Manuherikia
Catchment
WATER STRATEGY GROUP

MANUHERIKIA CATCHMENT - WATER DEVELOPMENT OPTIONS

Options Validation and Refinement Report

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1.0 OBJECTIVES

The Manuherikia Catchment Water Strategy Group (MCWSG) has undertaken this Options Validation and Refinement process to determine where project value can be improved and to identify/refine the water development options that are to be advanced. The objective of the process was to answer the following key questions:

- What are the implications of the do nothing approach? With the expiry of deemed permits in 2021, the expected increase in residual flows will induce a potential drop in water availability.
- What is required to maintain current supply reliability for the existing irrigators under the expected post 2021 conditions? What are the costs associated with maintaining the current status quo reliability?
- What is a reasonable level of water reliability within the Manuherikia Catchment and how much water storage is required? What are the costs associated with higher levels of reliability?
- What does the optimum solution for catchment water management look like? What are the advantages of a catchment approach over an individual approach?
- How can we pay for this both individually on-farm and collectively as a community? Are there options for staging the development and deferring some costs?

For water development to progress in the Manuherikia Catchment the community require confidence that the preferred options have been identified and robustly assessed. This includes environmentally and social acceptability, performance and affordability. This Options Validation and Refinement process has been undertaken to provide the community with information to assist them with their decisions on whether or not to proceed past the recently completed feasibility study and if so which options are to be progressed.

2.0 BACKGROUND AND PROCESS

The MCWSG was established with the aim of developing and implementing cost effective, efficient and sustainable options for water users within the Manuherikia River catchment while achieving wider community and environmental goals. A staged assessment approach has been adopted in order to assess the viability of potential water development options. Initially a High Level Overview Study assessed water availability and demand within the catchment (Aqualinc 2012a, 2012b and 2012c). A Prefeasibility Study (Aqualinc 2012d) followed, which assessed potential water development options for the catchment. The conclusions arising from these studies were:

"… that the catchment was not water short and that there are promising options that could increase the reliability of the current irrigation area or potentially increase the total area of irrigated land from approximately 15,000 hectares to 35,000 hectares" (MCWSG 2013).

Five water development options identified during the Prefeasibility Study were progressed through to the recently completed Feasibility Study (Golder 2015a), which assessed the technical, environmental, economic and financial feasibility of each option. High off-farm water supply cost estimates developed during the feasibility study induced widespread community concern regarding on-farm economic viability. A mid-process benchmarking review (Lilley, 2015) was commissioned by the Ministry for Primary Industries to assess the work undertaken and to provide the MCWSG with a suggested way forward. The mid-process benchmarking review found that:

"*Given the stage of development, the level of assessment undertaken is largely appropriate. Key areas of risk and uncertainty have been identified and largely addressed.*"

A key recommendation of the benchmarking review was that an optimisation process be undertaken. In response the MCWSG initiated this Options Validation and Refinement process to determine where project value can be improved and to identify/refine the water development options that are to be advanced.

Through a series of workshops and meetings a panel, led by Peter Lilley and consisting of Allen Kane, Kate Scott, Guy Blundell, Peter Brown, Murray Doak and Ian Lloyd reviewed the assessment process undertaken to date and stress tested the merits of various water development options. The process built on the existing information and included both validation of the current options and "blue skys brainstorming" to identify other potential options worthy of consideration. Key assumptions were stress tested to ensure resulting options were robust without being unnecessarily conservative. The various hydrological models developed during the feasibility study were used to develop a simplistic hydrological model for the whole catchment which was used to stress test various potential water development options.

This brief report documents the key findings and recommendations of the Options Validation and Refinement process.

3.0 OPTIONS CONSIDERED AND CRITERIA USED

The Prefeasibility and Feasibility studies clearly showed that storage is the critical factor in any water development in the Manuherikia and Ida valleys. Of the various potential storage sites assessed Falls Dam was concluded to be the preferred location based on; its water harvesting potential, the stage storage relationship of the reservoir, the suitability of the dam site and the expected cost per cubic metre of storage ($/m^3). This process reviewed the earlier work and confirmed Falls Dam as the preferred location but identified the existing large Ida Valley storages (Greenland, Manorburn and Poolburn reservoirs) as a potential opportunity for more efficient use of available water resources.

