# REPORT

**HAWKES BAY REGIONAL COUNCIL**

**Prefeasibility Study of Water Augmentation Opportunities - Ruataniwha Plains**

**Report prepared for:**

HAWKES BAY REGIONAL COUNCIL

**Report prepared by:**

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# Executive Summary

Irrigation on the Ruatanihwa Plains, in Central Hawke's Bay, is essential for annual security of pasture and crop production. The Plains average annual rainfall is 800 mm increasing to 1000 mm as you move from east to west, and the one in five year drought January rainfall ranges between 20 – 30 mm. However, more detailed analyses show there is considerable annual variation. Comparisons of averages also show the occurrence of drier and wetter periods on a decadal basis. This variation is forecasted to increase as a result of climate change. The Ruataniwha Plains is also dominated by shallow, free draining soils with low available water capacity (25 – 50 mm) which are therefore, very drought prone.

Water use and allocation is one of the greatest pressures and challenges facing water management on the Ruataniwha Plains. Three consecutive years of drought has seen increased interest in irrigation, with the high capital value of land neccessitating surety of production. However, the Plain's run-of-river surface water resources are fully allocated and the further allocation of shallow ground water has been put on hold until its relationship with surface water is better understood. Due to the complexity of this relationship, the scientific investigations and associated Regional Plan changes are expected to take a minimum of 5 years. In addition, the relationship between deep groundwater and surface water is not fully understood and so further allocation of deep ground water now requires a comprehensive Assessment of Environmental Effects. For these reasons, alternative water management options need investigating - the feasibility of a community water storage scheme being one of these.

Including rolling hill country, there are approximately 40,000 hectares of irrigable land within the Ruataniwha Plains, of which only about 5,000 hectares are currently consented for irrigation. The assessed foreseeable irrigation demand totals 22,500 hectares distributed over 4 geographical zones delineated by the main rivers of the Plains.

Large water storage dams on the main rivers have specifically been excluded because of anticipated significant environmental issues, such as fisheries protection and gravel transport and reservoir sediment in-fill. Therefore, identification of water storage opportunities has focussed on multiple dam sites located off-river or on minor tributaries.

An irrigation demand of 3,500 $m^3$ per hectare in a 1 in 10 dry year is considered an appropriately conservative area average demand for the Ruataniwha Plains. On this basis, a gross water storage requirement of 4,000 $m^3$/ha has been adopted for assessment of storage potential and arrangements, this larger figure allowing for dead storage to cover long term sediment infill in reservoirs and potential system losses and inefficiencies.

Following a map-based scoping exercise a shortlist of 14 sites were selected for further exploration. Limited field investigations have now resulted in 6 storage dams being identified with potential to service the full demand across the 4 zones. A scheme with fewer but larger dams was precluded by topographical constraints, and in any case, would be disadvantaged by the necessity to distribute water over such a large service area.

For 5 of the 6 storage dams, the local runoff provides on average only a small proportion of the storage infill, and water harvesting is required from principal rivers. This would be achieved using either gravity or pumped river intakes. Storage refill assumes winter-only flow harvesting from April to October when flows are naturally higher, with an appropriate environmental flow retained in the river for protection of in-stream values. Potential summer capture from any high river flows has conservatively been ignored.

It should be noted that when the scheme is fully developed, the average volume of surface water abstracted on an annual basis would be equivalent to less than 6% of the river flows leaving the Ruataniwha Plains.

One storage dam, located on the upper reaches of the Waipawa catchment (A1), borders on forest park land, but is outside of the protected tree area. The others are all located on farm land. Storage dam A1 can potentially be enlarged to enhance summer low flows in the Waipawa and lower Tukituki Rivers.

Preliminary estimates indicate the cost of a sustainable development being between about $5,250 and $6,000 per hectare irrigated excluding distribution, storage infill pumping charges and on-farm costs. Depending on arrangements, a distribution system to the farm gate plus requisite pumping stations would add roughly between $2,100 and $3,400 per hectare; the latter figure is for a fully piped system while the former for a delivery system comprised mainly of open races with piped pumping systems to service higher elevation areas. These capital cost estimates include a contingency allowance (5% or 20%), plus typical allowances for contractor establishment and administration and engineering.

Apart from site A1, direct environmental impacts from the storage dams are not considered significant, although detailed assessments of the native fisheries will be required to confirm this. For site A1, the benefits of river flow augmentation opportunities, contingent on extra storage being provided, may outweigh the loss of habitat, but this needs more detailed assessment. Indirect impacts of the development, particularly in relation to water quality, may be mitigated through implementation of on-farm best management practices related to accountable, monitored performance standards, but again this concept needs further exploration.

The storage dams create significant potential for increased recreational opportunities for the local community, either upon the reservoirs themselves or through the augmentation of summer river flows.

Irrigation of the Ruataniwha Plains would provide significant opportunity for increasing productivity and income to both individual landowners and the local and regional economy. Landowners would also benefit from a significant increase in asset values.

Feasibility level investigations, including water resource studies, geotechnical site investigations, engineering design, environmental and cultural assessments, economic/governance studies, and community and stakeholder consultation are recommended to confirm feasibility of the proposed scheme.

# 1 Introduction

This report presents the results of a prefeasibility study for water augmentation opportunities on the Ruataniwha Plains in Central Hawkes Bay, focussed on surface water harvesting and ability to service, in round terms, up to 40,000 hectares gross of irrigable land. The study has been carried out for Hawkes bay Regional Council (HBRC) by Tonkin & Taylor Limited, Environmental and Engineering Consultants in association with locally based agricultural and horticultural consultants, AgFirst NZ Limited.

Principal requirements of HBRC's study brief were:

- scoping out of potential water storage sites appearing to produce cost effective storages and their related viability for integration into a community based irrigation scheme or schemes
- undertaking rough order costing and benefit analysis of potential schemes and their qualitative environmental and economic effects
- utilising readily available data of relevance including that held by HBRC, and liaising with HBRC's Project Team in considering options and issues

The prefeasibility or scoping level study has essentially been at desk level with limited site inspection, given the funding available. Nonetheless, by application of a systematic process, quality of data available and HBRC support, what appear to be the most cost effective possibilities have been identified, servicing up to 22,500 hectares nett.

