Wairarapa Water Use Project

greater WELLINGTON REGIONAL COUNCIL Te Pane Matua Taiao

October 2014

Prefeasibility Phase - Review Point 3 Distribution Systems Investigations Key Findings

1. Introduction

This document summarises the key findings from the distribution system investigations conducted by Tonkin & Taylor between July and September 2014. These systems will determine how water transfers from possible water storage locations to the areas of highest potential demand. The investigations also identify the issues that need to be considered to achieve this by considering financial, technical, environmental, social and cultural viability. In addition, a set of recommendations and/or key findings follow based on the assessment of the findings.

The primary focus of this report is therefore a summary of the key findings to enable decisions to be made regarding the next steps for the project as it pertains to the command areas and their respective distribution systems. More particularly, this report will confirm those schemes suitable for further investigation i.e. which schemes should be advanced further.

The accuracy and status of the information contained in this report is consistent with that developed at prefeasibility level, with further more detailed assessment required on the 'short-listed' schemes. As applicable to the project's other information releases, commercially sensitive or private information will not be released.

2. Workstream 3 Tasks

The following tasks were conducted with respect to the assessment of the command area distribution systems:

a) Engineering assumptions review
b) Supply-demand modelling
c) Initial distribution arrangements
d) Site visit and geotechnical assessment of distribution arrangements
e) Distribution arrangements refinement, cost estimates and risk identification

2.1.Terminology

Key terms used in this and associated include:

Command area	Equivalent to “indicative irrigable area” as defined below, and used interchangeably within the current report
Dead storage	Portion of reservoir volume unavailable for consumptive use
Distribution system/network	Conveyance structures, comprising existing rivers, canals, races and pipework (located downstream of the reservoir) that transfer flow from the reservoirs to the indicative irrigable areas
Gross storage	Sum of dead and live storage
Harvesting	Transferring water to a storage from a nearby stream/river located in a different catchment. Note definition is different from the Proposed Regional Policy Statement, which uses harvesting to refer to on-river storage also.
Headworks	Storage reservoir, dam structures required to impound the reservoir, and any intakes, conveyances and pumpstations (if required) to “harvest” water to fill the reservoir
Indicative irrigable area	The gross area that could be irrigated, defined for the purposes of the current study using land slope
Live storage	Portion of reservoir volume available for consumptive use (excludes dead storage)
Net irrigated area	The portion of indicative irrigable area expected to actually be irrigated, after accounting for buildings, tracks, hedges etc.
Own catchment infill	Flow available from the local catchment of a stream on which a dam is situated
Refill reliability	Refers to the reliability or frequency with which a reservoir is completely filled. Refill reliability can be expressed as an Average Recurrence Interval or Annual Exceedance Probability of a failure to fill to full supply level. Refill reliability may or may not impact on supply reliability.

Reservoir	A natural or artificial pond or lake used for the storage and regulation of water, used interchangeably with "storage" within the current report in some contexts
Direct / run-of-river take	Abstraction occurring directly from a river or stream and that has no significant storage component
Scheme	Headworks and associated distribution network to transfer water from storages to an indicative irrigable area
Supply reliability	Refers to the ability of a scheme to supply water to the desired demand. Supply reliability can be expressed as an Average Recurrence Interval or Annual Exceedance Probability of a shortfall event. A shortfall could be expressed either in terms of units of discharge or in terms of volume to be supplied over a given period of time, or more complex criteria.
Uptake	The commitment of water users to use (buy) water from the scheme

2.2.Assumptions Review

Prior to any technical work starting on Workstream 3, an engineering assumptions workshop was undertaken to:

a) Agree on an approach in advance of undertaking the studies to ensure expectations are aligned and to minimise the potential for re-work

b) Revise assumptions from the Options Refinement Phase as necessary for an increased level of detail in the Preliminary Feasibility Phase

Subsequently, a revised set of key engineering assumptions was developed the distribution arrangements, together with the preceding supply-demand matching investigations.

In summary, the workshop resulted in a fundamental change from the initially envisaged multi-storage scheme options to a single-storage approach for Workstream 3. This assessed a series of 5 single storage schemes that are each optimised to a very preliminary extent to produce the most cost effective water supply.

At this stage, distribution area overlaps between schemes will largely, but not totally, be ignored and addressed once the viability of the individual storages and their associated distribution systems have been determined. Following this investigation, it is envisaged that site specific investigations will be conducted together with further 'non-engineering' investigations.

