FEEDING THE IRRIGATION DEMAND

Tony Miller, Principal Engineer with GHD

ABSTRACT (300 WORDS MAXIMUM)

The Hawkes Bay Regional Council has been the initiator for this project which is to regulate and redefine minimum environmental flows in the Makaroro, Waipawa and Tukituki Rivers. As part of the project, irrigation water will be supplied to the Ruataniwha Plains from dam storage. The project is being led by Hawkes Bay Regional Investment Company Ltd (HBRIC), a Council Controlled Trading Organisation (CCTO). HBRIC are responsible for the 4 main work streams as follows:

- Consenting Phase. The Board of Inquiry final decision, determined via the Environmental Protection Authority (EPA), is currently subject to appeals before the High Court.
- Finance,
- Uptake - Sales of Water to irrigators, and
- Design and Build Process.

A target irrigation area in excess of 60,000 hectares on the Ruataniwha Plains is a mixture of dry alluvial river terraces and recently deposited silt loams. The scheme will be capable of servicing between 20,000 – 30,000 hectares. There are approximately 6,000 ha of existing land irrigated from a mixture of groundwater/ surface water sources.

The project includes a dam on the Makaroro River (tributary of Waipawa and Tukituki Rivers) whereby flow is captured over the winter period and released back into the river during the irrigation season. The scheme includes a river intake 20 km downstream from the dam and a distribution network of canals, pipes and pumps to provide water to farm gate. In addition the scheme allows for release of environmental flows and flushing flows.

This paper looks at the river intake, canals, pipes and mechanisms to deliver irrigation water to the farm gate.

Downstream of the dam the Makaroro River joins the Waipawa River and a further 10 Km downstream of the confluence, a proposed river intake will draw allocated water from the river to feed the main distribution feed canal. The Waipawa River has significant flow variation from a mere few cumecs in summer to over 1,000 cumecs in flood.

This paper looks at the considerations involved in obtaining a stable river intake and the design considerations in conveying and controlling this flow in near flat canals along the distribution network.

The author was part of the design team for a design and build consortia who are now the preferred tenderer on this significant irrigation project. The paper addresses the design carried out for the D&B tender phase and the interactions between designers, constructors and the Principal.

KEYWORDS

Irrigation, River intake, canal, canal liner, underpass, design and build, tender design.

PRESENTER PROFILE

Tony Miller is a Principal Engineer in GHD's Stormwater and Asset Planning Service Group based in Auckland. He holds a BEng form the University of Auckland (1980) and is a CPEng accredited. Tony has more than 35 years' experience in the contracting and consulting engineering in NZ, UK, Canada, Australia and the Pacific Islands.

His experience covers a wide range of projects including canals and irrigation, hydro generation and pumping stations, bridges and river works, stream restoration; wetlands, ponds and dams for treatment and attenuation for a range roading projects Tony has presented evidence before at Council hearings, Environment Court and Board of Inquiry.

1 INTRODUCTION

The Ruataniwha Water Storage Scheme (RWSS) is a project being led by Hawkes Bay Regional Investment Company Ltd (HBRIC), a Council Controlled Trading Organisation (CCTO) of Hawkes Bay Regional Council.

1.1 HISTORY and BACKGROUND

The project's history can be traced back to the 1930 Napier earthquake. Following that event the Hawkes Bay Harbour Board inherited land that had been raised by the quake. Through amalgamation, ownership ultimately transferred to the Hawkes Bay Regional Council. Sale of this leasehold land and income from other strategic assets has been used to fund the scheme development phase and may be used to support the construction phase, with an emphasis on investing capital within the region for the benefit of the Hawkes Bay region.

The Hawkes Bay enjoys good sunshine hours (2200 hours per annum). The mountains and some coastal ranges receive the most rain, while the plains between Napier and southern Hawke's Bay (particularly the Heretaunga plain) receive the least. Summer is a traditional drought period with prediction for further drying with climate change.

The drier Heretaunga and Ruataniwha Plains suffer from significant moisture deficit during drought conditions. As such the productive capacity of the land can be significantly impacted by drought. To the west is the Ruahine Ranges, with rainfall up to 2000 mm/annum, however the rainfall gradient drops quickly away from the ranges to the east with average rainfall of 800mm on the Ruataniwha Plains.

1.2 A SCHEME IS BORN

The use of groundwater for irrigation in Central Hawkes Bay has evolved significantly over the last decade. On the Ruataniwha Plains, groundwater extraction for irrigation use has increased from approximately 3 to around 24 million m^3 per annum. This has impacted on surface water allocations in the Tukituki River Catchment, based on current allocation limits, and also impacted on flows for native fish and trout habitat and recreation use over the Summer months.

Downstream and within the Tukituki River both water quantity and quality issues have resulted in periods of excess periphyton[1] growth impacting on recreational use and fishing and wider river ecology.

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[1] **Periphyton** is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems

Hawke's Bay suffered from a series of droughts over a four year consecutive period from 2006 –2009. According to Ministry of Agriculture and Forestry estimates at the time, the negative economic impact for the region was regional significant.

Following 2007, 153 water take consents were renewed and granted but only for a reduced period of 5 years. Since then no new water take consents have been granted within the Tukituki catchment.