Following this Introduction, the report is structured as follows:

Section 2 - **Irrigation Areas and Water Demand**

which describes areas perceived as having highest potential or demand and volumes required for irrigation

Section 3 - **Storage Identification**

which outlines storage opportunities identified and the selection process

Section 4 - **Water Availability**

which describes water sources and capture of water to fill storages

Section 5 - **Geological Aspects**

which describes key geological aspects impacting on dam structures and storage selection

Section 6 - **Potential Scheme and Components**

which describes a comprehensive community based scheme outcome and its components

Section 7 - **Scheme Costs**

which outlines the preliminary level scheme costing

Section 8 - **On-Farm Economics and Benefits**

which summarises on-farm costs, the increased production deriving from irrigation and potential returns

Section 9 - **Environmental and Recreational Aspects**

which provides a qualitative cover view of environmental issues and recreational aspects associated with development

Section 10 - **Further Studies**

which summaries the scope of feasibility studies to confirm the nature and viability of a scheme or schemes

Section 11 - **Conclusions**

Section 12 - **Applicability**

# 2 Irrigation Areas and Water Demand

The Ruataniwha Plains and lower level rolling country at the head of the Plains cover, in round terms, some 400 km $^2$ (40,000 hectares) gross of land with irrigation potential as assessed by HBRC. Of this gross area, some 5000 hectares is already irrigated, principally by pumping from groundwater sources. This area has been subdivided into four principal zones labelled A, B, C and D as shown on Figure 2.1. This zoning has been adopted for the present study, based largely on adopting main rivers as zone boundaries and in recognition of the need for distributed storages, as described in Section 3.

In consultation with HBRC and with input from the HBRC Project Team, the estimated foreseeable irrigation demand in each zone has been rounded to the following:

- Zone A - 5000 hectares nett
- Zone B - 5000 hectares nett
- Zone C - potentially 7500 hectares nett
- Zone D - 5000 hectares nett

These areas, totalling 22,500 hectares, are taken as nett areas which could be irrigated. Typically the nett area is about 70% of gross, after allowing for road and other reserves, non-agricultural landuse, riparian margins and areas on-farm not able to be irrigated practically. Thus some 32,000 hectares gross land area, or 80% of the estimated gross potential, has been adopted for the study.

Most of this total is located on relatively flat land below the rolling hills where storage reservoirs would be sited, as described in subsequent sections. There may be irrigation demand on rolling country at higher elevations which can be considered in later more detailed studies, based on stakeholder input.

The irrigation water demand will vary depending on rainfall, soil type and the type of production. Storage requirements depend on all these factors plus the level of drought reliability selected. HBRC has commissioned and independently undertaken preliminary studies for the area. For example, using HortResearch's SPASMO model, which has been tested thoroughly (including in the Environment Court), HBRC has shown that for pasture the 90$^{th}$ percentile dry year demand (equivalent to 10 year drought conditions) ranges from about 2,300 m$^3$/ha to about 3900 m$^3$/ha depending on soil type and reference climate station, the former for Poporangi sandy loam (Makeretu) the latter for Takapau sandy loam (Ongaonga).

In consultation with HBRC, a drought year irrigation demand of 3500 m$^3$ per hectare irrigated has been adopted for the current study as a conservative areal average over the Ruataniwha plains. Recognising that the present study is essentially at scoping level, a gross storage requirement of 4000 m$^3$/ha has been adopted for assessment of storage potential and arrangements, the larger figure allowing for dead storage (to cover long term sediment infill) and potential system losses.

Clearly, there are several simplifying assumptions implicit in this estimate, notably future land use mix and distribution, irrigation management practices, irrigation efficiency (losses), and level of drought security. These parameters will need to be critically reviewed and the water demand confirmed as a matter of priority in subsequent studies.

Given that existing surface water resources (rivers) are already fully exploited in dry conditions and at present there are uncertainties about the potential for future groundwater abstraction, it is assumed that all of the irrigation supply is from reservoirs able to be kept at full supply level at the start of the 90 percentile design drought. On this basis, some 90 million cubic metres of reservoir storage would be required to assure irrigation of the 22,500 hectares nett via potential developments involving water harvesting and storage.

It is noted that this approach is inherently conservative because it effectively ignores any freshes or floods captured to storage during the irrigation season, although, some of this flow may have to be released as riparian maintenance flow during periods when the natural inflow to storage is less than the minimum residual flow. With more detailed hydrological modelling studies (proposed for subsequent feasibility), there will be scope to reduce storage requirements, particularly for Storage A1, which has relatively large inflow compared with the other storages.

As outlined later, some of the distribution arrangements to take stored water to the farm gate could enhance river flow, but otherwise any enhancement of low flows in streams or rivers, either for environmental reasons or for summer groundwater recharge, would require additional storage. One such storage case has been considered in the upper reaches of the Makaroro catchment, i.e. Storage A1 as described later.

# 3 Storage Identification

It was agreed at the outset that on-river storage dams (particularly large dams) on any of the main rivers, would not be considered because of environmental impact and difficulty in consenting, issues associated with the substantial gravel bedload from the ranges which would be trapped in the reservoir, and to a degree, distribution of water from one or more large dams over such a large service area. The tributary rivers in the ranges are in narrow valleys which generally do not enable cost-effective storages of suitable size, also have the gravel bedload problem, and are sited in the Ruahine Forest Park. Smaller scale storages on individual farms are possible, but they are typically much more expensive per unit of storage volume than larger shared dam storages and are not considered viable elements of a community scheme unless there is no better alternative.

The rolling foothills have valleys which enable larger scale, substantially "off-river" storages within each irrigation zone. These storages have the potential for filling from adjacent rivers, taking water from them in winter months when flows are elevated and there is relatively little demand on water resources. This kind of storage and infill arrangement has therefore been adopted in identifying potential storages. For the purposes of this concept level study, given that the storage catchments have low erosion potential, no specific dead storage has been included for sediment accumulation (other than in rounding up the total volume per hectare irrigated assumed) and no extra storage for riparian flow enhancement has been added. Storage identification has been carried out as follows:

i. an initial desk assessment of storage possibilities with a minimum storage volume of 4 million $m^3$ (some 30 sites identified)

ii. undertaking a preliminary shortlisting of possibilities, discarding those whose location/size were least favourable compared with others, or where storage infill looked to be difficult or relatively costly, or where it was judged that their storage to cost ratio would not be competitive (14 shortlisted)

iii. again at desk level without site inspection, reliance on the only available contour data (LINZ 20 m contours on 1:50,000 maps, but with preliminary hydrological analysis as described in Section 4), undertaking rough order assessment of storage potential, and headworks–only development costs for the 14 shortlisted sites, and in the process discarding 2 sites

iv. reporting these results to HBRC's Project Team (Stage 1 report) and undertaking a two day inspection of the 12 sites with Team members, where limited geological and topographical appreciation was made

v. Project Team consideration of the possible sites and receipt of their advice to base more detailed studies on five storages able to service the four zones - factors taken into account by the Team included impact on valuable farmland of some of the options

vi. as an initial stage of the more detailed studies, geological (satellite imagery) examination of sites, with two, where some land stability concerns had been noted during the field visit, found to have reservoir margin features indicative of past large scale land-sliding; this finding leading to deleting these two possibilities on a precautionary basis, and substituting three others – three being needed because of their lower maximum capacities compared with the two deleted.

Figure 2.1 shows the locations of the 14 shortlisted storage options. Appendix A provides a plan of the conceptual arrangement for each option on a 1:50,000 scale topomap base. The five options initially selected from these for more detailed consideration were A1, B1/B2 combined, C1, C2 and D2 (plus D1 if capacity of D2 insufficient).