In parallel with this process, the MCWSG commissioned Opus to investigate potential concrete faced rockfill embankment (CFRD) options at Falls Dam as an alternative to the roller compacted concrete (RCC) embankments investigated during the feasibility study. Opus (2015) found that a CFRD embankment was expected to be significantly more cost effective than a RCC embankment.

Options considered during this process primarily adopted CRFD Falls Dam concepts (Opus, 2015). Storage integration between Falls Dam and the existing Ida Valley storages, to provide improved catchment water management, was also assessed. Variations of each option, including: increased minimum flows to reflect expected conditions post 2021, use of Clutha River water, differing water supply rates and staging options were considered.

To allow comparative benefits and issues to be defined between options some variables were given set acceptance criteria. Options that failed to meet these criteria were considered invalid. All these criteria had been subjected to robust sensitivity stress testing by the group before being locked down.

Falls Dam. The existing storage capacity, and three options for increasing storage at Falls Dam (Low +5 m, Medium +12.5 m and High +20 m raise), were considered. Options included raising the existing dam over these three levels and building a new dam for the higher two levels.

Target Reliability. Target reliability (volume supply / volume demand) criteria of at least 96% on average and at least 90% during a 1 in 10 year drought was adopted.

Peak Irrigation. Supply rates of; 5.0 mm/day for areas below Ophir, 4.25 mm/day above Ophir and 4.0 mm/day in the Ida Valley were used and are considered appropriate when coupled with water supply restrictions predicted through the optimisation modelling. These supply rates match current practice in the area and broadly mirror the work completed by Aqualinc during earlier stages of the project.

Irrigation Practice. The area irrigated is fixed for each scenario and irrigation demand is based on spray irrigation of pasture with the peak rates outlined above. It is acknowledged that this is different to current irrigation practises which include considerable flood irrigation, large areas of partial irrigation, irrigators varying the area irrigated through the season to cater for changing water availability, and irrigation of a variety of crops. By not allowing the area irrigated to vary within the season and assuming spray irrigation, a smaller well irrigated area at a higher reliability is modelled. This is required to allow comparison with other scenarios but overstates reliability for the current practice of poorly irrigating a larger area at lower reliability.

4.0 KEY FINDINGS

Key findings are provided below according to discipline, followed by brief discussion. This Options Validation and Refinement process and the key findings are supported by various technical assessments as referred to.

4.1 Dam

- Storage is the critical factor in any water development in the Manuherikia Valley and storage costs represent the major cost component (cost split approximately 60:40 between storage and distribution).
- The Falls Dam Site is the most efficient storage site available in either the Manuherikia or Ida valleys.
- For Falls Dam a CRFD embankment is likely to be a more cost effective option than an RCC embankment.
- Increasing storage at Falls Dam from the mid (40 M m^3) to high (70 M m^3) options is very cost effective from a storage point of view, with the incremental 30 M m^3 increase in storage the cheapest on a $/m^3$ basis.
- Storage development could be staged although this is expected to increases overall construction costs.

Dam construction costs (see the table in Appendix B) were estimated using a top down approach based on comparison with the Lee River Dam near Richmond (Opus (2015). The Lee River Dam is similar in size and scope to the 20 m new CRFD Falls Dam option, is well advanced in its development process with designed progressed to 80% completion and the estimated constructed costs have been subject to independent evaluation. Hawkins Infrastructure, the preferred contractor for the Ruataniwha Irrigation Dam, is currently undertaking an independent cost estimate of the CRFD embankments developed by Opus (2015). Hawkins Infrastructure's review will be reported separately but iinitial indications are that the estimated costs are not expected to change significantly.

Particularly for new embankments, the concept of constructing the dam in stages (i.e. a new mid raise CRFD embankment now and raising it later) to meet future demand is considered technically feasible. The total cost associated with staged storage development is expected to be more but staging may reduce project risk.

