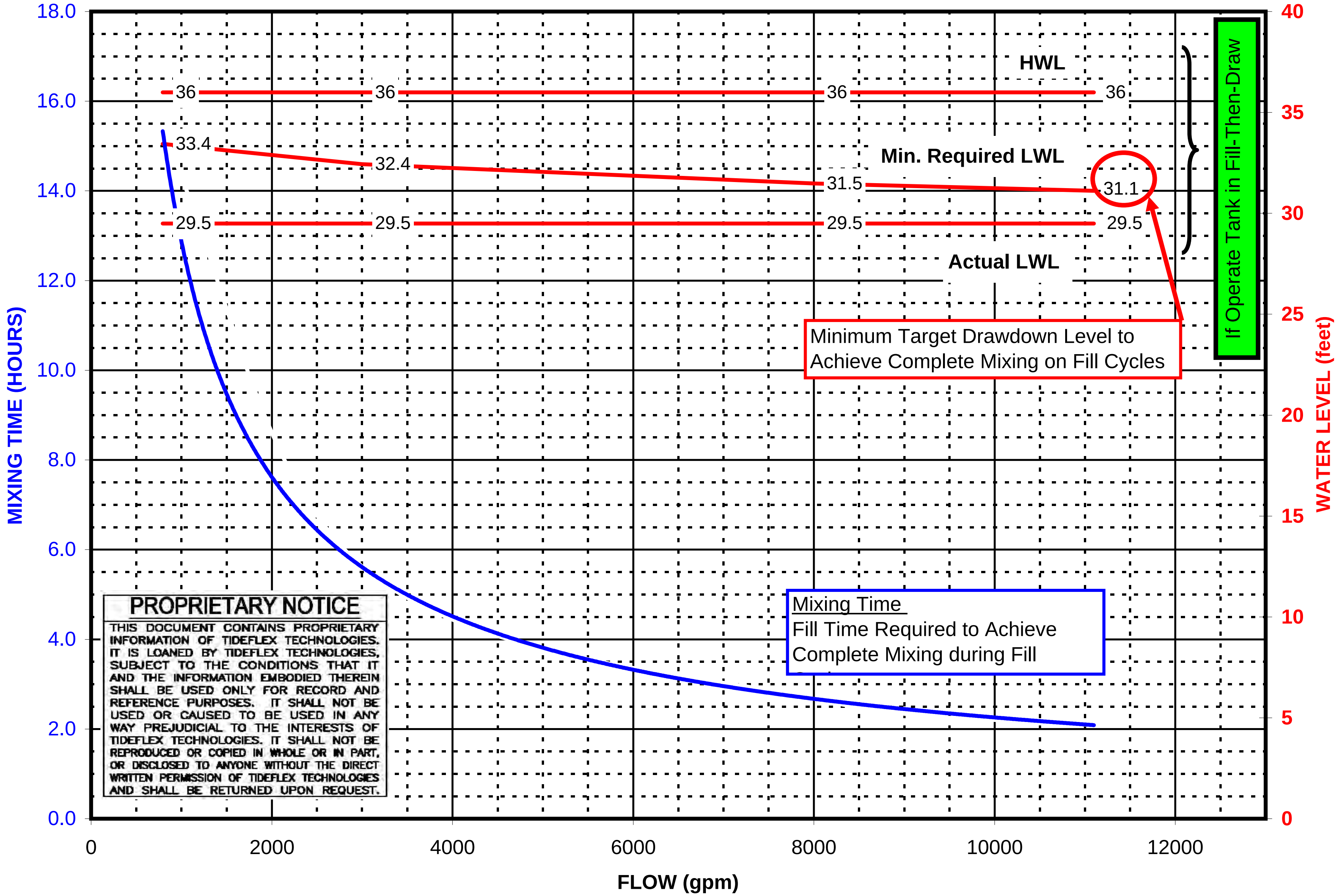
DRAW

OUTLET FLOW RATES (gpm)	TIME TO DRAW TANK FROM FULL TO EMPTY (Hours)	(Days)	Time to Draw Down 1' Depth (Minutes)	(Hours)	Pipe Velocity (fps)	Volume Exchange Required (gallons)	Draw Time Required (Hours)		
793	215.15	8.96	358.59	5.98	0.56	1,392,222	29.3	@	793 gpm Draw Rate
3000	56.87	2.37	94.79	1.58	2.13	1,392,222	7.7	@	3000 gpm Draw Rate
8000	21.33	0.89	35.54	0.59	5.67	1,392,222	2.9	@	8000 gpm Draw Rate
11100	15.37	0.64	25.62	0.43	7.86	1,392,222	2.1	@	11100 gpm Draw Rate

* NOTE: 1. TIDEFLEX VALVES ARE INHERENTLY A VARIABLE ORIFICE SO THE TMS EFFECTIVE DIAMETER VARIES WITH FLOW RATE
2. MIXING TIME EQUATIONS DO NOT ACCOUNT FOR DIFFERENCES IN TEMPERATURE BETWEEN INLET WATER AND TANK (BUOYANT JETS)
THESE CALCULATIONS MAY UNDERESTIMATE THE FILL TIME REQUIRED FOR MIXING.

TMS - Mixing Time and Minimum Required Drawdown

HPOW 38,000 m3 (10.0MG) Reservoir



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WATER AGE ANALYSIS

For Tanks That Operate in
FILL - THEN - DRAW
(Not simultaneous fill and draw)

Actual/Predicted Daily Turnover and Water Age

High Water Level (HWL) =	36	ft	**Turnover =**	6.5	feet	**Ave. Water Age =** 5.5 days
Low Water Level (LWL) =	29.5	ft		18.1	%	*(Assumes tank is mixed. CAUTION: A single inlet pipe often does not mix. Water age could be much higher*

Turnover Required for TMS to Achieve Complete Mixing

(GOAL: For Required Turnover for Complete Mixing to be Less Than Actual/Predicted Turnover)

The TMS will mix the tank with **Turnover =**	4.9	feet	**Ave. Water Age =** 7.4 days
(see Mixing Analysis)	13.6	%	*(Water age if tank turnover was the minimum required to achieve complete mixing)*