As noted earlier, two of these options, B1/B2 and C1, were discarded and 3 others brought in viz. A5, B3 and D1. Figure 3.1 shows the final six storages adopted for an integrated overall scheme: A1, A5, B3, C2, D1 and D2. Table 3.1 below summarises key statistics and provides an indication of supply capability of each storage. A more detailed description of storage and refill arrangements, and the supply/delivery concept for each irrigation zone is provided later in Section 6.

**Table 3.1 Summary of Storages Adopted for this Prefeasibility Study**

| Storage | Storage capacity (million $m^3$) | Approximate full supply level (m RL) | Approximate dam height (m) | Indicative service area (Ha) | Proportion of Each Irrigation Zone Serviced |
|---|---|---|---|---|---|
| A1 | 20 | 508 | 70 | 5000 | 20% of Zone A plus 75% of Zone B |
| [1] A1 | 30 | 515 | 77 | 5000+ flow augmentation | 20% of Zone A plus 75% of Zone B |
| A5 | 16 | 240 | 31 | 4000 | 80% of Zone A |
| B3 | 22 | 258 | 29 | 5500 | 25% of Zone B plus 57% of Zone C |
| C2 | 13 | 304 | 36 | 3250 | 43% of Zone C |
| D1 | 6 | 282 | 25 | 1500 | 30% of Zone D |
| D2 | 14 | 273 | 28 | 3500 | 70% of Zone D |

Note: [1] This is an enlarged version of Storage A1, which includes an additional 10 million $m^3$ of storage able to be released to enhance summer riparian low flows.

# 4 Water Availability

Water for irrigation to supplement direct rainfall, can be sourced from whatever river flow as may be available in summer conditions and groundwater via wells. Where these two sources are lacking, irrigation supply has to be harvested from winter flows and stored. Local rivers have little or no water able to be allocated to direct abstraction in dry conditions. Groundwater has been thought to be plentiful in parts of the Ruataniwha Plains, particularly in Zone A area, but more recent studies by HBRC have questioned the extent of the resource.

Ongoing studies by HBRC aim to understand the complex groundwater resource and its recharge, but there is a possibility that some recharge could be achieved by releasing harvested storage into the upstream reaches of the Waipawa River. The present study is based on water harvesting of winter flows, but it is noted that some of the harvested storage released from Storage A1 might go into Waipawa River groundwater recharge and enable new areas to be serviced by groundwater wells, potentially reducing distribution costs. This aspect can be assessed in feasibility studies with upgraded groundwater system knowledge.

As this study is restricted to water harvesting, the key issue is how and whether potential storages can be supplied with their required volumes. Complete evaluation of this question requires detailed understanding of catchment hydrology, flow regimes required to protect in-stream values and modelling to take into account aspects such as the effect of back-to-back droughts and related security of supply.

At this stage, simplified assumptions have been needed to reach what are judged to be reasonable estimates of water availability and the capacity of river intakes/pumpstations and transfer races or canals. Prior to outlining the assumptions/approach for reservoir infill analysis, it is noted that full development of 22,500 hectares nett of irrigated land would on average, use less than 6% of the mean river flow otherwise exiting the Ruataniwha basin below the irrigated areas (950 million $m^3$ per annum), assuming a 20% return flow from irrigation.

Sizing of river intake/pumping capacity has been based on the following assumptions:

- yield from the storage dam's local catchment inflow computed as the estimated mean runoff less the assessed 7-day mean annual low flow (MALF), the latter to provide for a nominal riparian flow, noting that many local streams appear to be substantially ephemeral in dry summers with low in-stream values
- infill of storage from rivers based on abstraction confined to the six winter months (April to October) and maintaining at least the MALF in the river, a figure corresponding generally with that which has been accepted elsewhere as the appropriate minimum flow for protection of in-stream values (abstraction from high summer flows when they occur, has currently been ignored).

The process for assessing these two contributions has involved:

- sizing local catchment areas and estimating mean runoff based on rainfall isohyets, and comparing this estimate with available flow records/catchment areas, including mean flow values provided on NIWA's Water Resource Explorer (WRENZ) database

- for river intake sites, developing estimated winter flow duration characteristics via relevant flow records for nearby catchments and proportioning on a catchment area basis
- where adjacent proposed storages involve multiple takes from the same river, allowing for the combined take from the river, and ensuring that an appropriate residual flow is retained below each intake
- estimating the MALF by applying ratios of MALF to mean flow from relevant flow records for nearby catchments.

Table 4.1 summarises estimated hydrological parameters for the proposed dam storages and river intake sites. Table 4.2 summarises local catchment water availability and harvesting take requirements for the proposed dam storages.

**Table 4.1 Hydrological parameters for local storage dam and harvested catchments**

| | LOCAL DAM CATCHMENT HYDROLOGY | | | | | RIVER INTAKE CATCHMENT HYDROLOGY | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Storage Option** | **Approximate storage capacity** | **Catchment area** | **Mean annual rainfall** | **Estimated mean flow** | **Estimated MALF** | **River harvested** | **Catchment area above intake** | **Estimated mean flow** | **Estimated mean winter flow** | **Estimated MALF** |
| | **million $m^3$** | **$km^2$** | **mm** | **$m^3/s$** | **$m^3/s$** | | **$km^2$** | **$m^3/s$** | **$m^3/s$** | **$m^3/s$** |
| A1 | 20 | 20.1 | 1750 | 0.67 | 0.10 | Makaroro | 71.6 | 2.2 | 2.87 | 0.41 |
| A1 | 30 | 20.1 | 1750 | 0.67 | 0.10 | Makaroro | 71.6 | 2.2 | 2.87 | 0.41 |
| A5 | 16 | 7.9 | 1000 | 0.08 | 0.01 | Mangaonuku | 197.2 | 2.9 | 3.78 | 0.55 |
| B3 | 22 | 9.4 | 1050 | 0.10 | 0.02 | Tukituki | 109.6 | 3.5 | 4.37 | 0.36 |
| C2 | 13 | 11.1 | 1050 | 0.09 | 0.01 | Tukipo | 103.4 | 3.4 | 4.58 | 0.32 |
| | | | | | | Tangarewai | 25.6 | 0.62 | 0.84 | 0.06 |
| D1 / D2 | 20 | 10.9 | 1050 | 0.10 | 0.02 | Makaretu | 44.5 | 1.3 | 1.62 | 0.13 |
| | | | | | | Manawatu | 47.6 | 1.3 | 1.62 | 0.13 |