4.2 Distribution

- There is considerable scope to further refine and optimise the distribution network once storage size and configuration is confirmed.
- There is potential to better utilise storage by transferring water between the Manuherikia and Ida valleys.
- Distribution costs are not directly proportional to supply area. There are a number of potential step changes in costs at particular supply area sizes.

- Distribution concepts have focused on providing pressurised supply were possible. This reduces long term operational costs but induces higher capital costs.
- Staging of distribution is possible. For example temporary pumped supplies, which utilise existing infrastructure, may provide a lower capital cost alternative to minimise initial update risk.
- Cost rates used to date have been reviewed and are considered appropriate for the current concepts.

This assessment conducted a high level review of the conceptual distribution network including an assessment of options for transferring water between the Manuherikia and Ida valleys. A preliminary review was also undertaken of the feasibility distribution assessment (Golder 2015b) by Downer.

Assessment to date has focused on distribution options for the Manuherikia Valley. Storage is crucial to any water development option and the potential to better utilise storage by transferring water between the Manuherikia and Ida valleys has been identified. Until storage configuration and size, and target supply area is confirmed, it is difficult to refine distribution network design and costing.

Four options for transferring stored water between the valleys were identified:

1) Increased use of the Mt Ida Race (previously assessed in Golder 2015b and 2015c).
2) Pumping over Home Hills Saddle (assessed in Golder 2015d as part of this process).
3) A high race between the two valleys (assessed in Golder 2015d as part of this process).
4) Release of water from the Ida Valley storages into Moa Creek, Pool Burn and Ida Burn to supply parts of the Manuherikia Valley. Existing infrastructure within the Ida Valley Irrigation Scheme can achieve the above so no further investigations were undertaken other than to note that the capacity of the existing infrastructure would need to be increased to cater for extra releases.

Options 2 and 3 were investigated via a high level desktop assessment (Golder 2015d). A potential race alignment was identified that is expected to be more cost effective than pumping over Home Hills Saddle. Integration and optimisation of the overall distribution network, in particular the proposed Manuherikia Valley high race, would need to be assessed if this option was progressed further.

Suppling pressurised water has operational cost advantages with assessments to date seeking to provide this where possible. This approach comes at a higher capital cost. Subsequent stages should confirm that the lowest "all of life cost" is being achieved.

There is a "stepped" nature to distribution costs as supply area increases. Small to moderate increases in supply area could be supplied from enhanced and expanded existing distribution systems. Larger developments would however require the high race (or similar) with a corresponding cost increase. Development options should be avoided that do not fully utilise each incremental step in scheme components and costs Existing infrastructure in the Manuherikia Catchment can deliver water to about 25,000 ha although not all of the area can be irrigated concurrently and much of this area is poorly irrigated due to insufficient water supply. Within the Manuherikia Valley (assuming suitable water supply) it is expected to be possible to irrigate up to approximately 18,500 ha through expanding the existing distribution infrastructure and some pumping to areas above the races and from the Manuherikia River directly. Irrigating more than this area will require significant new distribution infrastructure namely the proposed Manuherikia Valley High Race. The proposed High Race is expensive but provides potential to supply significant areas with gravity pressurised supply. For the Falls Dam mid raise option there is likely to be a distribution solution which does not require construction of the High Race. For the Falls Dam high raise option an alternative to the proposed Manuherikia Valley High Race is likely to be some pumping up from an expanded Omakau Main Race plus construction of a large link to the Ida Valley with some secondary distribution pipes back under the Manuherikia River.

Components of the distribution system could be staged to spread development cost and risk. For example temporary pumped supplies which utilise existing infrastructure may provide a lower capital cost alternative.

The feasibility distribution assessment and cost estimates (Golder 2015b) have been reviewed by Downer. The key findings from the review (Downer, 2015) were:

> "…*there are areas where Downer can offer learnings from other projects that will result in cost savings for the Manuherikia Irrigation project. Our dilemma in presenting helpful advice at this time is that there are many options and issues still to be resolved and each of these present quite different outcomes in terms of both cost and logistics. This is solely a reflection of the current level of design completed.*
>
> *We can also confirm that supply and lay rates provided included in the Golder Irrigation Report dated June 2015 are realistic and comparable to the achieved outcomes from the recently completed Stage 1 Central Plains Project.*"
> (From Downer 2015)

4.3 Optimisation modelling

- The model provides a quick, flexible and simple means of comparing options.
- The method adopted for modelling the existing situation (refer section 3.0) overstates current reliability. This approach however is necessary to provided comparable results between scenarios.

