A ONCE IN A LIFETIME UPGRADE OF THE MAYFIELD HINDS IRRIGATION SCHEME

David Carshalton (Beca Ltd)

ABSTRACT

The Mayfield Hinds Irrigation Scheme (MHIS) is situated between the Rangitata and Hinds Rivers in Mid-Canterbury. The scheme was developed by the Ministry of Works in the 1940s and is the largest privately-owned irrigation scheme in New Zealand.

The scheme takes water from the Rangitata River via the Rangitata Diversion Race, delivering 16.65m³/s of water to around 33,000ha. The scheme was designed to flood paddocks at a single rate (~230L/s) on a fortnightly roster. Changing to a continuous water supply would allow the scheme to make better use of storage and allow more efficient water use. To this end, the Mayfield Hinds Irrigation Ltd (MHIL) Board of Directors are investigating changing the water distribution system from an open channel system to a predominantly piped distribution system. The company has engaged Beca Ltd to advise them on the environmental and engineering aspects of the upgrade. Many of the current landowners' grandfathers were inaugural benefactors of the MHIS, so the proposed upgrades are likely to be the most significant in a lifetime.

This paper presents the drivers for upgrading the scheme, the challenges such an upgrade faces, the proposed design concept and how the works have been procured to date.

KEYWORDS

Irrigation, Rural Water, Piping Upgrade, Mayfield Hinds Irrigation Ltd, Rangitata Diversion Race

1 INTRODUCTION

1.1 BACKGROUND

The Mayfield Hinds Irrigation Scheme (MHIS) is the largest community irrigation scheme in New Zealand with an irrigable area of 33,000 ha, taking up to 16.65m³/s of water supplied by the Rangitata Diversion Race (RDR), which also supplies several other schemes in the area. Each shareholder is allocated the equivalent of 3.5mm/day. The scheme operates during the irrigation season, which is defined as 10 September through to 9 May every year. Figure 1 shows a map of Mid-Canterbury with the RDR and MHIS area marked.

The MHIS was built in the 1940s by the Ministry of Works. The Government owned and operated the scheme until the early 1990s, when it was privatised and sold to irrigators within the scheme, each of whom became shareholders of Mayfield Hinds Irrigation Ltd (MHIL). This company owns and operates the open channels used to deliver water to shareholders and has a share in Rangitata Diversion Race Management Ltd (RDRML), which owns and operates the RDR, including the water use consents.

Since 2007 the MHIL Board have been considering upgrading the scheme and, to this end, engaged Beca Ltd (Beca) in 2008 to advise them on the environmental and engineering implications of various upgrade options.

1.2 DESCRIPTION OF EXISTING SCHEME

The current water distribution system consists of a network of open channels that branch out in a spider web pattern across the scheme from the main supply race. The open channels discharge into on-farm races, originally applying water directly onto paddocks; however, in most cases these now discharge to on-farm storage ponds. Some farms along main open channels with large reliable flows pump directly from the channel to their on-farm

irrigation systems. The scheme is operated by two racemen who manually adjust gates to deliver the rostered flow to each farmer.

The irrigation scheme was designed to deliver water at flood flows (~230L/s) to flood paddocks on a fortnightly roster. Since construction, the scheme's operation has evolved as on-farm irrigation practices have changed to spray irrigation. In many cases, the flow rates and roster have been reduced. Ultimately, continuous flow and on-demand allocation is required.

The MHIS is a 'run of the river' scheme. Therefore, during periods of low river flows the scheme intake is restricted (referred to as being 'on restrictions'), and the water available to farmers is reduced commensurately.

MHIL has estimated there to be 15% - 20% distribution losses within the scheme. Losses are attributed to leakage from open channels, and the over-allocation of water to existing shareholders due to coarse flow measurement and lack of storage within the scheme. If all of the losses were recovered, shareholders could be supplied with 4.3mm/day, equating to the peak scheme flow spread over the existing scheme area. To realise this extra allocation, over the current allocation of 3.5mm/day, and convert it to a continuous delivery for each farmer, an upgrade to the scheme conveyance system is required.

