TARANAKI IRRIGATION STUDY

Final Report

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Front cover photo: Pasture irrigation near Manaia on south Taranaki coast, courtesy of Rob Tucker.

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EXECUTIVE SUMMARY

Background and scope

The primary purpose of this project was to increase understanding of the practicality and economics of developing water storage and distribution schemes to meet the growing needs for irrigation and other water users in the Taranaki region.

This strategic water study is pitched at a level of preliminary assessment of scheme feasibility. It provides an evidence base that the community needs to either change or confirm perceptions within the community that storage based schemes are either impractical or unaffordable.

Where might irrigation be viable?

A study of irrigation requirements and the economic benefits of irrigation was completed by Bob Rout from Lincoln Environmental in 2003 (Rout 2003). This showed that irrigation may be economically beneficial on the coastal plains to the east of Mt. Taranaki and extending southwards around the coast to Patea. Part of the aim of this study was to extend the climate data used in the 2003 study to the present, reassessing the conclusions drawn by that study, then looking for viable solutions to service irrigation demand if practicable.

The results of extending the work carried out by Rout did not correlate with the actual demand for irrigation within the region. Because of this a more detailed assessment was carried out. Whereas the study carried out in 2003 had identified broad zones where irrigation may be viable, this detailed assessment has identified more specific areas within the region where irrigation may be viable.

To assess where irrigation may be viable modelling of irrigation demand was carried out. Only land with a slope less than 15 degrees and that is currently classified as 'productive farmland' was considered. Weather and soil water holding data was then analysed and parameters around irrigation application rates and reliability of supply were applied.

For the cost benefits of irrigation to be determined the pasture yield response to irrigation was assessed using the AusFarm simulation model, developed by CSIRO, Australia. The value of pasture ($/kg-DM) was estimated using local farm parameters that were developed in consultation with Louise Hofmann, Taranaki FarmWise consultant. The results of that work showed that the values of pasture in the area range between $0.17 to $0.25/kg-DM, with an average value of $0.22/kg-DM.

Based on these values the irrigation marginal benefits were calculated for a range of rainfall and soil combinations for three values of pasture: low $0.15/kg-DM, average $0.20/kg-DM and high $0.30/kg-DM. For mapping purposes the marginal benefits of irrigation were categorised into four levels; low <$150/ha, medium $151-300/ha, high $301-500/ha and very high >$500/ha.

The results of these assessments are shown in the following three figures:

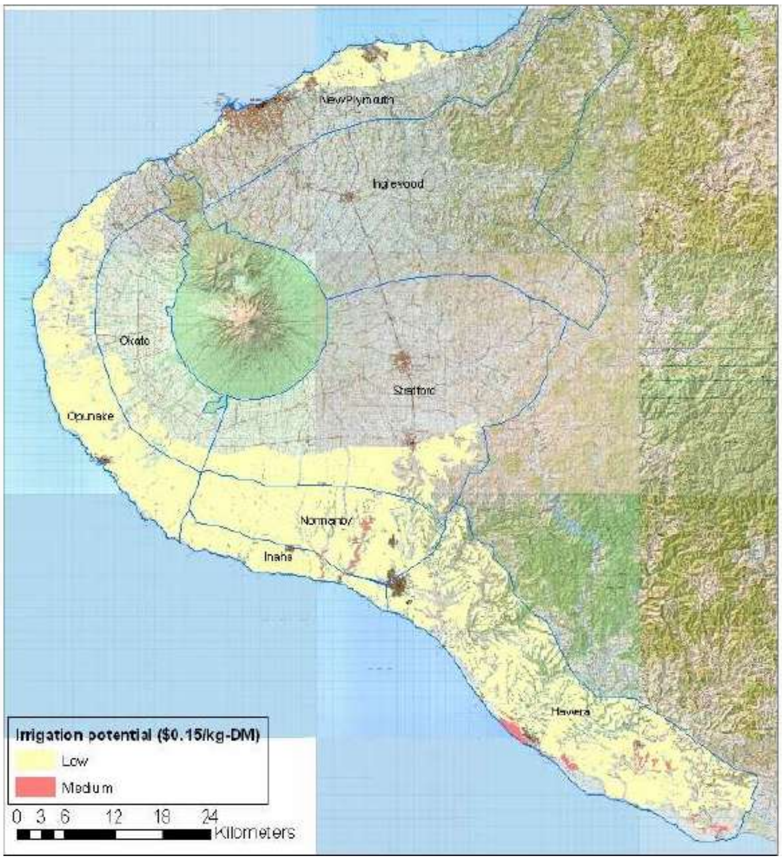

Figure 1: Irrigation development potential for low pasture price of $0.15/kg-DM

Figure 2: Irrigation development potential for moderate pasture price of $0.20/kg-DM

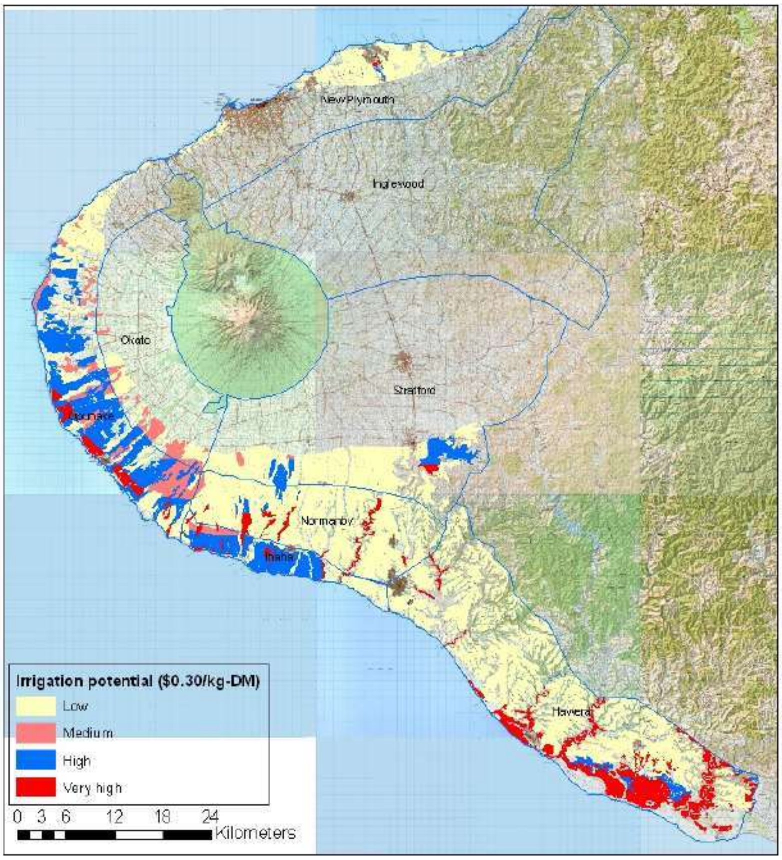

Figure 3: Irrigation development potential for high pasture price of $0.30/kg-DM

The results show that the most attractive area for irrigation development, in terms of economic viability, is the south eastern area of the Hawera zone, followed by the coastal belt of Opunake and Inaha. The viability however relies heavily upon average to high pasture values.

Options for irrigation water sources

Having identified where irrigation may be viable, the project focus turned to looking at the options for securing appropriate sources of water supply.

Consideration was given to the potential for groundwater being used for irrigation supply. This investigation concluded that the use of groundwater for irrigation is likely to be limited in scope and restricted to providing water to small properties, or topping up alternative supplies. The current understanding of the Taranaki Groundwater resource suggests that it is not likely to play a major role as an irrigation supply option for the region.

Analysis of surface water availability and reliability was carried out on four rivers (Waitotara and Whenuakura in the east Hawera area and Kapoaiaia and Punehu streams in the Opunake area). These were chosen primarily because of the flow data available and / or the relative catchment size.

TRC does not, at present, use specific rules for water harvesting. Therefore, to enable preliminary assessments the use of three allocation blocks was assumed. The allocation block assumptions are outlined in Table 1.

Table 1: Allocation regimes used in preliminary assessments

Block	Minimum Flow	Allocation limit	Source
A	Habitat flow	MALF - minimum habitat flow	TRC 2005
B	1:1 flow sharing above MALF	MALF×0.3	Assumed
C	1:1 flow sharing above 2×MALF	MALF×0.7	Assumed

Storage based schemes for the Inaha zone

An initial assessment of water availability and irrigation marginal benefits suggested that storage based community schemes may not be viable at this time. However, further assessment of the potential for a community scheme to serve the Inaha zone (6,500ha) was carried out. The purpose of this was to provide a sounder economic basis to concluding whether such schemes are viable at this time. It also allows for identification of schemes that may be viable if changes in the future (either economic or climatic) significantly alter the technical and economic data our analysis is based on.

The following storage options were investigated:

- centralise storage within the zone and distribute water via canals and/or pipelines (likely to be pumped);
- centralise storage outside the zone and distribute water via canals and/or pipelines (likely to be gravity); and
- distribute storage throughout the zone utilising the smaller streams that cross the zone.

The comparison of costs of these options indicated that a single centralised storage facility is the cheapest scheme design concept to serve the Inaha zone. The calculations suggest storage and distribution costs in the order of $50M excluding land purchase costs and GST.

The marginal benefit of irrigation calculated in this zone ranged from -$108/ha, $37/ha and $327/ha for pasture values of $0.15, $0.20 and $0.30/kg-DM respectively. The marginal benefits provide an indication of on-farm benefits assuming no scheme water charges.

For the development of large scale community schemes there has to be good support and "buy-in" from a reasonable proportion of land owners in the area. With the predicted on-farm economic returns (maximum modelled of $327/ha/year) and scheme development costs in excess of $7,800/ha for storage and distribution ($767/ha/year indicative annual charge), it is difficult to see that large scale community support would be achieved.

However, either due to significant increases in the value of pasture (over and above other input costs) or climate driven changes, there may be potential for such storage based schemes in the future. At such a time, further more detailed investigations into the type of scheme identified could be carried out.

Irrigation of the eastern Hawera zone

Analysis indicates that the Hawera zone can be irrigated by run of river supply, without the need for water storage.

Two schemes have been considered serving 5,000ha and 1,800ha. The smaller area would only serve properties with lighter soils. The concept is to pump water from the Waitotara River into a headrace traversing east to west across the Waverley rural area, with distribution races running from the headrace.

The costs to construct are estimated at \$18.2M (\$3,640/ha) and \$6.7M (\$3,722/ha) for the 5,000ha and the 1,800ha areas respectively. These costs exclude land purchase costs and GST. The operating costs are estimated at \$1.3M/yr (\$260/ha/yr) and \$0.35M/yr (\$195/ha/yr) for the two scheme concepts. These costs do not include debt servicing.

Although the scheme area has relatively low mean annual rainfall (1,100mm/year), there are areas within the larger scheme area with relatively deep soils (140mm & 160mm PAW). For these soil types the marginal benefits of irrigation (which exclude the cost of water supply to the farm) are calculated to be \$37 and -\$118 and \$327 and \$92/ha/year for pasture values of \$0.20 and \$0.30/kg-DM respectively. These returns are clearly insufficient to offset water supply costs and gain widespread community support at this time.

For the smaller scheme area, although the mean annual rainfall remains the same as for the larger area i.e. 1,100mm/year, the soils are predominantly lighter (80mm PAW). The marginal benefit calculated for this soil / rainfall combination for a pasture value of \$0.20/kg-DM is \$281/ha/year and for a pasture value of \$0.30/ha/year it is \$701/ha/year.

An approximate annual water charge per ha was calculated by making assumptions about finance rates and loan duration. The water charge calculated was \$539. This "cost of community supply" suggests that with a pasture value approaching \$0.30/kg-DM a community scheme may be viable serving properties with shallow soils in the Hawera zone.

For a community scheme to be successful, good community support is required. As such, the limited marginal benefits of such a scheme (i.e. \$162/ha maximum modelled) may not be sufficient to secure the necessary support without either significant net increases in the value of pasture or climatic changes.

Viability of irrigation

This investigation suggests that development of large scale community irrigation schemes is unlikely in Taranaki. However, it is important to note that this does not conclude that irrigation itself is not viable in this area. What it does show is that any such irrigation will need a low cost water supply, meaning;

- easy access to the water resource i.e. land close or immediately adjacent to the stream / river; and
- if storage is required, the property would need to lend itself well to storage.

The property would also need to be on lighter soils and in an area where the average annual rainfall is relatively low.

Individual or small clusters of properties may fit these criteria, especially if the land owners have a positive mindset towards irrigation. Large scale community development however, seems unlikely.

Incorporating non-irrigation water supply within community irrigation schemes

At the outset of this project feedback was sought from the three district councils in Taranaki about the issues faced with regard to providing reliable water supplies for non-irrigation uses, serving both the rural and urban communities. This information was sought so that consideration could be given to helping improve community supplies, with appropriate provisions being incorporated into conceptual irrigation scheme designs.

This project considered the irrigation demand and economic feasibility of providing irrigation supplies to the Taranaki Region. The results of this work have indicated that community scale irrigation schemes are unlikely to be feasible within the areas administered by the New Plymouth District Council or the Stratford District Council.

With the focus of this project being a review of irrigation potential, these results have meant that no further assessment has been made of the potential for new schemes to supplement or replace existing water supply schemes in these two districts.

The potential for community scale irrigation development is highest within the area administered by the South Taranaki District Council. This report comments upon existing community schemes in this district and how community scale irrigation development may be able to improve and expand community supplies.

Potential regional economic, environmental, social and cultural implications

Because large scale community irrigation development is unlikely at this time in Taranaki, no assessment of potential effects or implications of specific development are warranted. However, comments have been included regarding the typical effects that such developments have in these areas and matters are outlined that should be considered if such developments are considered in the future.

