# WETLANDS – HONOURING THE PAST, BUILDING FOR THE FUTURE

***Seb Head, Senior Civil (Water)Engineer, MWH NZ Ltd.***
***Sam Bourne, Associate Principal, Senior Landscape Architect, Boffa Miskell.***

**ABSTRACT**

Designing wetlands for stormwater management is more than meeting performance related criteria to satisfy regulatory requirements and the NZ Transport Agency (NZTA) stormwater standards. Increasingly through the NZTA's projects, urban and landscape design, environmental and heritage benchmarks are being applied to deliver multiple outcomes for stormwater management areas.

As part of the Waikato Expressway's: Rangiriri Section Project the NZTA, Fletcher Construction, Waikato Tainui, Archaeologist and the design team MWH and Boffa Miskell have sought to deliver, social, environmental and cultural outcomes through the stormwater aspects of the project. A Partnering Charter was formed between NZTA, Fletcher and Waikato-Tainui in acknowledgement of the unique cultural heritage of the project area which defined the function and form of stormwater management.

One of the key features is the Rangiriri Wetland, located on the site of the 1863 Battle of Rangiriri, a significant event in the context of the NZ Land Wars. The opportunities for this history to be revealed were established at an early stage through the urban design and landscape framework (UDLF). In close consultation with Waikato Tainui and the Archaeologist, this design framework developed, setting the scene for both the cultural mitigation works and the opportunities for the wetland design. Conceptually the wetland was envisaged to form part of the wider story of the battle site, Pa and historic trench, and Waikato River wetland margins.

This paper provides an overview of the project wide stormwater management philosophy with specific focus on the Rangiriri Wetland design, and how an integrated solution was developed. Commentary on the design will highlight how the form and function of the wetland was developed based on the site specific constraints.

The Rangiriri wetland demonstrates how, through collaboration; stormwater, urban design and landscape outcomes can reveal our important cultural heritage in the landscape.

**KEYWORDS**

*Wetlands, Rangiriri, Kīngitanga, Urban Design and Landscape Framework, Pa Trench, Social, Cultural, Heritage, Archaeology, Roads of National Significance, Waikato Expressway, Stormwater Treatment.*

**PRESENTER PROFILE**

Seb Head is a Senior Civil Water Designer and Pipeline Design specialist with MWH. He has 18 years' experience which includes hydrology, hydraulics, pumping station design, road drainage design and pipeline design. He has led design teams on multi-disciplinary projects in New Zealand, Australia, and the Middle East.

Sam Bourne, Associate Principal Boffa Miskell. Sam has been involved with a diverse range of infrastructure projects throughout New Zealand over the last 11 years. Including being the Rangiriri urban and landscape design lead collaborating with MWH, Fletcher Construction, the NZTA, Waikato Tainui, Archaeologist Warren Gumbley and NZ Heritage.

# 1 INTRODUCTION

Increasingly stormwater infrastructure is taking on LID (Low Impact Design) or Water Sensitive Design (WSD) approaches to deliver more sustainable outcomes. The Rangiriri stormwater treatment philosophy and particularly the Rangiriri wetland, has been created for a dual purpose: for the treatment and containment of stormwater and to highlight a unique cultural heritage story around the 1863 Battle of Rangiriri.

This paper provides an overview of the approach to urban, landscape, stormwater and engineering design, and the inter-disciplinary approach to achieving multiple outcomes (landscape, ecology, water quality, cultural heritage, and amenity benefits). In addition the paper will provide an outline of the technical constraints and overall design requirements to deliver a functionally integrated solution.

As the wetland design progressed a number of technical engineering constraints shaped the final layout. These were then refined to ensure that the heritage interpretation aspects of the design were clearly visible including associated artworks. The outcome shifted the wetland from a pure utilitarian function to creating a highway asset worthy of providing substantial community outcomes, amenity values and heritage interpretation.

This paper explains how site specific wetlands (such as the Rangiriri wetland) can be designed to address a particular set of circumstances and challenges. It explores the design process and collaboration between designers (landscape architects and engineers) and Waikato-Tainui as being instrumental in the Urban and landscape design. Many of the engineering design decisions stem from consultation with the Tangata Whenua (Waikato-Tainui). The paper will conclude in how this project could influence similar schemes.

# 2 PROJECT DEFINITION

The Waikato Expressway is a four lane highway (State Highway 1) over 115km long from the Bombay Hills to south of Cambridge. It is being built in seven sections by the NZTA as part of the government's Roads of National Significance Programme. The Rangiriri section is one of these sections.

The Rangiriri Section is 4.8km long and begins at the southern end of the Longswamp Section (north of the Te Kauwhata interchange). The newly aligned expressway redirects traffic flows further west from the Te Kauwhata Interchange towards the Waikato River and past the settlement of Rangiriri, joining with the existing State Highway 1 expressway south of the Te Onetea Stream.

One of the legacies of the current alignment of State Highway 1 is that it cuts through the historical Rangiriri Pa, site of the battle of Rangiriri. The Rangiriri project seeks to reveal the Pa (in a symbolic way) along with the associated land features such as the Rangiriri defensive line. The defensive line or trench was a long double ditch dug between the Waikato River and Lake Kopuera wetland. This too has been eroded over time, with the only visible remnants of the fortification being located within the NZ Heritage Historic Reserve. These features which have been established through detailed Archaeological investigations are key in recognising the site for iwi.

The Rangiriri site represents part of the wider entrenchments used by warriors under the Kīngitanga, the Māori King during the British invasion of the Waikato.

Emphasis has also been placed on the project delivering environmental outcomes tied to Vision and Strategy with regards to the restoration of the Health and Wellbeing of the Waikato River. This builds on the Waikato Raupatu (Waikato River) Settlement Act 2010 and is a key aspect for Waikato Tainui.

Key to the project's success has been the successful delivery of the Partnering Charter between the NZTA, Fletcher Construction and Waikato-Tainui in acknowledgement of the environmental and unique cultural heritage of the area around Rangiriri. This partnership provided the basis for discussing the integration of the highway with the surrounding environment and the process to deliver a package of mitigation measures associated around the recognition of cultural heritage and recognition of the battle site. Through this partnering the following vision statement was agreed:

"Honouring the past, we are building for the future."

The vision also embodies the proverb of Princess Te Puea which says:

"Ka moemoea ahau, Ko ahau anake, Ka moemoea  tatou, ka taea e tatou"

"If I dream, I dream alone, if we all dream, together it shall be achieved."