1.3 IRRIGATION PRACTICES

Until the late 1990s, 95% of the scheme was under border-dyke irrigation. During the last decade, around 80% of the scheme has been converted to spray irrigation, mostly using centre-pivot irrigation systems, such as that shown in Photograph 1. MHIL expects that the scheme will eventually move to close to 100% spray, driven by improved flexibility and increases in productivity. The advent of spray irrigation has required farmers to construct their own on-farm storage ponds to convert their batch allocation into a continuous irrigation flow.

The current scheme allocation of 3.5mm/day is insufficient to allow irrigators to make up the soil moisture deficit after restrictions have been imposed. During periods of high evapotranspiration (ET), farmers would like to be able apply 5mm/day. Currently, groundwater pumped from on-farm boreholes or on-farm storage ponds is used by a number of irrigators to supplement their scheme allocation to meet this higher application rate. An increased scheme supply rate (4.3mm/day) would reduce the reliance on other sources of water. However, storage and groundwater will still be an important part of the irrigation system in the future.

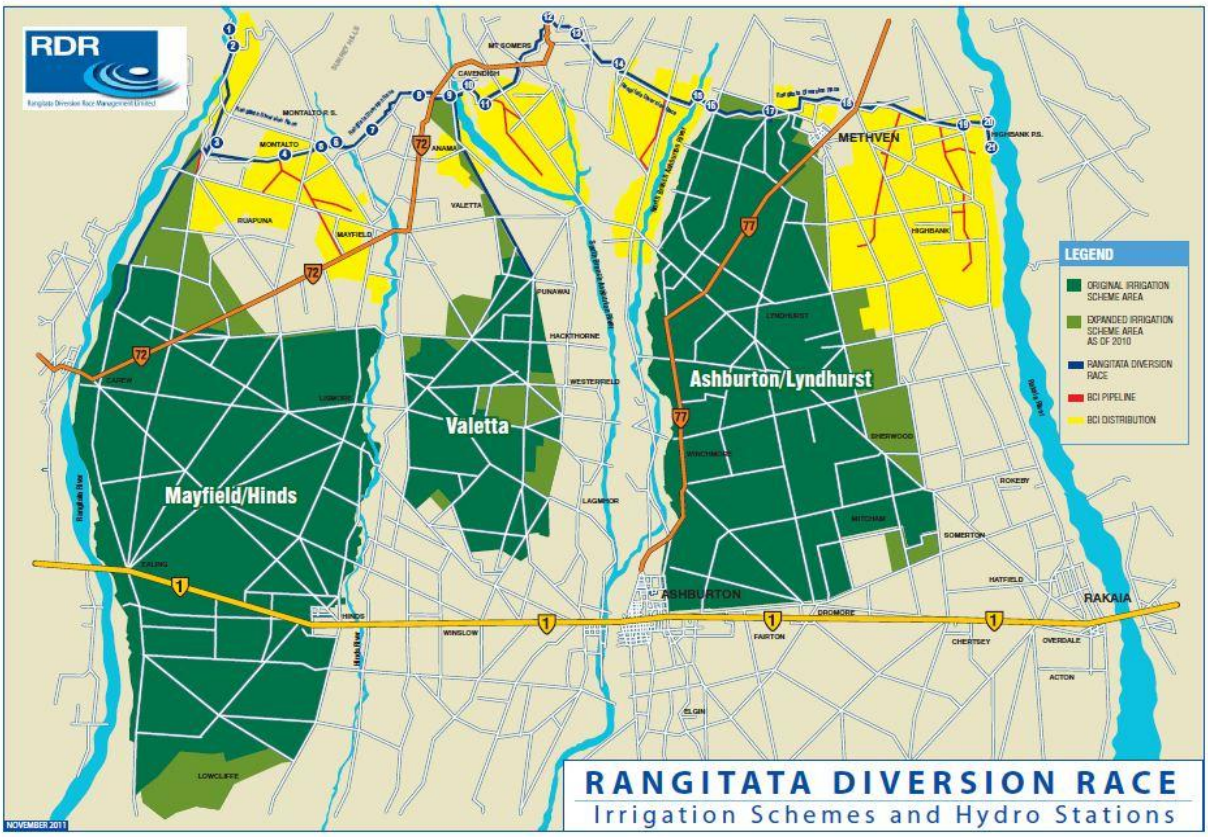

Figure 1: Map of the RDR Supply Area (Source www.mhis.co.nz)

1.4 DRIVERS FOR THE UPGRADE

The shareholders' drive to upgrade the scheme has its roots in the change in on-farm irrigation practices from border-dyke to spray irrigation. This change has required farmers to construct storage ponds to convert the rostered flow into a continuous flow, and to convert the 3.5mm/day allocation into what is effectively a 5mm/day application rate at peak times, as used for most spray irrigation. The investment and associated improvements in on-farm irrigation efficiency has led to a desire to achieve a commensurate upgrade of the supply system.

The MHIL Board identified that the drivers for the upgrade are to:

- Provide water at a continuous flow, removing the requirement to buffer rostered flows using on-farm storage.
- Improve energy efficiency of the scheme by supplying water at 40m pressure. This is sufficient to drive spray irrigators and eliminate the need for on-farm pumping for spray irrigation
- Improve water use efficiency – currently up to 20% of the scheme's water is lost to leakage or over-allocation. Up to 4.3mm/day could be supplied if all of the scheme's water was distributed to farmers, from 3.5mm/day currently
- Provide up to 5mm/day during peak demand periods (with the average allocation being 4.3mm/day). This requires scheme storage to supply the difference