TABLE OF CONTENTS

Page

Executive Summary 3
Background and scope 3
Where might irrigation be viable? 3
Options for irrigation water sources 5
Storage based schemes for the Inaha zone 6
Irrigation of the eastern Hawera zone 7
Viability of irrigation 8
Incorporating non-irrigation water supply within community irrigation schemes 8
Potential regional economic, environmental, social and cultural implications 8

1 Introduction 15
1.1 Project Context 15
1.2 Project Scope 16
1.3 Variations to Initial Project Scope 17
1.4 Status of Storage Options 17
1.4.1 Hill country storage sites 17
1.4.2 Conceptual nature of schemes 18

2 Description of the Environment 19
2.1 Landforms 19
2.1.1 Volcanic landscape and ring plain 19
2.1.2 Hill country 19
2.1.3 Marine terraces 20
2.1.4 Coastal environment 20
2.2 Climate 20
2.2.1 Climate change 21
2.3 The Rivers of Taranaki 22
2.4 Groundwater 23

3 Current State of the Environment 25

4 Assessing Where Irrigation Development May Be Viable 29
4.1 Study Area Classification 31
4.2 Irrigation Analysis 33
4.2.1 Maximum daily application rate 33
4.2.2 Irrigation demand 33
4.3 Irrigation Expenses 35
4.4 Irrigation Yield Response 35
4.5 Irrigation Cost-Benefits 36

5 Potential Sources Of Irrigation Supply, Allocation And Reliability 41
5.1 Groundwater Availability For Irrigation 41
5.1.1 Taranaki volcanics 41
5.1.2 Marine Terrace aquifers 42
5.1.3 Whenuakura formation aquifers 42
5.1.4 Groundwater use in Taranaki 42
5.2 Surface Water Allocation 43

5.3 Reliability of Irrigation Water ... 43
5.4 Assessment Of Surface Water Reliability ... 44
5.4.1 Waitotara River ... 45
5.4.2 Whenuakura River ... 45
5.4.3 Kapoaiaia Stream ... 49
5.4.4 Punehu Stream ... 52
5.5 Conclusions of Irrigation Marginal Benefits ... 55
5.5.1 Storage based community schemes ... 55

6 Irrigation Of The Inaha Zone Via Community Scheme ... 57
6.1 Zone Description ... 57
6.2 Hydrological Catchments ... 57
6.3 Inaha Storage Options ... 59
6.3.1 Potential storage concepts ... 59
6.3.2 Centralised storage in zone ... 59
6.4 Centralised Storage Out Of Zone ... 61
6.5 Distributed Storage ... 62
6.6 Cost Comparisons of Storage Options ... 63
6.6.1 Cost model ... 63
6.7 Comparison of Centralised and Distributed Storage ... 64
6.8 On- Farm Storage ... 65
6.9 The effects of sediment on storage ... 66
6.10 Financial Viability of Inaha Scheme ... 66
6.11 Possible Further Investigations for the Inaha Zone ... 67

7 Scheme Irrigation Of The Hawera Zone ... 69
7.1 Zone Description ... 69
7.2 Scheme Description ... 70
7.3 Hydropower Potential ... 71
7.4 Tidal Effects On Scheme Intake ... 71
7.5 Cost Estimate of Hawera Irrigation Scheme ... 72
7.6 Financial Viability of Hawera Schemes ... 73
7.7 Areas Outside Those Considered ... 74

8 Comparisons With Other Schemes In New Zealand ... 75
8.1 Waimea Water Augmentation Scheme – Tasman ... 75
8.2 Tarras Irrigation Scheme – Otago ... 76

9 Implications For Improving / Developing Water Supplies For Non-Irrigation Uses ... 77
9.1 New Plymouth District Council ... 77
9.2 Stratford District Council ... 77
9.3 South Taranaki District Council ... 78

10 Incorporating Non-Irrigation Water Supply Within Community Irrigation Schemes ... 79
10.1.1 Inaha Zone ... 79
10.2 Hawera Zone ... 79
10.3 Opunake Zone ... 80

11 Potential Regional Economic Implications ... 81

12 Potential Environmental Implications **83**
12.1 Water Quantity 83
12.2 Water Quality 83

13 Potential Social And Cultural Implications **85**
13.1 Social Impacts 85
13.2 Cultural Impacts 85
13.3 Tangata Whenua And The Environment 86
13.4 Land 87
13.5 Water 87
13.6 Impacts Of Irrigation Development On Cultural Values 87

14 References **89**

List of Figures:

Figure 1: The main rivers of Taranaki 22
Figure 2: Pie chart of consented surface water takes classified by use 27
Figure 3: Pie chart of consented groundwater takes classified by use............ 28
Figure 4: Map showing Rout (2003) Irrigation Zones............ 30
Figure 5: Distribution of mean annual rainfall within the study area 31
Figure 6: Map showing distribution of soil PAW within the study area 32
Figure 7: Irrigation development potential for low pasture price of $0.15/kg-DM......... 38
Figure 8: Irrigation development potential for moderate pasture price of $0.20/kg-DM38
Figure 9: Irrigation development potential for high pasture price of $0.30/kg-DM........ 39
Figure 10: Approximate Area of Inaha Irrigation Zone 57
Figure 11: Kaupokonui and Waingongoro Catchments 58
Figure 12: Kaupokonui Storage and Possible Distribution Layout 60
Figure 13: Existing Dam on the Waingongoro River (source: BECA 1985) 61
Figure 14: Waingongoro River – Typical Topography (source: BECA 1985) 61
Figure 15: Inaha Irrigation Zone – Distributed Storage 62
Figure 16: Estimated Storage Cost Curve ($/m³) 64
Figure 17: Potential Areas of Storage to be considered............ 68
Figure 18: 5,000 ha Hawera Irrigation Scheme 69
Figure 19: 1,800 ha (light soils only i.e. PAW <80mm) Hawera Irrigation Scheme 70
Figure 20: Schematic layout of possible Hawera Irrigation Schemes 71
Figure 21: Iwi boundaries 86

List of Tables:

Table 1: Allocation regimes used in preliminary assessments 6
Table 2: Consented water takes (except hydroelectric power schemes and diversions) classified by use............ 26
Table 3: Consented surface water takes (except hydroelectric power schemes and diversions) classified by use............ 27
Table 4: Consented groundwater takes classified by use 28
Table 5: Soil classification 32
Table 6: Irrigation demand for different rainfall and soil combinations 34
Table 7: On-farm irrigation expenses for different rainfall and soil combinations............ 35
Table 8: Irrigation yield response for different rainfall and soil combinations............ 36
Table 9: Irrigation marginal benefits for different rainfall and soil combinations............ 37
Table 10: Allocation regimes used in preliminary assessments 43
Table 11: Waitotara River water availability summary for different allocation blocks.......... 45
Table 12: Summary of Whenuakura River water availability for different allocation blocks............ 46
Table 13: Run-of-river reliability for the Whenuakura River allocation blocks 46
Table 14: Whenuakura C-block irrigation and economic analysis for PAW 60 mm and MAR 1,100 mm based on pasture value of $0.20 / kg-DM 48
Table 15: Summary of Kapoaiaia Stream water availability for different allocation blocks............ 49
Table 16: Run-of-river reliability for the Kapoaiaia Stream allocation blocks 49

Table 17: Kapoaiaia C-block irrigation and economic analysis for PAW 80 mm and MAR 1,200 mm based on pasture value of $0.20 / kg-DM 51
Table 18: Summary of Punehu Stream water availability for different allocation blocks 52
Table 19: Run-of-river reliability for the Punehu Stream allocation blocks 52
Table 20: Punehu C-block irrigation and economic analysis for PAW 80 mm and MAR 1,200 mm based on pasture value of $0.20 / kg-DM 54
Table 21: Kaupokonui Catchment Flows (April 1978 to May 2010).... 58
Table 22: Site Conditions Influencing Storage Costs.... 65
Table 23: Hawera Schemes Cost Estimate Summary 72
Table 24: Hawera Scheme Summary of Costs and Marginal Benefits 74

List of Appendices:

Appendix A: South Taranaki District Council existing community water supply schemes 90
Appendix B: Graphical representation of BECA 2003 survey results 91

List of Abbreviations

BOD	biochemical oxygen demand
DM	dry matter
GDP	gross domestic product
GIS	geographic information system
ha	hectare
kg	kilogram
km	kilometre
km^2	square kilometres
kwh	kilowatt hour
l/s	litres per second
l/s/ha	litres per second per hectare
mm	millimetre
mm/day	millimetre per day
mm/year	millimetre per year
m	metre
m^3	cubic metre
m^3/day	cubic metres per day
m^3/ha/year	cubic metres per hectare per year
m/s	metres per second
m^3/s	cubic metres per second
Mm^3	million cubic metre
MS	milk solids
°C	degrees Celsius
PAW	plant available water
PET	potential evapotranspiration
RL	reduced level
t-DM/ha	tonne dry matter per hectare
t-DM/ha/yr	tonne dry matter per hectare per year
VCS	virtual climate station
$/ha	$ cost per hectare
$/kg-DM	$ cost per kilogram dry matter
$/$m^3$	$ cost per cubic metre

List of Acronyms

CSIRO	Commonwealth Scientific and Industrial Research Organisation
TRC	Taranaki Regional Council
STDC	South Taranaki District Council
NPDC	New Plymouth District Council
SDC	Stratford District Council
NIWA	National Institute of Water and Atmosphere
LE	Lincoln Environmental
NZFSL	NZ fundamental soils layer
NZLRI	New Zealand Land Resource Inventory
LCDB	Land cover database
MALF	mean annual low flow
MAR	mean annual rainfall

1 INTRODUCTION

The primary purpose of this project was to increase understanding of the practicality and economics of developing water storage and distribution schemes to meet the growing needs for irrigation in the Taranaki region.

This strategic water study is pitched at a level of preliminary assessment of scheme feasibility. It will provide an evidence base that the community needs to either change or confirm perceptions within the community that storage based schemes are either impractical or unaffordable.

1.1 Project Context

Taranaki is generally well endowed with fresh water resources receiving regular rainfall and having many mountain-fed streams flowing through areas of high demand, particularly on the ring plain where intensive dairying predominates. This, together with the generally stable nature of river flows during dryer periods means that for most of the time there are no significant water use pressures on Taranaki rivers. However, Taranaki is one of New Zealand's leading dairying regions and this results in high water demands being placed on rivers and streams for stock, farm dairy, pasture irrigation and other on-farm uses. Interest in pasture irrigation has increased significantly in recent years, particularly on the sandy soils bordering coastal areas and in the dryer southern parts of the region.

Taranaki can experience water shortages and serious droughts. During such periods there is a need to restrict water abstraction with the attendant disruption for water users and lost economic opportunities. These water supply problems are compounded by the generally small size of rivers and reliance on run-of-river flows.

Increasing abstraction pressures can also lead to increasing and more persistent impacts on stream hydrology and ecology. Greater investment in water harvesting and storage at times when water is available has the potential to reduce these impacts and provide opportunities to boost economic activity and production in the region.

However, there is a perception that there is a shortage of practical storage locations and, in any case, the high cost of storage development renders storage-based irrigation water supplies uneconomic.

This project seeks to clarify this issue so that robust decisions can be made regarding irrigation and water supply potential.

A study of irrigation requirements and the economic benefits of irrigation was completed by Bob Rout from Lincoln Environmental in 2003 (Rout 2003). This showed that irrigation may be economically beneficial on the coastal plains to the south east of Mt. Taranaki and extending southwards around the coast to Patea. Part of the aim of this current study was to extend the climate data used in the 2003 study to the present, reassessing the conclusions drawn by that study, then looking for viable solutions to service irrigation demand if practicable.

1.2 Project Scope

This study considered the viability of irrigation throughout the Taranaki region. It then focused upon areas that have the greatest potential for economically viable irrigation.

The initial project scope sought answers to the following four questions:

1) Where is water needed?
    - Where is irrigation likely to be profitable, taking account of the full financial cost of the water supply?
    - Where can individuals provide for themselves a reliable supply of water of sufficient quality to meet their own needs for household, farm and irrigation water supply?
    - Where might a community water supply solve problems around the competition for water that develops as run-of-river water takes increase to the point where reliability and adverse environmental effects become an issue?
    - Where is a community water supply the only option, or likely to be the best long term option, for securing a reliable supply that meets the water quantity and quality needs of a community?

2) Where are the storage sites that have realistic prospects of being feasible?
    - What lessons can we learn from existing impoundments?
    - Where is the most favorable topography?
    - What are the geotechnical constraints and opportunities within and above the areas where water is needed?
    - Which areas present the lowest risk profile across factors such as: impoundment failure, water quality collapse, loss of storage lifetime due to sedimentation?
    - What are the top 10 ranked sites, with respect to engineering, cost and environmental factors, and likely stakeholder reaction?

3) What are the main options for connecting areas with water needs with water sources and existing or potential water storages, building on existing water infrastructure where appropriate?

4) Which of these scheme options are realistic options?
    - Which options are technically feasible?
    - Which options are financially viable from both a farmer perspective and a scheme owner's perspective?
    - What are the potential economic, social and environmental costs and benefits?

- Which options are likely to overcome perceptions that such systems are impractical or unaffordable in Taranaki?

Collectively this set of questions defined the scope of this project.

1.3 Variations to Initial Project Scope

As this study unfolded it became apparent that variations to the original project scope were required. The first variation came as a result of reassessing the Rout (2003) study, with extended duration of climate data.

The results of extending the Rout study did not correlate with the actual demand for irrigation within the region. Further explanation of this is outlined later in this report. A consequence of this discovery was that significantly more work was required to accurately determine irrigation demand requirements. As such, this aspect of the project took longer than planned and became a much larger aspect of the project than envisaged. As this report outlines, this work highlighted specific areas of the region where irrigation may be viable, rather than the more general zones identified in the Rout (2003) report. These more detailed results allow a more targeted approach to assessing the viability of irrigation.

After re-evaluation of the locations where irrigation may be appropriate, the project considered options for delivering irrigation water to the locations where it was deemed to be most viable. The project brief had a heavy bias towards evaluating storage options. However, review of the probable costs of providing a storage-based water supply for irrigation and comparison of these with estimated economic returns of irrigation, indicated that community scale scheme storage was unlikely to be a viable option. Because of this, there seemed little to be gained in looking at specific storage sites and ranking the top 10, as the project scope initially suggested.

Some storage options have been assessed in order to outline possible large scale storage concepts and to provide an indication of likely costs. However, given the high level / strategic nature of this study, this does not include a site specific and detailed assessment of storage as suggested within the original scope.

Despite these variations from the original project scope, this study does deliver answers to the most important two questions, being;

- Where in the Taranaki Region is it financially viable to irrigate?; and
- What are the options available to service these areas?

1.4 Status of Storage Options

1.4.1 Hill country storage sites

Specific storage sites in the inland hill country have not been evaluated. It became clear in the early stages of the study that the irrigation development potential of land beyond the ring plain that could be served by such a storage facility was low. The exception to this was the south eastern part of the Hawera zone. Much of this area however can be served with run-of-river water and so storage is not required.

1.4.2 Conceptual nature of schemes

This report evaluates storage and scheme options for securing reliable water supplies. It is important to note that the scheme options outlined are conceptual in nature and are not specific irrigation scheme proposals. They show what may be possible. More work would be required in order to determine the most appropriate water sources and to reach a point where more detailed feasibility studies could be carried out. The schemes explored in Sections 6 and 7 were considered the most promising community irrigation concepts, due to the availability of water and the on-farm value of irrigation.

2 DESCRIPTION OF THE ENVIRONMENT

The following provides a brief description of the environment as it relates to this project.

The Taranaki region comprises 723,610 ha, which is approximately 3% of New Zealand's total land area. There are three districts within the region, these being New Plymouth, Stratford and South Taranaki.

2.1 Landforms

The region consists of the following four distinct landforms:

- the volcanic landscape and ring plain centred on Mount Taranaki;
- the dissected Taranaki hill country;
- the coastal and inland marine terraces of the North & South Taranaki coast; and
- the coastal and marine environment.

The following provides a brief description of these four distinct land forms.

2.1.1 Volcanic landscape and ring plain

The volcanic cone of Mount Taranaki (2,518 m) dominates the Taranaki landscape. Over the past 50,000 years the cone of Mount Taranaki has collapsed intermittently causing very large and mobile debris avalanches and lahars (mudflows) to sweep down the mountain. As each volcanic cone was built up by successive eruptions, natural erosion has stripped away the volcanic debris and redistributed it in a 'ring' around the volcano base creating the Taranaki ring plain.

The soils of the ring plain are mostly deep, free-draining, fertile, volcanic ash soils known as yellow-brown loams. These soils support intensive pastoral farming, particularly dairying, which is most intensive on the flatter land in South Taranaki.

Over 300 rivers and streams flow from the flanks of Mount Taranaki in a distinctive radial pattern. These streams are characterised by short narrow catchments of steep gradient, normally well incised into the volcanic ash and debris flow material of the ring plain.

Egmont National Park acts as a huge reservoir, supplying a steady flow of water to the ring plain streams, even during prolonged dry periods, as well as maintaining high water quality in those streams. The rivers that flow from the mountain are extensively used by the community for agriculture, industry and community water supplies, and for a wide range of recreational purposes.

2.1.2 Hill country

The Taranaki hill country lies to the east of the ring plain. The inland terraces and frontal hill country are of strongly rolling topography and largely retain the volcanic ash soils, while the inland hill country is steeper and more deeply dissected. The underlying geology of the Taranaki hill country is not volcanic, but consists of older sedimentary rocks – mudstones, siltstones and sandstones.

The soils of the inland hill country are mostly shallow soils that have developed on steep, relatively unstable slopes. The composition and depth of soils are extremely variable, and often erosion has prevented the development of a mature soil.

While the hill country is more prone to erosion, it can support both pastoral farming and commercial forestry when managed in accordance with the physical limitations of the land. The rivers of the hill country have short tributaries contained by narrow valleys. In general, these rivers carry high sediment loads.

2.1.3 Marine terraces

Marine terraces raised by tectonic activity extend along the North and South Taranaki coasts. In the far north only a narrow strip of coastal plain is preserved, but between Waitara and Lepperton in the north and from Hawera south, the terraces extend up to 20 km inland. Along the coastline, cliffs ranging from three to 60 m in height have formed from high energy wave action. In the Whitecliffs area of North Taranaki, some cliffs are over 200 m high.