- Renewal of the many existing deemed permits which largely expire in 2021 is expected to results in residual and/or minimum flows being imposed on the various tributaries. A review of minimum flows in the main stem of the Manuherikia River is also expected.
- Any new residual flow constraints are expected to reduce the reliability of supply to existing users. The burden of impact will be carried disproportionally across the users. Some will suffer a significant reduction in supply reliability which may threaten the viability of their irrigation. Tributary users who do not have access to stored water to supplement low summer flows are expected to be the worst affected. There will be a temporal variation in the effect of reduced supply reliability with any reductions most keenly felt during drought years.
- Storage volumes of greater than 70 Mm^3 at Falls Dam (+20m) are unnecessary**.**
- Active reservoir management could improve storage performance and soften restrictions compared to modelled results.
- For the Falls Dam raise of:
  - +5 m (low raise) linking the two valleys and transferring water has significant benefit and allows an additional approximately 3,000 ha to be irrigated.
  - +12.5 m (mid raise) maximising irrigated area without requiring significant new distribution infrastructure is expected to be the optimum scenario. Linking the two valleys and transferring water remains very useful.
  - +20 m (high raise) requires a high race in order to access the large area that can be irrigated. Under this scenario the option of a high race on the eastern side of the Manuherikia Valley (facilitating a link to Ida Valley) rather than western side (as proposed in the Prefeasibility and Feasibility studies) should be investigated. For the high raise, linking the two valleys has less benefit but does open up more area (in the Ida Valley) that could be irrigated to improve overall uptake and facilitate a more holistic approach to catchment wide water management.
- A Falls Dam live storage of 70 Mm^3 with the existing 79 Mm^3 in the Ida Valley (Manorburn, Greenland and Poolburn) when coupled with run of river water is predicted to irrigate approximately 33,000 ha at the target reliability.
- Significant extra storage is required to measurably exceed the target reliability.
- The lower Manuherikia Catchment is water rich due to upstream irrigation, tributary inflow and storage releases. Use of Clutha River water in the lower Manuherikia Valley (below Ophir) is therefore not that useful.
- Reducing peak supply rates has minimal impact on storage requirements.

A simplistic hydrological model for the whole catchment was developed from the various hydrological models developed during the feasibility study. Potential options were stress tested including; the implications of higher minimum flows as expected post 2021, increased use of Mt Ida Race, linking the two valley and use of Clutha River water. Water allocation was prioritised; to residual/environmental, then run of river irrigation then storage filling. Model flexibility allows adjustment of: storage volume, minimum flows, area irrigated and the supply rate. The model predicts storage volume, residual flow and water supply reliability.

The strength of the model is in relative comparisons rather than detailed understanding of a single option. A brief description of the model and key findings from the various scenario runs is documented in Golder 2016. The current situation and the various scenarios associated with the Falls Dam raise options were modelled. The model is considered conservative and it is expected that the preferred options will be further refined and improved during detailed design allowing extra area to be irrigated and/or improved irrigation reliability.

Storage management is excluded from the model. Restrictions are not imposed as storage gets low, only when storage is empty or there is insufficient run of river supply. Active reservoir management could improve storage performance and soften restrictions.

The replacement of the many existing deemed permits in the catchment (which largely expire in 2021) is expected to results in residual and/or minimum flows being imposed on the various tributaries and potentially on the main stem of the Manuherikia River at the Campground flow monitoring site. Such changes will reduce the supply reliability currently experienced by existing irrigators, particularly for tributaries where flow is not able to be supplemented by releases from storage. Modelling indicates that water supply reliability on a volumetric basis for the whole catchment is expected to drop by an average of 2% under the expected post 2021 conditions. For Dunstan, Lauder and Thompson creeks an average reduction of greater than 10% is expected, with significantly greater impact in dry years. A high race from Falls Dam to allow flow in theses tributaries to be supplement from storage and some extra storage at Fall Dam is required to maintain supply reliability at its current level.