- Allow accurate flow measurement
- Allow scheme growth using water that is currently lost. This will make better use of the scheme's allocation and mitigate the risk of the allocation being reduced when the consent is renewed
- Improve the flexibility of the scheme to allow for water trading in the future.

The business case to install a new piped network based on electricity savings from pressurised water and leakage savings is currently marginal at current electricity costs and water value. However, the non-financial drivers have been key to convincing scheme shareholders to pursue scheme upgrades.

Although not formally identified as a driver for the upgrade, there is a strong sense of wanting to preserve the resource for future generations. In many cases, the MHIL Board members' grandfathers helped build the original scheme infrastructure and they have a personal desire to upgrade scheme infrastructure so the water resource can be sustainably utilised by their grandchildren in turn.

Photograph 1: Part of a centre-pivot irrigator. Spray irrigation is one of the factors that prompted MHIL to consider upgrading the scheme

2 RESOURCE MANAGEMENT SETTING

2.1 MHIS CONSENT ARRANGEMENT

The resource consents to irrigate the Mayfield Hinds Irrigation Scheme area are held by the Rangitata Diversion Race Management Limited (RDRML). MHIS is a shareholder in RDRML and orders its water on a daily basis based on the rostered flow.

In 2012, RDRML applied for a land use consent to allow water from the intake to be applied anywhere on land between the Rangitata and Rakaia Rivers. This would allow growth of the scheme area and water efficiency savings to be transferred to irrigate new areas. At the time of writing this paper, this application is currently awaiting additional information from the applicant.

2.2 SUMMARY OF EFFECTS OF THE MHIS UPGRADE

The RDRML consent requires water to be used for irrigation. The upgrading of the conveyance system is considered to be a permitted activity since the water use is not changing. Nonetheless there will still be effects, including:

- Less groundwater recharge. The 15 – 20% distribution losses are largely due to leakage from the open channels into the ground water. Removing this will affect lowland drain flows and other users of groundwater
- Applying water to an increased area will result in increased farm activity, resulting in economic benefit to the community
- Potential increased nutrient loadings, from increased farm activity. These adverse effects will need to be carefully managed through improved farm operations and will be partially mitigated by improved irrigation efficiency.