The volcanic deposits on the old terrace surfaces are deep and, because they are further from the volcanic centre, are finely textured. The soils of these areas are classic volcanic loams and are among the most versatile and productive in the region.

Sand accumulation is concentrated near river mouths, particularly along the southern coastline, where dune fields extend inland for several kilometres. Less than 2% of the Taranaki region is classified as coastal sand country. Because of their weak structure, these soils are susceptible to wind erosion if the vegetation cover is disturbed.

2.1.4 Coastal environment

The Taranaki coastline is exposed to the west, and as a consequence, high energy wave and wind conditions dominate the coastal environment. There are few areas of sheltered water beyond the estuaries.

Almost the entire Taranaki coastline is subject to varying rates of erosion from waves and wind. This has resulted in a predominantly cliffed coastline, with the western coast characterised by boulder cliffs and offshore reefs derived from erosion of lahar and other volcanic material.

In North and South Taranaki, erosion of marine sediments has resulted in a coastline of almost continuous papa cliffs and the famous black sand beaches.

2.2 Climate

Because of its exposure to disturbed weather systems from the Tasman Sea, this region is often quite windy, but has few climate extremes. The most settled weather occurs during summer and early autumn. Summers are warm with typical summer daytime maximum air temperatures ranging from 19°C to 24°C, although seldom exceeding 30°C. Winters are relatively mild with daytime maximum air temperatures ranging from 10°C to 14°C but are normally the most unsettled time of the year. Frost occurs inland during clear calm conditions in winter. Annual sunshine hours average about 2000 hours. Northwesterly airflows prevail and sea breezes occasionally occur along the coast during summer.

Rainfall varies markedly throughout the region, ranging from 1,100 mm in the coastal areas, to in excess of 8,000 mm at the summit of Mount Taranaki. Rainfall also increases with elevation in the Taranaki hill country.

2.2.1 Climate change

The TRC web site includes the following comments about climate change;

The general consensus of scientific opinion is that the world is getting warmer, causing its climate to change. Global temperatures today are about 0.6°C higher than they were in the early 1900's.

While there is not unanimous agreement, there is now strong evidence that most of the warming observed is attributable to increased concentrations of greenhouse gases. As more gases accumulate, the Earth gets warmer - resulting in rising sea temperatures and sea levels, the melting of glaciers and ice caps (which also increase sea levels) and greater extremes in weather patterns, such as more storms of greater intensity and longer droughts.

At a regional level, research indicates that, over the next 70-100 years, Taranaki's temperatures could be up to 3˚C warmer, the climate could be up to 20% wetter with more varied rainfall patterns, and flooding is likely to become more frequent and severe.

In rural areas, if extreme events such as floods and droughts become more severe and frequent, costs to farmers associated with dealing with stock losses, increased soil erosion and damage and disruptions to farm operations would be expected to increase. A wetter climate may also increase 'pugging' of pasture and cropping soils during winter. Hotter summer days could also increase competition for water uses in some areas between agricultural irrigation and domestic and industrial uses during drier periods. Generally warmer temperatures could further facilitate the spread of some pests, diseases and lover feed-quality sub-tropical grasses such as kikuyu grass. There may also be some benefits for agriculture and forestry through improved plant growth because of longer growing seasons and rising carbon dioxide levels and the potential for new crops and associated industries to move into new areas.

Climate change and the potential effects of global warming clearly need to be considered when assessing the feasibility of both small scale and community scale irrigation schemes. Although it is predicted that the region will become wetter, because of higher temperatures and the potential for longer, more severe droughts, having access to reliable irrigation water may become more valuable in the future than it is today. Because of this the potential impact of climate change needs to be considered when assessing the viability of irrigation development.

2.3 The Rivers of Taranaki

Many rivers and streams flow across the landscape of Taranaki. Of these, some 530 are named. The main rivers are shown in Figure 1.

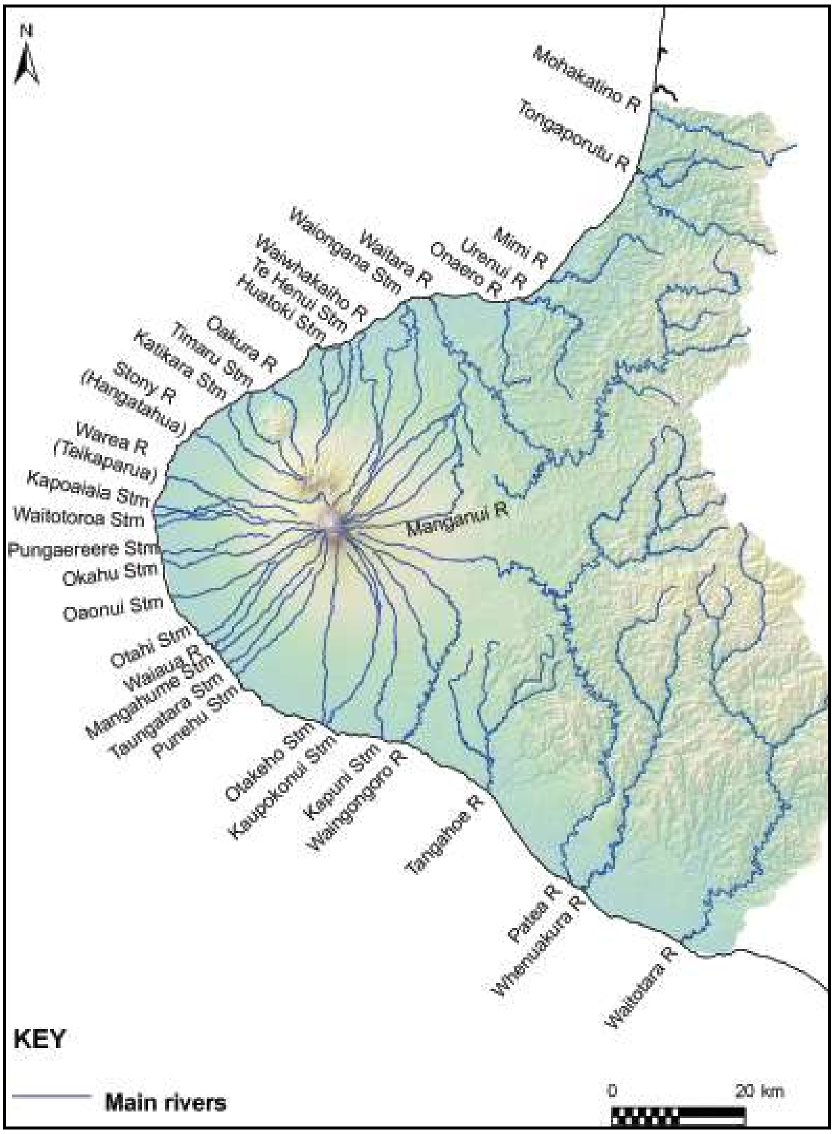

Figure 1: The main rivers of Taranaki

The latest State of the Environment Report (TRC 2009) produced by the Taranaki Regional Council (TRC) provides a useful snapshot of the "health" of the regions surface water features. The following are some of the conclusions from the 2009 report;

- measures of freshwater ecological health, such as the communities of invertebrates living in streams, are good to excellent in the upper catchments where there is more stream bank vegetation cover, but only fair further down catchments where land use is more intense. However, over the past 12 years, ecological health has demonstrably improved at a number of sites, including in the middle and lower reaches of catchments, and has not demonstrably deteriorated at any sites.

- The region's fresh water usually meets the bacteriological guidelines for swimming, except after floods or in some intensively farmed catchments. Taranaki rivers are naturally high in phosphorus and so do not meet national guidelines, and furthermore, phosphorus levels are generally increasing. Nitrogen levels meet guidelines in the upper reaches of catchments, but not further down, where impacts of agriculture are more intense.
- The Regional Council has a riparian management programme designed to help improve stream health and improvements continue to be made with fencing and planting of stream banks. In 2011 72% of stream banks on the ring plain were fenced, with 58% vegetated. The Regional Council has a target for fencing and vegetation of 90% of streams on the ring plain by 2015.
- Measures of levels of organic pollution (BOD), bacteriological pollution (faecal coliforms and enterococci) and toxicity (ammonia) are now stable regionally, after past improvements.
- Most of Taranaki's 530 streams and rivers are not under any allocation pressure, although interest in water abstraction for irrigation has increased in recent years. More than 20% of the average low flow is allocated for use in the nine most highly allocated catchments, but flows at which abstraction must cease are set to safeguard ecological values.

2.4 Groundwater

Groundwater is an important water resource in Taranaki as it is used for a variety of purposes including domestic, industrial, agricultural, and water supply for private and municipal use, particularly in South Taranaki. Groundwater is also the major component of stream flow during dry weather for most streams.

The true size and capacity of the region's aquifers are highly complex and therefore uncertain despite the geology and characteristics of the formations they are encountered in being extensively studied. The yields of the aquifers in the region are relatively low compared with other regions of the country due to the nature of geological formations.

Aquifers are recharged by rain percolating through the soil and into the groundwater. The amount of rain available to recharge aquifers is the total rainfall less the amount that evaporates, is consumed by plants, stored in the soil or runs off into surface water.

Although there has been an increase in the amount of groundwater abstracted in recent years, there is not significant pressure on groundwater levels.

Groundwater quality in Taranaki is generally high with no problems associated with pesticide residues, microbial contamination or saltwater intrusion, and groundwater quality, in terms of nitrate levels, is generally improving.

3 CURRENT STATE OF THE ENVIRONMENT

Farming Operations in Taranaki

Dairying dominates farming in Taranaki, particularly on the ring plain. There are 1,870 dairy herds in Taranaki – 16% of all New Zealand dairy herds with 480,000 dairy cows making up 12.2% of all New Zealand's dairy cow population.

Sheep and beef farming, concentrated in the hill country, has an important role in the regional economy. Approximately 880 sheep and beef farms in Taranaki stock approximately 679,000 sheep and 131,000 beef cattle.

Overall, agriculture and associated food processing industries contribute almost 20% to regional GDP, generating around $850 million in GDP in 2006.

Water allocation

Over most of the region (i.e. the largest 25 catchments) water allocation is only a small proportion of median flows (1 to 2%). Some smaller catchments have higher allocations, but these represent a relatively small proportion of the total surface water resources of the region. Taken overall, water allocation in Taranaki is only 4.6% of the total median flow.

The proportion is higher when compared with Mean Annual Low Flow (MALF), but overall, total water allocation is still reasonably low at 12.9% of MALF. Some catchments however have a higher proportion of their summer low flow allocated in accordance with the Regional Fresh Water Plan. The 2009 State of the Environment Report showed that 24 catchments, or 10%, have more than 20% of their MALF allocated.

Recent national guidelines for water allocation have proposed, in the absence of regional plan rules, interim primary allocation limits of 30% of MALF in rivers and streams with a mean flow less than 5 m^3/s, and 50% of MALF in rivers with a mean flow greater than 5 m^3/s (MfE 2008). Interim values are intended to provide an environmentally conservative limit, until such time as a site specific study can be undertaken. Generally a site specific study would indicate a greater volume of water can be allocated. In Taranaki, 19 catchments, or 8%, have more than 30% of MALF allocated.

Regional water use

Water is used for a number of consumptive uses. Table 2 shows the region's resource consents for consumptive water use at 30 June 2011.

Table 2: Consented water takes (except hydroelectric power schemes and diversions) classified by use.

Use Classification	Number of Resource Consents	Total Consented Abstraction (m3/day)	Percentage of Total Abstraction Volume
Dairy Farm	74	176,495	31.60%
Water Supply or Treatment	34	149,881	26.83%
Petrochemical Processing	13	55,299	9.90%
Dairy Processing/Manufacturing	5	30,916	5.54%
Power Generation - Thermal	2	19,440	3.48%
Meat and By-Product Processing	8	15,160	2.71%
Hydrocarbon Exploration	67	103,582	18.54%
Quarries	2	2,480	0.44%
Recreation/Tourism/Culture	11	2,506	0.45%
Horticulture	14	2,014	0.36%
Swimming Pool	1	270	0.05%
Chemical Processing/Manufacturing	1	90	0.02%
Timber Treatment/Sawmill	2	78	0.01%
Piggery Farm	2	255	0.05%
Power Generation - Wind	1	88	0.02%
Total	**237**	**558,554**	**100%**

In addition to consented takes, there are also a number of consumptive uses that are permitted activities. The majority of the permitted activities are for agriculture, such as for farm dairy supplies.

At 30 June 2011, the Taranaki Regional Council had a total of 145 active resource consents to abstract surface water and 92 resource consents to abstract groundwater. These figures do not include consents granted to divert water for hydroelectric power generation.

Consented Surface Water Takes

The 145 surface water take consents abstract water out of 46 catchments in Taranaki. With five catchments supplying over 50% (or 224,141 m^3/day) of the surface water that has been allocated.

There are 57 resource consents with the “Dairy Farm” classification. Dairy Farm encompasses all activities that can occur on the farm, which includes taking water for stock drinking, wash down, domestic purposes and pasture irrigation. 52 of these are for pasture irrigation and equates to 38.32% (or 168,774 m^3/day) of the total water allocated. Table 3 and Figure 2, show the surface water takes according to use classification.

Table 3: Consented surface water takes (except hydroelectric power schemes and diversions) classified by use.

Use Classification	**Number of Resource Consents**	**Total Consented Abstraction (m3/day)**	**Percentage of Total Abstraction Volume**
Dairy Farm	57	170,298	38.67%
Water Supply or Treatment	22	138,802	31.52%
Petrochemical Processing	10	54,749	12.43%
Dairy Processing/Manufacturing	3	30,000	6.81%
Power Generation - Thermal	2	19,440	4.41%
Meat and By-Product Processing	6	10,860	2.47%
Hydrocarbon Exploration	19	9,332	2.12%
Quarries	2	2,480	0.56%
Recreation/Tourism/Culture	9	2,140	0.49%
Horticulture	10	1,732	0.39%
Swimming Pool	1	270	0.06%
Chemical Processing/Manufacturing	1	90	0.02%
Timber Treatment/Sawmill	2	78	0.02%
Piggery Farm	1	75	0.02%
Total	**145**	**440,346**	**100%**

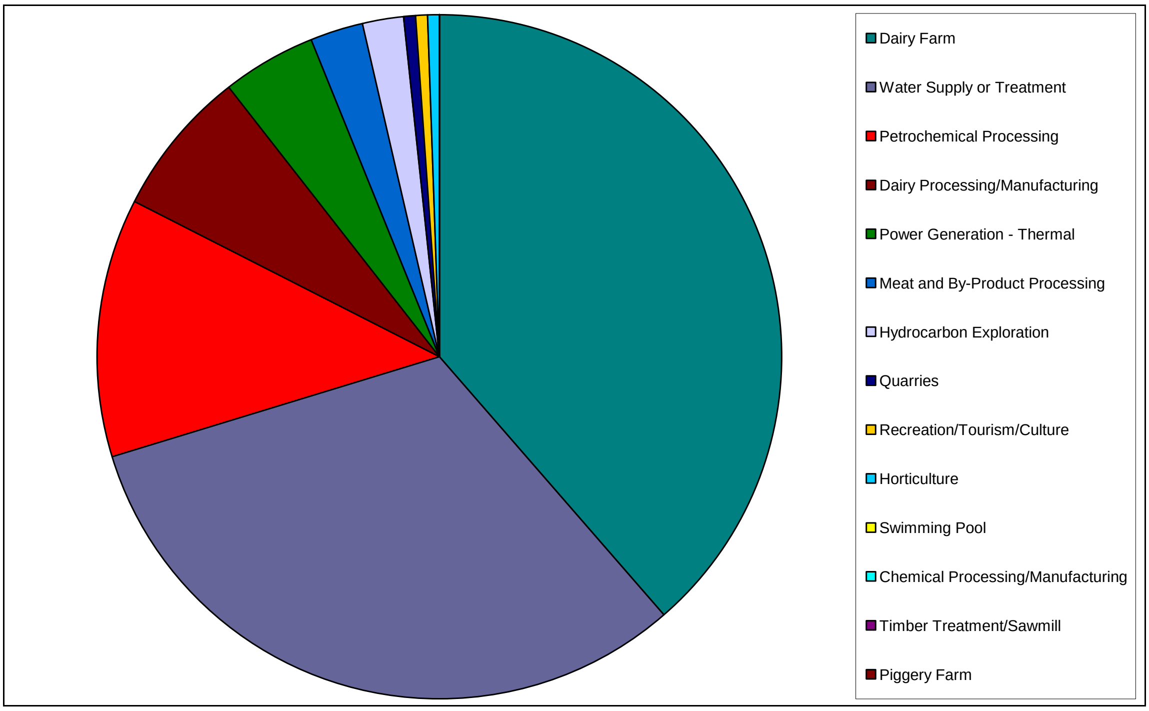

Figure 2: Pie chart of consented surface water takes classified by use

Consented Groundwater Takes

A total of 92 resource consents to abstract groundwater are currently active in the region. With over 50% of the resource consents being to take groundwater for Hydrocarbon exploration.