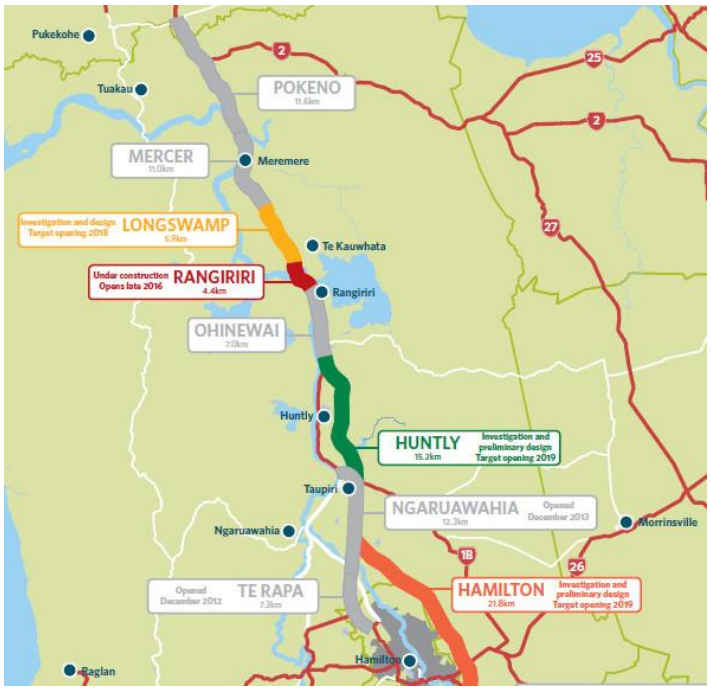



*Figure 1: Waikato Expressway Sections (NZTA).*


*Figure 2: Rangiriri Section Overview (MWH).*

# 3 THE CULTURAL HERITAGE CONTEXT – BATTLE OF RANGIRIRI

It was on 20 November 1863, British troops engaged warriors under the Kīngitanga, Māori King Movement[1] . The Battle of Rangiriri ensued. This was a significant event of the NZ land wars and as with many of these sites, each has a unique story, the significance of which is only now being fully acknowledged 150 years on.

A detailed description of the battle of Rangiriri is unnecessary here, and has been extensively described elsewhere (eg. Belich 1988, Cowan 1983, Lennard 1986). But in order to understand the physical arrangement of features associated with battle fortification and how these have been acknowledged within the design some description is needed.

## 3.1 THE BATTLEFIELD

The map below illustrates the key features recorded by the British military, and the accompanying sketch illustrates the geometric forms of the entrenchments. Essentially the Rangiriri Pa fortification occupied the higher ground above the adjoining flood plain and wetland, with a lineal trench extending from the Pa East to Lake Kopuera and West to the Waikato River.

[1] http://www.teara.govt.nz/en/kingitanga-the-maori-king-movement

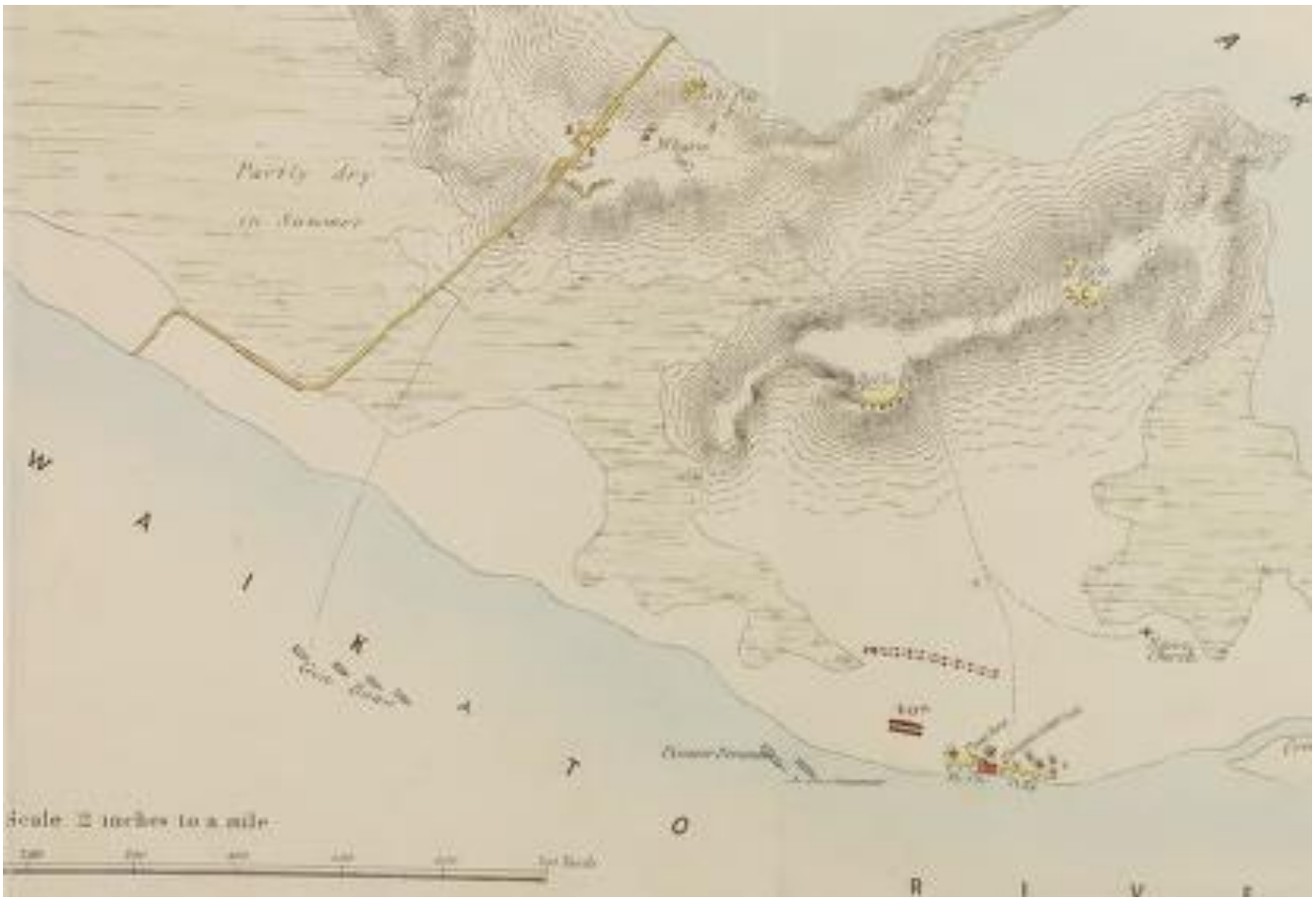



*Figure 3: Part of the Gamble 1863 plan "Sketch of Action at Rangiriri" (Auckland Museum Library).*

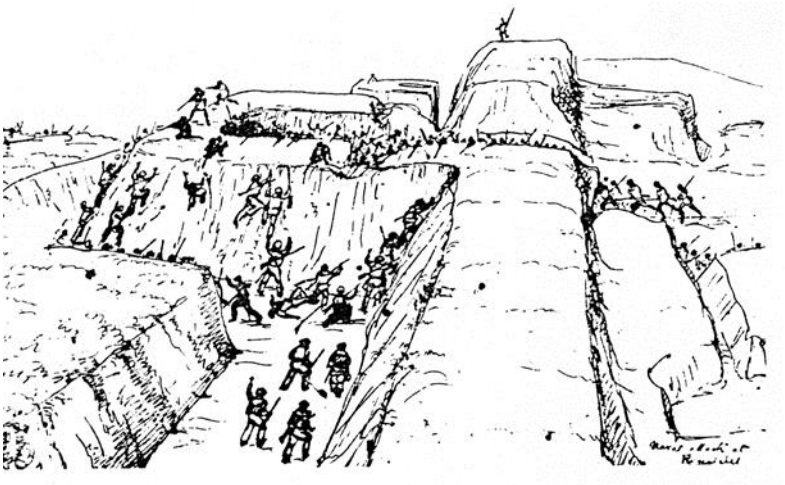


*Figure 4: Sketch, Major C Heaphy.*

## 3.2 INTERPRETATION

The relocation of this section of State Highway 1 away from the Rangiriri village towards the Waikato River provides the opportunity for revealing and recognising this historical and cultural significant site. Between 2009 and 2015 the NZTA began working in partnership with Waikato-Tainui and developed concepts for recognising the Rangiriri battle trench and site of the Rangiriri defensive Pa.