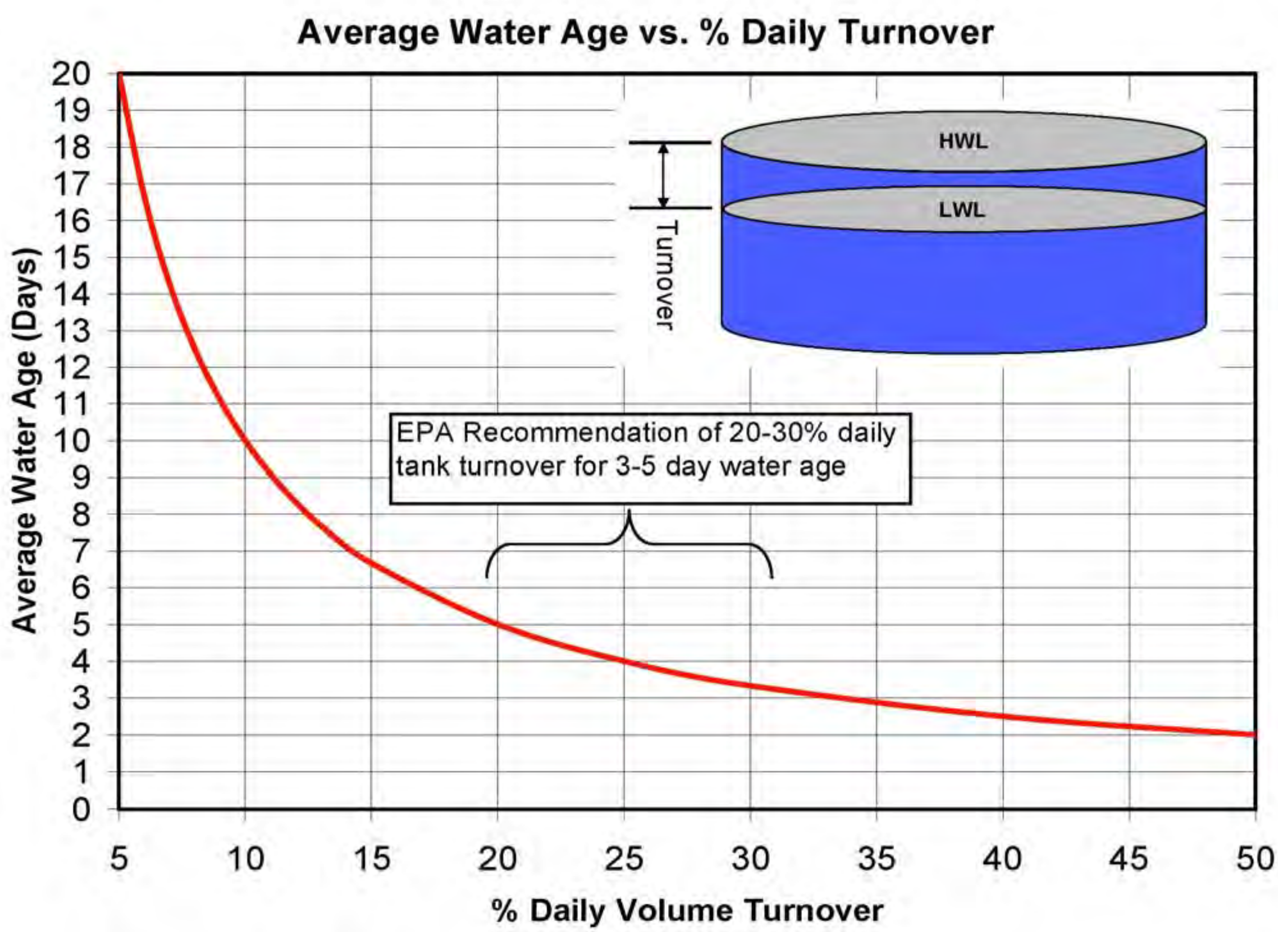
RESULT

Is Actual Turnover Greater than Required Turnover to Mix with TMS? **YES**

If Yes, the TMS will Completely Mix the Tank. Applicable Water Age is from Actual/Predicted Turnover
If No, Tank May not be Completely Mixed but Will Not Short-Circuit. The TMS Separates the "Inlet" and "Outlet" and will Draw the Oldest Water from the Tank First

WATER QUALITY:

* Maintaining storage tank water quality is a function of:
  1) Maximizing volume turnover to minimize water age. See Water Age vs. Turnover Guideline below.
  2) Achieving complete mixing to avoid a localized increase in water age due to incomplete mixing and short-circuiting
* The TMS design addresses #2. Consultant and/or Owner to address #1 by looking at the "operation" of the distribution system and tank in order to maximize turnover. See Water Age vs. Turnover Guideline below.