Table 4 shows the resource consents for groundwater takes classified by use.

Table 4: Consented groundwater takes classified by use

Use Classification	Number of Resource Consents	Total Consented Abstraction (m3/day)	Percentage of Total Abstraction Volume
Hydrocarbon Exploration	48	94,250	79.73%
Water Supply or Treatment	12	11,079	9.37%
Dairy Farm	17	6,197	5.24%
Meat and By-Product Processing	2	4,300	3.64%
Dairy Processing/Manufacturing	2	916	0.77%
Petrochemical Processing	3	550	0.47%
Recreation/Tourism/Cultural	2	366	0.31%
Horticulture	4	282	0.24%
Piggery Farm	1	180	0.15%
Power Generation - Wind	1	88	0.07%
Total	**92**	**118,208**	**100%**

NOTE: Due to the nature of Hydrocarbon exploration work, rates and volumes to be extracted were not included in consents. So for the purposes of calculating abstractions, a standard rate of 25 litres per second, or 2160 cubic metres per day was used for the 40 consents that did not have rates or volumes specified.

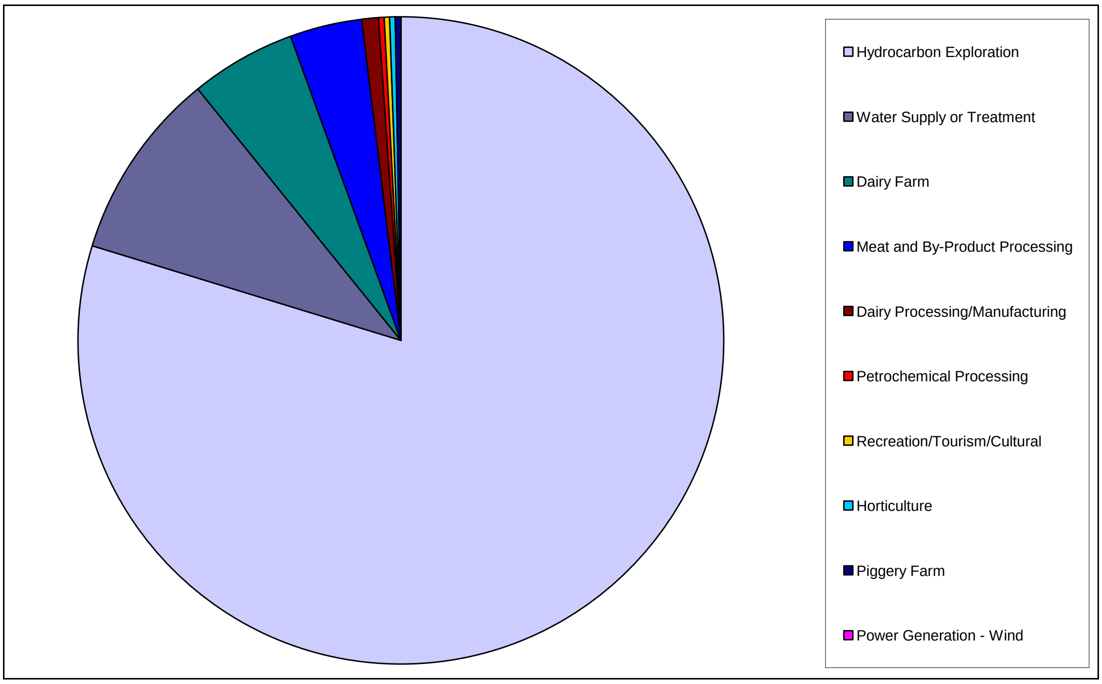

Figure 3: Pie chart of consented groundwater takes classified by use

4 ASSESSING WHERE IRRIGATION DEVELOPMENT MAY BE VIABLE

Previous Studies

A study of irrigation requirements and the economic benefits of irrigation was completed by Rout (2003). That study indicated that irrigation was likely to be economically beneficial on the coastal plains to the south-east of Mount Taranaki.

Rout (2003) reported that although there has been dairy farming in the region for over 100 years, only a limited number of irrigation related studies have been conducted.

For this current study the proposal was to retain the irrigation zones defined by Rout (2003) and to use the same soils data and climate stations for each zone to enable meaningful comparison (review) of technical information. It was then proposed to extend the period of analysis through to 2010.

Figure 4 shows the irrigation zones defined by Rout (2003).

Figure 4: Map showing Rout (2003) Irrigation Zones

The re-assessment of the Rout (2003) work was carried out with improvements in soil categorisation to enhance the representation of soil variability. The results were presented to the TRC for discussion. The feedback from TRC staff was that the interest for irrigation and the locations where irrigation consents had already been granted, did not appear to correlate with the locations identified within the re-assessment of the Rout work.

Further review determined that by drilling down into greater detail with regard to defining the irrigable land parameters, rainfall bands and soil classifications, the results would more closely align to expressions of interest for irrigation. Notwithstanding that this project is aimed at conducting a high-level regional scale study, it was decided to increase the resolution of both climate and soil classification to better represent the study area.

4.1 Study Area Classification

For the study area it was assumed that all future irrigable areas would be on land with:

1. Landslope < 15^{o} (Land slope classes "A", "B" or "C" from Land Resource Inventory GIS database).
2. Classified as currently productive farmland (Classified as "high production exotic grasses", "horticulture", and "Short rotation cropping" in Land Cover Database version 2 (LCDBv2)).

For the remaining irrigable land, the areas were classified based on mean annual rainfall (MAR), and soil profile available water (PAW).

- MAR is highly variable within the study area. Therefore, the study area was divided into six climate classes based on MAR: 1100, 1200, 1300, 1400, 1500 and ≥1600 mm/year (Figure 5).

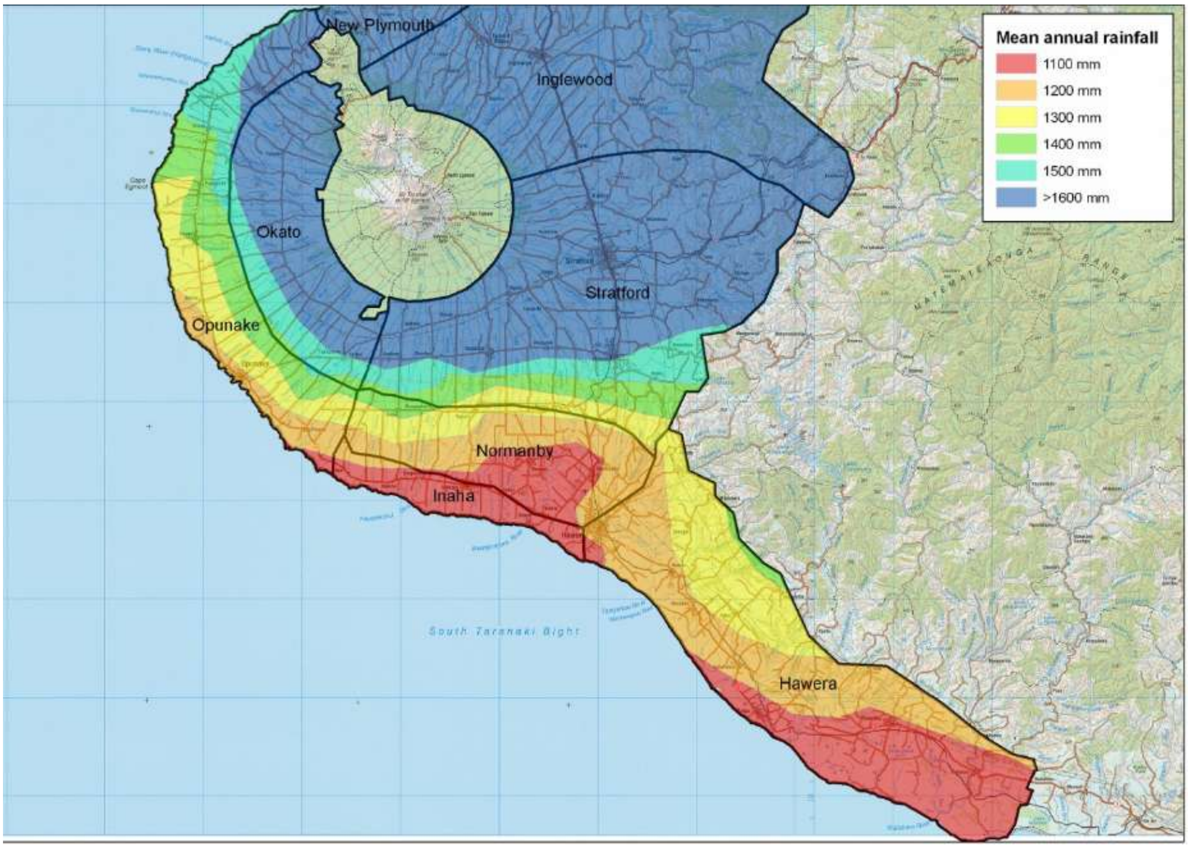

Figure 5: Distribution of mean annual rainfall within the study area

- The distribution of soil was classified into 20 mm intervals based on the Plant Available Water (PAW) given in New Zealand Fundamental Soils Layer (NZFSL) (Landcare, 2000). This classification increases the number of permutations by a large proportion compared to the 2003 study that used a single PAW for each irrigation zone. Table 5 shows the methodology of the soil classification for 600 mm rooting depth of pasture and Figure 6 illustrates the distribution over the study area. The second column of Table 5 shows the selected "midpoint" of the PAW class for analysis; the last column represents the corresponding midpoint value for 600 mm rooting depth of pasture. Note that it is assumed that the top 200 mm contributes 40 mm soil moisture. NZFSL shows there are no 100 mm PAW soils within the study area.

Table 5: Soil classification

PAW range 900 mm rooting depth	PAW class midpoint	
	900 mm rooting depth	600 mm rooting depth
0-30	0	0
31-90	75	60
91-125	110	80
126-160	145	100
161-195	180	120
196-225	215	140
>225	250	160

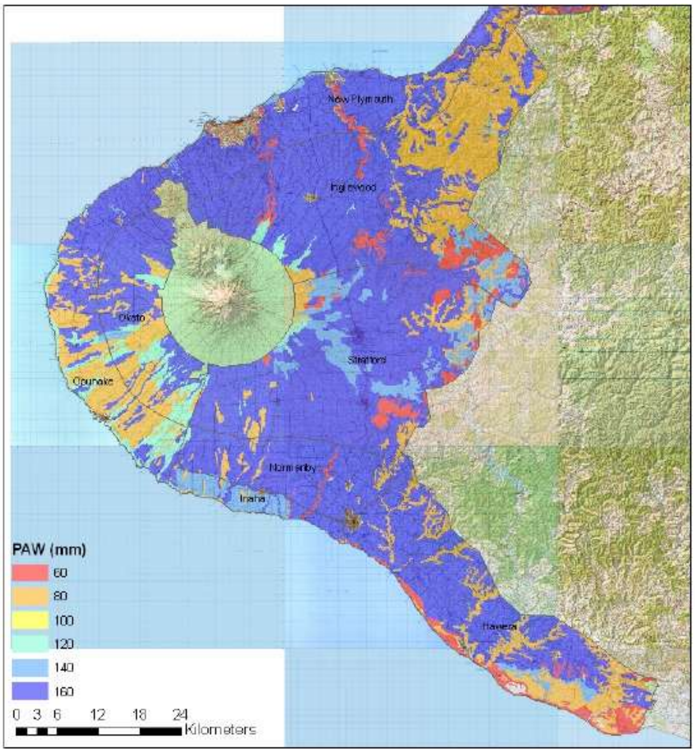

Figure 6: Map showing distribution of soil PAW within the study area

Based on Table 5 soil classes, irrigation demand and pasture production modelling have been carried out for five soil PAW classes (60, 80, 120, 140 and 160 mm) and five climate classes based on MAR (1100, 1200, 1300, 1400 and 1500). It is assumed that it is not economical to irrigate the areas where mean annual rainfall is higher than 1,600 mm. This resulted in 25 model permutations in total (i.e. 5 soil classes x 5 climate classes = 25).

It was assumed that potential evapotranspiration (PET) and all other climate parameters were constant across the Hawera, Opunake and Inaha climate zones. All climate parameters were obtained from the virtual climate station nearest to the Manaia and Normanby climate stations. This seems a reasonable assumption given the available information. The short climate record at Hawera indicates PET is similar at Hawera and Manaia. There are no climate stations in the Opunake zone so it is not possible to confirm whether or not it is appropriate to use the Manaia/Normanby record.

It has also been assumed that the proportion of summer and winter rainfall was relatively similar within each rainfall class. This assumption was tested for a few climate records and found that this was a reasonable assumption.

4.2 Irrigation Analysis

4.2.1 Maximum daily application rate

It is important to identify the optimum maximum daily application rate for irrigation. Whilst similar production rates may be achieved with different application depths and return periods, use of higher daily application rates will increase abstraction pressures and can have a detrimental effect on aquatic ecosystems during periods of low river flows. Therefore, analysis has been conducted to identify the optimum and pragmatic daily application depth.

The methodology employed in this analysis included estimating the annual dry matter (DM) production for full or unlimited water supply and compared that production level with different peak daily application depths. Average annual production for the study area under full irrigation was modelled at 20.3 t-DM/ha. It was assumed that up to 1% production loss maybe acceptable to reduce the peak water demand. It was found that with a peak daily demand of 3.5 mm/day, the average production loss over the different soil-climate combinations is 0.52% with a maximum loss of 1%. Therefore, this analysis is conducted for a daily application rate of 3.5 mm/day.

4.2.2 Irrigation demand

Table 6 lists the predicted annual irrigation demand for different soil and climate combinations. The 90% reliability shows the annual water requirement to meet nine years of irrigation demand out of 10 years, i.e. it is probable that one-in-10 years the full irrigation demand may not be able to be met. This study assumes an irrigation efficiency of 80%.

Table 6: Irrigation demand for different rainfall and soil combinations

Mean annual rainfall (mm)	PAW (mm)	Annual demand (mm/year)			Seasonal allocation (m^3/ha/year)	
		Mean	90% reliability	Maximum	90% reliability	Maximum
1,100	60	347	422	525	4,220	5,250
	80	297	387	508	3,870	5,080
	120	263	387	525	3,870	5,250
	140	252	387	525	3,870	5,250
	160	236	369	508	3,690	5,080
1,200	60	341	420	473	4,200	4,730
	80	282	369	438	3,690	4,380
	120	251	368	420	3,680	4,200
	140	238	368	420	3,680	4,200
	160	225	350	403	3,500	4,030
1,300	60	319	420	473	4,200	4,730
	80	263	369	420	3,690	4,200
	120	226	336	420	3,360	4,200
	140	212	319	403	3,190	4,030
	160	198	315	385	3,150	3,850
1,400	60	305	389	455	3,890	4,550
	80	244	352	403	3,520	4,030
	120	207	319	385	3,190	3,850
	140	192	299	385	2,990	3,850
	160	180	299	368	2,990	3,680
1,500	60	284	354	420	3,540	4,200
	80	224	317	368	3,170	3,680
	120	182	298	350	2,980	3,500
	140	171	282	333	2,820	3,330
	160	154	264	333	2,640	3,330

4.3 Irrigation Expenses

Table 7 lists the estimated average on-farm irrigation expenses for different soil-climate combinations. The irrigation system installation and running cost varies significantly between irrigation systems. Therefore, the irrigation expenses are based on the following parameters that represent the average values for irrigation of 200 mm over a hectare area. These parameters are taken from Rout (2003) and adjusted for inflation. Note that the annual repayment, and operation and maintenance costs are assumed to be fixed for a hectare area irrespective of the irrigation application depths.