2.3 SUMMARY OF EFFECTS OF THE PROPOSED LAND AND WATER REGIONAL PLAN FOR FARMERS

In August 2012, Environment Canterbury (ECan) released the Proposed Land and Water Regional Plan (pLWRP). In this plan, ECan proposes some significant changes for farmers:

- Shifting the focus of water use regulation to include both quantity and quality (rather than just the former)
- Taking into account the effect of the runoff and leaching from irrigated land
- Requiring a farm environmental plan for each farm
- Limiting the volume of nutrient runoff (especially nitrogen) from a particular catchment
- Requiring land use consent when the land use is changed.

The pLWRP does not currently set out the nitrogen limits for each catchment or how limits will be met, especially in catchments that are already over-allocated. Instead, the plan requires farmers to record their nitrogen runoff until 2017, when further decisions will be made. The plan provisions will comply with the requirements set out in the National Policy Statement for Freshwater Management (2011).

The key implication of the pLWRP on the MHIS is that its ability to grow the scheme by selling excess water or through share trading will be difficult because potential shareholders may not be able to intensify their existing farm activities.

Photograph 2: The MHIS Main Race

3 MHIS PIPING UPGRADE

3.1 OVERVIEW

Having confirmed the drivers of the upgrade, MHIL commissioned Beca to prepare an options report to inform MHIL of the requirements, and associated cost, to upgrade the scheme to meet these drivers. The options considered were:

- Lining the existing open channels to reduce leakage, installing automated control and measurement at major channel junctions
- Installing a series of pipe networks to supply one of the following levels of service:
    - 5mm/day at 40m head. This is sufficient to supply all of the scheme shareholders with sufficient pressure to irrigate concurrently
    - 5mm/day at 0m head. This would require the shareholders to boost the supply pressure at peak times. At off-peak times (when some farmers are not irrigating) there would be sufficient pressure in the system not to boost the pressure.

MHIL's preferred option was a pipe network supplying 5mm/day at 40m head. Although this option was the most expensive, it was seen by the scheme shareholders as that which best met the drivers of the scheme.

The level of service for the piping upgrade was determined by the desire to be able to supply all farmers concurrently with their full allocated flow at 40m pressure. This pressure was selected because it is suitable for running most on-farm irrigation systems.

During the options study and the preliminary design process of the piping upgrade, Beca investigated lower levels of service to reduce the cost of the works. At both stages, MHIL concluded that the associated cost savings did not justify the resulting reduction in value to the famers.

3.2 SUMMARY OF MHIS PIPING UPGRADE DESIGN

The preliminary design of the piping upgrade split the scheme into nine separate pressure zones. Each zone has its own dedicated piping network that is supplied by a main supply pipe. Parts of the existing open channel system are retained to convey flow to a pipe inlet pond provided at the top of each main supply pipe. Figures 1 and 2 show a schematic and plan, respectively, of the preliminary design of the pipe upgrade design.

The main components are:

- Retaining 80km of existing open channels. These are needed to convey water from the RDR and discharge into ponds at the head of each pipe network
- New controls on the retained open channels. This is designed as automated flume gates or fixed weirs at each junction in the open channels to control the flow split out of each junction. These will be monitored and controlled by a SCADA system
- 10 no. pipe inlet ponds, ranging in size from 80,000m^3 to 160,000m^3. These are designed to be flat-bottomed ponds to provide buffer storage for day-to-day scheme control. The ponds will be a mix of existing ponds, purchased from the existing owners and new ponds on existing shareholders' land. The pond size is set by the largest likely daily variation in demand. This allows the scheme to order its water from RDRML based on the previous day's demand
- 40km of main supply pipes; 1200mm – 1600mm in diameter. These will take water from ponds and deliver pressurised water to irrigation supply zones. These pipes will traverse 45m in elevation to generate the required 40m head for each off-take
- 200km of reticulation pipe networks of 1200mm diameter pipe and below. These are fed by supply pipes and convey pressurised water to individual off-takes within each supply zone
- 176 no. off-takes to individual farmers. These consist of a pressure-reducing diaphragm control valve, flow meter and connection to a SCADA system. All of the equipment will be contained in a precast concrete box or similar
- A new SCADA system with the ability to record flows at each off-take, remotely operate the open channel junctions, and remotely operate the off-takes to farmers.