The following table sets out the key engineering assumptions for Workstream 3 some of which are indirectly related to the command areas and their distribution system.

Key Revised Workstream 3 Engineering Assumptions

Item	Parameter	Proposed Assumption for Prefeasibility
1	'No go 'areas	No dams on the main stems of the Ruamāhanga River, Tauherenikau River, Waiohine River, Waingawa River or in the Tararua Forest Park, though reservoirs may flood back into the Park. This constraint does not relate to low, run-of-river weirs, which would not store water but instead release it at a similar rate to inflows.
2	Approach to on-plains storage, recycled wastewater, Lake Wairarapa, groundwater, water races	Consideration of incorporation of these elements as integrated components of the scheme to be deferred for reconsideration at Workstream 5.
3	Storage Sizes	Live storage sizes from the Options Refinement Phase for single-storage schemes to be retained for Workstream 3, specifically: • Site 10 Tividale 25.9 million m3 (MCM) • Site 135 White Rock Road 26.0 MCM • Site 197 Te Mara 23.1 MCM • Site 210 Black Creek 47.5 MCM (plus Wakamoekau variant 20.7 MCM) • Site 215 Mangatarere 29.6 MCM
4	Dead storage	Dead storage to be provided for accumulation of sedimentation based on the annual suspended sediment volume from WRENZ (http://wrenz.niwa.co.nz) multiplied by125% multiplied by 100 years of accumulation. This provides for retention of 100% of suspended sediment, and provides an allowance of 25% of suspended sediment for retention of bedload. Additional volume to be set aside for environmental flushing flows. We note that this is a new allowance not included during the Options Refinement Phase and will be additional to: (1) the live storage set aside as per Item 1; and (2) the dead storage allowance for accumulation of sedimentation. No extra storage volume to be set aside specifically for visual amenity / recreation /flood mitigation. This may be reconsidered during future phases. We note that the supply-demand modelling implicitly provides for augmentation to maintain minimum environmental flows in the river during natural low flow periods when the river would otherwise have fallen below the minimum flows set out in the Regional Plan.
5	Supply-demand matching	Live storage sizes (as specified per Item 3) to be matched to command area extents based on supply-demand modelling undertaken during the Options Refinement Phase using Landcare's demand modelling work (May 2013), subject to the adjustment factor below. The following assumptions are implicit in the use of this previously completed supply-demand modelling work: • On-farm efficiency of 85%

Item	Parameter	Proposed Assumption for Prefeasibility
		• Average distribution losses of 5% • Based primarily on irrigation demand as expected to be the dominant growth area for demand in terms of volumes • Areas with existing consents are included, but the analysis only provides for 'top up' over and above their existing allocations to the estimated theoretical demand • Drainage return water is not accounted for, in line with discussions with Dr M Gyopari during the Options Refinement Phase • No core allocation is available for harvesting (based on Scenario 1 from the Options Refinement Phase). The sensitivity analysis carried out on four alternative scenarios during Options Refinement indicated that storage sizes required are not overly insensitive to the availability of core allocation. • Allocation rules as assumed in the Options Refinement Phase (refer Appendix B.2 and B.3 of the Options Refinement Report) • Supply reliability - live storage capacities of possible storage sites have been matched to the 1 in 10 year drawdown volume derived from a frequency analysis • Refill reliability – for a given demand area, storage sizes are set so that they completely refill each year generally, but at least every two years • During the Options Refinement Phase, an adjustment factor was applied when determining the command areas and net percentage irrigated to use for distribution design (these factors directly influence conveyance lengths, design flows and pipe sizes). The adjustment factor was based on work in SPASMO (November 2012), and resulted in the adopted command area and net percentage irrigated essentially representing an 'average' of the WWUP field work and Landcare demand models. This adjustment factor will be replaced by a new adjustment factor as outlined in Item 6 following.
6	Adjustment of annual demand volume estimates for mixed land use	Annual demand volumes based on Landcare's modelling for 100% pasture to be adjusted by 85% to provide for the likely mix of land uses. This will increase the command area assumed to be supplied from the storage sizes adopted (as specified in accordance with Item 3 above).
7	Seasonal volume cap	No seasonal volume cap to be adopted for Prefeasibility. This may be reconsidered during future phases.
8	Peak delivery rate to the secondary network	4.5 mm/day as advised by GWRC based on peak rates averaged across the likely mix of land uses as agreed in Engineering Assumptions workshop 20 May 2014.
9	Diversification factor	The peak daily volume requirement for a whole scheme tends to be less than the sum of the peak daily volume requirements for all the individual farms supplied. This is because it is unlikely that 100% of farmers will apply the estimated peak demand concurrently. The approach to diversification during Options Refinement was endorsed at the Engineering Assumptions Teleconference, specifically: • A factor of 85% to be applied when sizing pipes for the primary conveyance systems. • A diversification factor will not be applied for secondary pipelines since each secondary branch of the network supplies a smaller number of farms and it is more likely that these farms would all be irrigating at the same time.