Annual repayment cost for the irrigation system	$375/ha/year
Electricity	$45/ha/200mm applied
Operation and maintenance	$80/ha/year
Labour	$25/ha/200mm applied.

Table 7 values were derived from applying the above irrigation expense parameters to mean annual irrigation demands listed in Table 6. For example, irrigation expenses for 60 mm PAW – 1,100 mm MAR combination is calculated as follows:

Mean annual irrigation demand	347 mm/year (Table 6)
Annual repayment cost for the irrigation system	$375/ha/year
Electricity	$45/200*347 = $78.08
Operation and maintenance	$80/ha/year
Labour	$25/200*347 = $43.38
Total annual irrigation expenses	**$576/ha/year.**

Table 7: On-farm irrigation expenses for different rainfall and soil combinations

Mean annual rainfall (mm)	Average annual irrigation expenses ($/ha/year)				
	PAW60	PAW80	PAW120	PAW140	PAW160
1,100	576	559	547	543	538
1,200	574	554	543	538	534
1,300	567	547	534	529	524
1,400	562	540	527	522	518
1,500	554	533	519	515	509

4.4 Irrigation Yield Response

Table 8 shows the average annual pasture yield response to irrigation for different soil-climate combinations as given by the AusFarm simulation model (developed by CSIRO, Australia). The yield response varies between 0.9 to 5 t-DM/ha/year.

Table 8: Irrigation yield response for different rainfall and soil combinations

Mean annual rainfall (mm)	Average yield response (t-DM/ha/year)				
	PAW60	PAW80	PAW120	PAW140	PAW160
1,100	5.0	4.2	3.6	2.9	2.1
1,200	4.6	3.7	3.0	2.5	1.9
1,300	4.2	3.2	2.6	2.1	1.5
1,400	3.7	2.9	2.3	1.7	1.2
1,500	3.0	2.4	1.7	1.2	0.9

4.5 Irrigation Cost-Benefits

The feedback received from TRC indicates that farm and irrigation management practices vary considerably within the region. Therefore, it is appropriate to limit this high-level regional scale study to the "bottom-line" that farmers use to determine whether irrigation is viable. The decision is ultimately based on the difference between costs and benefits of irrigation. Farm benefits are primarily dependant on the milk production payouts and dry matter production. The cost is dependent on the stock numbers and associated expenses, including irrigation expenses. With variable farm practices the return from pasture varies between farms.

The value of pasture in the region was estimated using local farm parameters that were developed in consultation with Louise Hofmann, Taranaki FarmWise consultant. The results of this work showed that values of pasture range between $0.17 to $0.25 /kg-DM with an average value of $0.22 /kg-DM.

Based on these values irrigation marginal benefits have been calculated for three values of pasture; low $0.15 /kg-DM, average $0.20 /kg-DM and high $0.30 /kg-DM. The results are shown in Table 9. It is envisaged that the value of pasture can increase in the future with higher milk solid payouts. Therefore, a high value of $0.30 /kg-DM has been modelled to enable estimation (i.e. interpolation) of marginal benefits for a wider range of values than is currently experienced.

Table 9: Irrigation marginal benefits for different rainfall and soil combinations

Pasture worth ($/kg-DM)	Mean annual rainfall (mm)	Irrigation marginal benefits ($/ha)				
		PAW60	PAW80	PAW120	PAW140	PAW160
0.15	1,100	174	71	-7	-108	-223
	1,200	116	1	-93	-163	-249
	1,300	63	-67	-144	-214	-299
	1,400	-7	-105	-182	-267	-338
	1,500	-104	-173	-264	-335	-374
0.20	1,100	424	281	173	37	-118
	1,200	346	186	57	-38	-154
	1,300	273	93	-14	-109	-224
	1,400	178	40	-67	-182	-278
	1,500	46	-53	-179	-275	-329
0.30	1,100	924	701	533	327	92
	1,200	806	556	357	212	36
	1,300	693	413	246	101	-74
	1,400	548	330	163	-12	-158
	1,500	346	187	-9	-155	-239

Figure 7, 8 and 9 illustrate the areas that have the economically viable potential for irrigation development for pasture values of $0.15, $0.20 and $0.30 /kg-DM, respectively. For mapping purposes the marginal benefits of irrigation have been categorised into four levels; low <$150/ha, medium $151-300/ha, high $301-500/ha and very high >$500/ha.

The results show that the most attractive area for irrigation development, in terms of economic viability, is the south eastern area of the Hawera zone, followed by the coastal belt of Opunake and Inaha. The viability can be significantly improved with high commodity prices as shown in Figure 9.

As mentioned above, the value of pasture, based on current income and expenses, range between $0.17 to $0.25 /kg-DM with an average value of $0.22 /kg-DM for the study area. It is difficult to ascertain the future values of pasture. This is dependent on both milk solid payouts and farm expenses. The milk solids payout can directly and indirectly relate to expenses. Both these parameters, to some extent, reflect both national and international economies. It is possible that gains from increased milk solids payouts will be negated by increased farm expenses. Because the value of pasture is not solely driven by milk solids payouts Aqualinc considers that a pasture value of $0.30 /kg-DM represents a rational upper limit for this analysis.

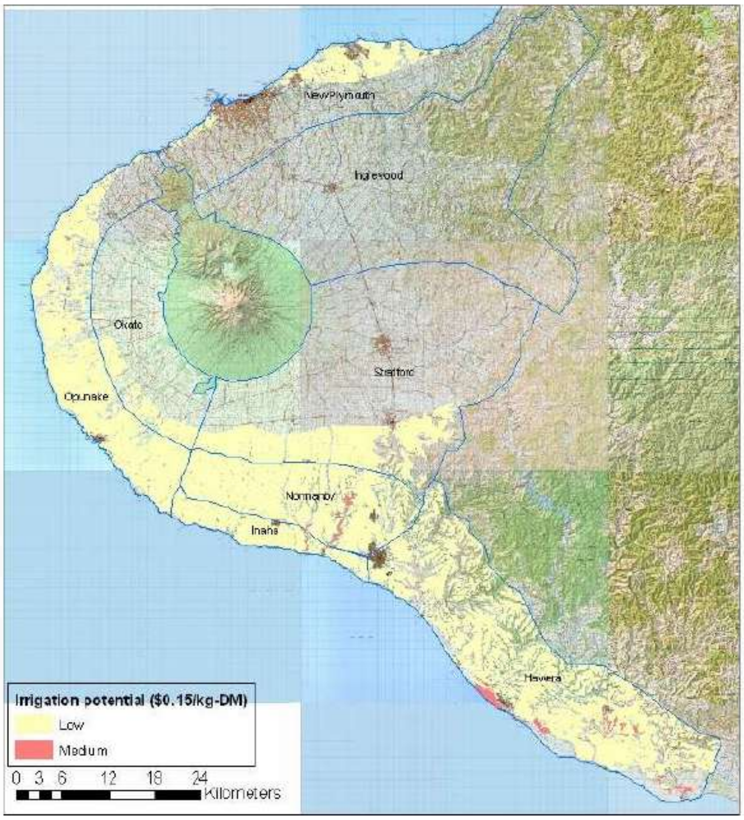

Figure 7: Irrigation development potential for low pasture price of $0.15/kg-DM

Figure 8: Irrigation development potential for moderate pasture price of $0.20/kg-DM

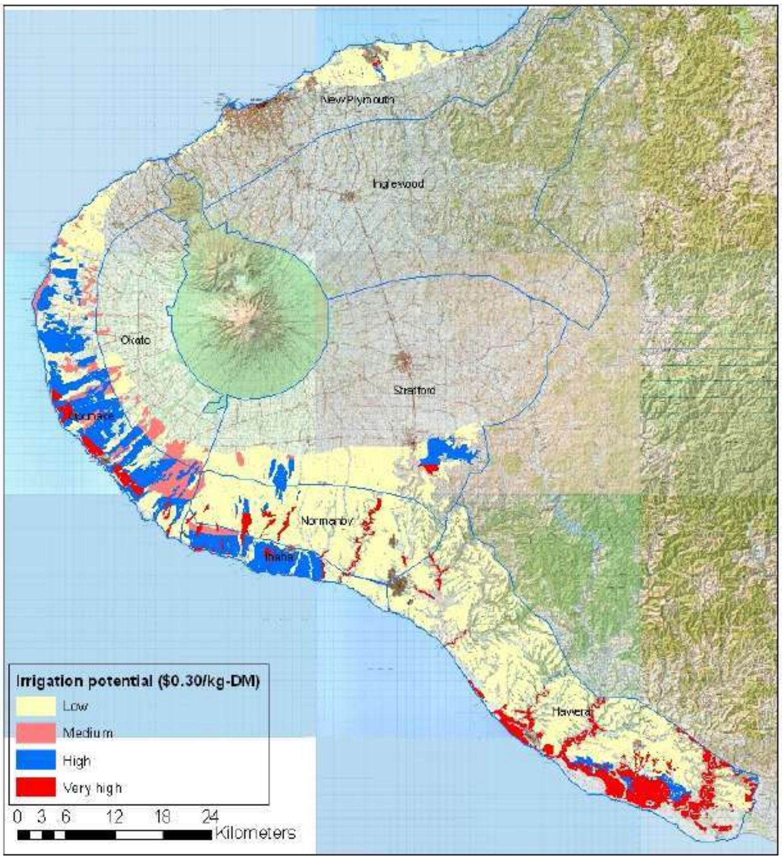

Figure 9: Irrigation development potential for high pasture price of $0.30/kg-DM

5 POTENTIAL SOURCES OF IRRIGATION SUPPLY, ALLOCATION AND RELIABILITY

5.1 Groundwater Availability For Irrigation

The purpose of this section is to outline the main hydrogeological systems in the Taranaki Region, in order to consider the potential for groundwater abstraction for irrigation in the area.

The Taranaki State of the Environment report for 2009 identifies five main groundwater zones:

- Matemateaonga Formation aquifers;
- Taranaki Volcanics aquifers;
- Marine Terrace aquifers;
- Whenuakura Formation aquifers; and
- Tangahoe Formation aquifers.

The region's aquifers are understood to be highly complex, although the geology and hydrogeology have not been extensively studied. The yields of the aquifers are relatively low compared with other regions of New Zealand due to the nature of the formations. The previous section of this report highlights the areas with highest potential for irrigation development, based on rainfall and soil properties. These areas tend to be in the locality of the Taranaki Volcanics, the Marine Terrace aquifers, and the underlying Whenuakura aquifer in the south Taranaki area.

5.1.1 Taranaki volcanics

The Taranaki volcanic deposits are derived from a group of four volcanoes. The deposits include lava, pyroclastic and lahar deposits. Thicknesses are greatest near Stratford (170 m), and thin away from the volcanic source. The deposits include both coarse material (sands, breccias and agglomerates) and fine material (such as clays, tuffs and ash), which results in a complex sequence. Thus, there is a complex system of perched aquifers and partially confined aquifers, and heterogeneous and anisotropic hydrogeological conditions.

The water table on the ring plain is around 1 to 10 m below ground level, again being a subdued reflection of the topography. Yields are generally low, with rates of up to 2 to 2.5 l/s being typical (Jaramillo, pers. comm.). Stevens (2001) noted that yields of up to 13 l/s have been recorded. Recharge is predominantly through rainfall infiltration.

Overall, whilst there is the potential for a moderate yield, there is a high risk of not being able to locate a suitably transmissive part of the aquifer. Even at the higher end of potential yields, they would not be sufficient for irrigation. Travelling irrigators, for example, typically require a flow of 30 l/s to operate properly.

5.1.2 Marine Terrace aquifers

The Marine Terrace aquifers occur in coastal areas south of Hawera, and also to the north of New Plymouth. The area to the south of Hawera is of interest because of the higher potential for irrigation development. The sediments are up to 40 m thick, and comprise sands, often with conglomerate or shell layers, grading upwards into terrestrial sediments. They include multiple unconfined aquifers.

Yields are low: average bore yield is 1.3 l/s, with a maximum recorded yield of 3.8 l/s. The highest yields are obtained from the coarser grained basal sands and conglomerates. Stevens (2001) noted that the yield is very much dependent on the bore construction.

The water table is between 1 and about 10 m below ground level, and is a subdued reflection of the topography. Infiltration is predominantly from rainfall recharge.

5.1.3 Whenuakura formation aquifers

The Whenuakura aquifers are not exposed at the surface, being overlain by the Taranaki volcanics to the north of Hawera, and the Marine Terrace aquifers to the south. It is not exposed except in some incised river valleys in the south. The formation is Tertiary in age, and comprises siltstones, mudstones, sandstones, limestones and shellbeds.

Groundwater is taken from sandstones and limestones, and several relatively extensive aquifers have been identified within the formation. Some yields are reported to be up to 12 l/s (Jaramillo, pers. comm).

Recharge sources are not well understood, but suggested to be possibly from recharge via the volcanic and marine terrace deposits. There may also be recharge where the formation is exposed at surface in the incised river valleys.

5.1.4 Groundwater use in Taranaki

The use of groundwater has steadily increased within the region over the last decade. In 2001 (Steven, 2001) reported there were 26 consents to take groundwater, with a total allocation of 13,183 m^3/day. In addition, there were unconsented (permitted) takes, abstracting probably around half this amount. The Taranaki Regional Council 2009 State of the Environment report stated this had increased to 81 resource consents, taking a total of 44,022 m^3/day. At 30 June 2011 there were 92 active groundwater consents. However, excluding those for hydrocarbon exploration at June 2011 there were only 44 active groundwater consents permitting a maximum daily take of 23,958 m^3. To deliver this daily volume would require abstraction at a rate of approximately 277 l/s for 24 hours.

The Taranaki Regional Council State of the Environment Report (TRC, 2009) highlighted the fact that groundwater takes for irrigation are mainly to supplement water from other sources due to the low yield of the Taranaki aquifers. With the yields reported above, the use of groundwater for irrigation is likely to be limited in scope and restricted to providing water to small properties, or topping up alternative supplies. The current understanding of the Taranaki groundwater resource suggests that it is not likely to play a major role as an irrigation supply option for the region.

5.2 Surface Water Allocation

TRC does not, at present, use specific rules for water harvesting. The TRC does however have water allocation and minimum flow policies and guidelines that enable general calculations of water availability while ensuring sufficient flows are left in the water body for ecological, recreational and other water uses.

Guideline values for primary allocation are given in "A guide to surface water availability and allocation in Taranaki, Taranaki Regional Council" (TRC 2005). This guide recommends for most rivers the primary allocation (i.e. A-Block allocation) be set at the Mean Annual Low Flow (MALF) minus the minimum habitat flow. In order to complete the preliminary assessments we used this guide to estimate A-Block limits.

In the absence of specific rules for water harvesting B and C block allocation regimes have been assumed in line with approaches by other regional councils (see Table 10). No ecological work was done to assess whether these B and C allocation regimes are appropriate in Taranaki. Consequently, they should be treated as untested assumptions intended only for use within the preliminary assessments and should not be relied upon for consenting or plan development purposes.

Table 10: Allocation regimes used in preliminary assessments

Block	Minimum Flow	Allocation limit	Source
A	Habitat flow	MALF - minimum habitat flow	TRC 2005
B	1:1 flow sharing above MALF	MALF×0.3	Assumed
C	1:1 flow sharing above 2×MALF	MALF×0.7	Assumed

1:1 flow sharing means that only half of any flow in excess of the minimum flow (i.e. MALF for B-Block water and 2×MALF for C-Block water) is available for abstraction, the remaining water must remain in the river. Flow sharing helps rivers retain their natural flow variability.