Investigation into the feasibility of water storage is one of a suite of initiatives that Hawke's Bay Regional Council (HBRC) has been progressing since 2009, to address increasing pressures on the water resource in the Tukituki River Catchment. The proposal is to store high winter flows for use in summer when pressure on the water resource is greatest.

HBRIC consultants identified a shortlist of potential dam sites, both on-river and off-river, which was reduced through investigation, design and analysis to the preferred on-river dam site on the Makaroro River.

Figure 1: Map showing Hawkes Bay Region and location of the Makaroro Dam Site

1.3 THE DAM

The proposed dam is located on the Makaroro River some 10 km above the confluence with the Waipawa River. The Waipawa joins the Tukituki River a further 36 km downstream adjacent to the central Hawkes Bay township of Waipawa.

The Tukituki River discharges into Hawke Bay a further 64 km downstream.

The proposed CCRD[2] dam is over 87 m high, with a total storage of more than 90 Mm³ at notional full level.

1.4 WATER STORAGE SCHEME

The Ruataniwha Water Storage Scheme (RWSS) project forms a significant element of a range of initiatives designed to address water quantity and quality issues in the Tukituki, Waipawa and Makaroro Rivers within Central Hawkes Bay. The Scheme also has a purpose of providing irrigation water to up to 30,000 ha of farmland in a command area downstream of the dam.

The main element of the project is a dam. However the RWSS is much more than just a dam. The key infrastructure elements include:

- Dam outlet structures including, spillway, intake tower and bypass tunnel to be used during dam construction.
- Penstocks, power house and very large bypass valves.
- The valves and power house discharge into the Makaroro River where water is conveyed downstream for a distance of 10 km, combining with the Waipawa River.
- The combined flows travel a further 10 km before a series of intake structures harvest the dam water and bypass to canals and pump stations.
- The scheme includes for a primary distribution network of canals and large low pressure pipelines,
- The balance of this phase of the project includes for pump stations and higher pressure secondary network of pipes to deliver pressured water to the farm gate.

However the RWSS scheme is more than just the structural infrastructure elements described above, the scheme includes for:

- A priority of allocation of water released from the dam for environmental flows, urban and irrigation use,
- Power generation,
- Water allocation, sales of water and an ability to deliver allocated water to the farm gate, with high efficiency,
- Environmental controls for nutrient management, and
- A management and financial structure to run the $250 M project.

1.5 MAJOR WORK PACKAGES

Following the project initiation, there have been four recent tranches of work to develop the scheme as follows:

- Concept Design, Investigation, including lodging of Resource Consents and subsequent hearings,

[2] CCRD dam: Central Core Rock Fill dam

- Project Finance,
- Sales of Irrigation Water,
- Design and Build.

1.5.1 FEASIBILITY DESIGN AND CONSENT PHASE

The Hawkes Bay Regional Council established and transferred responsibility for the Ruataniwha scheme to the Hawkes Bay Regional Investment Company Ltd (HBRIC) in 2012. Tonkin and Taylor were engaged as the primary engineering consultants to develop the water storage scheme through the prefeasibility and feasibility phases. The feasibility level of design for the scheme was developed to a stage suitable for progressing the necessary consent applications. Responsibility for the engineering consultancy and Clients Engineer role has been undertaken by Snowy Mountain Engineering Corporation (SMEC) since the completion of the feasibility phase.

HBRIC decided to progress the consents, along with a Plan Change, through the Environmental Protection Authority (EPA) as a project of National Significance. A Board of Inquiry (BoI) heard evidence through the latter part of 2013. The BOI released their final decision in June 2014. This decision was appealed to the High Court which has heard the appeal. The High Court decision sent narrow elements of points of law back to the BoI for further consideration with a further final decision due in May 2015. Once the BoI rules on this issue, there is still a possibility of a further appeal. As such the consenting progress is still in progress.

1.5.2 FINANCE

The project capital cost is $275 M inclusive of all scheme infrastructure, development costs, land acquisition costs and carry costs through the construction phase.

Some on farm infrastructure already exists as part of the 6000 ha's of existing irrigation. Potentially some bores and water supplies could become redundant when the scheme proceeds, particularly those landowners who migrate to the scheme, however the scheme is envisaged to be a mixture of new and existing infrastructure over the balance of the 25,000 ha scheme area.

For the RWSS scheme, HBRC via HBRIC has been the primary promoter and driver of the scheme, contributing capital through the development phases. The scheme was also the first project to successfully obtain funds from the MPI Irrigation Acceleration Fund (IAF) for these phases.

The scheme capital funding will be a mixture of public and private investment. HBRC have committed up to $80M of funding to the capital phase subject to achieving a number of condition precedent requirements. Ongoing discussions are also continuing with Crown Irrigation Investment Limited (Government), Iwi, farmers within the scheme and other institutional investors.

1.5.3 WATER SALES

A necessary element of progressing water storage schemes is achieving sufficient water sales. A condition precedent threshold of 40m m3 of 104m m3 of available water needs to be in a contractually binding position by financial close for the scheme to proceed.

HBRIC has committed significant resource to this area with work progressing well at this time.