### Table 4.2 Water availability from local and harvested catchments, and peak and average takes

| | LOCAL CATCHMENT WATER AVAILABILITY | | | FLOW HARVESTING FROM RIVER INTAKE | | | |
|---|---|---|---|---|---|---|---|
| **Storage options** | **Approximate capacity storage** | **Catchment area** | **Runoff available for storage** | **Harvested catchment** | **Catchment area above intake** | **Maximum take** | **Average winter pump rate** |
| | **million $m^3$** | **$km^2$** | **million $m^3$** | | **$km^2$** | **$m^3/s$** | **$m^3/s$** |
| A1 | 20 | 20.1 | 17.94 | Makaroro | 71.6 | 0.19 | minor |
| A1 | 30 | 20.1 | 17.94 | Makaroro | 71.6 | 0.97 | 0.39 |
| A5 | 15 | 7.9 | 2.01 | Mangaonuku | 197.2 | 1.05 | 0.74 |
| B3 | 22 | 9.4 | 2.80 | Tukituki | 109.6 | 1.39 (gravity) | n/a |
| C2 | 13 | 11.1 | 2.36 | Tukipo | 103.4 | 0.50 (gravity) | n/a |
| | | | | Tangarewai | 25.6 | 0.37 | 0.22 |
| D1 / D2 | 20 | 10.9 | 2.78 | Makaretu | 44.5 | 0.84 | 0.84 |
| | | | | Manawatu | 47.6 | 0.32 | 0.05 |

# 5 Geological Aspects

The geology of the study area has a strong influence on storage dam feasibility and costs and to a lesser degree arrangements and costs of open canals/races used for water conveyance. The present study has not extended to geological mapping of sites or included any subsurface investigation, but has been limited to review of published geological maps, satellite imagery examination and observations of exposures during the site visit tour. Reference has also been made to some gradation testing of local "red metal" for a proposed farm dam in the district, ex T&T files.

Virtually all damsites of interest lie in valleys eroded into dense silty, sandy gravel deposits, locally referred to as "red metals". Where the local road crosses the A1 site valley a few hundred metres downstream of the damsite, mudstone (papa) is exposed below the red metal sequence. Valley floors vary from relatively flat to moderately sloping and may be the result of erosion only, or may have eroded in the past below present ground level and have been infilled by alluvial deposits derived from erosion of the valley slopes upstream. Generally only a thin surficial cover of fine grained soil the order of 0.5 m to 1 m thick covers the red metals, principally derived from windblown loess.

The relatively flat land of the Plains comprises alluvial deposits of varying material types with near surface deposits tending to be coarser grained to the north and finer grained to the south. From an engineering perspective, the principal issue is potential for leakage from open channels and the need for lining to prevent leakage. There have been open stockwater races in the Plains in the past, now replaced, but there is no reliable knowledge of their performance.

Examination of satellite imagery indicates past relatively small scale instability near damsites or on reservoir margins not adversely impacting on dam feasibility. However, as already referred to, substantial past landsliding is evident at two of the initially preferred sites. Here there are strong reservoir edge lineations and graben type features indicating large scale ancient land movement. The study area is in a seismic zone where strong shaking can occur, influenced primarily by the Mohaka fault which runs near the edge of the ranges to the west of the Ruataniwha Plains.

It is inferred that severe shaking at some time in the past has affected a band running NE through part of the foothills and caused the features referred to. Such sliding of materials overlying papa where there is a weak interface, occurs throughout Hawkes Bay. While these features might be shown to have acceptably low risk of future movement affecting the two storages (e.g. landsliding which causes stored water to be pushed over the dam which may lead to a collapse), at this stage it has been judged prudent to substitute other storages as described in Section 3.

Available mapping indicates that the A1 site and reservoir area are bounded by geologically active faults, and an active fault with a relatively short mapped length may run through the smallest reservoir, D1. Special measures may be needed at these two sites to achieve safe dams. Confirmation of seismic risk and such measures, and if necessary, modifying storage capacity and site location, will need close attention in future studies.

In broad terms, the geology of the damsites and the size of potential earthquake shaking, are similar to conditions at a dam designed a few years ago by the authors to modern standards and successfully commissioned (Delta Dam near Blenheim and the active

Wairau fault). Valley floor conditions are uncertain at the Ruataniwha damsites, but none is swampy and indications are that no substantial foundation strength or seepage control issues will occur. There is restricted availability of fine grained soils for a dam core zone, and blending of loess and gravels is anticipated as included in the Blenheim dam example. Races may need to be lined to restrict loss of valuable water.

# 6 Potential Scheme and Components

## 6.1 Introduction

What appear to be the most cost effective community based storage schemes servicing the bulk of the Ruataniwha Plains have been identified at a preliminary or conceptual level. The number of storages has been minimised to gain the benefits of economies of scale and reduce impacts. However, there are other storage possibilities, which at similar or higher costs, could enable smaller scale community schemes, and if found necessary, replace a shortlisted storage found not to be sustainable during feasibility studies. When groundwater resources are better understood, including potential to recharge areas in summer months from upland storage, further scheme variations integrating surface and groundwater may be achievable.

While this study has essentially identified six storage supply systems servicing the four adopted irrigation zones, the strategy of minimising storage dams means that water stored in Zone B is distributed into Zone C and the upland storage originally allocated to Zone A, services part of Zone B. The upland A1 storage services both Zones A and B. The linkage between storages and supply zones is summarised in Table 3.1, and is repeated below:

- Zone A: approximately 20% supply from Storage A1 and 80% from Storage A5
- Zone B: approximately 75% supply from Storage A1 and 25% from Storage B3
- Zone C: approximately 43% supply from Storage B3 and 57% from Storage C2
- Zone D: approximately 30% supply from Storage D1 and 70% from Storage D2.

If each zone were to be developed separately, whether geographically or to a development programme, some amendment to storage arrangements would be required.

Storage A1 in the upper Waipawa catchment has been favoured not only for its apparent cost being competitive with other sites, but for its potential to be increased in size, should augmentation in summer river flows for environmental enhancement be integrated into future development.

The following subsections outline distribution assumptions, then the features of the storage supply systems servicing Zones A to D, as already introduced.

Figure 3.1 provides an overall plan of supply arrangements together with an indicative schematic plan of a possible supply distribution system (see next section), including intakes on the Waipawa River to pick up water released from the A1 storage dam, which is located well above the service areas.

## 6.2 Distribution

Distribution from the storages to the "farm gate" could in principle be via open races to areas below the dams and be delivered to higher elevations by pumping through pipelines. Alternatively, a fully piped system could be utilised. The latter usually is more expensive unless high pressure in the pipeline can be used to avoid or minimise on-farm pumping. Pipelines can be buried, substantially be located in road reserves and are much less sensitive to fluctuations in ground levels. They also enable more effective management of varying demand, avoidance of waste and, if well constructed and maintained, lower losses from leakage.

Design of an appropriate distribution system is dependent on many factors, including detailed knowledge of farm location and demand and for open races, willingness of landowners to have these cross their properties. The principal objective for this study is to make an indicative estimate of distribution costs to include in preliminary cost benefit assessment. A piped system with pipes mainly located in roads has been assessed to provide an upper limit indicative cost for distribution. The cost effect of adopting open races on flat land below reservoirs has also been considered.

Pipe sizing for cost estimation purposes and pumpstations included in the system are based on the following:

- all areas under irrigation simultaneously able to take peak irrigation demand at lowest reservoir level
- minimal pressure at the farm gates and separate pumping on-farm.