As run-of-river abstractions are much cheaper than the storage-based water supply for irrigation, it is appropriate to first assess the potential for irrigation from run-of-river. Whilst A-block water is highly reliable for almost all rivers, reliability of B-block water may be sufficient in some areas dependant on the flow dynamics of the sourced river. If sufficient quantities and reliability cannot be achieved from the run-of-river supply, then storage options could be considered.

5.3 Reliability of Irrigation Water

Four key factors have to be considered to quantify reliability of supply. These are:

- Severity – size or amount of restriction;
- Frequency – how often the restrictions occur;

- Duration – how long the restrictions last; and
- Timing – when restrictions occur.

On any day during the irrigation season, the supply of water available under an allocation rule can be compared with the demand for irrigation on that day. If available supply equals or exceeds demand, reliability is 100%. If demand exceeds supply, reliability is calculated by dividing supply by demand to give a supply/demand ratio. The daily ratios can be combined into weekly, monthly, seasonal (spring, summer, autumn), irrigation season or annual figures. Irrigation season values are often used to indicate the overall reliability of a particular supply.

As a general guide, the following average irrigation season reliability assessments apply:

100%	Very good reliability
94-99%	Good reliability
87-94%	Marginal reliability
<87%	Poor or very poor reliability.

This study has adopted the following two indicators to determine the irrigation water supply reliability. It is assumed that for the irrigation water supply to be reliable, both of the following conditions are met:

- Mean irrigation-season average supply-demand ratio to be greater than 94%; and
- Periods of restrictions exceeding 10 consecutive days will occur in no more than 10% of the irrigation seasons modelled.

5.4 Assessment Of Surface Water Reliability

The assessment of economic viability for irrigation indicates that east Hawera and the coastal belt of Opunake and Inaha have the highest economical potential for irrigation development. Therefore, initial analysis of surface water availability and reliability for irrigation has been conducted for four rivers in these areas. Waitotara and Whenuakura rivers were analysed for the east Hawera area, and Kapoaiaia and Punehu streams for the Opunake area. The location of these rivers is identified on Figure 1.

The largest river flowing through the Hawera zone is the Waitotara River. However, the assessment for this river is limited to the flow statistics supplied by TRC, as no continuous flow data is available for the river. Flow data is available however, for the Whenuakura River for the period 1983 to 2010. This river flows through the eastern part of the Hawera zone. Therefore, the daily mean flows of the Whenuakura River have been assessed for water reliability.

Two streams have been assessed within the Opunake zone; Punehu and Kapoaiaia streams. These streams have been selected primarily because they are the largest two in the zone where flow data is available. Other smaller streams that flow through the zone are unlikely to be significant resources for supplying irrigation water as there appears to be limited allocable water from these streams.

Note that the modelling to determine the storage requirements for the Inaha zone was carried out following the work to re-assess the Rout (2003) results. This was prior to the more detailed assessment with greater climate and soil data. Because the more detailed assessment showed that the marginal benefits of irrigation in the Inaha Zone are not high (certainly insufficient to support a large scale community scheme), a more detailed assessment of river flows and water availability was not considered necessary for this zone.

The following provides the results of the assessments on the four rivers considered.

5.4.1 Waitotara River

The Waitotara River is one of largest rivers in Taranaki and flows through east Hawera where irrigation marginal benefits are high. There is no continuous flow data available for the river. However, TRC (2005) shows that the estimated median flow at the river mouth is 16,000 l/s with a MALF of 6,478 l/s.

As shown in Table 11, based on these estimates there is potential for further irrigation of over 5,000 ha from A-block run-of-river takes. Whilst there is theoretically the potential to irrigate a further 4,300 ha from B and C-block allocations, it is not possible to complete the analysis of economic viability and reliability of supply in the absence of flow data.

Table 11: Waitotara River water availability summary for different allocation blocks

	A-block	B-block	C-block
MALF (l/s)	6,478		
Habitat flow (l/s)	4,340		
Minimum flow (l/s)	4,340	6,478	12,956
Current allocation (l/s)	19	0	0
Block size (l/s)	2,138	1,943	4,535
Remaining allocation (l/s)	2,119	1,943	4,535
Block size for irrigation (l/s)	2,138 (max)	972	2,268
Daily peak irrigation application rate (mm/day)	3.5	4.0[1]	8.64[2]
Maximum irrigable area (ha)	5,231	2,112	2,267

[1] A higher daily peak irrigation application rate has been used for the unreliable B-block supply as more water is needed to 'catch-up' the soil-moisture deficit.

[2] A higher rate (this equates to 1 l/s/ha) is permitted to take into the storage during the high flows, however, peak irrigation application rate supply from the storage is limited to 3.5 mm/day.

5.4.2 Whenuakura River

The Whenuakura River also drains through the eastern Hawera zone. Flow data for the river is available for the period of 1983 to 2010. TRC (2005) shows that the median flow of the Whenuakura River is 5,670 l/s. The MALF for the river is 2,000 l/s with minimum flow set at 1,340 l/s.

Based on the above allocation rules, available water for different allocation blocks for the Whenuakura River are given in Table 12. This shows the total area that could be irrigated, if economical, is 2,450 ha. If this was not considered large enough for a community level irrigation scheme, this resource could be combined with a supply from the Waitotara River.

Table 12: Summary of Whenuakura River water availability for different allocation blocks

	A-block	B-block	C-block
MALF (l/s)	2,000		
Habitat flow (l/s)	1,340		
Minimum flow (l/s)	1,340	2,000	4,000
Current allocation (l/s)	212	0	0
Block size (l/s)	660	600	1,400
Remaining allocation (l/s)	448	600	1400
Block size for irrigation (l/s)	660 (max)	300	700
Daily peak irrigation application rate (mm/day)	3.5	4.0[1]	8.64[2]
Maximum irrigable area (ha)	1,100	650	700
Refer to Table 10 for notes.			

Table 13 illustrates the reliability of the run-of-river supply for the irrigated area given in Table 12 for three allocation blocks. Based solely on the supply-demand ratio, the irrigation of 1,100 ha from the A-block run-of-river supply has very good reliability. However, the supply is unreliable (in terms of the criteria set for this project) with respect to the number of occurrences of 10 consecutive days or more restrictions, as there are more than three periods of 10 days or more consecutive restrictions for the 27 years of record (1983-2010). As expected B and C block run-of-river supply are highly unreliable for both criteria assessed.

Table 13: Run-of-river reliability for the Whenuakura River allocation blocks

Allocation block	Average supply/demand ratio	No. of periods of 10 days or more consecutive restrictions (1983-2010)
A-block	99.5%	5
B-block	87.7%	35
C-block	47.3%	180

B-Block Irrigation

As shown in Table 9, highest irrigation marginal benefits are available for the soil-climate combination of 60 mm PAW – MAR 1,100 mm, which is the lightest soil in the driest area. Therefore, this initial analysis has been conducted for this soil-climate combination. It is assumed that the minimum size of the storage per hectare is 300 m^3, as smaller volumes would increase the unit cost due to “fixed” components of engineering and other expenses.

Average annual pasture yield from run-of-river B-block supply is 19.4 t-DM/ha/year. A 300 m^3 storage will increase the pasture production up to 19.7 t-DM/ha/year. This analysis is based on the following parameters:

Cost of the on-farm storage	= \$3 / m^3
Value of pasture	= \$0.20 /kg-DM
Loan duration for the capital investment for storage construction	= 15 years
Loan interest rate	= 8% per annum

Income due to storage	= (19.7 – 19.4) t-DM/ha/year x 1,000 x \$0.20 /kg-DM
	= \$60 /ha/year
Storage cost	= 300 m^3/ha x \$3 / m^3
	= \$900 /ha
Annualised cost for storage	= \$103.20 /ha/year
Benefits of the storage	= \$60 - \$103.20 /ha/year
	= -\$43.20 /ha/year.

The loss will be reduced to \$13.20 with the higher pasture price of \$0.30 /kg-DM. A higher storage volume will increase the loss. This shows that it is not economically viable to supplement the run-of-river B-block supply with storage for the area with highest irrigation marginal benefits (60 mm PAW – MAR 1,100 mm). The viability of storage for other areas would be more unattractive. Therefore, the analysis for the other soil-climate combinations has not been undertaken.

C-Block Irrigation

As stated above C-block run-of-river supply is highly unreliable. Therefore, the analysis, as shown in Table 14, is undertaken to assess the viability of storage and irrigation reliability for 60 mm PAW – MAR 1,100 mm soil and climate combination. This shows it is not economical to invest in storage with a pasture value of \$0.20 /kg-DM. Whilst 300 and 600 m^3 storages would provide small positive marginal benefits the irrigation reliability is poor. It is possible to improve the reliability with larger storage size such as 900 m^3 as shown in Table 14, however, this increases the cost and introduces a loss.

The marginal benefits can be improved to \$360, \$425 and \$404/ha for 300, 600 and 900 m^3/ha storage with a higher pasture value of \$0.30 /kg-DM. However, there are other expenses, such as additional pumping into the storage and pipe or canal for conveyance of water that make the storage option less attractive.

Table 14: Whenuakura C-block irrigation and economic analysis for PAW 60 mm and MAR 1,100 mm based on pasture value of $0.20 / kg-DM

Irrigation option	Average pasture production (t-DM/ha/yr)	Average annual irrigation (mm)	Average deficit (%)	Consecutive deficit days > 10 days	Benefit of the storage (t-ha/yr)	Income due to irrigation ($/ha)	storage cost ($/ha)	Annualised storage cost ($/m3/yr/ha)	Irrigation cost ($/ha)	Net benefit ($/ha)
No irrigation	15.3									
with 300 m^3/ha storage	18.6	205	72.2	23	3.3	660	900	103.21	526.75	30.04
With 600 m^3/ha storage	19.2	240	83.7	12	3.9	780	1800	206.42	539.00	34.58
With 900 m^3/ha storage	19.5	260	89.7	6	4.2	840	2700	309.63	546.00	-15.63

5.4.3 Kapoaiaia Stream

Water from the Kapoaiaia Stream can be utilised to irrigate within the Opunake zone where irrigation marginal benefits in some areas are reasonably high. Like many of the streams flowing from Mount Taranaki, the Kapoaiaia Stream catchment is small and narrow, and flows are smaller compared to the larger rivers in the Hawera zone. Therefore, the potential for utilising a single stream for a community irrigation scheme is not high. However, almost all the streams around Opunake and Inaha zones may be able to supply sufficient quantities of water for small areas of irrigation in respective catchments.

A summary of flows and water availability for the Kapoaiaia stream at "The Lighthouse" for different allocation blocks based on 1986 to 2010 data is given in Table 15.

Table 15: Summary of Kapoaiaia Stream water availability for different allocation blocks

	A-block	B-block	C-block
MALF (l/s)	305		
Habitat flow (l/s)	204		
Minimum flow (l/s)	204	305	610
Current allocation (l/s)	39	0	0
Block size (l/s)	101	92	214
Remaining allocation (l/s)	62	92	214
Block size for irrigation (l/s)	101 (max)	46	107
Daily peak irrigation application rate (mm/day)	3.5	4.0[1]	8.64[2]
Maximum irrigable area (ha)	152	99	107
Refer to Table 10 for notes.			

Table 16 illustrates the reliability of the run-of-river supply for three allocation blocks for the Kapoaiaia Stream. The A-block run-of-river supply has a very high reliability for both the criteria assessed. However, the reliability is poor for B and C block run-of-river supplies.

Table 16: Run-of-river reliability for the Kapoaiaia Stream allocation blocks

Allocation block	Avg. supply/demand ratio	No. of periods of 10 days or more consecutive restrictions (1986-2010)
A-block	98.2%	2
B-block	84.5%	25
C-block	37.9%	166

B-Block Irrigation

As shown in Figure 5 and Figure 6, the lightest soil and climate combination in the Opunake zone is 80 mm PAW and 1,200 mm MAR (i.e., no 60 mm PAW soils class in the zones and minimum mean annual rainfall band is 1,200 mm). Therefore, the initial assessment for the Opunake zone has been carried out for this soil-climate combination (i.e., PAW of 80 mm and MAR of 1,200 mm).

Average annual pasture yield from the run-of-river B-block supply is 19.5 t-DM/ha/year, and that can be increased to 19.7 t-DM/ha/year with a 300 m^3 storage. This level of limited increased production, with a 300 m^3 storage, would result in a loss of $63.20/ha/year (i.e. 200 kg @ $0.20 /kg - $103.20 (storage cost)). The loss can be reduced to $43.20 if a higher pasture value of $0.30 /kg-DM can be achieved.

As constructing a storage to increase the B-block run-of-river supply reliability is not economically viable for 80 mm PAW – MAR 1,200 mm areas, analysis for other soil-climate combinations where irrigation marginal benefits are lower, has not been undertaken.

C-Block Irrigation

Table 17 shows the economic analysis of irrigation with three different sizes of storages with C-block water supply for the soil-climate combination that has the highest irrigation marginal benefits (80 mm PAW – MAR 1,200 mm) in the zone. All the storage options are highly uneconomical at a pasture value of $0.20 /kg-DM and the water supply is unreliable. Although economics can be improved to $6.72, $43 and $53/ha for 300, 600 and 900 m^3/ha storage, respectively if the pasture value increases to $0.30 /kg-DM, additional canal/pipe costs and low reliability of the supply make irrigation using the C-block water unattractive.

Table 17: Kapoaiaia C-block irrigation and economic analysis for PAW 80 mm and MAR 1,200 mm based on pasture value of $0.20 / kg-DM

Irrigation option	Average pasture production (t-DM/ha/yr)	Average annual irrigation (mm)	Average deficit (%)	Consecutive deficit days > 10 days	Benefit of the storage (t-ha/yr)	Income due to irrigation ($/ha)	storage cost ($/ha)	Annualised storage cost ($/m3/yr/ha)	Irrigation cost ($/ha)	Net benefit ($/ha)
No irrigation	16.6									
with 300 m^3/ha storage	18.7	185.9	57	27	2.1	420	900	103.21	520.07	-203.28
With 600 m^3/ha storage	19.2	215.8	72.1	19	2.6	520	1800	206.42	530.53	-216.95
With 900 m^3/ha storage	19.6	235.5	78.8	16	3.0	600	2700	309.63	537.43	-247.06

5.4.4 Punehu Stream

Similar to the Kapoaiaia Stream, the Punehu Stream flows from Mount Taranaki and flows are relatively low. Flow records are available for the stream at Pihama from 1970 to 2010. This recorder station is located at the upstream of the confluence of the Mangatawa Stream. The Mangatawa Stream has a MALF of approximately 17 l/s and a median flow of approximately 134 l/s (per. comm., F. Jansma, TRC). Therefore, flows of the Punehu Stream at Pihama were adjusted to reflect the contribution of the Mangatawa Stream flows and a flow series was developed for the Punehu Stream at the stream mouth for this analysis. A summary of flows is given in Table 18.

Table 18: Summary of Punehu Stream water availability for different allocation blocks

	A-block	B-block	C-block
MALF (l/s)	287		
Habitat flow (l/s)	192		
Minimum flow (l/s)	192	287	574
Current allocation (l/s)	79	0	0
Block size (l/s)	95	86	201
Remaining allocation (l/s)	16	86	201
Block size for irrigation (l/s)	95 (max)	43	100
Daily peak irrigation application rate (mm/day)	3.5	4.0[1]	8.64[2]
Maximum irrigable area (ha)	39	94	100
Refer to Table 10 for notes.			

Table 19 lists the reliability of the run-of-river supply for the irrigated area given in Table 18 for three allocation blocks. Similar to supply reliabilities of the Kapoaiaia Stream, reliability from the A-block supply is high and other two blocks are low.