Item	Parameter	Proposed Assumption for Prefeasibility
10		It was agreed that 5% remains an appropriate allowance for distribution losses for the Pre-Feasibility phase (represents an average for pipes and canals).
11		The net irrigable area to be assumed to be 70% of the Landcare adjusted gross area. Landcare had removed the areas of river bed and reserves from the gross area. The 70% factor is intended to take into account roads, buildings, paved areas, small farm holdings, and less than 100% uptake.
12	Pressures to be provided at offtake points	Minimum pressure of 35m to be provided as advised during the Engineering Assumptions Teleconference. Maximum static pressure of 1,000kPa to be targeted, noting pressure reduction provision may be necessary in some locations.
13	Optimisation of pipe sizes and head losses	Agreed to maintain 1.8m/s as a blanket target peak velocity for pipe sizing, which provides an approximately economic balance between increased pumping due to head losses and pipe sizes.
14	Extent of distribution network to be modelled and costed	To be modelled to within 2km of 'farm gate', noting uncertainties around the location of 'farm gate' given limitations of using cadastral boundaries. Extents and layout of pipework to be reviewed and agreed with GWRC prior to finalisation. Costs for pipes beyond the modelled extent to be excluded for Prefeasibility as likely to be relatively minor.
15	Scope of cost estimates	The following revisions were agreed at the Engineering Assumptions Teleconference: • Indicative cost estimates to be included for upgrade of local electricity lines as needed for pump stations. • Allowances for easements of conveyances across private land to be incorporated at rates provided by GWRC, though noting that pipes will be located within road reserves where practical. • Allowance for land areas inundated by reservoirs plus a surrounding operational buffer. • Allowance to be made for realigning public roads where inundated by possible reservoirs.
16	Operational costs	The following revisions are proposed: • The term for Net Present Value calculations to be revised to 50 years. Following discussions with PWC, this is considered a reasonable approach to provide for the long-term. It is noted that increasing the term beyond 50 years has minimal impact on the resulting Net Present Value calculated. • Cost of electricity \$0.20/kWhr for Net Present Value calculations. Discount rate to be confirmed. • Replacement costs for the mechanical and electrical components of pump stations to be incorporated – two replacements to be assumed during the 50 year period. • Costs of ongoing management and administration of schemes to be estimated by others.

For the purposes of Workstream 3, each of the schemes were investigated using the same 'global' assumptions; in future the assumptions will be further refined. In addition, different assumptions will be applied to each of the schemes to help determine the optimal scheme arrangement.

2.3.Supply demand modelling

In summary, the following issues were addressed as part of the supply demand modelling i.e. the process of determining the relationship between the water that is stored in a reservoir and how, when and how much is supplied to the command areas:

a) Command areas – areas of land steeper than 7 degrees were omitted from consideration, as were lifestyle blocks especially around Masterton. Other factors were considered, but had relatively minor effects on the extent of the command areas. Generally the command areas were located in areas which incurred the least distribution costs.

b) The net irrigated areas average 64-68% of gross command areas – this is a combination of eliminating areas occupied by large streams, reserves and localised steep areas, and a general factor of 70% to allow for the likelihood that landowners won't irrigate 100% of their property i.e. it allows for buildings, farm tracks, wind breaks, general areas that they just don't want to irrigate, and less than 100% uptake.

c) Peak rate of supply per day is considered independently from annual volume requirements per hectare.

d) Peak rate of supply is critical for the size of the pipes – its been assumed that peak rate of supply is 4.5mm/day or 0.52l/s/ha at offtake points, though diversification factor of 85% applied for trunk lines (primary pipelines) and dam outlet capacity.