In understanding the battle, the events, the remaining archaeological evidence and footprints of the entrenchments lost, the design team drew on expertise from the project Archaeologist Warren Gumbley. The Assessment of Archaeological Values (2009) along with the Maori values brought through in working closely with Waikato Tainui directly provided critical reference for integrating the stormwater design.

British military surveys of the site conducted after the battle have been utilised in setting the footprint of the battlefield. These maps have been a tremendous resource to draw from. Both the Brooke's (1863) and Gamble's (1863) plans show detail relating to the fortifications and both are accurate with scales provided. In combination with Archaeological guidance and on site archaeological surveys (including ground penetrating radar) the design team geo-spatially located the footprint of the historic Pa and Trench.

In addition the Archaeological work addressed the required setback from the actual footprint of the original features and identified opportunities for minimising all disturbance of remaining archaeological evidence, for example, the use of an existing farm drain as the best location (with least disturbance) for connecting the north and south sides of the wetland.

Research into historic photographs, paintings and sketches further enriched the review and helped develop the design vision.


*Figure 5: Rangiriri Wetland and historical trench alignment, MWH.*

# 4 ENVIRONMENTAL AND SOCIAL DRIVERS

The NZTA has published a series of strategic goals and a strategic plan for management of the extensive State Highway network and this relates to the provision of environmental and social values on new and existing schemes.

Five Strategic Goals of the NZTA:

1) *Ensure State Highway corridors make the optimum contribution to an integrated multi-modal land transport system.*
2) *Provide safe state highway corridors for all users and affected communities.*
3) *State Highways will enable improved and more reliable access and mobility for people and freight.*
4) *Improve the contribution of state highways to economic development.*
5) *Improve the contribution of state highways to the Environmental and social well-being of New Zealand, including energy efficiency and public health.*

The New Zealand Transport Agencies Strategic Plan outlines how item five may be achieved:

1. *Resource efficiency improvements relating to recycling and reuse of resources to reduce waste.*
2. *Reduction in traffic noise and vehicle energy consumption*
3. *Water quality improvements*
4. *Visual quality improvements through landscaping*
5. *Ensuring that construction project plans incorporate new standards which demonstrate Transit's commitment to social and environmental responsibility.*

The above clearly demonstrates the values and drivers in requiring the treatment of road stormwater runoff.

Furthermore, the NZTA has also developed an Environmental Plan with several key objectives relating to environmental sustainability:

- *For new projects, avoid, to the extent reasonable in the circumstances, adverse effects on sensitive receiving environments by developing and implementing project specific water quality and quantity management objectives.*
- *On the existing network, identify sensitive receiving environments that are adversely affected by state highway runoff. As appropriate, treat the identified sites, based on a prioritisation approach.*

The NZTA has published a guidance document 'Stormwater Treatment Standard for State Highway Infrastructure, May 2010' and it is the intention that this is used for the provision of stormwater treatment devices on new build projects.

This guidance document was used for the design of Wetlands on the Rangiriri Project. In addition, the Auckland Regional Council Technical Paper 10 'Stormwater Management Devices' was also required to be followed. The two design guidance documents are closely aligned but for the purposes of the design on the Rangiriri Project, the NZTA document took precedence as this had a more national coverage than TP10, and was specifically tailored towards infrastructure.

# 5 CULTURAL AND LANDSCAPE DRIVERS

The following outcomes have been highlighted to illustrate some of the multiple objectives sought for the wetland design and wider outcomes for the project.

## 5.1 CULTURAL HERITAGE OUTCOMES

- Symbolic restoration and interpretation of the Rangiriri Battle Site, Pa and trench.
- Visually and spiritually re-connecting the three key Maori heritage sites -- Rangiriri Battle Site and Pa, Te Wheoro's Redoubt, and Old Rangiriri Pa through removal of vegetation within N.Z.T.A and other crown, agency land, and through consultation with adjoining private land wherever possible.
- Highlight the lineal 1863 battle field trench, with topography and an artwork features (e.g. line of Pou).

- Integrated the essential form and function of the wetland (including hard engineering elements) so that the historic landscape and interpretation of the 1863 trench are the dominate features.

## 5.2 ECOLOGICAL LANDSCAPE OUTCOMES

- Removal of exotic shelter belt trees and re-creation of a significant wetland on the existing river flats to emulate the landscape character of the area in 1863.
- Provide and encourage a range of appropriate historical wetland species (plants and birds) to enhance the habitat values of the area.
- Provide ecological linkages to other areas of habitat value, including ponds, lakes and the river.
- Consider opportunities for native fish habitat.

## 5.3 TOURISM AND RECREATION LANDSCAPE OUTCOMES

- Provide additional visitor facilities to enhance the experience and value of Rangiriri Village.
- Create a river side park for boat launching, walking and cycling for locals and visitors alike to link with wider trail networks (including Te Araroa – 'The Long Pathway' walk which consists of an 18 kilometre section from Meremere to Rangiriri).
- Create a series of linked destinations within Rangiriri to enhance visitor experience - wetland, battle site, trench, riverside park for boat ramp, interpretation centre.

## 5.4 URBAN LANDSCAPE OUTCOMES

- Ensure good connectivity to, within and out of Rangiriri for locals and visitors.
- Wherever practicable separate out heavy traffic from local vehicles, cyclists and walkers.
- Enhance the existing town centre for locals and visitors to encourage tourism and a sense of identity.

## 5.5 HIGHWAY LANDSCAPE OUTCOMES

- Create a logical, legible and responsive landscape treatment along the proposed highway to enhance the experience of the travelling public.
- Reinforce key nodes and features to signal Rangiriri as a special place with a character all of its own.
- Maintain and enhance views out over the landscape and countryside and in particular to the Waikato River and cultural heritage / historic sites.
- Provide a simple pallet of plant material to reduce maintenance of the highway network and relate to the adjoining topography and land use (eg. steep batters vs. flat grazed farmland).

# 6 REVEALING THE BATTLE FORTIFICATIONS

A design framework was developed early on in the design process. This Urban Design and Landscape Framework (UDLF) document helped with the integration of large scale infrastructure and/or complex road infrastructure projects into the surrounding environment, to ensure the best possible project outcome for the benefit of all users.

The design concept was led by the MWH and Boffa Miskell design team. Opportunities for restoration of the defense positions and recognition of the site as one of historical and cultural significance arose from this work.

A decision was made to reinstate a large wetland in recognition of the natural character of the area at the time of the battle in addition to providing for stormwater treatment.

The flood plain context for the battle field trench interpretation was seen as a key part of revealing the story of the Rangiriri Pa and its strategic location surrounded by wet and boggy ground, auspiciously positioning on this narrow wedge of higher ground. Refer to figure 6 below.