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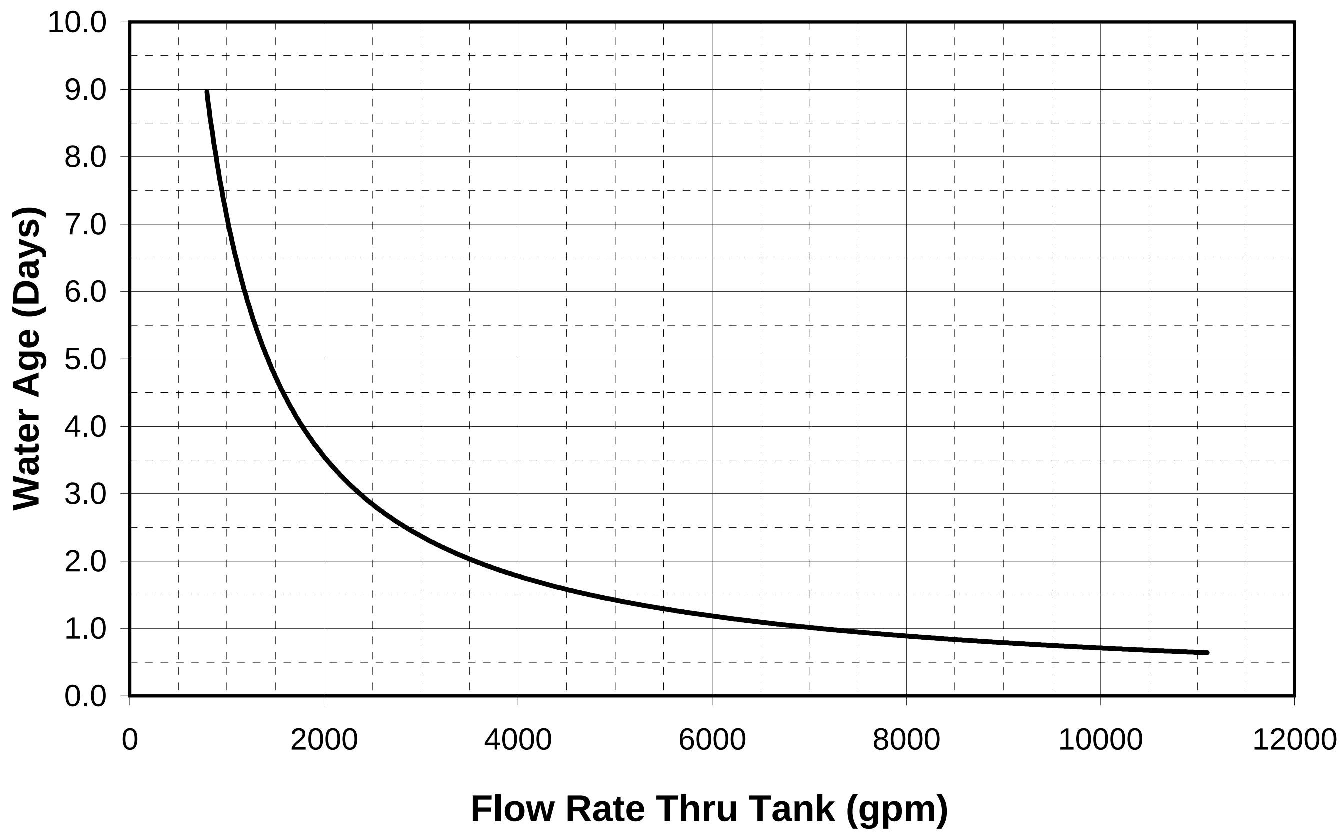
WATER AGE ANALYSIS

For Tanks That Operate in
SIMULTANEOUS FILL & DRAW
(Not fill-then-draw)

Tank Volume	**Flow Rate**	**WATER AGE** (Assumes fill/drawing 24 hours per day)			**Mixing Time** **from Mixing Analysis**
(Gallons)	(gpm)	(Minutes)	(Hours)	(Days)	(Hours)
10,236,924	793.0	12,909	215.2	8.96	15.3
	3000.0	3,412	56.9	2.37	5.6
	8000.0	1,280	21.3	0.89	2.7
	11100.0	922	15.4	0.64	2.1

These Water Age Calculations are valid if the tank is completely mixed.
(TMS will completely mix tank if the actual fill time is greater than the theoretical mixing time as shown here and on Mixing Analysis)