Catchment integration, through linking the valleys and transferring water, (refer Section 4.2) has significant benefit particularly for smaller Falls Dam storages. Integration allows the Falls Dam reservoir, with its good inflows and refill ability, to be worked hard while the slower filling Ida Valley reservoirs are held back for periods of drought. If irrigation demand in the Manuherikia Valley and part of the Ida Valley is met by Falls Dam storage, utilisation of that storage is increased. In parallel demand on the Ida Valley reservoirs is reduced allowing them to refill quicker. In dryer periods and low Falls Dam storage the large Ida Valley storages take on the irrigation demand in Ida Valley and part of the Manuherikia Valley (i.e. unmet demand below Ophir and demand for the Blackstone Hill and Omakau Main Race irrigation schemes).

Increasing desired reliability disproportionately requires more storage. For example, at the target reliability approximately 28,300 ha can be irrigated within the Manuherikia catchment with the Falls Dam mid raise option. To achieve near 100% reliability over the same area requires the Falls Dam high raise option.

Reducing peak supply rates reduces distribution infrastructure size but has a lesser impact on storage requirements. The smaller irrigating amount is offset by more frequent use and for a longer season. Demand diversification however (i.e. different crops) is likely to reduce the storage requirements.

4.4 Production modelling

- Irrigation reliability is influenced by a combination of supply rate and certainty (i.e. the peak irrigation rate in mm/day and availability per season).
- The implication of differing water supply reliability was assessed through modelling of pasture production. Aqualinc (2016) briefly describes the key findings.
- The peak supply rates and supply reliability adopted in this process will result in annual production losses due to water stress of 2-3% on average and 10-15% during a 1 in 10 year drought. These losses are considered acceptable and are comparable to other irrigations schemes currently being developed. The supply rate component of the production losses is ~1% on average and ~5% during a 1 in 10 year drought. The water supply reliability component is ~1-2% on average and ~5-10% during a 1 in 10 year drought.
- For non-irrigated dryland conditions annual production losses are ~75% on average and ~90% during a 1 in 10 year drought

When peak irrigation supply rates are less than peak evapotranspiration demand, soil moisture levels fall which results in potential production losses. It is cost prohibitive to design irrigation systems for peak evapotranspiration demand as the excess capacity is unused for most of the season. It is normal therefore to design for a portion of deficit during periods of peak demand.

4.5 Economics

- The predicted production losses (compared to 100% reliability) are unlikely to affect overall on-farm economics.
- The significant increase in storage required to provide even modest increased reliability is difficult to justify on economic grounds.
- On-farm economic viability is currently being assessed and will be reported separately.
- Targeted use of existing distribution infrastructure, possible staging options and interim configurations should result in reduction in distribution costs.

- To allow full assessment of the estimated project costs for the various water development options a standard cost estimation methodology is required for both the dam and the distribution parts of the project.
- Overall project viability should be assessed on an "all of life" basis for both costs and benefits.

It is expected that the production losses that occur from less than 100% reliability will be able to be farmed around through adoption of appropriate farm management strategies. Moving from the target reliability to full volumetric supply reliability during a 1 in 10 year drought requires significantly more storage. The slight increase in production (~1-2% on average and ~5-10% in a 1 in 10 year drought) that results from the improved water supply reliability is unlikely to justify the cost of the increased storage.

The reassessment of storage options and costs (Opus 2015) has reduced estimated storage costs. The same process can be undertaken on distribution infrastructure once storage size and configuration is more narrowly defined. There is expected to be considerable opportunity to reconfigure, refine and stage the distribution network to reduce costs.

4.6 Environmental

- While this process was not specifically tasked with reassessing community and environmental drivers the resulting options are not inconsistent with the scope and scale of previous work.
- Larger storage volumes and the larger development options provide more opportunity to increase residual flows and provide increased environmental flows (i.e. minimum flows, flushing flows etc.) throughout the catchment.
- Some of the options assessed provide greater development flexibility. This may help achieve wider community and environmental goals.