*Figure 6: A 1922 photograph showing the earthworks between the current Historic Reserve and Waikato R (Alexander Turnbull Library). Note trench remnants.*

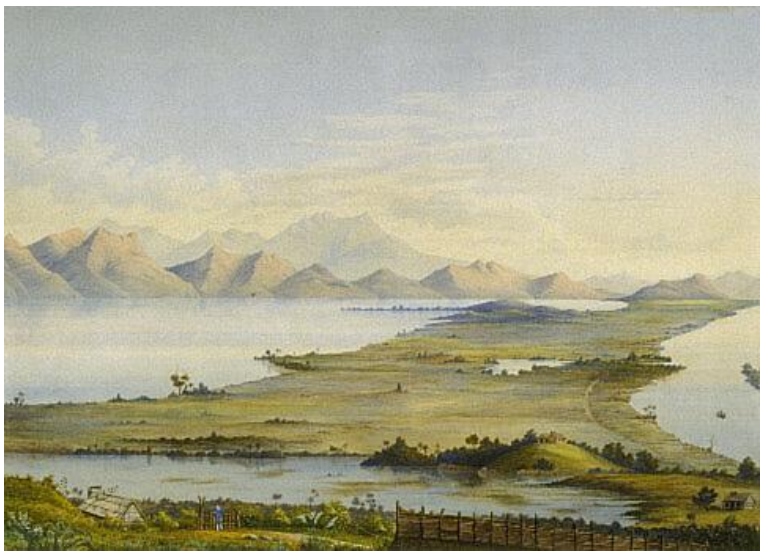


*Figure 7: Lake Waikare and Waikato River, from Rangiriri pa, Artist: Alfred Sharpe Date: 1876. Source www.aucklandartgalerygovt.nz*

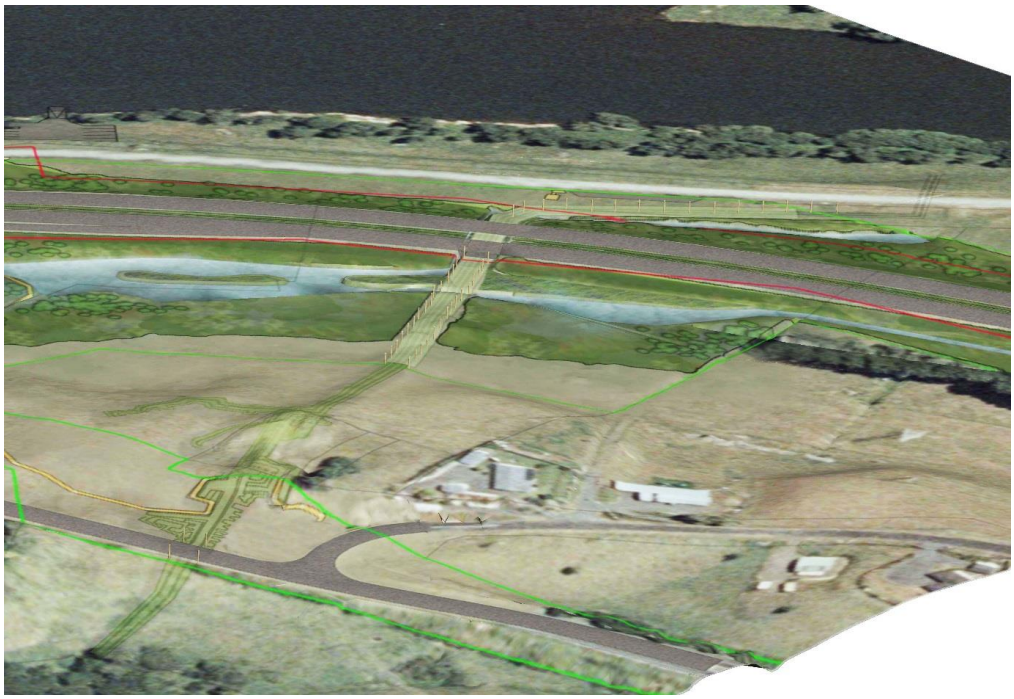
Early on in the design process the story of the Rangiriri Pa and its strategic military association with this wetland landscape was seen as a design driver for the project. Research was carried out to determine the exact footprint of the historic Pa and trench.

These natural defences provide the landscape context for the Pa and fortifications at Rangiriri which included a defensive line, a long double ditch (1863 trench) formed between the Waikato River and Lake Kopuera. The front line of the battle ran east-west, comprising the trench, and geometric earthworks design to withstand cannon fire behind which a parapet of banked up earth and another trenches were formed.

The trenches were 2.7m and 4.2m deep with the parapet rising 2m above surrounding ground level. Another line of defences ran south from the main line at right angles to it, facing the river to protect the line from any river borne force. These features were then embedded in the Urban Design and Landscape Framework (UDLF)[2].

The design of the Rangiriri wetland then sought to achieve the following:

1. Revealing the historic landscape of the flood plain as the natural context to the Pa and associated earthwork fortifications.
2. Reinterpret the historic trench line, as a key feature of the battlefield.
3. Integrated the essential form and function of the wetland (including engineering elements) so that the historic landscape and interpretation of the 1863 trench are the dominant features.
4. Consideration of ecological opportunities.
5. Consideration of cultural harvest (eg. pa harakeke) opportunities.
6. Location of artworks.
7. Other matters such as health and safety, required setbacks from the power transmission line corridor and maintenance access to it and the wetland.



[2] Refer: NZ Transport Agency (2013) *Bridging the Gap: Urban Design Guidelines*. http://www.nzta.govt.nz/resources/bridging-the-gap/docs/bridging-the-gap.pdf Appendix 2 pp.113

*Figure 8: Setting out the footprint of the Pa and Trench in relation to the wetland*

# 7 THE DESIGN

The diagram below illustrates the design process followed through the design development phase. The key to success was the integration of Urban and Landscape Design, and engineering to provide an integrated solution combining both function and form.