e) The annual volume requirements per hectare are critical for balance of water availability, storage size and command area extent. This was addressed through supply-demand modelling, and basically involved looking at the balance of inflows to the dam from local catchment and harvesting and outflows from the dam for residual flow, supply of scheme water, spillway flows on a daily basis to determine how much water is in the storage each day and if demand can be supplied.

f) In assessing the annual volume requirements, the volume supplied each day has been modelled as being:

- Proportional to net irrigated area
- Reduced for wet soils (typically 93-99%)
- Reduced based on portion of theoretical demand already allocated under existing consents
- Reduced to represent a likely land use mix rather than 100% pasture (multiplied by 85% factor)
- Increased to account for losses associated with on-farm efficiency (divided by 85%)
- Capped at the peak rate of supply and spread to days to either side – no change in volume, just spread over more days.
- Increased to account for distribution losses (divided by 95%)

g) In terms of supply reliability, the live storage size has been set as being equal to the 1 in 10 year draw down. Strictly, based on how its been modelled it, this means supply will be unconstrained except in years drier than the 1 in 10 dry year. In reality, a more sophisticated system would impose limits on supply when a reservoir starts getting close to empty, so could continue to supply water even in years drier than the 1 in 10 dry year.

h) Currently, no allowance has been made for a seasonal volume cap; in reality this will need to be considered to reflect environmental constraints and expectations.

i) Harvesting infrastructure and maximum size of storage has been capped so that a reservoir will completely refill at least every two years – it should be noted however that the selected reservoir size is well below this maximum cap based on the cost curves optimisation work conducted during Options Refinement. The maximum size associated with 2 year refill reliability is typically an economic point - diminishing returns will result the storage is made bigger than this as less and less water will be available compared with storage volume added.

2.4.Schemes

Five priority storage sites were recommended for further investigation during the previous phase of the WWUP:

- Tividale (Site 10)
- White Rock Road (Site 135)
- Te Mara (Site 197)
- Black Creek (Site 210)
- Mangatarere (Site 215)

A single-storage scheme arrangement has been developed for each of the shortlisted sites above, including an additional 'variant' option for the Black Creek site. This 'variant' has been developed in parallel with the other schemes because it is so interrelated with Black Creek; it could possibly be introduced if the Black Creek scheme was deleted. Each scheme arrangement comprises a single water storage reservoir, a distribution network to transfer water from the storage to a command area, and for Te Mara and Black Creek, additional infrastructure to harvest and transfer water to fill the storage.

Command areas have generally been located with the aim of minimising construction costs. This has resulted in overlaps of command areas for some schemes especially in the part of the valley where several schemes would logically irrigate certain areas. The overlaps have been permitted at this stage of the investigations on the basis that the schemes are being assessed as independent, alternative options that would not be constructed in combination. If more than one scheme appears economically viable based on this first stage assessment, consideration could be given to rearranging command areas so that multiple schemes could possibly be constructed in combination.

The following summarises the key descriptors and findings for each of the schemes principally as it pertains to the command areas and their water conveyance systems:

Tividale

- The gross command area is 12,300ha, of which it is assumed that 8,400 ha of land will actually be irrigated (net area)
- The scheme is not viable without conveyance by river 70km, with an anticipated travel time of 1.5-3 days for the water to flow down the Tauweru River,
- The water then travels down the Ruamahanga River - a provisional buffer storage has been assumed at present at downstream end
- The command area covers an area either side of the Ruamāhanga River between the confluence of the Tauweru and Ruamāhanga Rivers downstream of Papawai and then an area south of Greytown towards Lake Wairarapa
- Significant booster pumping is required to harvest the water from the Ruamāhanga River
- As currently envisaged, the scheme could supplement existing surface water takes between the confluence of the Tauweru and Ruamāhanga Rivers with no distribution system required

White Rock Road

- The gross command area is 9,600ha, with a net irrigated area of 6,100ha
- It is envisaged that water will be released from the storage reservoir and flow down the Huangarua River where significant booster pumping will be required to get the water out of the river in the vicinity of Martinborough.
- It is assumed that there will be 10-15km conveyance by river with an anticipated travel time of 6-8 hours
- The command area covers an area on the true left of the Huangarua River as far as Martinborough, and then an area between Martinborough approaching Lake Wairarapa

Te Mara

- The gross command area is 10,900 ha, with a net irrigated area 7,200ha
- The command area covers an area immediately north of Masterton; overlaps with Black Creek Variant (Wakamoekau)
- No booster pumping is required as water pressure is achieved through gravity
- The storage reservoir is filled by harvesting pumped from the Ruamāhanga River, supplementing its own catchment infill
- Alternative gravity infill options are currently be considered
- Water will be provided via a direct off-take from storage reservoir into distribution network, with a rising / falling main used for both harvesting and distribution

Black Creek

- The gross command area is 21,300 ha, with a net irrigated area 14,300ha
- The reservoir is filled by harvesting from the Waingawa River, supplementing its own catchment infill.