Table 19: Run-of-river reliability for the Punehu Stream allocation blocks

Allocation block	Avg. supply/demand ratio	No. of periods of 10 days or more consecutive restrictions (1970-2010)
A-block	99.7%	1
B-block	88.0%	38
C-block	40.2%	152

B-Block Irrigation

Analysis of irrigating with B-block water through storage for the soil-climate combination of 80 mm PAW and 1,200 mm MAR is discussed in this section. Average annual pasture yield can be increased by 0.2 t-DM/ha/year to 19.7 t-DM/ha/year with a 300 m^3 storage facility. Such small increases in pasture production would result in a loss of $63.20 and $43.20/ha/year with pasture values of $0.20 and

$0.30 /kg-DM, respectively. Therefore, storage development for irrigation with B-block water in the Opunake and Inaha zones is not economically viable.

C-Block Irrigation

Table 20 presents the economic analysis of irrigation from Punehu C-block water supply. All three storage options bring loses. A higher pasture value of $0.30 /kg-DM also results in unattractive returns at -$15, $19 and -$29/ha/year for 300, 600 and 900 m^3/ha storage, respectively.

C-Block Irrigation

Table 20: Punehu C-block irrigation and economic analysis for PAW 80 mm and MAR 1,200 mm based on pasture value of $0.20 / kg-DM

Irrigation option	Pasture production (t-DM/ha/yr)	Average annual irrigation (mm)	Average deficit (%)	Consecutive deficit days > 10	Benefit of the storage (t-ha/yr)	Income due to irrigation ($/ha)	storage cost ($/ha)	Annualised cost ($/m3/yr/ha)	Irrigation cost ($/ha)	Net benefit ($/ha)
No irrigation	16.6									
with 300 m^3/ha storage	18.6	163	49.5	57	2.0	400	900	103.21	512.05	-215.26
With 600 m^3/ha storage	19.1	196.4	65.1	36	2.5	500	1800	206.42	523.74	-230.16
With 900 m^3/ha storage	19.3	215.3	73.9	29	2.7	540	2700	309.63	530.36	-299.99

5.5 Conclusions of Irrigation Marginal Benefits

Analysis of the marginal benefits of irrigation assuming a pasture value of $0.20 /kg-DM shows that east Hawera and the coastal belt of Opunake and Inaha zones could achieve higher returns with irrigation. The light soils and low average rainfalls in these areas require irrigation for increasing the reliability of production for farming systems.

Higher allocable flows in the Hawera zone show that there is high potential for irrigation from run-of-river supply. To assess the options of abstractions above the TRC's current minimum flow level during high flows, three allocation rules have been assumed. However, the analysis for four rivers, two each in Hawera and Opunake, shows that storage-based irrigation is not likely to be economically attractive in Taranaki.

5.5.1 Storage based community schemes

Although an initial assessment of water availability and irrigation marginal benefits suggested that storage based community schemes may not be viable at this time, further assessment of the potential for community schemes has been carried out. The purpose of this was to provide a sounder economic basis to concluding whether such schemes are viable at this time and also to identify schemes that may be most viable if changes in the future (either economic or climatic) significantly alter the technical and economic data this analysis is based on.

The first storage based assessment has been carried out to serve the Inaha zone. The study carried out by Rout (2003), feedback from TRC staff and the number of irrigation consents within the zone, suggest that there is demand for irrigation water in this coastal area. In addition to this, the zone is served by two relatively large catchments; The Kaupokonui catchment (approx. 146 km²) and the Waingongoro catchment (approx. 219 km²). Being two of the larger catchments on the Ring Plain means there is a higher likelihood of these rivers providing greater quantities of water for irrigation, maximising the scope for a community based scheme.

6 IRRIGATION OF THE INAHA ZONE VIA COMMUNITY SCHEME

6.1 Zone Description

The area considered is bounded by the Mangatoromiro Stream and Oeo Road in the west, Hawera in the east, and inland along South Road (between Manaia and Hawera). The total gross area is estimated at approximately 6,500 hectares (ha), stretching along the coast approximately 26 kilometres (km), and inland between 1 km and 4 km (average of 2.5 km – generally the north boundary follows the 80 m contour). The approximate area of the Inaha irrigation zone is shown in Figure 10.

Figure 10: Approximate Area of Inaha Irrigation Zone

6.2 Hydrological Catchments

The catchments that cross the Inaha irrigation zone vary in size from very small and localized, to much larger catchments originating from Mount Taranaki. One catchment (Kaupokonui) has been the focus of further analysis in this study of its hydrology and potential to provide water storage.

The Kaupokonui catchment is shown in Figure 11. It has a catchment area of 146 square kilometres (km²). A summary of various flow data is presented in Table 21.

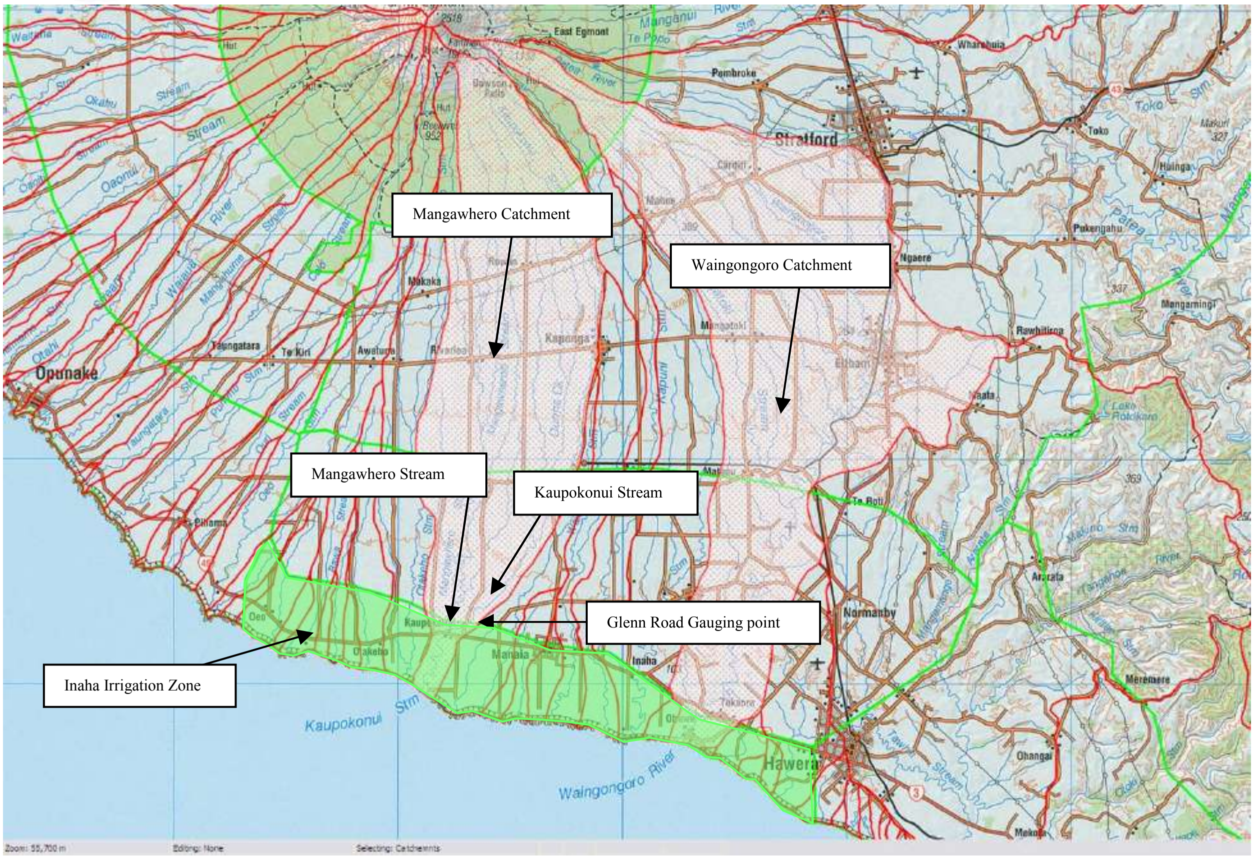

Figure 11: Kaupokonui and Waingongoro Catchments

Table 21: Kaupokonui Catchment Flows (April 1978 to May 2010)

Flow (m^3/s)	Glenn Road	River mouth
Historical mean flow	3.14	6.121
Historical maximum flow	130	255
Historical minimum flow	0.37	0.71

Table 21 indicates that flows approximately double from Glenn Road to the River mouth. This is due to the influence of the Mangawhero Stream confluence joining the Kaupokonui immediately downstream of Glenn Road.

Irrigation demand modelling has determined an irrigation application of 3.5 mm/day is appropriate to serve the areas 6,500 ha of irrigable land. This equates to a maximum demand take rate of 2.6 m^3/s for the zone.

Flows in the Kaupokonui Stream have been modelled using the Glenn Road gauge data to determine the storage volume required to satisfy the Inaha irrigation zone (which is approximately 12 million cubic metres (Mm^3)).

Note that the modelling to determine the storage requirements to serve this zone was carried out following the work to re-assess the Rout (2003) results. This was prior to the more detailed assessment with greater climate and soil data. Because the more detailed assessment showed that the marginal benefits of irrigation in the Inaha Zone are not high (certainly insufficient to support a large scale community scheme), re-modelling of the storage requirements was not considered necessary.

6.3 Inaha Storage Options

6.3.1 Potential storage concepts

The Inaha zone is crossed by a number of small streams at broadly regular intervals. The storage option potential exists to either:

- centralise storage for the zone within the zone and distribute water west and east via canals and/or pipelines (likely to be pumped) and then via major streams to individual irrigators;
- centralise storage for the zone outside the zone and distribute water via canals and/or pipelines (likely to be gravity); or
- distribute storage throughout the zone utilising the smaller streams that cross the zone.

The following sections outline the potential options in which these options could be implemented to serve the Inaha Irrigation Zone.

6.3.2 Centralised storage in zone

A large storage to service the whole Inaha irrigation zone could be located on the Kaupokonui Stream, above the 80 m contour. Hydrological modelling indicates that a 12 Mm^3 storage volume would be required to meet irrigation targets. At a conceptual level the storage could comprise the following elements, as illustrated in Figure 12.

- An intake structure on the Kaupokonui Stream to harvest peak flows into a nearby off-stream storage facility. The capacity of the intake structure would likely cap flows at approximately 5 m^3/s, which is estimated to be approximately the 90th percentile of flows at the storage location.
- A 12 Mm^3 off-stream storage constructed as a balanced cut and fill operation. The operating range of such a structure would likely be in the order of 10 to 15 m, meaning a surface area of approximately one square kilometre (100 ha).
- A distribution canal to the west of the storage pond, following approximately the 80 m contour. This would have an approximate maximum flow capacity of 1.2 m^3/s, be approximately 9 km long, would cross under (e.g. via inverted syphon) 12 major streams, and would traverse (with stream culverted under canal) at least 2 minor streams.
- A distribution canal to the east of the storage pond, following approximately the 80 m contour. This would have an approximate maximum flow capacity of 1.4 m^3/s, be approximately 15.5 km long, would cross under (e.g. via inverted syphon) 6 major streams, and would traverse (with stream culverted under canal) at least 6 minor streams.
- Outlet structures. The canals would discharge the required demanded flows into 11 of the major streams of the Inaha irrigation zone as the canal traverses across the top of the zone, around the 80 m contour. Water could then be abstracted from the streams by individual irrigators.

Figure 12: Kaupokonui Storage and Possible Distribution Layout

MWH consider it may be possible to construct a storage dam on the Kaupokonui Stream at a lesser cost than an off-stream storage pond. Assessment of this option would require detailed assessment of topography and geological information which has not been considered in detail in this study. A similar in-stream or out of stream storage concept could also be developed on the Waingongoro River, above the 80 m contour, in the area of Normanby and Mawhitiwhiti Roads. It is noted that an existing dam has already been developed on the Waingongoro River (refer to Figure 13), although it is not of a scale suitable for full irrigation of the zone. The topography in the area of the existing dam appears to preclude the enlargement of the storage to the scale required for the full irrigation of the Inaha Zone. However, further upstream the topography appears more suited to larger scale on stream storage development as illustrated in Figure 14.

Figure 13: Existing Dam on the Waingongoro River (source: BECA 1985)

Figure 14: Waingongoro River – Typical Topography (source: BECA 1985)

6.4 Centralised Storage Out Of Zone

If a larger out of zone storage site was to be utilised it would likely be shared with the nearby Normanby and Hawera irrigation zones. The most likely location for such storage would be a dam located on either the Tangahoe, Patea, Whenuakura, or Waitotara Rivers, with delivery of water via a combination of canals and/or pipelines to the Inaha Zone.

Given the existing hydroelectric storage dam on the Patea River, it may be possible to utilise the stored water for irrigation purposes (provided acceptable commercial terms could be negotiated for lost electricity generation), or develop a secondary storage downstream of the existing dam that takes advantage of the flow regulating effects of the existing scheme. Although the Patea River could probably easily supply irrigation flows, storage may be required due to the hydroelectric scheme operation. This would be confirmed or otherwise with more detailed study of the Patea River irrigation potential.

However, for the purposes of this study the Kaupokonui Stream provides a suitable example for further investigation.

6.5 Distributed Storage

The Inaha Zone is broadly subdivided into equal sized areas by the existing road network. The road network largely reflects the alignment of streams in the zone and provides a useful framework to conceptualise a distributed storage system. It appears on the basis of catchment area scaling the 12 Mm^3 storage estimated for the centralised storage could be distributed with ponds of approximately 1 Mm^3 located at the top of the irrigation sub zones, as illustrated on Figure 15. Water from the storage ponds could be released into the streams as required and then abstracted by irrigators.

If the storage locations were at higher elevations above the Inaha Zone, this could provide the advantage of pressurised water if a pipe distribution network was used.

Further refinements of the concept could be considered by breaking the storage requirements in each zone into a larger number of smaller sized ponds. This ultimately becomes an exercise in optimising storage costs against distribution costs and has not been considered in detail in this study.

Figure 15: Inaha Irrigation Zone – Distributed Storage

6.6 Cost Comparisons of Storage Options

6.6.1 Cost model

The Inaha Zone is located on the Ring Plain of Taranaki. Based on discussions with a local contractor (pers comm. Chris Whittiker of Whittiker Civil Engineering) storage reservoirs have traditionally been constructed utilising either small on stream dams or off stream storage ponds, generally lined with local compacted ash (clay) materials. The cost of on-stream dams is highly site specific and opportunities for storages of several million cubic metres may be limited given the topography of the area. It has therefore been elected to develop a cost model based on out of stream storage ponds, formed with balanced cut to fill earthworks operations. These would be located adjacent to water courses and lined with locally available soils. In general terms, the cost per cubic metre of water stored for storage ponds of this type generally decreases as the size of the pond increases.

The key requirement for an off stream storage pond is generally identifying a suitable lining material to prevent excessive seepage losses. Local experience is that some of the local ash soils, when compacted, form a low permeability material suitable for lining storage ponds. MWH has experience in utilising these soils through construction of a landfill site near Eltham. Testing on the locally available soils resulted in compacted permeability results in the order of 1×10^{-9} to 1×10^{-11} m/s, within the range that would be considered very suitable for retaining water. Soil conditions across the ring plain are variable, with local experience indicating that the soils in northern Taranaki are generally less permeable than southern Taranaki, but noting that suitable soils can generally be located within economic haul distances in southern Taranaki.

The depth of off-stream storage ponds is heavily influenced by the elevation that water can be abstracted from a water body and transferred into the storage pond, and the elevation that water can be discharged from the pond to supply irrigation infrastructure. On a gradually sloping topography such as the ring plain, it is typical to maximise this operating range by abstracting water upstream of the pond location and transfer it into the pond via an elevated canal. An excavated trench can be used at the outlet end of the storage pond to allow water to be abstracted down to a lower elevation, thereby maximising the available storage operating range and volume. In general terms larger ponds with a larger natural ground elevation change between the inlet and outlet ends of the pond will be able to be constructed with a larger operating range than smaller ponds.