Water Age vs. Flow Rate Thru Tank



WATER QUALITY:
* Maintaining storage tank water quality is a function of:
1) Maximizing volume turnover to minimize water age. The greater the flow rate thru the tank, the lower the water age.
2) Achieving complete mixing to avoid a localized increase in water age due to incomplete mixing and short-circuiting
Ensure that tank is filling for longer than what is shown on the theoretical mixing time in the mixing analysis

TMS Manifold Hydraulics (FILL CYCLE)

Tideflex Technologies
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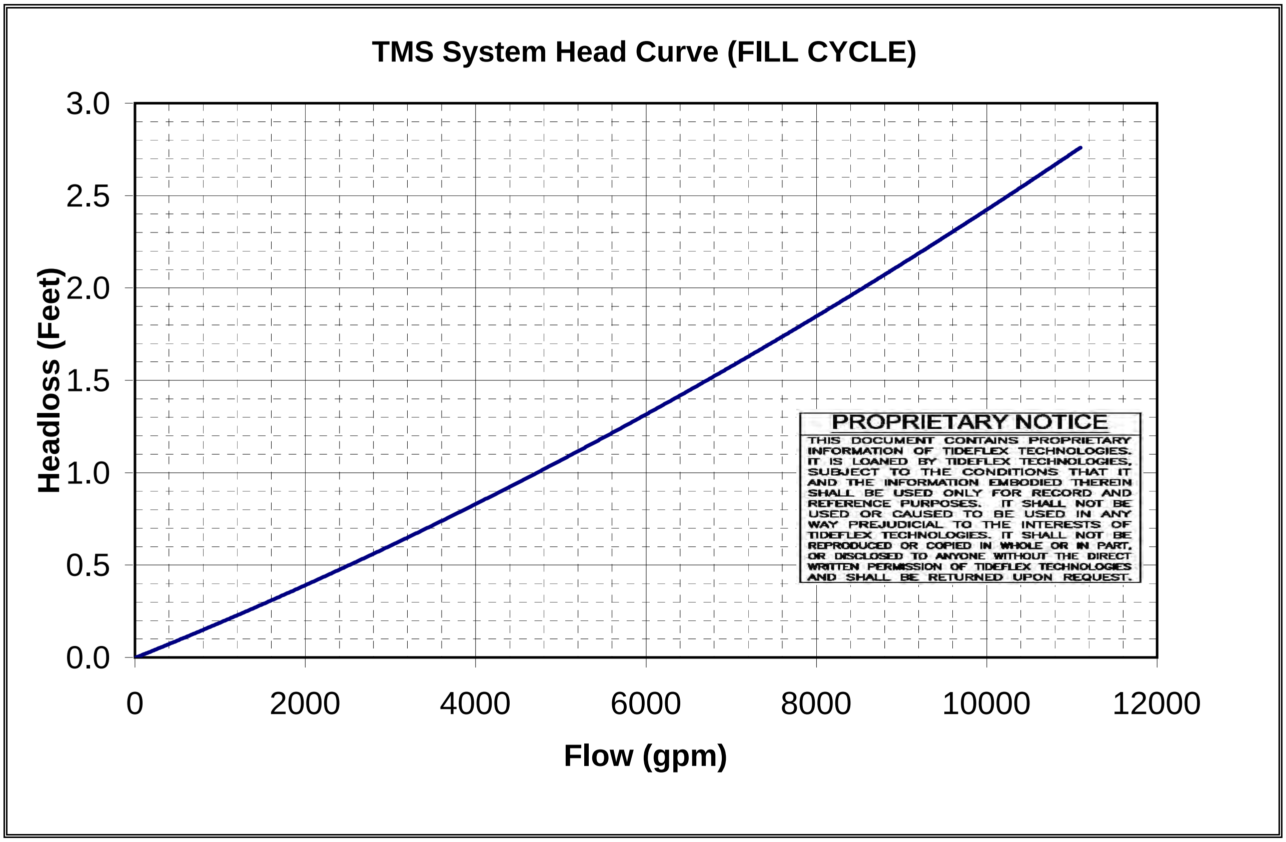
Reservoir Name: **HPOW 38,000 m3 (10.0MG) Reservoir**
Reservoir Size: **220' Dia. x 36.4'**
Reservoir Capacity: **38,000 m3 (10.0MG)**
End User: **Wellington, New Zealand**
Consultant: **Beca**