1.5.4 DESIGN AND BUILD PHASE

Expressions of interest were sought from appropriately qualified contracting consortia in 2013. From a short list of 5 consortia, two were selected to progress to a 20 week competitive design and tender phase. These were:

- Bouygues Construction. Bouygues is a French-based contractor operating globally on large infrastructure projects including dams.

  Their dam and irrigation design engineering teams were MWH and Opus.

- OHL – Hawkins Joint Venture. Obrascon Huarte Lain (OHL) is established globally as one of the largest infrastructure players and is currently ranked 21st among the 225 largest international contractors. Hawkins is one of New Zealand's largest privately owned construction companies.

  The dam and primary irrigation design team is led by GHD, an Australian-based consultancy with a strong New Zealand presence and good experience in detailed design of a range of dam types.

  Water Infrastructure Group NZ (WIG) is involved in the secondary irrigation distribution area, while GHD would cover the design of structures and canals. WIG has current design and construction experience with canal and pipe optimization work on the Ashburton Lyndhurst Irrigation scheme and Barrhill Chertsey Irrigation.

The tender phase for provision of a fixed time, fixed price submission commenced in April 2013, with tenders closing 5 month later in August 2013.

Representatives from HBRIC and other expert advisors undertook a three month tender evaluation process, including a significant Q&A phase and formal consortia interviews and presentations.

In November 2013, HBRIC advised the OHL-Hawkins JV they had been selected as the Preferred Respondent for final contractual negotiations. The team was also advised that actual award would not take place until consents were granted, financial investment commitments in place and final project approval was confirmed.

The process of final contract negotiations and terms continues at this time.

2 FURTHER SCHEME DETAILS

2.1 THE DAM

The 87 m high dam has a reservoir area of 376 Ha when full. The reservoir lake will be more than 6 km long and have a stored volume of approximately 90 Mm^3.

During the construction of the dam, dam core materials will be won, in part, from material within the reservoir, thus increasing the available storage volume. The Makaroro River also has an annual bedload of material with much of this moved during flood conditions. Over time this will begin to impact on reservoir storage so a provision of 4m m^3 of dead storage is included in the reservoir design requirements.

For the hydrologist the 100 and 10,000 year events exceed 250 and 800 m^3/s respectively. The design of the spillway needs to accommodate these flows.

The 5 year low flow is less than 1 m^3/s. An ongoing permanent environmental flow contribution from the dam was determined as 1.23 m^3/s and has been confirmed as a condition of consent.

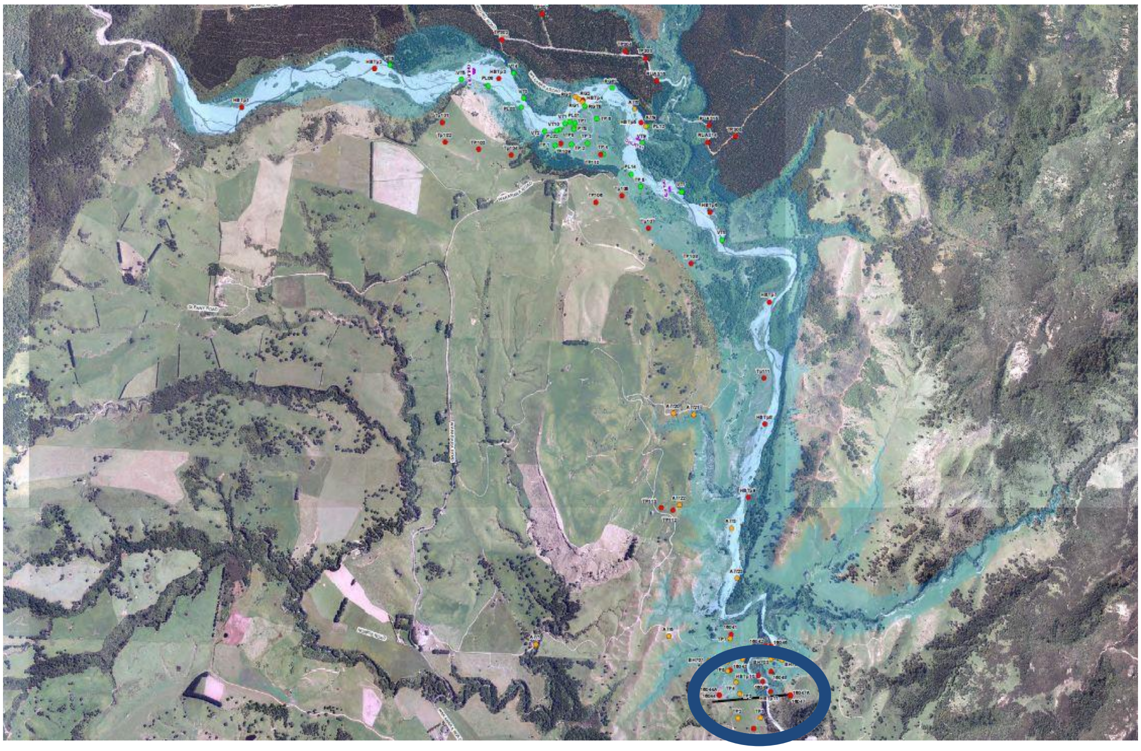

Figure 1: Aerial Photo showing location of the Makaroro Dam Site and Reservoir

2.2 RELEASE OF ENVIRONMENTAL FLOWS FROM THE DAM

As part of the environmental investigations and final consent conditions determined for the scheme, the RWSS has been designed to include and cater for a range of environmental flows.