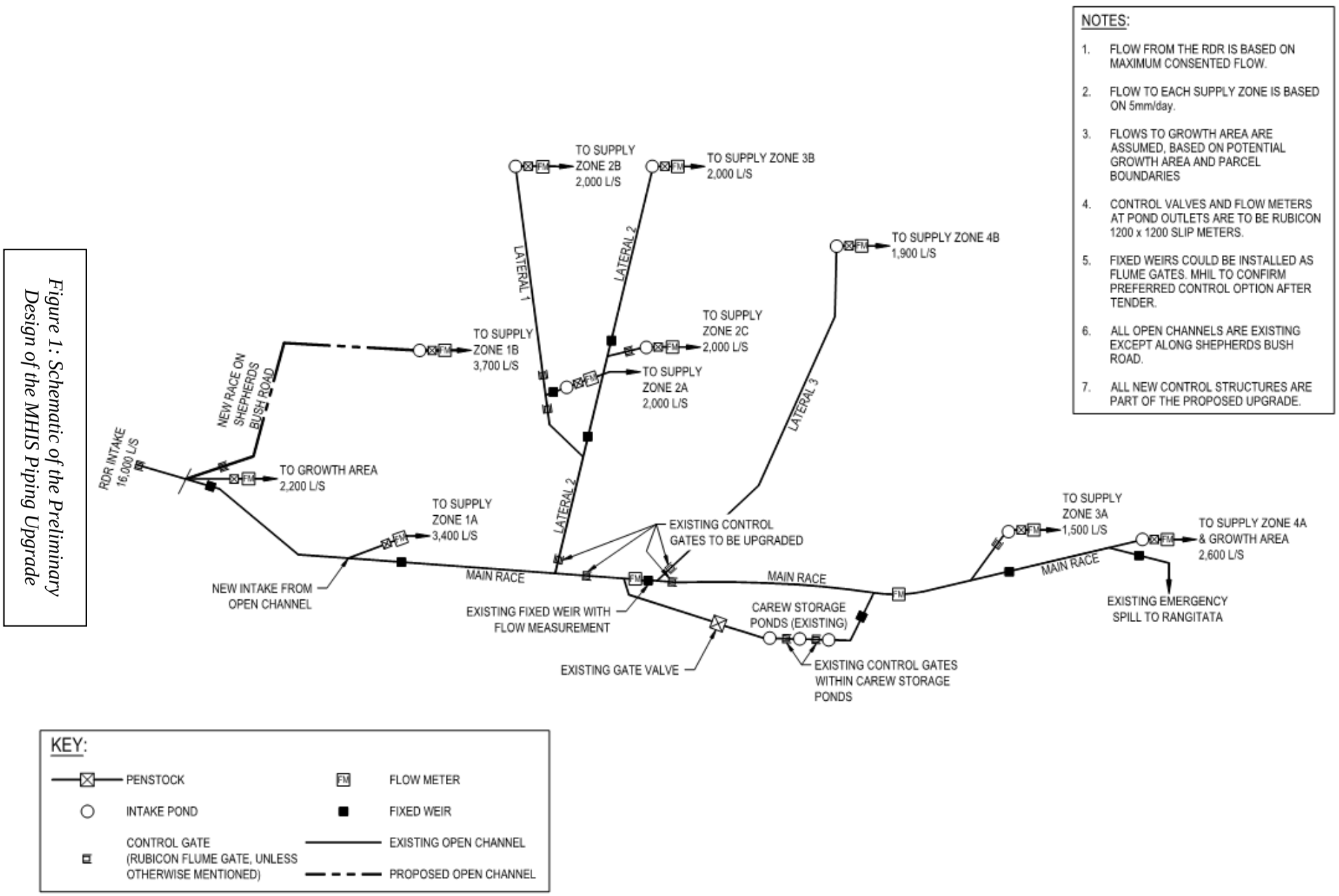

Figure 1: Schematic of the Preliminary Design of the MHIS Piping Upgrade

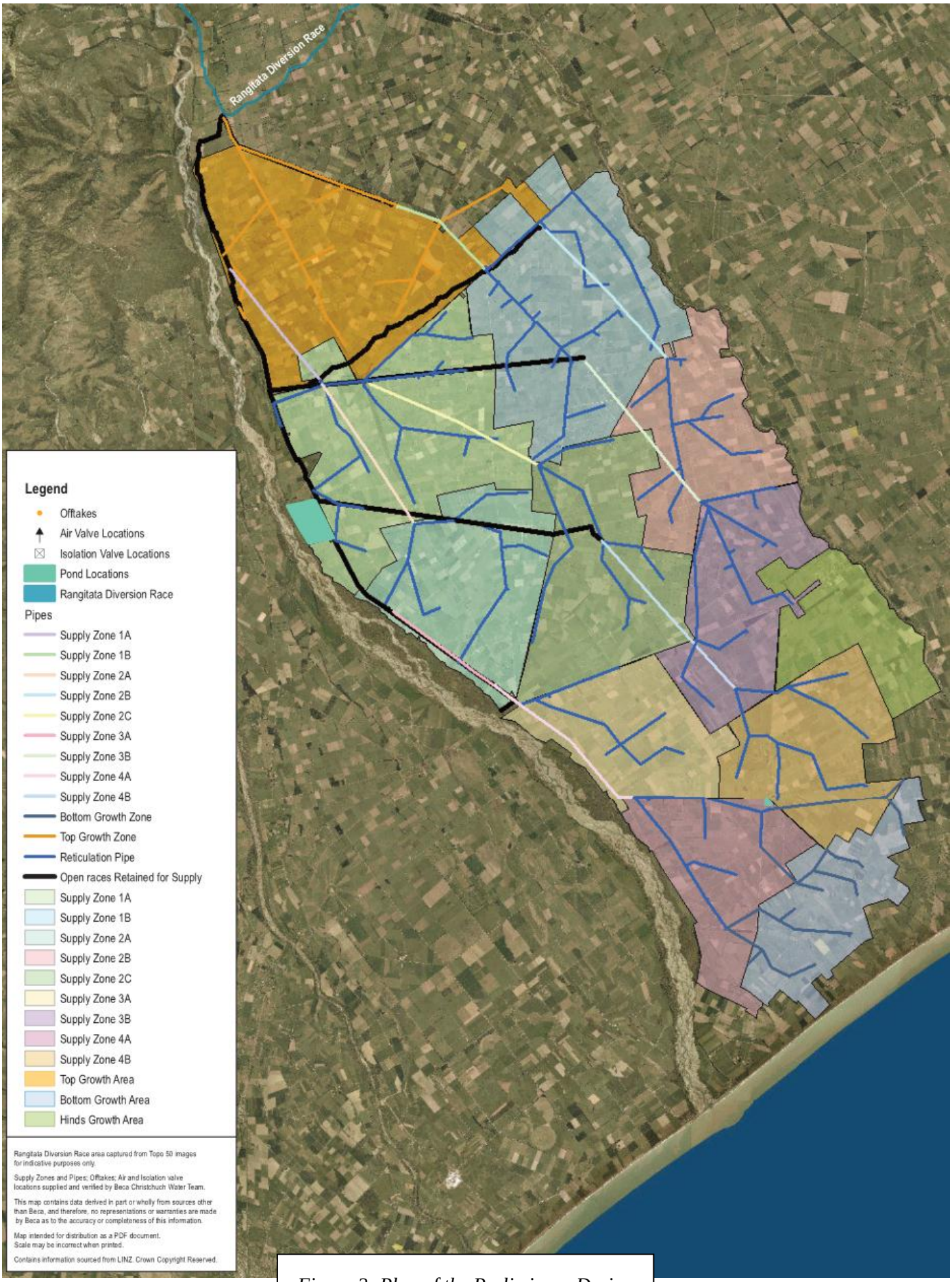

Figure 2: Plan of the Preliminary Design of the MHIS Piping Upgrade

3.3 HYDRO POWER GENERATION

MHIS has 300m of elevation difference from its highest to lowest point. This is substantially more than the 40m pressure needed by farmers to run on-farm irrigation systems. Therefore, there is a surplus of potential energy in the scheme, making generating electricity an attractive option. There are already a number of private hydro turbines within the MHIS that pressurise water for spray irrigation, such as the one shown in Photograph 5.

Estimating the potential power that can be harnessed at different sites is relatively straightforward. However, safety considerations for any design (such as bypass structures), the future value of electricity, how the power is used (e.g. sold to a retailer or directly used by the scheme), and the cost of generation equipment all significantly affect the viability of hydro-electricity generation. In general, only locations with relatively stable large flows, and a grade of at least 1:150 are viable.