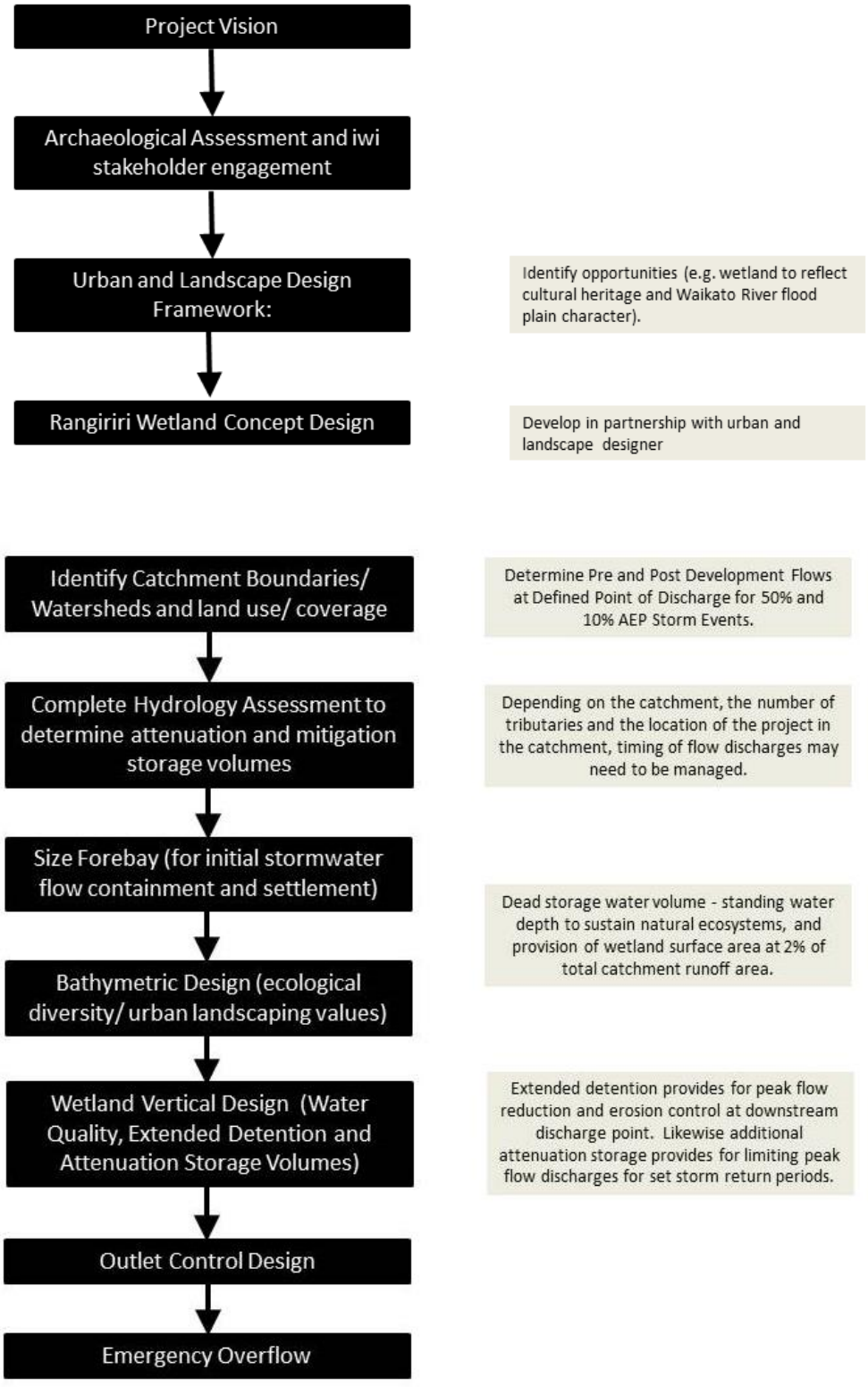


*Figure 9: Design Flow Diagram, MWH*

The design was developed by combining both cultural and landscaping features together with functional design elements.

Functional design elements included:

- Alternating deep and shallow water ponding areas (banded bathymetry).
- Wetland plants for stormwater treatment.
- Impermeable ground treatment to maintain soil saturation levels.
- Impermeable bunds to contain elevated stormwater levels.
- Maintenance access road.
- Forebays provided for each main inflow (there is one each side on the Rangiriri Wetland).
- Outlet control device.
- Emergency spillway.
- Minimising ground excavation and cut to waste
- Scour protection – rock rip rap, gravel base.

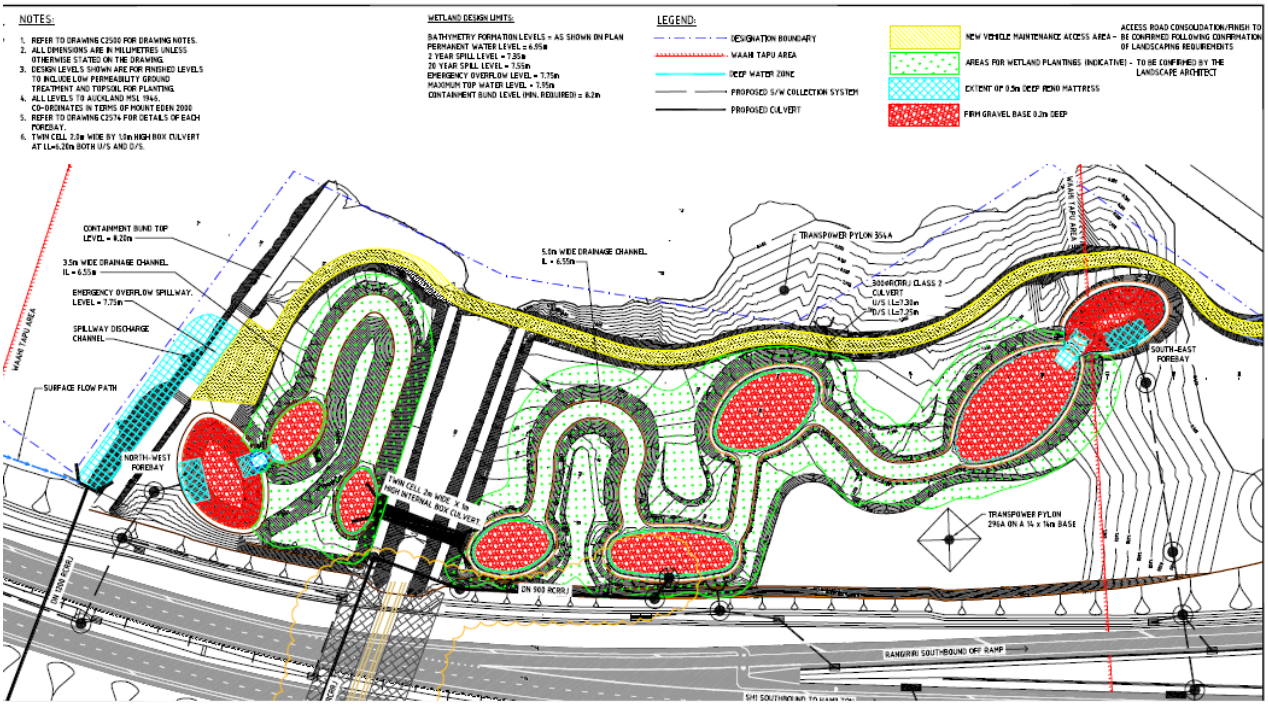



*Figure 10: Functional Design Features*

Cultural and Landscaping features included:

- The highway bridging over the historic trench footprint.
- A 'naturalistic' wetland formed in relation to the natural environment character.
- Aligning the connection between the north and south part of the wetland with an existing farm drain to minimise any disturbance to the sub-surface archaeology of the 1863 trench.
- Lineal bunds which form the edges of the original trench alignment, as a border to the footprint of the original trench.
- A series of post features/ Pou as an artwork feature and a landscape scale statement of the line across the battlefield that can be viewed from the highway, Rangiriri Pa and Waikato River side.

- Integration of planting and all structural elements so that the landscape and trench interpretation dominate the view.