Ambient Density = **62.4** lbm/ft^3
Effluent Density = **62.4** lbm/ft^3
dS/S = **0**
C = **100** Hazen Williams Coeff.
Cd = **0.95** Cd

Flow Rate (gpm)	Jet Velocity (fps)	Friction Headloss (ft)	Total Headloss (ft)
793.0	2.9	0.01	0.1
3000.0	5.8	0.08	0.6
8000.0	9.5	0.46	1.8
11100.0	11.3	0.84	2.8



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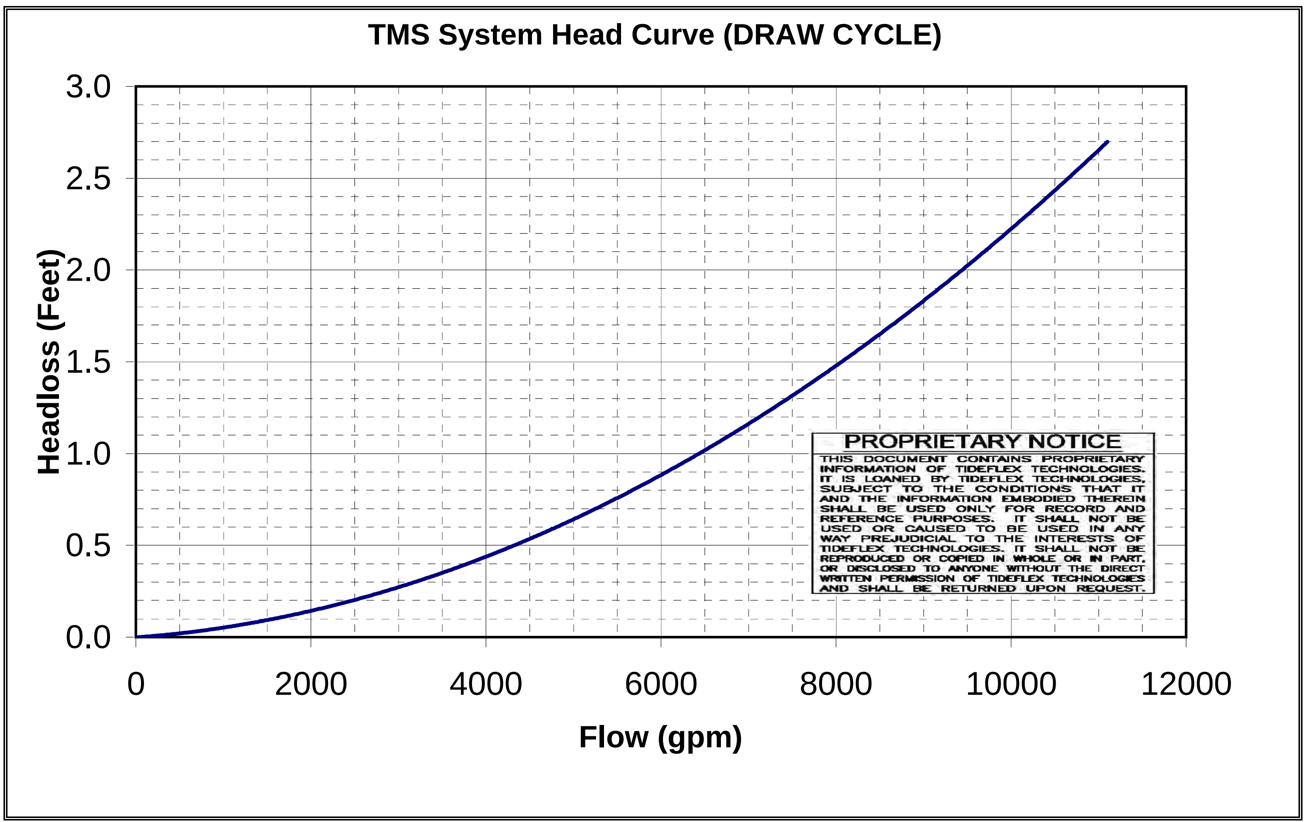
TMS Manifold Hydraulics (DRAW CYCLE)