The dam has been designed to meet a range of discharge condition where a priority is placed upon environmental flows. The priority of release includes:

- A continuous environmental low flow discharge from the dam of 1.23 m^3/s and this flow gets the highest priority.
- Two flushing flows of up to 1 Mm^3/s released at a rate of 25 to 30 m^3/s over 9 hours. This high release rate flow gets the next priority. This water will aid in providing flushing flows in the Tukituki river,
- Irrigation flow of up to 90 Mm^3 released at a rate of up to 11 m^3/s,
- Two further high release rate environmental flushing flows of up to 1 Mm^3 each,
- Release of secondary irrigation water (when available).

2.3 RELEASE OF IRRIGATION FLOWS

As part of the RWSS, the Ruataniwha Plains will be provided with irrigation water supplied from the dam that will allow for intensification of agriculture and horticulture within the plains. The intensification and regional economic flow on affects were key factors in the RWSS being successful in obtaining development funding from the Irrigation Acceleration

Fund and will hopefully also realise capital funding from the Crown Irrigation Investment fund.

The dam will store up to a notional full dam of 90 Mm³. However over the irrigation season (October to April) the dam on average will release 128 Mm³ due to the additional inflows that are available once the dam begins to draw down. Once environmental flows have been accounted for there is a potential irrigation volume of 104 Mm³ available for irrigation supply to irrigate up to ~25,000 hectares. The irrigation water will be delivered through two systems

- The primary distribution system which will form the 'backbone' of the irrigation scheme, and
- The secondary distribution system that includes secondary pumping and a higher pressure network of pipes to the farm gate. The OHL-Hawkins bid also offered a pressurized pipe network to irrigators and water users.

The primary distribution system involves major river intake structures, 16 km of lined canal, 23 km of existing stream rehabilitation and 13 km of large diameter low pressure pipeline. The secondary distribution system includes 19 pressure boosting stations, ~195 km of pressure pipeline (ranging in size from DN1200 to DN150) and up to 180 property offtake connections.

3 TENDER PHASE

Following the pre-selection of the design and build consortia, two groups were selected for the tender phase.

I was a member of the GHD team involved with the preliminary design phase for the design of the primary distribution for the Hawkins OHL JV. For me this was a challenging, demanding and rewarding project over approximately 5 months. I will share some of my reflections of this journey.

Parallel phases of work were also undertaken by another GHD (Dams) team out of another office.

During this tender phase, a project office was formed with the designers, estimators, and bid team members all domiciled in the same space. GHD Auckland office hosted this phase of the works. Thus the office had a group of staff from a number of companies all cohabitating in the same space. For me this was different but a good experience as interactive meetings between designer and constructor would take place regularly.

3.1 PRIMARY DISTRIBUTION SYSTEM

3.1.1 SCHEME DESIGN

Tonkin and Taylor had been engaged by HBRIC to develop the feasibility design for the scheme. This formed the basis of design and assessment for the design submitted with the resource consent application, environmental assessments and consents that were on a parallel but independent path to the design and build consortia path of determining a complying bid.

The T&T feasibility design used for the consent phase was renamed the specimen design and this formed the basis for confirming a conforming tender.

3.1.2 INTERACTIVE MEETINGS

Following the feasibility design and consenting phase work package, HBRIC appointed new consultants and Technical Advisors for the tender phase works, being Snowy Mountain Engineering Corporation (SMEC).

During the five month tender period, a series of interactive meetings were convened between each of the design and build consortia and the Principal and Principals Technical Advisor. Each meeting was commercial in confidence and attended by a probity officer to ascertain correct procedures were carried out.

The principal's agents, in my opinion, carried out this task diligently and in confidence. In any large project there is always intent interest on what the opposition may be doing, do we have a commercial advantage, and do we have the innovation and enthusiasm to produce a winning tender.

I have reflected on this process and to the credit of the HBRIC staff and their agents (SMEC), confidentiality requirements were very well handled.

3.1.3 PRINCIPALS REQUIREMENTS

Principal's requirements (PR's) were developed by SMEC to guide the design requirements to ensure a conforming bid was provided by the consortia.

Through the tender phase we had internal discussions and challenge sessions on the PR's. The wording of which was not always clear. On occasions we would analyse the PR's to ascertain the true intent versus the literal translation of the PR's. We did not want to give away IP (Intellectual Property) or commercial advantage by seeking points of clarification from the principal. Hence questions to the principal were well considered.

At times we did seek approved departures from the PR's where the literal translation of the PR's would lead to an undesirable outcome, or be overly costly to fully comply with and where other value engineering could lead to a better outcome.

A process of documentation of approved variations to the PR's was well documented and set out clearly in our final bid documentation.

In summary and as more projects fall into the design and build style of tender, the PR's will be the tenderers bible in which to submit a conforming bid. To those working in the design and build environment, my advice would be 'Don't be afraid to challenge the PR's', for better cost or environmental or life cycle cost outcomes. Once these clarifications or variances have been approved by the principal, then there is a need to document the work and be able to sell the benefits in the tender bid.