This Options Validation and Refinement process has focused on identifying preferred water development options that are affordable to the community. Without an affordable option it is unlikely that significant water development will occur and current environmental conditions throughout the catchment are unlikely to change significantly. As such this Options Validation and Refinement process has not focused directly on environmental considerations other than potential flow regimes and their impact on the storage required for the various development options. This is at least in part due to the fact that the options have not deviated measurably away from the previous scope and scale of options assessed.

4.7 Summary

A table summarising the key attributes of the various water development options that were assessed and the pros / cons for each is attached in Appendix A.

5.0 RECOMMENDATIONS

The following eleven recommendations have been identified:

1) Larger storage options (high raise) at the Falls Dam should be advanced as the preferred development as this site is the most cost effective storage location for both valleys. Larger storages at Falls Dam (i.e. the high raise rather than the mid raise) provide the cheapest storage on a $/m^3 basis.

2) Options larger than 70 Mm^3 of live storage at Falls Dam are not recommended as they cannot be justified on economic grounds.

3) Staging storage development while technically feasible should not be advanced unless uncertainty around demand uptake cannot be adequately addressed.

4) Development options should be based on the following irrigation regime that provides good reliability performance comparable to other modern irrigation schemes:

   i) Peak irrigation supply rates of 5.0 mm/day for areas below Ophir, 4.25 mm/day above Ophir and 4.0 mm/day in the Ida Valley.

   ii) A supply reliability on a volumetric basis (i.e. volume supplied / volume demanded) of at least 96% during an average year and at least 90% during a 1 in 10 year drought.

5) The benefits and reservations around linking the two valleys (Manuherikia and Ida) and transferring water should be assessed further.

6) Using the Clutha River to supplement water supply to the Manuherikia or Galloway irrigation schemes is unlikely to be beneficial and should not be considered further.

7) Once decisions on storage size and configuration are made the distribution network should be subjected to a similar options and verification process. This can be done in parallel with advancing other work streams.

8) Any scheme developed should aim to improve the current poor water supply reliability and ensure that irrigators do not have to use the current practice of reducing the irrigated area during the season to handle poor water supply reliability.

9) Scheme viability is ultimately a function of uptake and wider community acceptance and value. It is recommended that further end user and community engagement be undertaken to refine option configuration.

10) A standardised cost and economic viability methodology should be adopted to allow optimisation to progress. Disparate methods make comparative optimisation challenging and risks ill-informed decision making.

11) Presentation of the costs on a per ha basis should be produced in association with an economic funding model.

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APPENDIX A
Potential Development Options - Summary Table