A high level review of the business case for hydro power on the MHIS showed that 11km of the main race, used to deliver all of the flow from the RDR to the irrigated area, is the most suitable part of the scheme for generating electricity. There is about 12MW of generation potential along this section of race. The other races in the scheme have smaller, variable flows, and have a shallow gradient, consequently have less generating potential.

Currently MHIL is investigating the potential for generation with an established generation company in a Joint Venture arrangement.

Photograph 5: An existing privately-owned hydro installation on the MHIS Main Race

3.4 PROCUREMENT METHOD AND CONTRACT TYPE

Following the preliminary design process, the MHIL Board opted to procure the upgrade using a Design and Build contract for the following reasons:

- Early contractor involvement means that the innovations in construction methodology and supply chain management can be incorporated at an early stage. These will have a significant impact on the total cost, which needs to be approved by the shareholders prior to construction.
- The pipe network layout needs to be flexible until excavation begins. Experience of similar projects has demonstrated that landowners sometimes highlight their conflicting needs (for example, where a future dairy shed is to be located in the intended path of a pipe route) only when the construction crew is due to arrive on site. Therefore, it is best for the Contractor to control the detailed design in order that alternative routes can be assessed quickly.
- The scale of the project has attracted interest from many of the major contractors and consultants in New Zealand. By allowing a design and build process, the best of the industry's innovation has been applied to the scheme design before it was set by a detailed design process.

Beca prepared a contract document based on NZS3910:2003. This contract form was chosen because of its flexible nature, and the familiarity of both the contracting community, as well as MHIL, with it. Due to the likelihood of scope changes, particularly pipe lengths changing marginally to suit landowners needs, and the dominance of pipe supply and installation in the final cost (approximately 75% of the total cost), a Measure and Value Contract was selected to tender the works.

The tender is broken into two stages:

- Stage 1 – contractor selection based on specimen design
- Stage 2 – developed design with the preferred contractor

3.4.1 STAGE 1 TENDERING

The purpose of this stage was to select a contractor to take into Stage 2. Tenders were prepared using a schedule of prices based on the preliminary (specimen) design and a performance specification. This schedule will form the basis of the measure and value contract. Tenderers were required to submit a conforming tender based on the specimen design, as well as being encouraged to submit non-conforming designs that offered innovations in terms of reduced costs and/or changes in levels of service.