Reservoir Name: **HPOW 38,000 m3 (10.0MG) Reservoir**
Reservoir Size: **220' Dia. x 36.4'**
Reservoir Capacity: **38,000 m3 (10.0MG)**
End User: **Wellington, New Zealand**
Consultant: **Beca**

Ambient Density = **62.4** lbm/ft^3
Effluent Density = **62.4** lbm/ft^3
dS/S = **0**
C = **100** Hazen Williams Coeff.
Cd = **0.95** Cd

Flow Rate (gpm)	WF-3 Headloss (ft)	Friction Headloss (ft)	Total Headloss (ft)
793.0	0.0	0.0	0.0
3000.0	0.2	0.0	0.3
8000.0	1.2	0.3	1.5
11100.0	2.2	0.5	2.7

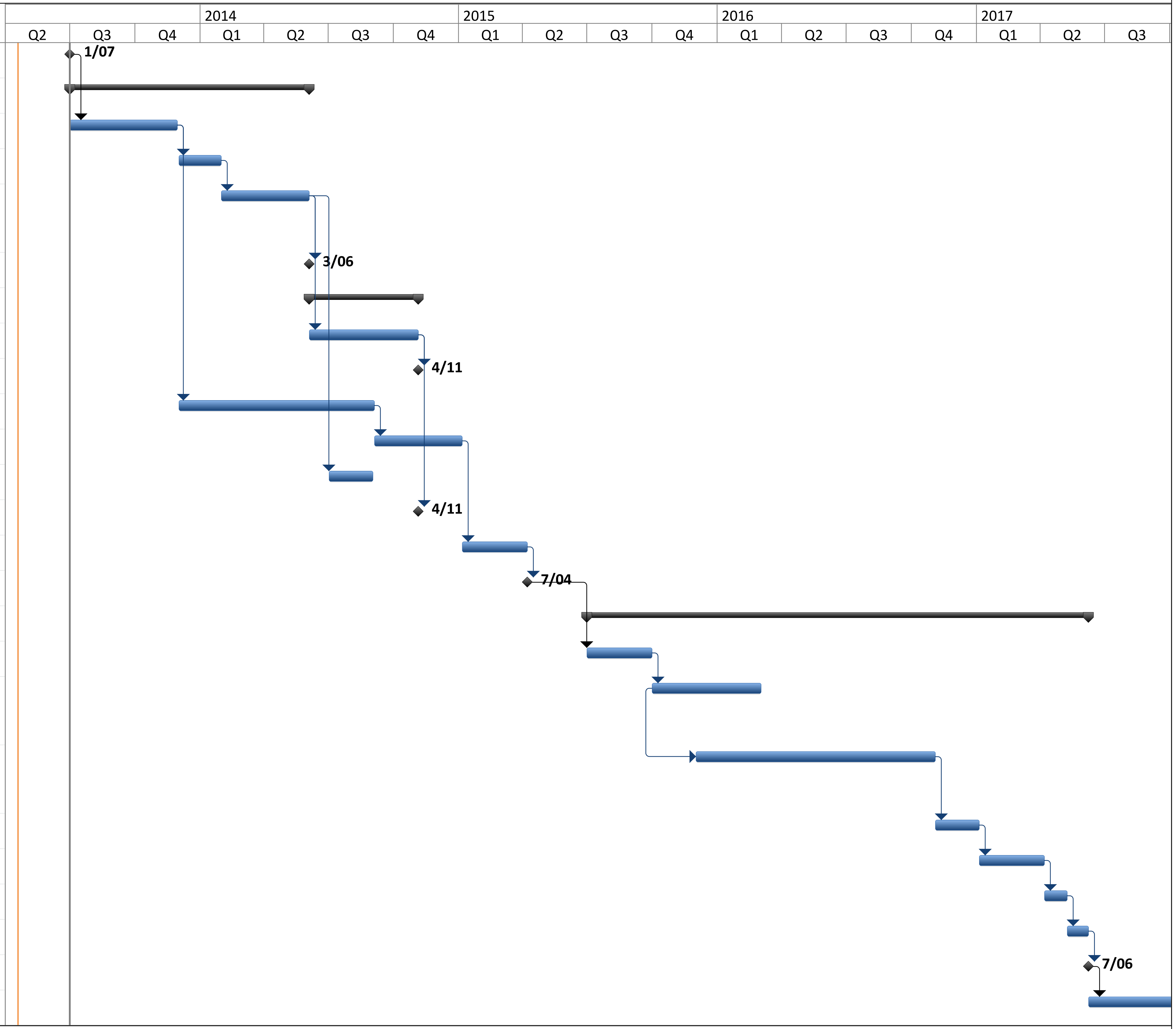


Appendix F

Preliminary Project Programme

Hospital Price of Wales Reservoir **Appendix E - Preliminary Project Programme**

ID	Task Name	Duration	Start
1	**Client Approval Project Stage 2**	0 days	Mon 1/07/13
2	**Resource Consent Process**	**11 mons**	**Mon 1/07/13**
3	Design Development, AEE, Consultation	5 mons	Mon 1/07/13
4	Complete Resource Consent Applications	2 mons	Mon 2/12/13
5	Notification, Submission Period, Hearing and Decision Time (no appeals assumed)	4 mons	Fri 31/01/14
6	Resource Consent Obtained (earliest)	0 days	Tue 3/06/14
7	**Resource Consent Process Extended**	**5 mons**	**Wed 4/06/14**
8	Hearings	5 mons	Wed 4/06/14
9	Resource Consent Obtained (extended)	0 days	Tue 4/11/14