3.1.4 TENDER DESIGN PHASE

The tender design phase started with the specimen design (as developed by T&T) for the consent phase. This formed the basis of our initial design and provided some real boundary constraints to more innovative design.

Our tender design is not detailed design, but was developed to a stage suitable for the contract team to price and stage the works. The process was challenging, demanding and involved many challenge sessions, whilst trying not to be involved in too much detail.

Our design was different to the specimen design and was presented in a format to convey intent with sufficient detail to inform on quantities, staging and scope. The tender design is not detailed design but needs to be sufficiently detailed for the main contractor to price with certainty. I have often likened this to a 10 % detailed design developed in such a way as to inform the tender team but not to affect the final price.

The tender documents required whole of life costing to be approached including provision for maintenance and replacement. A discount rate of 8% was adopted and as such replacement at 25 years or longer had little impact.

Many elements of the specimen design were challenged and often resorting to first principles approach to challenge assumptions, minimum pipe wall thicknesses, redundancy for water hammer etc., how rivers behave in flood and how to recover thereafter, or to design more redundancy into the infrastructure whilst keeping the tender team informed of that journey for a no surprises outcome.

3.1.5 PRIMARY DISTRIBUTION IRRIGATION

Our team was responsible for the primary distribution system. The key elements in this package were:

- Three river intakes off the Waipawa River. The river at this stage has a low flow of a few cumecs but a high flow of over 1,000 m^3/s.
- A lined canal, complete with drop structures, control gates and the potential for in-race hydro.
- A series of off takes to deliver water to the secondary distribution system, and
- Piped or culverted sections to pass under roads, streams, rivers and deal with steeper gradient sections.

The alignment for the primary distribution was set out in the specimen design. The laying of underground pipes is a permitted activity, but construction of a canal is not. The planning phase sought to obtain a designation for the canal alignment.

As part of our tender submission, we had a series of alternatives. One of these was an alternate route that involved maintaining the canal at a higher elevation (approx. 25m higher. Although the route crossed undulating land, there were significant benefits with reduced pumping. I shall discus this again below.

14km

17km

Figure 3: Photo showing typical lined canal and trench construction

3.1.6 PRIMARY SYSTEM INTAKES

I grew up on a braided river which is similar to the Waipawa and Makaroro Rivers but to the west side of the Ruahine Ranges on the Pohangina River (Tributary of the Manawatu River.

Following significant floods of a similar magnitude, we would often see major changes in the notional bank full channel with horizontal shifts of up to 100 m. The Pohangina River was aggrading due to major slips in the Ruahines. In part these have been due to reduced control of deer and possums in combination with some major floods and storms.

The Waipawa River where the primary intakes lie has similar issues with an aggrading river and very large potential floods of up to 1,000 m^3/s. Our intake structures had to cope with taking up to 11 m^3/s and allowing environmental low flows to pass. These structures had to withstand the force of large floods and be operational within a few days of the floods passing.

The path we chose was to adopt the intake structure just downstream of a rock outcrop where the river had been relatively stable for a number of years. Our strategy following larger floods was to enter the river with a digger following large flood events and re-excavate a channel to the concrete intake structure and thus incur a maintenance regime.

The intake structure incorporated environmental flushing flow bypass, fish screening, irrigation flow measurement and gates to exclude floodwaters from the canal. The canal surface was 3 m below the adjacent peak flood level.

3.2 SECONDARY DISTRIBUTION SYSTEM

The design of the secondary irrigation system was undertake by WIG (Water Infrastructure Group). Much of the design work was undertaken out of their Christchurch office, their team did spend some time in Auckland, with a number of long working meetings to sort out details of interface between designs.

3.3 MAKARORO DAM AND HYDRO

The design of the diversion tunnel, dam, spillway, intake tower, penstocks, powerhouse and large dump valves was undertaken by GHD but out of the Australian offices.

Again a number of meetings with the tender teams were conducted in the Auckland project office to coordinate and advise the lead contractor and estimators.

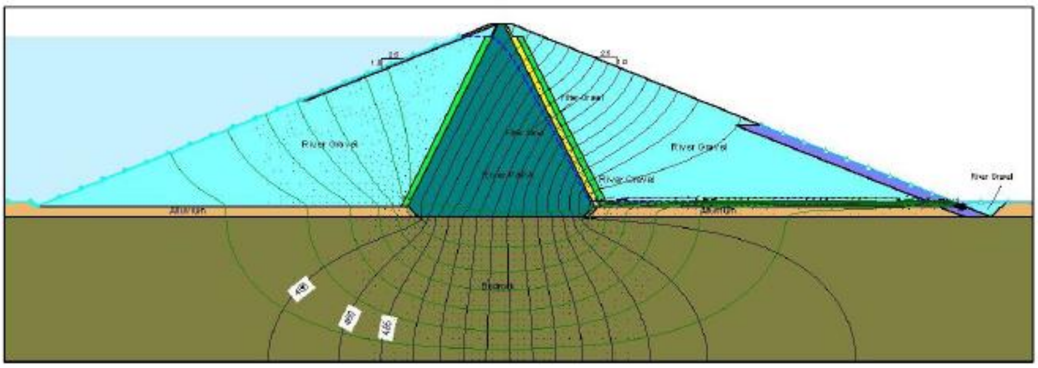

Figure 4.13 Typical Seepage Analysis results

Figure 4: Diagram showing section through a Central Core Rock Filled Dam

4 ALTERNATE CANAL DESIGN

As stated above, The OHL-Hawkins bid included a number of alternatives, which impacted on the PR's. One of these involved rerouting the primary irrigation system.