In the case of a piped system, pressures in pipelines will be higher when reservoir levels are high, offsetting pumping demand for distribution to areas above minimum drawoff levels in reservoirs (e.g. ex Storages A5, B3, C2 and D1) and provide extra on-farm pressure for areas located below reservoir level. Where a piped system is adopted for a confirmed development, it may be more cost effective to have all pumping located at the dam (or river intake), the system then being similar to the Downlands Scheme in North Otago.

## 6.3 Zone A system

Servicing of Zone A is based on Storage A5 located east of Tikokino and Mangaonoku Stream , which would supply some 80% of the 5000 hectare nominal demand area, with the balance of the area serviced by flow released into the Waipawa River from Storage A1. The latter is located on Dutch Creek in the Gwavas forest area with part of the reservoir in the forest park, but outside the protected tree zone. Water from A5 would principally service areas below elevation 200 m and water from A1, areas between elevations 200 m and 300 m.

Subject to more detailed hydrological and environmental evaluation as applies to all schemes and storages, A1 requires only a small and rarely used top-up pumpstation (order of 200 kW) located on the Makororo River. Storage A5 requires a 600 kW pumpstation on the Mangaonuku Stream, as the local catchment can only contribute a small percentage of required inflow. Storage A1 (servicing Zones A and B) requires a top normal storage level at about elevation 508 m, which means a dam about 70 m high, the bottom of which is in a narrow gorge some 25 m deep. The A5 dam would be about 31 m high. However, given that A1 has a catchment of appreciable size, it is anticipated that detailed modelling will result in a lower storage volume than given by the simple approach so far adopted.

The river intake and race to take water to the higher levels of Zone A would have a maximum capacity of around 0.6 $m^3/s$. Supply from the dam will be down to a base storage elevation at about elevation 210 m. It will therefore be necessary at low reservoir levels to pump up to the higher ground serviced from A5. A pumpstation of around 200 kW capacity is indicated. For a piped distribution system, of the type assumed, pipe diameters for Zone A would range from 300 to 750 mm diameter.

Open races for areas below elevation 200 m would effectively be modest ditches of triangular profile, the order of 4 m to 6 m wide and 1 m to 1.5 m deep, with small drop structures at regular intervals.

If, for example, an extra 10 million $m^3$ of storage were to be provided in A1 to boost summer low flows in the Waipawa River, then based on the simple assessment of storage capacity, the dam would need to be increased in height by about 7 m and the pumpstation size increased to about 900 kW capacity. As noted above, this result is considered to be conservative. As an indication, this amount of additional storage may be used to boost natural flows by an average of 4 $m^3/s$ for a total duration of 4 weeks over the lowest flow periods each summer/autumn.

Figure 6.1 provides a schematic plan of the proposed supply arrangements for Zone A.

## 6.4 Zone B system

Zone B is serviced in part from the upland A1 storage, as described above, and from Storage B3 located across Blackburn Road valley about 5 km west of Ongaonga. The Waipawa River intake capturing water released from A1 would service some 75% of area B, with B3 servicing the balance. Storage B3 has larger storage capacity than needed for the area and some of that is transferred to Zone C which has a larger demand potential at up to 7,500 hectares and more limited storage opportunities.

Secure infill storage for B3 appears achievable from the Tukituki River without pumping, via a race above the top storage level. The initial section of the race, which would intercept up to 1.4 $m^3/s$ maximum winter flow, has to climb a low river terrace, which will require a reasonable amount of excavation and appropriate flood protection. The B3 storage, allowing for its contribution to Zone C, requires some 22 million $m^3$ of storage, with the dam some 29 m high across the relatively broad flat valley.

The Waipawa River intake would service an area of about 3,750 hectares below elevation 260 m. With a base level storage at about elevation 232 m, B3 would service the remaining 1,250 hectares below this level by gravity flow. Pipe diameters for distribution within the zone would range from 900 mm to 300 mm diameter but a larger pipe would be needed between the dam and the Tukituki crossing, to convey flow to Zone C as outlined below. As for Zone A, open races would be of small size.

A schematic plan of the proposed arrangement associated with Storage B3 is shown in Figure 6.2. The Waipawa River intake servicing Zone B is shown in Figure 6.1.

## 6.5 Zone C system

Unless Storage C1 can be shown to be technically feasible, Sorage C2 located across the Parikaka Stream about 4 km west of Ashcott is the largest single storage in Zone C, but with a maximum capacity of about 13 million $m^3$, can only cater for about 43% of the ultimate 7500 hectare potential adopted for this study. The balance would come from B3 as outlined above.

Apart from its own catchment inflow, C2 can be filled by a gravity intake/race on the Avoca River (a tributary of the Tukipo) to the north and pumping from the Tangarewai Stream (also a tributary of the Tukipo) to the south. The intake/race capacities would be around 0.5 $m^3/s$ and 0.37 $m^3/s$ respectively and the pumpstation capacity for the latter around 160 kW. The C2 dam would be around 36 m high.

About a third of the Zone C area is at levels which cannot be serviced from Storages B3 and C2 entirely by gravity flow. Also at low levels in the B3 reservoir, the distribution arrangement assumed for this study would also require pumping to take water over the Tukituki road bridge to service Zone C areas. An alternative distribution arrangement could be considered with a crossing further downstream and avoidance of or reduced pumping. Two other pumpstations are required to service higher ground in Zone C. Areas served by the indicative distribution system would be approximately as follows and pumpstation capacities, also as follows:

- ex Storage B3, 4,250 hectares and 1,300 kW
- high level terraces adjacent Tukituki River, 750 hectares and 300 kW
- high level areas in southern part of the zone 2,500 hectares and 1400 kW

Pipe diameters would range between about 1500 mm and 300 mm and alternative races would be small in general.

Figure 6.2 provides a schematic plan of the proposed arrangement.

## 6.6 Zone D system

Zone D has proven marginal to supply because of limited storage possibilities, limited stream sources to tap and, compared with elsewhere, storage sites being at comparatively lower elevations relative to service areas. Servicing 5,000 hectares in Zone D requires two storages (D1 and D2) located in two adjacent valleys north of Whenuahou and pumped intakes on both the Makaretu River and upper reaches of the Manawatu River, with races and pipes connecting to the reservoirs. Around 70% of the identified potential service area is above minimum reservoir levels allowing gravity supply to farms.

The Makaretu and Manawatu catchments at their respective intake sites are of closely similar size and anticipated flow characteristics. Neither by itself can supply all of the necessary top-up flow under the criteria assumed for flow capture. It is unclear where the optimum split between the two sources would lie, but for this study, the bulk is assumed taken from the Makaretu River within the Ruataniwha catchment under HBRC jurisdiction, and the balance from the Manawatu.