- To date its been assumed that water will be pumped from the Waingawa River, but an alternative gravity infill option also from the Waingawa River is currently being considered
- The command area covers an area immediately southwest of Masterton which also surrounds Carterton almost identical to the Mangatarere command area. Part of the command area also overlaps with the southern part of the Te Mara command area.
- Minimal booster pumping is required to achieve the required 35m head
- Water will be provided via a direct off-take from main Black Creek storage reservoir into distribution network, rising / falling main used for both harvesting and distribution
- Downstream of Wakamoekau Creek storage reservoir, conveyance is by river for short section of the gorge

Black Creek Variant (Wakamoekau)

- The gross command area is 8,300 ha, with a net irrigated area 5,400ha, with minimal booster pumping required
- The reservoir is filled by harvesting from the Waingawa River, supplementing its own catchment infill
- The command area covers an area immediately both north and south of Masterton; the northern area also overlaps with Te Mara command area
- At this stage it is assumed that the reservoir will be filled using pumping, but an alternative gravity infill options is currently considered
- Downstream of Wakamoekau Creek storage reservoir is a short length of conveyance by river for short section of the gorge

Mangatarere

- The gross command area is 12,800ha, with a net irrigated area 8,700 ha,
- Some booster pumping is required after the water is conveyed over a short distance down the river through a gorge
- The command area covers an area immediately southwest of Masterton which also surrounds Carterton almost identical to the Black Creek command area. Part of the command area also overlaps with the southern part of the Te Mara command area
- The water is supplied via own catchment infill only with no harvesting required
- The command area covers an area immediately

3. Opportunities and Risks

A number opportunities, risks and exclusions have been identified below that are direct relevance to the command areas, especially those considered to be more likely and/or have a more significant consequence for overall viability.

Further work may be required to determine whether such opportunities or risks are technically viable. Some of the opportunities and risks are interrelated, and the magnitude of the cost saving or increase may change if multiple interrelated opportunities or risks are pursued in conjunction.

3.1. Risks and opportunities common to all schemes

The following are matters that are potentially common to all schemes:

a) 35m head supplied at offtake point:
- a more significant opportunity for some schemes than others i.e. where there is significant pumping or where there is potential to reduce the pipe pressure ratings
- if pumping is required on-farm with the 35m currently provided, there may be minimal additional on-farm cost to pump from say 5m rather than 35m
- may need to be integrated with assessment of alternative ways to provide peak supply rate at offtakes i.e. sacrificing pressure provided for short periods of peak demand in order to provide peak supply rate without increasing pipe sizes

b) Supply reliability standard:
- informed by crop yield and dry matter modelling
- test supply reliability standard against impacts on plant growth and budget on-farm. Balance against savings in capital cost - relaxing supply reliability could provide for a reduction in dam size and/or increase in command area size or both
- take guidance from existing irrigators and crop yield specialists
- assess volumetric supply reliability at farm gate in addition to current scheme measure of supply reliability.

c) Annual volume requirements per hectare:
- crop yield and dry matter modelling, possibly just for a sample area

d) Land use mix factor of 85%
- sensitivity of factor to a range of alternative land use mixes could be tested

e) Allowance for distribution losses
- allowance for distribution losses to be reviewed on a scheme specific basis, accounting for proportion of conveyance by stream, canal and pipe

f) Opportunity to reduce peak supply rate of 4.5mm/day at offtake points:
- Assess the impact of a lower peak delivery rate in terms of:
    i. Impact on scheme costs
    ii. Impact on plant growth on-farm
    iii. Impact on on-farm budget, considering costs of providing supplementary feed on balance with the cost of water and decisions around peak delivery rate

g) Incorporate seasonal volume cap:
- expected to be part of consent conditions
- volumes in current consents based on *x* mm for y days
- consider likely seasonal volume caps as part of consent conditions. Input also from crop yield and dry matter modelling.
- assess impacts on storage volume and command areas that can be supplied.