4.1.1 CANALS VS PIPELINES

The construction of pipelines is a 'permitted activity' in regards to planning and consenting requirements. However canals involve the acquisition of sections of private property for construction and ongoing maintenance during its design life. Canals do not fall into the permitted activity and designation and resource consent approvals were therefore required.

HBRIC and their property consultant have been negotiating with private land owners and GHD has been assisting with preparation of information on the proposed canal footprint.

The canal conveys design flows from more than 8.0 m^3/s as it flows south through the Ruataniwha Plains, reducing in capacity as allocated water is extracted from the canal into the irrigation zones. The cross section reduces following the offtakes to the secondary distribution pressure boosting stations. The vertical alignment of the canal was critical to maintaining the highest water level in the canal as possible, so as to reduce the pressure boosting requirements for the secondary irrigation system.

Unfortunately the Ruataniwha Plains do not have a constant gradient from the foothills of the Ruahine Ranges down toward the Waipawa and Tukituki Rivers, much to the disappointment of designers. Consequently there will be sections of the canal alignment requiring earthworks cutting through regions of elevated topography and engineered fill through lower lying areas to match the required hydraulic energy grade line for the scheme.

Canals are very efficient methods of transporting large volumes of water at high flow rates. There are preferences for the use of large diameter pipelines to conveying flow, however due to the diameters required and length of canal that they would replace for the RWSS the business case was not feasible. An economic cross over point was found to occur when the flow rate was less than 2.0 m^3/s and required pipe diameter was less than 1200 millimetres.

Pipelines provided minimal permanent impacts on existing land use and topography as they can be considered "out of sight, out of mind". As pipelines were not considered economically feasible for the top portion of the primary distribution system, a primary canal was adopted. Canals do have a major impact on the topography and land use of properties they traverse.

4.1.2 CANAL GEOMETRY

Geotechnical advice during the canal design identified cut batters of 1:2 and fill batters of 1:2.5 as suitable for the predominant river gravel based material through which construction would occur. Based on these side slopes the canal footprint increases in size by 4 m and 5 m for every 1 m increase in cut or fill respectively. When combined with the access road and maintenance requirements, these dimensions result in the canal footprint being approximately 20 m wide before significant cut or fill sections are incorporated into the design.

A canal with an invert 2.0 m above the existing topography (embankment conditions) would have an overall width of 37 m. Similarly a canal with an invert 2.0 m below the existing topography (battered excavation) would have an overall width of 26 m.

Both of these situations present major impacts to land owners particularly for issues such as access to land, reduction of useable agricultural land and impacts to existing on-farm irrigation infrastructure and compensation requirements.

4.1.3 LAND OWNER CONSULTATION

The majority of PDS drawings produced by GHD for OHL-Hawkins tender design were at scales of the main alignment at 1:5,000 per A3 sheet. As a reference, drawings with this scale would display 1.5 km of alignment per sheet. While detailed design plans in the future will display a higher level of detail through use of smaller scales, currently it can be difficult to discern differences in the changing widths of the canal footprint. Thus during discussions between land owners and HBRIC a common question raised when viewing the tender design plans, was:

- "How big will this be?"
- "How will this affect my stock movements?"
- What will happen to my fences?"

To assist with the land owner consultation, HBRIC engaged GHD to prepare a 3D "fly through" model of a critical section of canal.

4.1.4 3-D COMPUTER AIDED DESIGN

GHD utilised 12D software by 12D Solutions for the tender design of the canals and pipelines. The software allowed for generation of digital terrain models from previous LiDAR surveys over the Central Hawkes Bay region. From the digital terrain model, earthwork quantities for the canal could be directly assessed and incremental changes made to both horizontal and vertical alignments.

The models designed in 12D were exported to AutoCAD for post processing and the production of designs plans. While engineers are able to identify features and symbols on design plans, interpreting this information can be difficult for non-engineers.

The 12D software was used to produce a three dimensional model of the canal section including the addition of scalable indicators to help landowners understand visual effects on properties. The model included:

- Property boundaries (cadastre);
- Fence lines;
- Overhead power and telephony cabling;
- Vegetation such as stands of trees;
- Topographic features such as streams, existing carriageways and driveways; and
- Existing buildings.

Aerial photography was 'draped' over the digital terrain model subject to using suitable file types (vector based compared with raster based imagery).

The addition of scalable objects in the model assists with land owner consultation as they provided a relative reference to known objects. Land owners can judge the impacts of proposed infrastructure to their property by comparing with existing objects that are important to them such as access roads and fencing.

The critical section of canal that was modelled ran parallel with a local road. Two options were developed for the canal with each option being on a different side of the carriageway. A camera path was defined in 12D following the centreline of the road. The camera path was then used for a fly through animation to show the impacts of the two canal alignment options.