The Makaretu River intake would be around 0.84 $m^3/s$ capacity with a 330 kW pumpstation lifting flow to a race taken to Storage D1 and a pipe and race connection from there to Storage D2. The Manawatu intake would have 0.32 $m^3/s$ capacity with a 90 kW pumpstation taking water via a race to the larger Storage D2. The nominal 20 million $m^3$ storage for Zone D is split as follows, with corresponding dam heights:

- Storage D1, 6 million $m^3$ and 25 m high
- Storage D2, 14 million $m^3$ and 28 m high

Either storage can release flow to service the bulk of Zone D demand by gravity below elevation 260 m, and the Porangahau Stream valley appears to be able to be adopted as a spine open race component of a distribution system. The D1 storage has capacity to service the higher ground between elevations 260 m and 360 m and the indicative distribution system assumes pumping from D1. A peak flow of around 0.9 $m^3/s$ is required to service the approximately 1,500 hectare area with a pumpstation of some 900 kW capacity. Pipe diameters would be in the range 900 mm to 300 mm. Most of the lower level areas appear able to be serviced by an open race system with turnouts off the Porangahau stream, but higher levels to the south may require pumping to the farm gate depending on farm boundaries.

While tapping into the Manawatu catchment provides potential to meet storage requirements from the closest stream sources, it may not be possible to take Manawatu water for various reasons, including Maori cultural values. Without the Manawatu source, it may not be possible to fill the storage reliably from the Makaretu River and the effect of that could be to reduce the area within Zone D able to be irrigated, or require water to be brought from further afield within the Ruataniwha catchment, at higher cost.

Figure 6.3 provides a schematic plan of the proposed arrangement.

If active fault considerations rule out D1 as a suitable damsite and/or if the Zone D potential is restricted by water availability, it may be feasible to achieve a single storage solution by increasing D2, possibly requiring low saddle dams at places on the reservoir rim.

# 7 Scheme Costs

Rough order costing as required in the study brief has aimed at achieving a realistic preliminary estimate of capital and operating costs for the potential 22,500 hectare (nett) irrigation scheme. On-farm costs are addressed in Section 8. The principal development costs for the scheme are:

- costs of storage dam works
- land acquisition and infrastructure costs (e.g. road replacement, new power lines)
- river intake systems for storage infill including pumpstations, pipelines and races
- distribution system to farms including capture of river releases, pumpstations and monitoring
- associated engineering costs

The costs of the principal works components have been estimated by:

- quantifying main items such as dam earthworks, pipework, races and areas of land affected;
- then applying current values; and
- using a combination of sizing and reference to an established contract rate database and precedents of similar size, to assign lump sums for other items, such as spillways, irrigation release components and pumpstations.

Typical percentage allowances have been added to base costs to cover engineering and contractor establishment and administration. Given the essentially desk level nature of the study and lack of detailed information, a suitable contingency (or uncertainty) allowance has been included to cover unforseen conditions and unscheduled items. Upper and lower contingency allowances of 20% and 5% respectively of the base cost have been considered.

Table 7.1 summarises the indicative cost estimates.

Development costs will also include financing costs incurred during development, legal costs and developer administration which are not considered in this section.

Scheme operating costs will, in addition to pumping costs, comprise routine maintenance, consent compliance, insurance, general management, customer billing and the like. Energy costs for storage refill and distribution pumping will be a significant annual cost and these have been estimated.

HBRC analysis indicates that average irrigation use will be about 80% of peak. Thus, given that most of the storage volume has to be abstracted from rivers, for abstraction involving pumping, it is assumed that average annual pumping requirements will be 80% of peak and for pumping included in distribution, pumping on average around 2800 $m^3$ per season. Results are also included in Table 7.1, adopting a current indicated energy plus line charge cost of 20 cents per kilowatt hour.

Consent compliance costs and insurance are also likely to be significant but have not been estimated and taken into account at this stage.

## Table 7.1 Scheme Cost Summary

| Item | Approximate Cost (excluding GST) | | Indicative Cost per Hectare Irrigated (see note 2) (excluding GST) |
|---|---|---|---|
| **A. HEADWORKS** | | | |
| Storage Dams | **Base Cost plus 5% Contingency** | **Base Cost plus 20% Contingency** | |
| A1 (see note 1) | $26,552,000 | $30,345,000 | |
| A5 | $16,781,000 | $19,178,000 | |
| B3 | $25,224,000 | $28,827,000 | |
| C2 | $18,226,000 | $20,830,000 | |
| D2 | $8,058,000 | $9,209,000 | |
| D1 | $11,244,000 | $12,850,000 | |
| Sub-total storage dams | $106,085,000 | $121,239,000 | $4,715 to $5,388 per hectare |
| Storage infill components including power network extensions | $12,382,000 | $14,151,000 | $550 to $629 per hectare |
| **Total for headworks** | **$118,467,000** | **$135,390,000** | **$5,265 to $6,017 per hectare** |
| **B. DISTRIBUTION TO FARM GATE (at minimum pressure)** | | | |
| (a) Intakes and pump stations | $6,781,000 | $7,750,000 | |
| (b) Piped network only | $60,375,000 | $69,000,000 | |
| (c) Open races + high level pumping as required | $41,125,000 | $47,000,000 | |
| **Total for distribution:** | | | |
| (i) Piped network only: (a)+(b) | **$67,156,000** | **$76,750,000** | **$2,985 to $3,411 per hectare** |
| (ii) Open races + high level pumping: (a) + (c) | **$47,906,000** | **$54,750,000** | **$2,129 to $2,433 per hectare** |
| **C. ANNUAL ENERGY COST** | | | |
| (a) Storage infill | $860,000 per year | | |
| (b) Distribution pumping (similar for both (i) and (ii)) | $495,000 per year | | |
| **Total for energy** | **$1,355,000 per year** | | **$60/hectare/year** |

NOTES:

1. The cost shown for A1 is based on a dam with 20 million $m^3$ storage capacity. For an option which includes an extra 10 million $m^3$ for environmental release (total storage 30 million $m^3$), the additional costs are dam $7,890,000 and intake pump station $1,810,000 (includes 20% contingency), plus $330,000 per annum for pumping energy. The additional costs are equivalent to a 7.2% increase in capital cost and 24% increase in annual energy cost compared with tabulated values above.

2. Note that the per hectare costs are based on a nett irrigated area totalling 22,500 hectares and a storage volume equivalent to 4000 $m^3$/hectare, which is greater than the adopted conservative drought year usage of 3500 $m^3$/hectare. The margin allows for system losses and dead storage to cover long term sediment infill. Pumping energy is based on typical annual usage of about 80% of the drought usage i.e. 0.80 x 3500 = 2800 $m^3$/hectare.

# 8 On-Farm Economics and Benefits

Irrigation of the Ruataniwha Plains would provide significant opportunity for increasing productivity and income to individual landowners and to the regional economy. The AgFirst models indicate that sheep and beef production could be increased by over 210% and irrigated dairying could lift gross income per hectare by almost seven times the current typical dryland sheep and beef policies. Experience from other regions such as Canterbury would suggest that landowners would typically enjoy a significant increase in asset values if irrigation water was available at an economic price.