Manuherikia Catchment Potential Development Options - Summary Table

Scheme Options(1)	Link to Ida Valley Y/N	Falls Dam Storage (2)		Area Irrigated (3) (ha)				Supply reliability (3)	Distribution comment (4)	Pros	Cons
		(Mm³)	Capital cost (M$)	Above Ophir	Below Ophir	Ida Valley	Total				
Existing	N	9.5	2	9000	2720	6000	17720	96.3	Maintenance of current network required.	Lowest capital cost option. Environment conditions remain unchanged no new inundation.	Poor irrigation reliability remains and potentially decreases in tributaries due to increased minimum flows. Some areas of existing irrigation in tributaries may become unviable. Very limited potential to supplement flows.
Current Storage	N	9.5	2	7500	4500	6500	18500	95.2	Above plus expansion in lower valley (MIS and GIS) with some piping.	Low capital cost option. Environment conditions remain unchanged no new inundation. Improved irrigation efficiency leads to expansion in lower Manuherikia Valley. Improved reliably of supply above Ophir but to smaller irrigated area.	Poor irrigation reliability remains particularly above Ophir and potentially decreases in tributaries due to increased minimum flows. Some areas of existing irrigation in tributaries may become unviable. Reduction in area irrigated above Ophir. Very limited potential to supplement flows.
	Y			8500	4500	7500	20500	95.4	Above plus new link to Ida Valley which creates potential to provide pressurised supply to BIS and part of IVIS.	As above but with potential to improve irrigation efficiency in BIS and IVIS. Allows small increase in irrigated area.	As above plus: Requires full catchment cooperation.
Low (+5m) Raise	N	18	25	11200	4500	6500	22200	95.5	As per line 2 plus new irrigation in Greenfields and Downs areas and potential small expansion in BIS and/or OIS main race.	Modest capital cost option. Environment conditions remain similar with some potential to supplement flows. Improved irrigation efficiency leads to expansion in lower Manuherikia Valley. Improved reliably of supply above Ophir. Allows small increase in irrigated area	As per line 2 plus: Highest cost/m³ storage, as significantly underutilising potential at Falls Dam. Some new inundation at Falls Dam Limited potential to provide pressurised water.
	Y			11500	4500	7500	23500	95.5	As per line 3 plus new irrigation in Greenfields and Downs areas and potential expansion in BIS, OIS main race and IVIS.	As above but with potential to improve irrigation efficiency in BIS and IVIS. Allows larger increase in irrigated area and significantly larger command area increasing potential uptake.	As above but with slightly higher capital cost. Requires full catchment cooperation.
Mid (+12.5m) Raise	Y	40	58	16300	4500	8600	29400	95.7	Above plus expansion of OIS main race, leading to increased expansion potential there. Potential to expand the irrigation area between Dunstan & Lauder creeks.	Mid to high capital cost option. Modest potential to supplement flows. Large increase in irrigation efficiency, irrigated area and supply reliability.	Modest cost/m³ storage as underutilising potential at Falls Dam. Limited potential to provide pressurised water. Requires full catchment cooperation.
High (+20m) Raise	N	70	68	21000	4500	7500	33000	97.2	As per line 4 plus expansion of OIS main race and BIS race. New high race to Matakanui	Maximises potential irrigation development in the catchment. All irrigation reliable. Lowest cost/m³ storage as utilising potential at Falls	Highest capital cost option. Requires significant uptake in Manuherikia Valley.

									Station boundary with significant new irrigation in Manuherikia Valley above Ophir.	Dam. Significant potential to supplement flows in the Manuherikia River and many tributaries.	Requires significant new distribution infrastructure. Significant inundation above Falls Dam. Potentially excessive supply reliability, suggesting slightly oversized storage at Falls Dam.
	Y			21000	4500	8000	33500	97.1	As per line 6 plus pumping up from OIS main race. Distribution back under Manuherikia River from link race to Ida Valley to supply the Downs, Dunstan and Lauder areas – No new high race.	As above but with slightly larger irrigated area and significantly larger command area increasing potential uptake. Provides a full catchment option.	As above plus: Slightly higher capital cost. Reduced potential to supplement flows in western tributaries. Requires full catchment cooperation

Notes:

(1) Scheme Option descriptions predominantly based on changes in full supply level of the Falls Dam reservoir.

(2) Falls Dam storage volumes and estimated capital costs (conservative outrun estimates rounded to nearest $1 M where appropriate) from Opus 2015. The capital cost estimates for the Existing and Current Storage options are for maintenance of the current structure. For the Low raise option the capital cost estimates are for raising the current CRFD embankment. For the Mid and High raise options the capital cost estimates represent new CRFD embankments downstream of the current embankment. Costs estimates are for Falls Dam only and no allowance for maintenance or upgrading of the Ida Valley storages is included.

(3) Area Irrigated and Supply Reliability (calculated on a volumetric basis for the total area irrigated i.e. volume supply / volume demand) are derived from a simplistic hydrological model for the catchment and represents full spray irrigation of pasture. It is acknowledged that this is different to current irrigation practises which include considerable flood irrigation, large areas of partial irrigation, irrigators varying the area irrigated through the season to cater for changing water availability, and irrigation of a variety of crops. The model significantly overstates reliability for the current practice of poorly irrigating a larger area at lower reliability.

(4) For distribution cost estimates and explanation of the irrigated areas and the abbreviations used the reader is referred to the feasibility distribution assessment (Golder 2015b).