12D allows for the model including camera path to be exported as a three dimensional portable document format (*.pdf). The software allows GHD to prepare a title block and overview plan showing the canal alignment with aerial photography background, which appears as a typical engineering style plan as per Figure 5.

The overall file size for the portable document format with the inclusion of the 3D model was approximately 14 megabytes. This relatively small file size means that the file can be viewed on a PC screen, with a tablet or even smart phone.

4.1.5 MODEL VIEW MANIPULATION

When the right hand plan is clicked (refer to Figure 5), the three dimensional navigation tool bar is activated. This starts the fly through for the alignment and allows the user to pause the animation at any point in time as displayed in Figure 6. The tools also allow the user to pan, rotate, and zoom from any point in the model.

Preset views can be accessed from the drop down box on tool bar as per Figure 7. These were configured to show the canal alignment from a number of locations that were important to the stakeholders, such as existing dwellings.

Figure 5: Plan layout of Canal

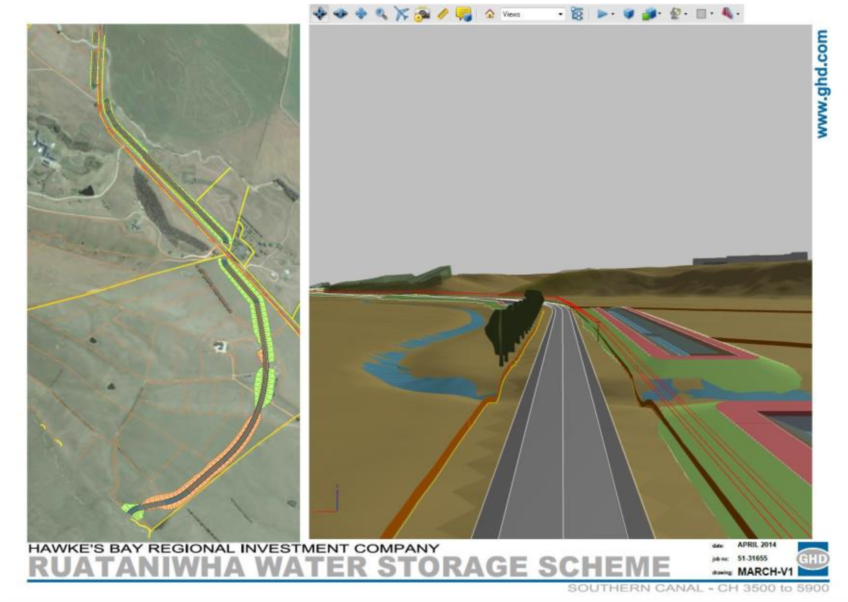

Figure 6 Commencement of fly through

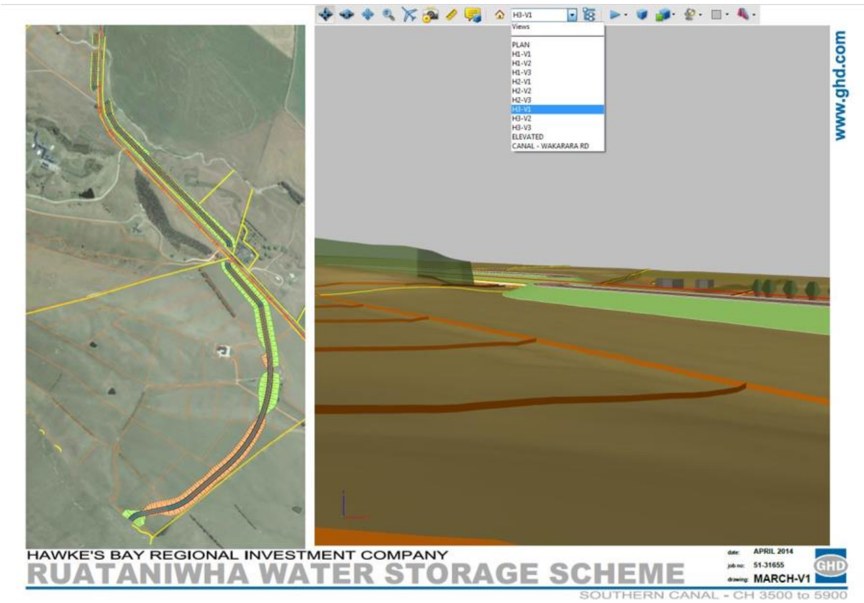

Figure 7 Typical preset view 1 set up for critical locations

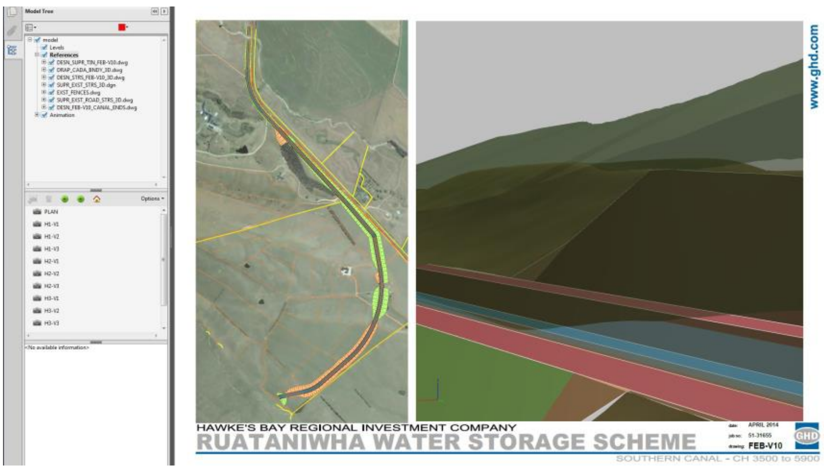

Figure 8 Typical preset view 2 set up for critical locations

Figures 7 and 8 also show another way of accessing the preset views, other than through the drop down box.