A key factor in evaluating the on-farm economics is the cost of getting water to the gate. Based on the capital costs outlined in the previous section and using a capital charge of 8% and $60/ha pumping costs, it is estimated that water supply will cost the landowner between approximately $650/ha/year and $815/ha/year. The higher estimate corresponds with an off-farm capital cost with a 20% contingency allowance and a fully piped delivery system (i.e. capital cost of $9428/ha), while the lower estimate corresponds with a 5% contingency and a delivery network comprised of open races and piped pumping systems to service higher elevation areas (capital cost of $7394/ha).

The farmer then needs to invest approximately $5,500/ha to irrigate and develop the farm for intensive sheep and beef and/or cropping.

A modern dairy farm will require a total investment of over $21,000/ha for irrigation, land development, stock and dairy company shares. Of this the cost of establishing the on-farm irrigation is estimated at $3,200/ha.

The on-farm running costs for irrigator repair and maintenance and electricity is estimated at $250/ha/ year.

An overall annual cost of irrigation is therefore close to $1,000/ha/year, plus debt servicing on development and depreciation costs.

After meeting these costs the medium term status quo models suggest that the average sheep and beef farmer will get a return on marginal investment in irrigation and associated farm development of less than 2%, arable farmers approximately 3% and dairying approximately 8% to 9%. High value crops such as fresh and process vegetable rotations, pipfruit and viticulture have not been analysed. These are likely to produce a return more comparable to dairy as gross margins are higher than those in the arable sector. It is also noted that water storage and distribution costing is at prefeasibility level only, and more accurate costing will derive from feasibility level study to enable a better assessment of returns.

In the interim, based on the above, it is considered the proposed scheme is likely to be attractive to landowners who are interested in dairying or high value crops such as viticulture and horticulture, but traditional sheep and beef or broad acre cropping are unlikely to be economic options.

These on-farm economics will vary for each landowner. At this stage it is not expected that there will be significant variation in the fundamental economics for each of the schemes proposed. Most of the proposed service areas are in the 800 -1000 mm annual rainfall range and would respond well to irrigation. The heavier soils to the East of Ongaonga generally have a lower water requirement but are also more useful for higher returning enterprises such as specialist crops.

The farm models used have accounted for drought one year in five and are currently based on pre-tax scenarios. There will be a further advantage in cashflow if based on a post-tax scenario. Further, this assessment has not taken into account the benefits to the wider region; the regional income multipliers are expected to be significant.

Experience from irrigation development in other regions is often that the on-farm economics are challenging in the early years, and for this relatively high cost scheme some landowners will not have the financial resources to invest in irrigation. However, others will identify high returning opportunities and utilise the opportunity to generate increased production, cashflow and asset values.

# 9 Environmental and Recreational Aspects

The study brief requires a qualitative assessment of environmental and recreational aspects. Reference has been made to baseline data contained in HBRC's document entitled Resource Inventory, a check for potential District Plan issues, features noted from map and site inspection, and feedback provided by the Fish & Game and Department of Conservation (DoC) representatives on the HBRC Project Team.

## 9.1 Environmental aspects

The following primarily explores the direct environmental aspects of the water storages. Potential indirect environmental aspects, particularly in relation to water quality, are also recognised but are programmed to be better defined and addressed during the next stage of investigations.

For the direct environmental aspects of the development, the challenges and related effects arise in three areas:

- storage dams including capture of local catchment flow
- taking water from rivers to fill storages
- pipelines and open races to transfer flow into reservoirs and pipes and/or open races distributing water to farms and, potentially, extensions to the power network

Except for Storage A1, dams are located on developed farmland with minor tree cover and small streams, understood to carry little or no flow in periods over summer, and too small to support a sports fishery. The District Plan shows all of the six storage sites to be clear of protected vegetation and other designated features. Again excepting A1, it is anticipated that each dam should require only a small riparian flow release to the stream.

Storage A1 is mainly on land under pine forest but encroaches on DoC administered land which is outside the limits of the State Forest Park area assigned as having significant Native Conservation Values under the District Plan. Its local catchment is the largest of the six and the stream consequently larger, albeit still small. Preliminary indications from Fish & Game are that the main concerns will be protection of trout habitat under river abstraction regimes, and the loss of trout habitat above A1, but that the latter could be accepted if the development includes a worthwhile enhancement of low summer flows downstream.

DoC has no concerns with storage site D2 but wishes to see environmental assessment of the other storage sites, with particular focus on the indigenous fishery.

Dam break is a potential effect which, in a well designed, constructed and maintained dam, has extremely low probability but high impact on downstream areas. Considering the expansive and planar nature of the Plains and the communities within, the proposed storage dams are all likely to fall into the "high" potential impact category as set out in the recently promulgated Building (Dam Safety) Regulations 2008. Thus, it is likely that investigations, design, construction, operation and maintenance of the dams will have to be to the highest applicable standards. This is to ensure that the probability of failure is extremely low commensurate with the high potential impact of the dam.

The taking of water from the large rivers, and the rules for doing so, probably constitute the largest environmental issue. The rivers and streams of the Ruataniwha Plains are a significant component of the Tukituki River system, which is a nationally recognised trout fishery. However, it should be noted that when the scheme is fully developed, the volume of surface water abstracted on an annual basis represents on average less than 6% of the river flow otherwise exiting the Ruataniwha basin.

The present assumptions for winter flow abstraction in Section 4 assume lower minimum flows than being contemplated by HBRC planners. A higher minimum winter flow regime will require larger intake and infill pump capacities and may in some situations limit what can practically or cost-effectively be harvested in winter, thus reducing irrigation potential below that targeted.

Transfer races across farmland will raise few or minor environmental issues, as will buried pipelines. The more significant issues will arise during construction. The local lines company advises that the existing power network has the capacity to supply the pump stations required to fill reservoirs and deliver water to farms at higher elevations, except for some 6 km approximately of upgraded line to the A1 infill pumpstation and 5 km to A5, plus short local connections between existing lines and other pumpstations.

There is often concern that irrigation development may impact on water quality. It is common perception that land use change to intensive agricultural systems, such as dairying, is the cause of this. However, it is important to understand that it is typically the actual on-farm land management practices coupled with climatic and soil characteristics that drive potential impacts and not necessarily the land use type. For example, an extensive system with poor management practices will have a greater impact on water quality than a well managed intensive system.

In the current study, a generous riparian margin has been assumed in the definition and delineation of irrigable areas, which is prudent in terms of protection of stream water quality.

A significant component of the next stage of the water storage investigations (feasibility study) will explore water quality management options. The merits of riparian protection and wetland creation, at both farm and catchment scale, as well as implementation of on-farm best practices for nutrient, irrigation and soil management will all be investigated with solutions put forward. Potentially, a condition which requires irrigators to adopt consistent sustainable practices can be imposed as a condition of being part of the scheme. This will ensure any potential impacts on water quality from the development are addressed and mitigated.