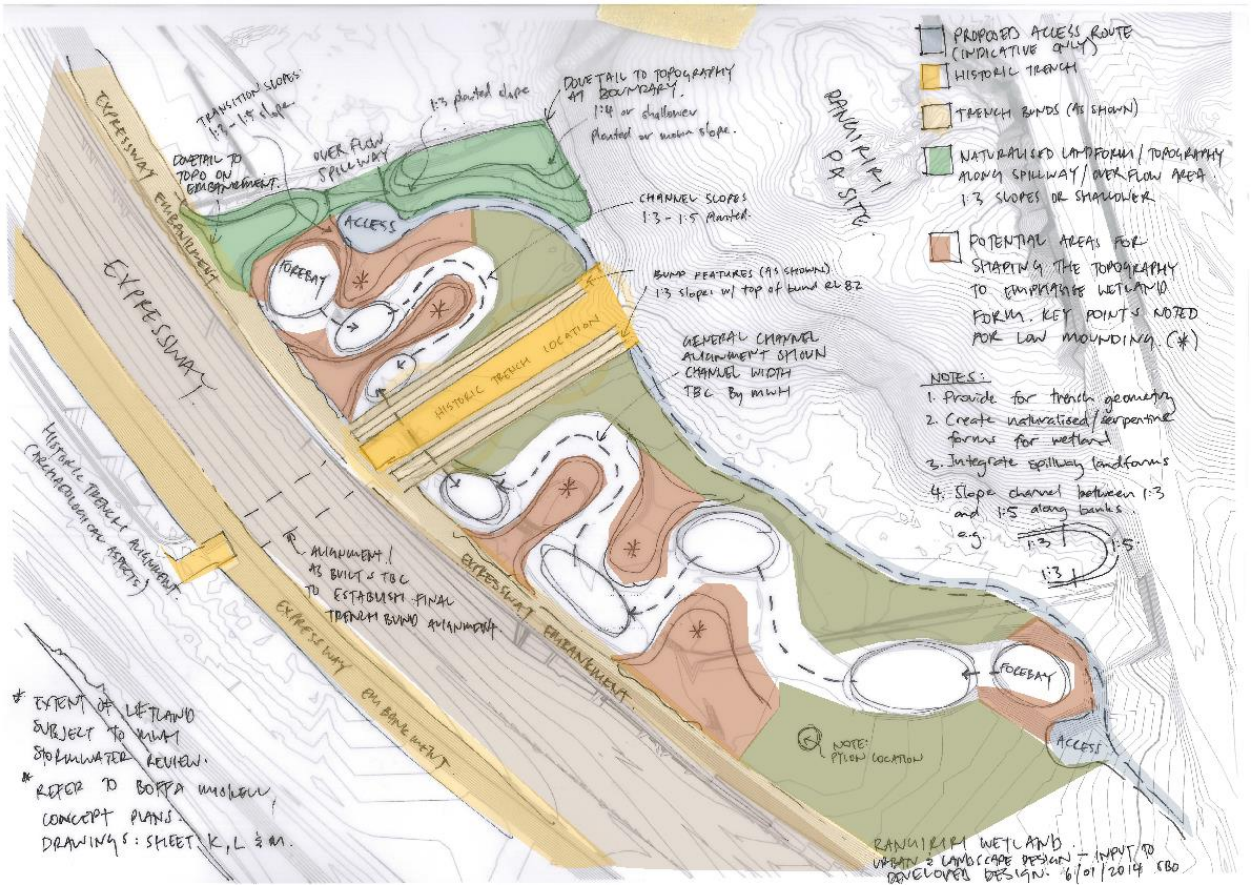



*Figure 11: Landscaping / Cultural Architectural Form Design Features*

In addition it should be noted that all design aspects associated with this proposal were signed off by Iwi. This included review by the lead Iwi liaison, the Tangata whenua working group, and once concepts were refined the Maori King's office.

# 8 URBAN DESIGN OBJECTIVES

A number of project success factors were set as follows:

1. Enhance cultural values at the Rangiriri Pa Site. Value Proposition: Address major objective of Rangiriri Project driver and maximise the benefit to the local community and gain support from Waikato-Tainui.

2. Enhance social values at the Rangiriri Pa Site through the provision of open access and landscaping, providing a social amenity value to the local community.

# 9 STORMWATER MANAGEMENT OBJECTIVES

The five main objectives for providing stormwater management were;

1. Compliance with the project resource consent conditions.
2. Provision of extended detention for stormwater quality treatment and mitigating storage to limit all discharges to pre-development flow levels for both 50% and 5% AEP storm events.
3. Maintain the natural flow regime and hydrology of streams ensuring that the effect is no more than minor.
4. Preserve and reinstate ecological habitat where practicable.
5. Provide stormwater treatment to meet or exceed TP10 and NZTA standards.

In consideration of the above requirements a number of project success factors were set as follows:

1. Maximise stormwater stream separation at source between clean water and contaminated road runoff streams. Value Proposition: Minimise the volume requiring treatment and hence the size of collection systems and the wetland, to provide cost savings to the Project.

2. Enhance ecological diversity. Value Proposition: Meeting the requirements of the New Zealand Transport Agencies Strategic Plan.

# 10 STORMWATER TREATMENT

## 10.1 CONTAMINANTS

Stormwater runoff from highways can contain significant levels of contaminants, particularly following on from a long dry period in which contaminants have had a long time to accumulate.

Contaminants can be split roughly into three main categories:

- Sediments.
- Hydrocarbons and oils.
- Vehicle related contaminants.

Contaminant Breakdown source of Vehicle related contaminants (from NZTA Stormwater Treatment for State Highway Infrastructure) as shown in the table below.

*Table 1: Vehicle Related Contaminants*

| | |
|---|---|
| Particulates | Pavement wear, vehicles, atmosphere, maintenance works. |
| Lead | Tire wear, lubricating oil and grease, bearing wear. |
| Zinc | Tire wear, motor oil, grease. |
| Iron | Rust, steel highway structures, moving engine parts. |
| Copper | Metal plating, bearing and bushing wear, moving engine parts, brake liner. |
| Cadmium | Tire wear. |
| Chromium | Metal plating, moving engine parts. |
| Nickel | Diesel fuel and petrol exhaust, lubricating oil, metal plating. |
| Manganese | Moving engine parts. |

## 10.2 STORMWATER TREATMENT DEVICES

There are a number of stormwater treatment devices available to suit a range of runoff areas, the largest and most effective stormwater treatment device being the Wetland towards the smaller at source devices such as Swales and Filter Strips. While Wetlands or alternative stormwater ponds may be efficient treatment devices they are located at the downstream end of stormwater collection systems and require a suitable land take (sometimes these areas can be quite substantial).

It may be possible to use a treatment train approach, to incorporate upstream treatment and stormwater storage or retention devices coupled together with downstream stormwater ponds or wetlands.

Ponds and wetlands also provide for hydraulic storage or detention, which can reduce peak storm flows on the downstream environment and often mitigating or offering full counter balance on the impacts of new road construction (where new road construction leads to higher peak storm flows and volumes from a combination of shortening the catchment time of concentration, together with increasing the total impermeable area).

Generally design guidance[3] states that stormwater collection ponds are suited to total catchment areas exceeding 8Ha, while wetlands are suited to catchment areas greater than 6Ha.

On the Rangiriri section of the expressway, a combination of downstream Wetlands and upstream Swales (treatment at source) was used with two wetlands (including the Rangiriri Wetland) and a stormwater detention pond. The decision on providing a wetland instead of a pond was made to meet environmental and cultural project objectives to provide maximum benefit to local eco systems and eco diversity.

## 10.3 THE TREATMENT TRAIN APPROACH

A treatment train approach ideally considers both source control and treatment as part of the overall approach to a successful outcome, creating diversity, operational flexibility, and security of treatment.

- Catchpits with silt traps and regular maintenance to remove trapped gravels and trash.
- Source stream separation (to minimise volume requiring stormwater treatment).
- Swale Collection (quality treatment and peak flow control).
- Wetland Stormwater Quality Treatment.
- Wetland Storage Mitigation (peak flow control).

# 11 WETLAND DESIGN - CIVIL

## 11.1 GENERAL

The Rangiriri wetland has been designed to sustain complex natural ecosystems that are dominated by hydrophytic vegetation, providing stormwater quality treatment through sedimentation, filtration, adsorption and biological uptake.

[3] NZ Transport Agency, Table 5-4 Stormwater Treatment for State Highway Infrastructure.

The Wetland provides the means to capture, contain, and treat stormwater flows while supporting natural ecosystems and ecological diversity.