4.1.6 DESIGN COLLABORATION

Generally the use of 'pdf' is the easiest method of providing information to stakeholders, particularly those with non-technical/non engineering backgrounds. However there is an increasing use of three dimensional software containing attributed data for design collaboration. A number of software packages are available (Bentley Navigator, AutoDesk Navisworks and Design Review) which allow for technical multidisciplinary collaboration. The packages allow for designers of separate discrete portions of the works (access roads, buildings or structures, underground services) to store and access design information in a single location.

Multi-disciplinary projects increasingly mean the contribution of non-technical people to project outcomes, rather than those from a different branch of engineering. Stakeholders and their associated communities are formally and informally involved in the direction of infrastructure projects. These relationships have become further formalized through steering committees and community boards. The use of three dimensional modelling assists both non-technical and stakeholders with developing a 'sense of scale of the project' and communicating progress on the design.

As design progresses from concept through to construction phases, stakeholders can be provided with updates on how their contributions fit within the overall project. This can include how landscaping contributions have been adopted, or how alignment contributions may not be able to be integrated where they adversely affect design disciplines.

4.1.7 ENGAGING WITH STAKEHOLDERS

The three dimensional model was displayed to stakeholders so that they could compare the relative impacts of the two canal alignments.

One specific landowner was concerned with the potential impact to the landscape on their properties due to the canal realignment. A preference had been expressed for the canal alignment to be located on a specific side of the road. The preference was based on the canal being less intrusive to the landscape and proposed planting and vegetative screening was considered to increase the visual amenity of the alignment.

Figure 6 shows the preset panoramic view looking north-east from the stakeholders dwelling for their preferred alignment. This can be compared with the same preset view showing the alternative alignment as per Figure 7.

These two comparable views can then be used in discussions with the stakeholders with regards to the permanent visual impact on the landscape.

4.1.8 FUTURE MODELLING USES

Additional modelling can be undertaken to show the temporary impacts during construction due to activities such as:

- Haul roads;
- Temporary site fencing;

- Road closures, diversions and temporary access
- Stream diversions;
- Erosion and sediment control measures;
- Site establishment compound and temporary materials supply yards; and
- Staging of works particularly with regards to separable portions.

While not displayed for these three dimensional plans, these construction impacts can be added as scalable indicators. This allows for the animation and three dimensional model to show the extents of site compounds, where vehicle access from existing roads would be located and temporary fencing to isolate the construction zone.

5 SUMMARY AND CONCLUSIONS

In this paper I have attempted to give an overview of the Ruataniwha $275M project for the construction of a dam including primary and secondary distribution water systems. As a result of the investigation during the consenting phase a range of environmental mitigation measures were identified and incorporated into the project. These include minimum low flows and high level flushing flows.

The infrastructure for this portion of the overall investment and benefits to the region go far wider than just this water storage and primary conveyance. Additional on farm investment is required as well as downstream transportation, food processing, housing and other infrastructure will be required before the full benefits are realised. Thus at least an additional $300M investment will be required.

- The RWSS project involves four main tranches of work including:
  - Feasibility design and consent phase. This work is substantially complete with the final decisions before the Board of enquiry.
  - Finance. I have not covered this in this paper.
  - Sales of Water. Heads of agreement phase with potential irrigators has completed and sale of committed water is underway.
  - Design and build phase. I have covered this from a participant perspective involved with the tender and post tender process. First from a work package perspective and further drilled down into some of the tools we have used in the form of 3D computer aided design to develop presentation tools for use with landowner and stake holder negotiations.

The use of the three dimensional modelling and fly through can be used for any linear infrastructure project. The use of portable document format (*.pdf) means that the majority of end users can view three dimensional models and associated fly throughs using commonly available freeware such as Adobe Reader.

Providing information in readily accessible format for stakeholders over the design and construction phases helps with engaging and communicating with those parties.

With the relatively small file sizes, sending the information to clients, stakeholders and 3rd parties can be accomplished easily using email or file transfer systems such as ‘Dropbox’.

Using three dimensional modelling for linear and large scale infrastructure is comparable with the increasing adoption of Building Information Modelling using products such as Revit. The modelling fits within existing project workflows and can be used to assist with reviewing and checking.

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REFERENCES

Many of the references for this paper are in the public domain and are hosted on the following websites:

- http://www.hbrc.govt.nz/Hawkes-Bay/regional_development/hbric/Pages/rws.aspx
- http://www.epa.govt.nz/resource-management/tukituki/Pages/default.aspx

The principle documents include the resource consent application project descriptions, Principal’s Requirement document used for the DnC tender and subsequent press release documents as published on the HBRC website.