## 9.2 Enhancement and recreation

There is much potential for using the dams (particularly A1) to augment river flow during low flow periods. This would greatly benefit the many recreational users of the Tukituki River system. An alternative option to augmenting river flow would be transferring existing surface water takes to storage during low flow periods, thus affording a return to the river's natural (unadulterated) low flow regime during the summer/autumn low flow months. This option would also give significantly higher reliability of supply to those with surface takes.

The dams present significant recreational opportunities, such as boating, rowing or fishing, particularly for the Central Hawke's Bay community. As a result, there is much interest, amongst irrigators and the local community, in having one of the proposed dam's summer water levels managed for recreational purposes. This is readily achievable due to the interconnectivity of the proposed distribution systems (except for sites D1 & D2). However, such an option will likely reduce the total area able to be irrigated from storage. That is, unless additional storage is provided at extra cost (such as considered for site A1) specifically for the purpose of maintaining a permanent lake of a minimum specified size.

# 10 Further Studies

In taking potential irrigation development further, the next step is to confirm technical feasibility, environmental sustainability and refine cost estimates, closely involving potential stakeholders. A feasibility study is anticipated to require the following:

1. **Water Resource Investigations**: confirmation of demand and irrigation requirements, including variations across the potential service area; detailed assessment of catchment hydrology and water availability; supply-demand storage modelling; confirmation of surface/ground water interaction including potential to recharge groundwater from upland storage and to augment irrigation supply to on-farm wells; modelling of proposed operating regimes.
2. **Environmental Investigations**: confirmation of in-stream residual flow requirements, and thus sustainable abstraction regimes, including potential summer capture when flows are high; fish passage requirements; reservoir water quality; visual and landscape assessment; potential for wetland enhancement within reservoirs; assessment of indigenous vegetation and fauna affected by reservoir siting; assessment of instream aquatic values, effects of land-use intensification on water quality.
3. **Geotechnical Investigations**: geological mapping; seismic assessment; sub-surface investigations at each site (drilling, test-pitting and laboratory testing of materials), including construction materials availability and suitability.
4. **Engineering Design**: confirmation of dam sites and general arrangements; design flood determination; diversion and spillway requirements; dam break hazard assessment; confirmation of dam type and construction methodology; river intake arrangements; irrigation off-take requirements; power supply requirements; ability to incorporate hydroelectric power generation; cost estimation to as high an accuracy as data and funding will allow; layout and costing of irrigation distribution network to farm gate.
5. **Cultural Assessment:** assessment of cultural values of sites; taonga survey; effects of land use intensification.
6. **Economic and Governance Assessment**: refined assessment of on-farm works and production potential; cost/benefit analysis of scheme on per hectare basis, including assessment of the lost-opportunity cost of non-augmentation; assessment of water allocation regime and policy provisions; assessment of options for ownership and governance of scheme, funding and irrigation allocation; financial and cash flow analysis.
7. **Community Issues and Consultation:** confirmation of land ownership; consultation with landowners, stakeholders, local community and iwi; assess requirements for road re-routing; assess potential recreational use of reservoirs; canvass community views and issues; presentation at project update and public meetings; newsletters.
8. **Reporting:** prepare progress reports; prepare final report for each investigation package and overall summary report; report and present to funders.

Elements of such a feasibility study are currently being addressed by HBRC including detailed river hydrology, transient groundwater modelling and cultural investigations by local iwi.

# 11 Conclusions

(i) The assessed foreseeable irrigable demand in the Ruataniwha Plains totals some 22,500 hectares nett distributed over 4 geographical zones delineated by the main rivers of the Plains. An irrigation demand of 3500 $m^3$ per hectare in a 1 in 10 dry year is considered an appropriately conservative areal average demand for this pre-feasibility design. On this basis, a gross storage requirement of 4000 $m^3$/ha has been adopted for assessment of storage potential and arrangements, the larger figure allowing for dead storage to cover long term sediment infill in reservoirs and potential system losses.

(ii) From a shortlist of 14 sites, a scheme requiring 6 storage dams has been identified with potential to service the full demand across the 4 zones. A scheme with fewer but larger storages is precluded by topographical constraints and in any case would be disadvantaged by the necessity to distribute water over such a large service area. Large storage dams on the main rivers have specifically been excluded because of anticipated significant environmental issues and difficulty in obtaining consents.

(iii) For 5 or the 6 storages, the local runoff provides on average only a small proportion of the storage infill and water harvesting is required from principal rivers. This would be achieved using either gravity or pumped river intakes. Storage refill assumes winter-only flow harvesting from April to October when flows are naturally higher, with an appropriate environmental flow retained in the river for protection of in-stream values. Potential summer capture from any high river flows has conservatively been ignored. When the scheme is fully developed, the average volume of surface water abstracted on an annual basis is estimated to be less than 6% of the river flow otherwise exiting the Ruataniwha basin.

(iv) Preliminary estimates indicate the cost of a sustainable development of between about $5250 and $6000 (excl. GST) per hectare irrigated excluding distribution, storage infill pumping charges and on-farm costs. Depending on arrangements, a distribution system to the farm gate plus requisite pumping stations would add roughly $2100 to $3400 per hectare (excl. GST); the latter figure is for a fully piped system while the former for a delivery system comprised mainly of open races with piped pumping systems to service higher elevation areas.

(v) Allowing for on-farm costs plus debt servicing on development, the medium term status quo models suggest that the average sheep and beef farmer will get a return on marginal investment in irrigation and associated farm development of less than 2%, arable farmers about 3% and dairying between about 8% and 9%. High value crops such as fresh and process vegetable rotations, pipfruit and viticulture have not been analysed. These are likely to produce a return more comparable to dairy as gross margins are higher than those in the arable sector. It is also noted that water storage and distribution costing is at prefeasibility level only, and more accurate costing will derive from feasibility level study to enable a better assessment of returns.

(vi) Apart from site A1, direct environmental impacts from the storages are not considered significant, although detailed assessments of the native fisheries are required to confirm this. For site A1, the benefits of river flow augmentation (Waipawa and lower Tukituki), contingent on extra storage being provided, will offset the loss of habitat. Indirect impacts of the overall development, particularly in relation to water quality, may be mitigated through implementation of on-farm best management practices related to accountable, monitored performance standards.

(vii) The storages create significant potential for increased recreational opportunities for the local community, either upon the reservoirs themselves or through the augmentation of summer low flows. Irrigation would also provide significant opportunity for increasing productivity and income to individual landowners and to the local and regional economy. Landowners would also benefit from a significant increase in asset values.

(viii) Feasibility level investigations, including water resource studies, geotechnical site investigations, engineering design, environmental and cultural assessments, economic/ governance studies, and community and stakeholder consultation are recommended to confirm feasibility of the proposed scheme.

# 12 Applicability

This report has been prepared for the benefit of Hawkes Bay Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

TONKIN & TAYLOR LTD

Environmental and Engineering Consultants

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## FIGURES

# Appendix A: Initial Short-List of Storage Sites