The evaluation criteria for Stage 1 were:

- Price (based on the detailed schedule).
- Ability to innovate – this was used as a criteria because it was expected that the Stage 1 tender prices would need to be reduced through innovation. The non-conforming designs, track record, and tenderer interviews were used to assess this.
- Site management, farmer liaison and contractor capability. The MHIL Board has made it clear that the success of the project will hinge on keeping the farmers on board. The pipe upgrade will be constructed through working farms and so require the cooperation of the farmers to keep installation productivity high, and therefore keep within the agreed budget.
- The relative weightings of the criteria were not set prior to the tender being released, other than to acknowledge that the price would be more than 50% of the final weighting. Once the scores were agreed by Beca and MHIL, the sensitivity of the weightings demonstrated that there was a clearly preferred contractor.

3.4.2 STAGE 1 PIPE SUPPLY AND INSTALLATION INNOVATIONS

The scale of the Piping Upgrade Project has allowed pipe suppliers and contractors to propose alternative methods of supply and construction to reduce the cost of the scheme. These include:

- On-site manufacture of large diameter PE pipe. This reduces the transport cost of the pipes. An on-site manufacturing plant is shown in Photograph 4
- Manufacture and installation of 100m – 200m lengths of pipe. The open nature of the ground, removing the need for short radius bends to avoid obstacles, and on-site manufacture of pipes allows long lengths to be transported to the work site and installed. This saves approximately 12 welds per 100m compared to traditional methods of pipe installation and allows up to 500m of pipe to be installed each day. Photograph 3 shows a typical pipe installation in similar irrigation scheme in which Beca was involved
- Direct path between points, as opposed to following road corridors or property boundaries. The rural environment allows pipes to be installed on the most direct route possible, without following roads. This also reduces the long term loading of the pipe for most of their length as the majority of the length is located below pasture
- On-site sourcing of bedding and backfill. The large volume of excavation, in-situ ground conditions, and the unconfined nature of the work sites allows contractors to consider screening excavated material to supply bedding and backfill material instead of importing it
- Innovations in installation methodology. The lengths of pipe in open areas has allowed contractors in similar irrigation scheme upgrades to use unusual compaction techniques, such as vibrating the pipe to compact the backfill, instead of using plate compactors or rollers. In these installations, pipes have been tested to check that deflection is within the limits set by the manufacturer.

Photograph 3: A typical pipe installation, demonstrating the long straight lengths of pipe that are installed for a piping upgrade

Photograph 4: On-site pipe manufacturing plant

3.4.3 STAGE 2 DEVELOPED DESIGN

Following Stage 1 tendering, the preferred tenderer, Fulton Hogan, was invited into a design development stage to refine the preliminary design to reduce the cost of the upgrade and remove uncertainties allowed for in the Stage 1 pricing. The outcome of this stage will be a scheme design suitable for review with shareholders and for accurate costing and securing finance.

The evaluation for Stage 2 of the tender process is a shareholder vote of the final price and the developed design. It needs to achieve a 75% approval from the shareholders at a special general meeting. This vote is scheduled for early 2014.

4 CONCLUSIONS

The Mayfield Hinds Irrigation scheme has supplied three generations of farmers without any significant changes to the scheme infrastructure. Over time, the on-farm and regulatory environment has changed, especially in the last 10 years with the widespread implementation of spray irrigation. This has driven the MHIL Board to consider how they can improve their scheme to meet the needs of the next generations of farmers.

The scale of the upgrade has presented a number of opportunities to innovate that result in a reduction in the cost of the scheme, while maintaining the value to the scheme's shareholders. The planning, design, procurement and eventual construction the MHIS Piping Upgrade will continue to present a number of unique challenges that the client, Beca and Fulton Hogan team look forward to overcoming.

Photograph 6: Shepherds Bush Road in the Mayfield Hinds Irrigation Scheme

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