Provision of a Wetland is one of a number of possibilities in consideration of the best value stormwater treatment device. An alternative would have been the provision of a stormwater holding pond. Both pond and wetland support ecosystems, provide environmental values and social amenity/ values, however, the wetland was deemed suitable for providing enhanced environmental benefits and met cultural and landscaping values.

In the selection of a Wetland for collection and treatment of stormwater flows, the following:

- Catchment Area – ideally it should be more than 6 Hectares.
- Soil type should be reasonably impermeable and able to hold a water body with some natural ground infiltration (silty through clay and not for example river gravels).
- Avoid sites which have steep slopes or slope stability issues.
- Avoid sites with limited access for maintenance.

Each of the Wetlands requires that the following be accounted for in the design:

- Water Quality – treatment of runoff to provide 75% Total Suspended Sediment (TSS) removal on a long term average basis;
- Extended Detention – attenuation of the water quality rainfall event, released over a 24-hour period to provide erosion protection downstream of the wetland; and
- Attenuation of the 50% AEP and 5% AEP year events – flood control downstream of the wetland.

## 11.2 FUNCTIONAL COMPONENTS

There are a number of functional components that make up a complete wetland treatment device, these combined, provide not only stormwater treatment but also control of peak stormwater runoff and mitigation of the effects that the new road development has on catchment hydrology.

### 11.2.1 INFLOW FOREBAY

This is the immediate receiving environment for stormwater inflows and provides a minimum storage volume (albeit small in comparison to the main wetland area).

The purpose of the Forebay is to collect the bulk of the silts and gravels prior to discharge into the main wetland. These constitute the largest volume of sediments from a stabilised catchment and capture of these within a Forebay reduces the frequency of cleanout of the wetland portion of the basin.

The Forebay transition to the main wetland also acts to spread the flows to help obtain even and laminar flow through to the main wetland.

### 11.2.2 PERMANENT WATER QUALITY VOLUME

The permanent Water Quality Volume (WQV) is otherwise referred to as ‘Dead Storage’. The WQV is set to allow the long term removal of 75% of total suspended sediment. This WQV assures a minimum detention time for ‘first flush’/ the initial storm flows received during the start of a storm event. The first flush stormwater runoff contains the highest contaminant levels. It requires a time of residence to ensure these contaminants are retained within the wetland.

Bathymetry (the variance in pond permanent water depth) can either be provided as 'banded' or 'trapezoidal' design. Banded is preferred for having variable depth between deep and shallow water areas, which encourages dispersed flows through vegetation with deeper areas for fish (which assists in minimising mosquito populations). The deeper areas also allow for a more mixed and diverse aquatic environment. In effect a banded bathymetric wetland design represents a more natural ecosystem than the more uniform trapezoidal form. Deep water areas are typically 0.5 to 1.0m depth while shallow water being between 0 to 0.4m depth (effectively a suitable depth to sustain wetland plant growth).

### 11.2.3 EXTENDED DETENTION VOLUME

The principle of the Extended Detention volume is to capture and release the first runoff from the defined water quality rainfall over a 24 hour period. This storage capacity reduces peak flows, velocities, and scour on downstream waterways during smaller runoff events.

### 11.2.4 ATTENUATION STORAGE

It is common practice to be required to provide mitigation storage to mitigate on peak discharge flows from post to pre development levels for both 50% AEP and 5% AEP storm events.

This storage volume is controlled with an outlet flow control structure. The actual sizing of this outlet flow device will need to be modelled to balance inflows and outflows. Inflows based on the unique catchment characteristics determining the critical time of concentration for a peak flow, the rainfall intensity and the catchment soakage/ runoff potential. Outflows based on a staging relationship between the hydraulic head and the orifice or opening size of the outlet flow device.

A typical design feature of an outflow control structure is the provision of spill control slots, circular weirs or a combination of both, in order to limit the maximum spill flow for a 50% AEP and 5% AEP year storm event. Sizing the outlet structure is likely to be an iterative process, hence the benefit in time saving by using a hydraulic model.

### 11.2.5 STORM EVENTS > 20 YEAR (5% AEP)

Peak flow mitigation storage may be required for storm events exceeding a 5% AEP, however this would be based on an assessment of needs, based on the tolerance of the impact of the scheme on the catchment hydrology. Where there are existing downstream flooding problems then additional storage mitigation may become a requirement.

This would usually have been identified as a requirement at the time of setting the Resource Consent conditions.

### 11.2.6 EMERGENCY OVERFLOW

An emergency overflow is required to; a) protect the containment area / pond from over topping; b) to protect and maintain earthworks stability (cut slopes and embankments; c) provide a controlled discharge of flow exceeding the design storm event (usually up to a 1 in 100 year storm event).

An emergency overflow should be provided as an additional means of flows to exit the wetland or pond, in case of blockage of the main outlet structure.

At the Rangiriri Wetland, there was an opportunity to provide for an overflow weir structure (20m long) built into one of the containment bunds, provided by a concrete spillway.

### 11.2.7 VEHICULAR ACCESS

Vehicle access to the Forebay will be necessary to allow for removal of silts and debris which will accumulate over time. It is difficult to estimate the frequency of removal, as this will be mostly catchment specific and depend on the amount of silts/ gravel that may be washed from the road surface. As a guide, a Forebay may require maintenance every five years. The track to access the Northern Forebay was specifically designed to align with the upper extent of the trench interpretation.

# 12 PROJECT SPECIFIC DESIGN ASPECTS

## 12.1 CATCHMENT ANALYSIS

Stream flow separation is an important consideration in the concept/ planning stages of a new highway scheme. Transverse surface flow crossings should firstly be identified and opportunities made to provide for cut off and interception drains to capture and convey surface flows into cross drainage systems, thereby minimising the impact of the road / highway on the natural catchment hydrology.

Where practicable, all surface runoff from the carriageway and grass berm should be captured and transferred for treatment, either at source (Swale) or downstream point such as a Wetland or Pond, however the contribution of surface flows from surrounding land upstream of the Highway would be considered to form part of the natural catchment system and not be included in the NZ Transport Agencies mandate on stormwater quality improvements. But because it is outside of the road corridor it is likely to be unpolluted. Such a decision to treat additional sources from outside of the road corridor is outside the scope of this paper as overall stormwater catchment management practices are not covered here.

The catchments considered to form the parts which include both the road runoff areas and also the remaining runoff surface areas which cannot be separated into transverse cross drainage systems were 14Ha for the Te Kauwhata Wetland and 28Ha for the Rangiriri Wetland. Selecting a wetland over provision of a wet pond was made to provide an added benefit to local environment, fish, bird life and other aquatic ecosystems.

## 12.2 REVEALING THE BATTLE TRENCH

The 1863 Battle trench was revealed through the placement of geometric shaped earth bunds on each side of the original alignment. These bunds also delineate a clear zone between the two parts of the wetland. There is also a concept for these bunds to be lined with Pou to further enhance this feature of the battle field/ line of defense through the wetland and towards the Waikato River.