10	**Detail Design**	9 mons	Mon 2/12/13
11	**Detail Design Potential Extension**	4 mons	Thu 4/09/14
12	**Contract Procurement Strategy Agreed / Actioned**	2 mons	Wed 2/07/14
13	**Approval to Tender**	0 days	Tue 4/11/14
14	**Tender to Award Process**	3 mons	Tue 6/01/15
15	**Contract Award**	0 days	Tue 7/04/15
16	**Construction Period**	**23 mons**	**Wed 1/07/15**
17	Site Possession and Establishment	3 mons	Wed 1/07/15
18	Initial Excavation, Tunnel Construction, Inlet / Outlet Pipework	5 mons	Thu 1/10/15
19	Remaining Reservoir Excavation and Reservoir Construction	11 mons	Wed 2/12/15
20	Commissioning / Testing	2 mons	Fri 4/11/16
21	Backfill, Landscaping, Upper Park	3 mons	Thu 5/01/17
22	Sundry Works including As Builts	1 mon	Fri 7/04/17
23	Potential Extension of Time	1 mon	Tue 9/05/17
24	**Practical Completion (handover)**	0 days	Wed 7/06/17
25	**Commence Defects Liability Period (DLP=1 yr)**	12 mons	Thu 8/06/17



Project: Hospital Price of Wales Reservoir
Date: Fri 19/04/13

Task	Project Summary	Inactive Milestone	Manual Summary Rollup
Split	External Tasks	Inactive Summary	Manual Summary
Milestone	External Milestone	Manual Task	Start-only
Summary	Inactive Task	Duration-only	Finish-only
Deadline	Progress		