h) Uncertainty and risk associated with pumping:
- electricity prices in the future
- electricity upgrade requirements and costs

i) Allow for higher design velocities in pipes for schemes where excess head is available, such as Te Mara, in order to minimise pipe sizes and thus cost:
   - assessment and reanalysis of each scheme to select most beneficial pipe velocities generally for large diameter pipes

j) Pressure rating of pipes may be minimised for some schemes by inclusion of over pressure protection measures resulting in significant cost savings for some schemes:
   - assessment and reanalysis of each scheme to select most beneficial pipe pressure classes, balancing cost against risks due to over pressure and structural considerations, especially for large diameter HDPE pipes.

3.2.Risks and opportunities for individual schemes

The following are matters specific to individual schemes:

a) **Tividale**
   - buffer storage as currently included at the main river intake and pumpstation
   - risk associated with complexity of managing flows, ensuring water is able to get into the pond when flows are naturally low
   - potential to eliminate buffer pond by reducing environmental release requirements or allowing take to cover short periods when there is a shortfall
   - consider alternative in-river buffer pond

b) White Rock Road
   - reconsider direct offtake option to minimise pumping costs
     i. initial indications are that this will be more expensive based on whole of life costs
     ii. use buffer pond on terrace to even out scheme flows and reduce direct pipe size and cost
     iii. consider paying a premium for a direct piped outlet to eliminate pumping for more cost certainty electricity upgrade costs and long-term electricity prices
     iv. leave putting in the direct pipe to a later stage

   - Use of river for conveyance. Current indications all indicate viable, but if proved otherwise, there would likely be additional costs.

c) Te Mara
   - increase the design velocities to take advantage of excess head and minimise pipe sizes; potentially a major saving
   - use of a buffer pond at river intake:
     i. to fill storage to even out rate of harvesting and reduce pumpstation and riser main design flow and size
     ii. to supplement supply from storage with direct supply i.e. reducing volume of storage needed at dam and volume pumped
   - use of on-plains storage filled from Ruamahanga River near middle of command area to supplement supply from the main storage, possibly minimising pipe sizes and the main storage size
   - alternative gravity harvesting to fill storages

d) Black Creek

- use of a buffer pond
  - to even out rate of harvesting (and reduce pumpstation and riser main design flow)
  - to supplement supply from storage with direct supply i.e. reducing volume of storage needed at dam and volume pumped
- supplement harvesting from Waingawa with harvesting from:
  - Mikimiki Stream
  - Waipoua using a portion of the distribution network
- alternative gravity harvesting to fill storages
- consider whether an alternative smaller scheme size that does not cross the 'no demand'/'low demand' zones northeast and west of Masterton would be more economically favourable

e) Black Creek Variant (Wakamoekau)

- use of a buffer pond
  - to even out rate of harvesting and reduce pumpstation and riser main design flow
  - to supplement supply from storage with direct supply i.e. reducing volume of storage needed at dam and volume pumped
- supplement harvesting from Waingawa with harvesting from:
  - Mikimiki Stream
  - Waipoua using a portion of the distribution network
- alternative gravity harvesting to fill storages
- consider whether an alternative smaller scheme size that does not cross the 'no demand'/'low demand' zones northeast and west of Masterton would be more economically favourable

f) Mangatarere

- Extension of the scheme, potentially into the Te Ore Ore area, although there is limited capacity/benefit in expanding the command area in other locations.
- Potential to supplement supply from storage with direct supply from the Waipoua River, utilising an on-plains storage pond