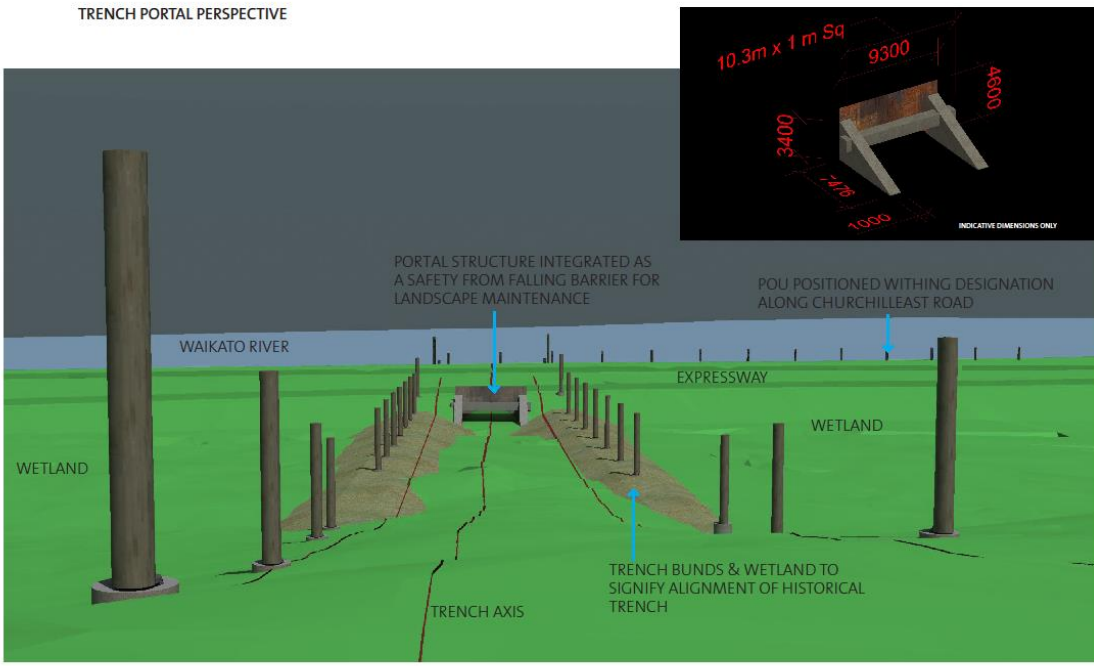



*Figure 12: Perspective illustrating the concept design options for the 1863 trench, pou artworks line the historic trench on both sides of the new Expressway. Note the red lines in image, the central line being the centre of the historic trench alignment*

In addition to adding a visual element to the revealing of the 1863 trench, an arch culvert has been constructed over the location where the new State Highway crosses the Pa trench, the arch culvert spanning each side of the trench.

## 12.3 GROUND CONDITIONS

A ground investigation was required to confirm the soil type underlying the wetland area and also the level of the groundwater table.

Ground types which are highly permeable will not be suitable for locating a wetland/ pond containment zone. The soil type should be reasonably impermeable, the degree of impermeability may vary locally and careful consideration should be made in deciding whether the ground is capable of sustaining a wetland type environment (maintaining a good soil saturation level, elevated groundwater levels and areas of ponding).

There are ground treatment options to improve the ground impermeability. One such option applied on the Rangiriri Wetland was the introduction of impermeable soil lenses, placed under zones reserved for wetland planting. This measure was implemented to provide a benefit to soil saturation levels during a long dry summer period. The Rangiriri wetland is expected to have elevated groundwater levels throughout much of the year. The impermeable lenses were placed in a concave shape to help to contain groundwater.

Ground investigations also identified pockets of soft ground at the Rangiriri wetland. These pockets, combined with elevated groundwater levels produced unfavourable conditions for deep excavations. The Rangiriri Wetland site required significant mitigation storage volumes, which was not available without removing large cut to waste volumes. To mitigate this requirement, a decision was made to raise the wetland storage level by providing stormwater containment bunds to provide for elevated flood storage levels above existing ground level.

The Wetland was also enclosed by an earth bund along the northern side, and naturally constrained by rising ground levels to the east and south. To the west runs the expressway embankment to complete the containment.

A geotechnical review determined the necessity to protect the expressway embankment from soil saturation arising from elevated water storage levels. This was provided by an impermeable barrier (high clay content), provided within the vicinity of the embankment adjacent to the wetland, and also placed within the two pa trench bunds.

### 12.4 PLANTING

Local eco-sourced species will be provided within the wetland, as a benefit to remove contaminants to improve stormwater quality, as well as promoting ecological diversity within the local area, provided as a mitigation measure for loss of wetland habitat with the new State Highway alignment.

All plant species were reviewed by Iwi and the plants types will be selected as suitable for a range of deep water to shallow water conditions, as the wetland design provides for a range of water depths for wetland planting.

*Figure 13: Planting concept image, illustrating the intended character of the proposed wetland.*

## 13 CONCLUSIONS

The Rangiriri Bypass and restoration works which began in 2013 are well advanced and will continue to completion over the next couple of years. Construction of the wetlands has commenced, including revealing of the 1863 battle trench. The earthworks are substantial and complex and outside the scope of this paper, however it is worth noting that the Rangiriri wetland is beginning to take shape.

A liaison person from the local hapu provided regular input to the design team, feedback on designs and plans throughout the duration of the development phases of the project. Waikato-Tainui's inputs assisted in appropriately reflecting mana whenua history of the battle. In addition to this the landscape design, planting plans, and cultural interpretation aspects of the project are consistent with mana whenua expectations. These include aspects of local ecology; stormwater management and waterway restoration, to enhance and protect and the local environment.

The symbolic recreation (in line with the NZ ICOMOS Charter), and the protection of the significant archaeological features and historic riverside and wetland ecology is reflective of the cultural landscape story and will act as a memorial to the battle.

A good understanding of particular site constraints (challenging ground conditions, cultural, environmental, landscape visuals, proximity of other structures), was vital in developing the engineering concept design. The success to this project was the integration with the landscaping and cultural architectural vision/ values. Many of the design features were multifunctional in providing for both functional and form design elements, established through collaboration within the design team.

Stormwater assets are a critical part of the overall highway landscape and key to creating a sense of place through different parts of the network. Where historically these assets have been treated as purely functional, they are now being considered in delivering multiple benefits and stakeholder outcomes.

This paper provides an example of how a wetland can provide for multifunctional design aspects; mitigating the effect of the State Highway on stormwater runoff, providing for a place of nationally significant cultural values, providing for ecological diversity and value, and providing for a vision encompassing all major project stakeholders.

The legacy on the Rangiriri section of the Waikato Expressway is the provision of a robust stormwater treatment and storage mitigation system; Swales throughout much of the highway, providing first stage treatment of stormwater runoff, the provision of two Wetlands (one at each of the Expressway Interchanges) – the Te Kauwhata and the Rangiriri Wetland, and a stormwater holding pond at Te Onetea (the southern extremity of the project). The Te Onetea stormwater holding pond has already been created and has quickly established into a site of ecological value and importance.

The Rangiriri Wetland will provide for a site of national importance, both culturally and ecologically, to be enjoyed by generations to come.

## ACKNOWLEDGEMENTS

We would like to thank Fletcher's Construction, the NZTA, Waikato Tainui and the Archaeologist Warren Gumbley for their support in this paper.

## REFERENCES

Goodwin, J. & Bourne, S (2010) *Waikato Expressway: Rangiriri Section Landscape & Urban Design Report*, prepared for the NZTA by Boffa Miskell Limited (Figures to Accompany Assessment report), NZ Transport Agency.

Gumbley, W (2009) *Rangiriri Bypass: Assessment of Archaeological Values*, NZ Transport Agency.

NZ Transport Agency (2010) *Stormwater Treatment Standard for State Highway Infrastructure.*

NZ Transport Agency (2013) *Bridging the Gap: Urban Design Guidelines.*