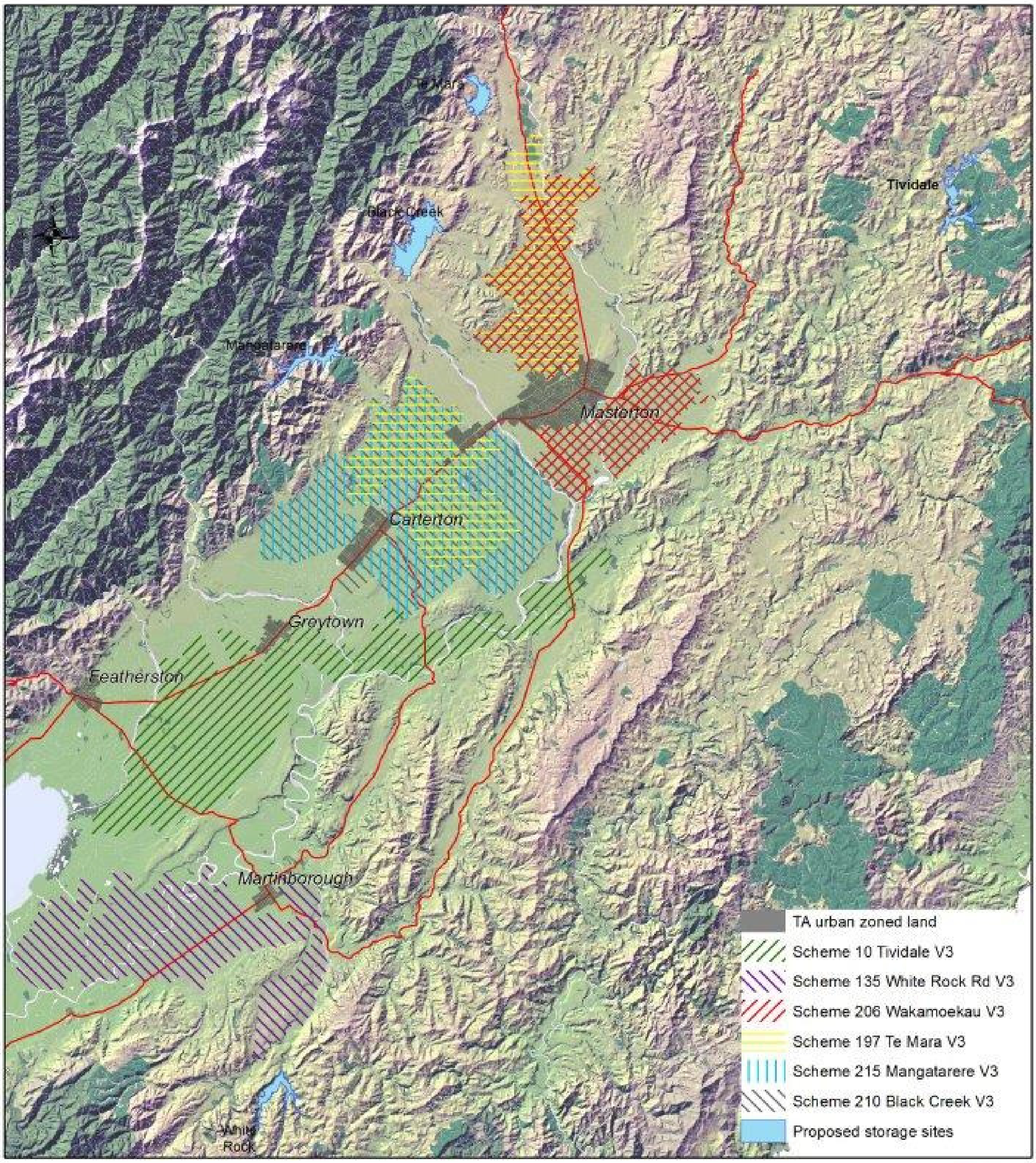
4. Summary

The key points to emerge from the distribution investigations conducted during Workstream 3 are as follows:

i. A number of design criteria and assumptions have the potential to have a significant impact on construction costs. The sensitivity of changes to key criteria and assumptions on farm productivity and whole-of-scheme costs (incorporating on-farm costs) could be assessed further in order to optimise the benefit-cost ratio. Initial indications are that a number of design criteria and assumptions could be modified resulting in significant cost savings but with only relatively minor reductions in farm productivity.

ii. A number of possible changes to scheme arrangements may result in significant changes to scheme costs, though in most cases further work is required to determine whether the changes are technically viable and to determine the magnitude of saving.

iii. As a result of the Workstream 3 distribution investigations, it became apparent that no schemes could be justifiably dropped from further consideration i.e. all 5 schemes including and the Black Creek variation should continue to be investigated at this stage. This will allow for significant opportunities surrounding costs to be assessed prior to non-economic factors to be integrated into the assessment



WWUP Pre-feasibility Investigation (Sept 2014)
Indicative Command Areas for Prefered Schemes

0 12,000 24,000 Meters