To provide a basis for a cost model the following assumptions have been made:

- The ponds will be formed by a balanced cut to fill earthworks operation in the local soils;
- Ponds at the higher end of the storage range considered (15 Mm^3) can achieve an operating depth of 15 m, while ponds at the low end of the range considered (1 Mm^3) can achieve an operating depth of only 10 m;
- Ponds will be lined with a 600 mm thick layer of compacted ash soils, assumed to come from selective borrow sites on the ring plain. Based on local advice the cost to import and place this material is approximately \$12/m^3; and
- The internal slopes of the pond will be protected from wave erosion by imported rock protection (rip rap).

Based on these assumptions, an approximate cost curve has been developed (refer to Figure 16). The costs are presented for the storage pond, including allowances for inlet and outlet works. The costs presented exclude engineering fees, contingencies, land purchase costs, and GST. The costs should be considered indicative only, as there are site specific factors (especially for inlet and outlet works) that influence the cost of a pond development that can't be accounted for in a high level assessment such as that presented.

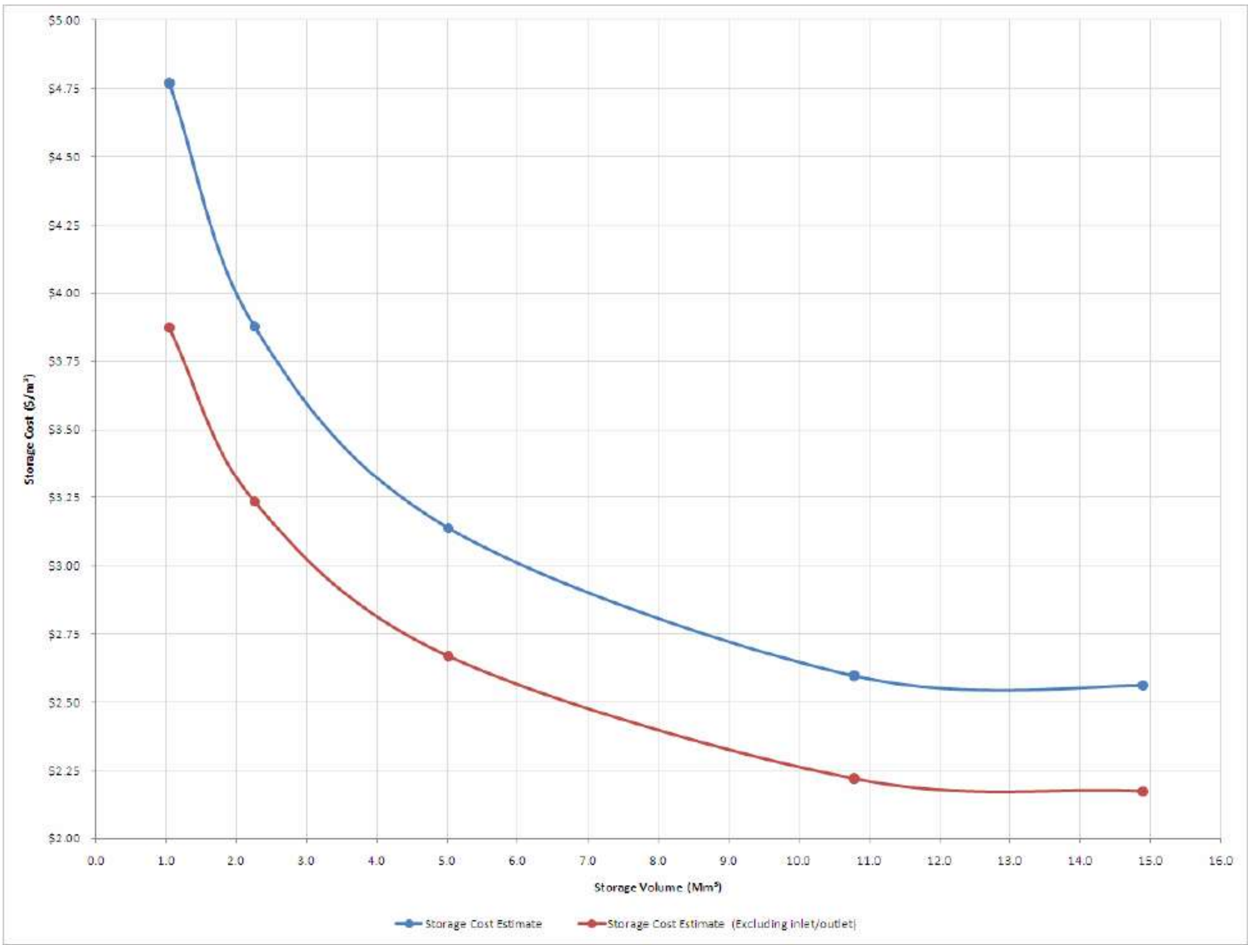

Figure 16: Estimated Storage Cost Curve ($/m³)

6.7 Comparison of Centralised and Distributed Storage

From Figure 16 it can be seen that there is a gradual reduction predicted in the cost per cubic metre of water stored as the size of storage ponds increase. Within the Inaha Zone a comparison can be made between one centralised storage of 12 Mm³ and 12 distributed storages of approximately 1 Mm³ each. The centralised approach is predicted to offer savings of approximately $2/m³ or $24M in the Inaha Zone. i.e. a 1 Mm³ storage will cost in the order of $4.75/m³ (12 times 1 Mm³ storages equals $57M) compared to a 12 Mm³ storage costing in the order of $2.75/m³ ($33M). This cost saving must be balanced against the additional distribution costs required to deliver water throughout the zone. Preliminary cost estimates for the 26 km long canal shown in Figure 12 are approximately $6M. This would still give an estimated total cost saving of $18M over the 12 distributed storages.

Note that this cost estimation assumes that property owners will have access to either the head race canal or the streams being supplied with stored water. There will be additional costs in situations where this is not the case. Given the high level nature of this investigation, detailed designs to determine how many land owners this may include, and the costs of this secondary reticulation, have not been carried out.

While the canal cost can only be considered indicative without site specific studies, this analysis indicates that the concept of a centralised storage site with a distribution network would be worthy of further consideration and study as an alternative to a number of smaller scale storage facilities if irrigation scheme options were investigated further. At that stage the more detailed work necessary to assess the viability of serving land without direct access to the head race or supplemented streams could be carried out.

6.8 On- Farm Storage

The full extrapolation of a distributed storage model is to store water on individual farms. The costs for storing water on farms will be highly site specific. Table 22 describes the site conditions that will have the greatest influence on storage costs and summarises the cost ranges that could be expected based on the different site conditions.

Table 22: Site Conditions Influencing Storage Costs

Case	Site Conditions	Cost of stored water	Cost of land inundated
Best case	• in-stream dam site available. • storage ratio of 10 or better i.e. the storage volume in the formed reservoir is at least ten times the volume of the earth fill required to form the dam.	Less than \$1.00 per cubic metre (m^3)	Variable but generally low value land inundated less than 30c per cubic metre of water stored.
Favourable	• in-stream dam site available with storage ratio of 5 or better. • out of stream storage site available where low permeability soils from the pond footprint are used to line the pond. • lining soils have resistance to wind erosion and erosion protection not required.	Less than \$2.00 per m^3	Variable but ponds generally less than 3m deep so at \$30,000 per hectare of land the cost of land is approximately \$1 per m^3.
Typical	• no in-stream storage site. • low permeability soils not available on site but can be borrowed within a few kilometres. • imported rock or gravel used as wind erosion protection.	Less than \$4.00 per m^3	Generally same depth as outlined for favourable site conditions, therefore approximately \$1 per m^3.
Unfavourable	• no in-stream storage site. • no low permeability soils within an economic haul distance. • synthetic liner used.	Less than \$5.00 per m^3	Ponds will generally be deeper than in cases above therefore cost of land likely to be less than \$1 per m^3.

Costs of on-farm storage are highly variable. Under typical conditions the cost of on-farm storage will be similar to a 1 Mm^3 pond, once land purchase costs are accounted for (both around \$5/m^3). The larger and deeper pond would be expected to have a higher standard of engineering given the greater consequences of a pond failure. Losses from evaporation would be less due to the greater depth and therefore reduced surface area per cubic metre of water stored.

To match the costs per cubic metre of favourable on-farm storage sites, it would be necessary to build centralised storage sites of several million cubic metres. To match the cost of the most favourable on-farm storage sites it would be necessary to develop in-stream storages on larger scale rivers in the district.

6.9 The effects of sediment on storage

Sediment loading can have a significant impact upon storage facilities. Where high sediment loading is expected this would need to be considered within feasibility studies and appropriate steps taken to ensure that long term performance of storage is not impaired.

The rivers that serve the Inaha zone are sourced from Mount Taranaki. These rivers do not have exceptionally high sediment loading compared to the rivers sourced from the inland hill country. It is not therefore likely that sediment load will be of major significance to storage design in this area.

6.10 Financial Viability of Inaha Scheme

A single centralised storage facility is the cheapest scheme design concept to serve the Inaha Zone. Calculations indicate that storage costs alone will be in the order of $33M, with distribution costs of approximately $6M. These figures exclude engineering fees, contingencies, land purchase costs and GST.

MWH indicate that typically engineering fees and contingencies with projects such as this may be 10% and 20% of the estimated development cost respectively. This suggests a cost of storage and distribution of approximately $50M, which still excludes land purchase expenses. This also excludes reticulation to land without direct access to the head race canal or supplemented streams.

The soils in the Inaha Zone are predominantly 140 mm PAW and the mean annual rainfall is approximately 1,100mm/year. Calculations indicate that the marginal benefit of irrigation in areas such as this may range from -$108/ha, $37/ha and $327/ha for pasture worth values of $0.15, $0.20 and $0.30/kg-DM respectively. These benefits exclude scheme costs.

For the development of large scale community schemes there has to be good support and “buy-in” from a reasonable proportion of land owners in the area. With the predicted on-farm economic returns (maximum modelled of $327/ha/year) and scheme development costs in excess of $7,800/ha for storage and distribution ($767/ha/year indicative annual charge), it is difficult to see that large scale community support would be achieved.

In 2003 STDC through its consultants BECA, commissioned a farmers survey aimed at finding out the level of interest in reticulated water supplies in areas not currently supplied by water. The survey asked a variety of questions about water use, desire for water supply and the price people were prepared to pay. The focus of this study was on rural water supplies, rather than irrigation. However, the survey did gauge the level of interest in reticulated irrigation supplies and the conclusion was that there was not a lot of interest in such supplies. Perhaps if the survey was only confined to the areas where the marginal benefits of irrigation are highest the results may have been different. However, the response may be indicative of a general consensus that irrigation isn't highly sought after by many land owners. If this is the case, then large scale community schemes are unlikely to succeed. It is more likely that irrigation development will occur on an individual basis or as small clusters.

However, in the future either due to significant increases in the value of pasture (over and above other input costs) or climate driven changes, there may be potential for such storage based schemes. At such a time, further more detailed investigations into the type of scheme identified could be carried out.

This does not conclude that irrigation itself is not viable in this area. What is does show is that any such irrigation will need to be inexpensive to develop, meaning;

- easy access to the water resource i.e. land immediately adjacent to the stream / river.
- if storage is required, the property would need to lend itself well to storage i.e. best or favourable case as outlined in Table 22; and
- the property would need to be on the lighter soils.

Individual or small clusters of properties may fit this criteria, especially if the land owner(s) has a positive mindset towards irrigation, but large scale community development seems unlikely.

6.11 Possible Further Investigations for the Inaha Zone

If it is considered viable for large scale irrigation development it is recommended that further studies be focussed on centralised storage (approximately 12 Mm^3) on Kaupokonui Stream and the Waingongoro River, above the 80 m contour along with studies of the potential for a canal or pipeline constructed along the Inaha Zone broadly following the 80 m contour. The storage studies should consider the potential for both off-stream and on-stream storage and the recommended areas for these studies are shown in Figure 17.

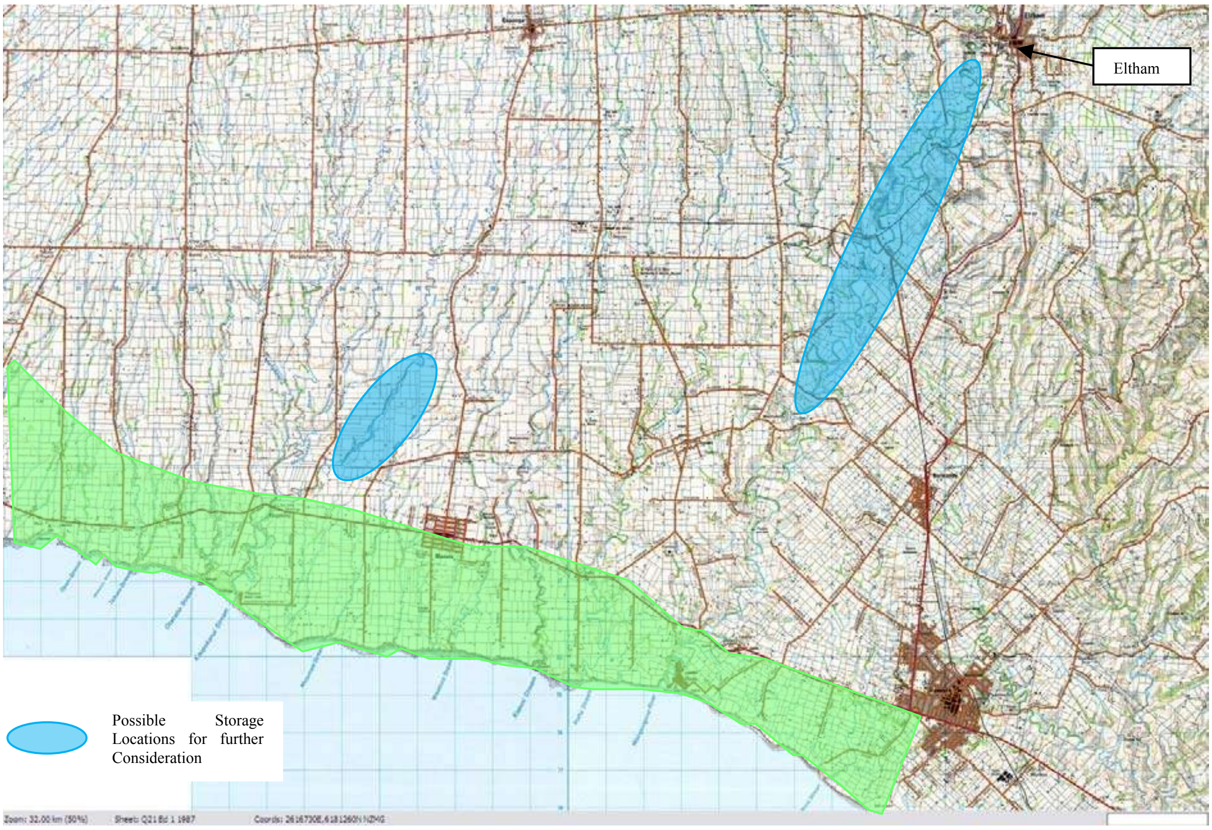

Figure 17: Potential Areas of Storage to be considered

It is envisaged that development of these concepts would allow detailed discussions to be held with potential irrigators regarding the advantages of a centralised storage approach, compared to farm scale storage. Identification of a highly favourable (particularly on-stream) large scale storage site could significantly increase the attractiveness of a centralised approach. Any cost advantage that was able to be gained from a centralised approach would need to be balanced against the additional flexibility of, and ability to stage, distributed storage.

7 SCHEME IRRIGATION OF THE HAWERA ZONE

7.1 Zone Description

The Hawera irrigation zone, located on the southeast Taranaki coast, has the potential for irrigation development, in particular in the southeast portion of the zone. The area is approximately that between the Waitotara and Whenuakura rivers, and between the coastline and approximately 10 km inland. The two areas considered for irrigation are a 5,000 ha scheme and a smaller 1,800 ha scheme (based on irrigating areas with lighter soils only), as shown on Figure 18 and Figure 19.

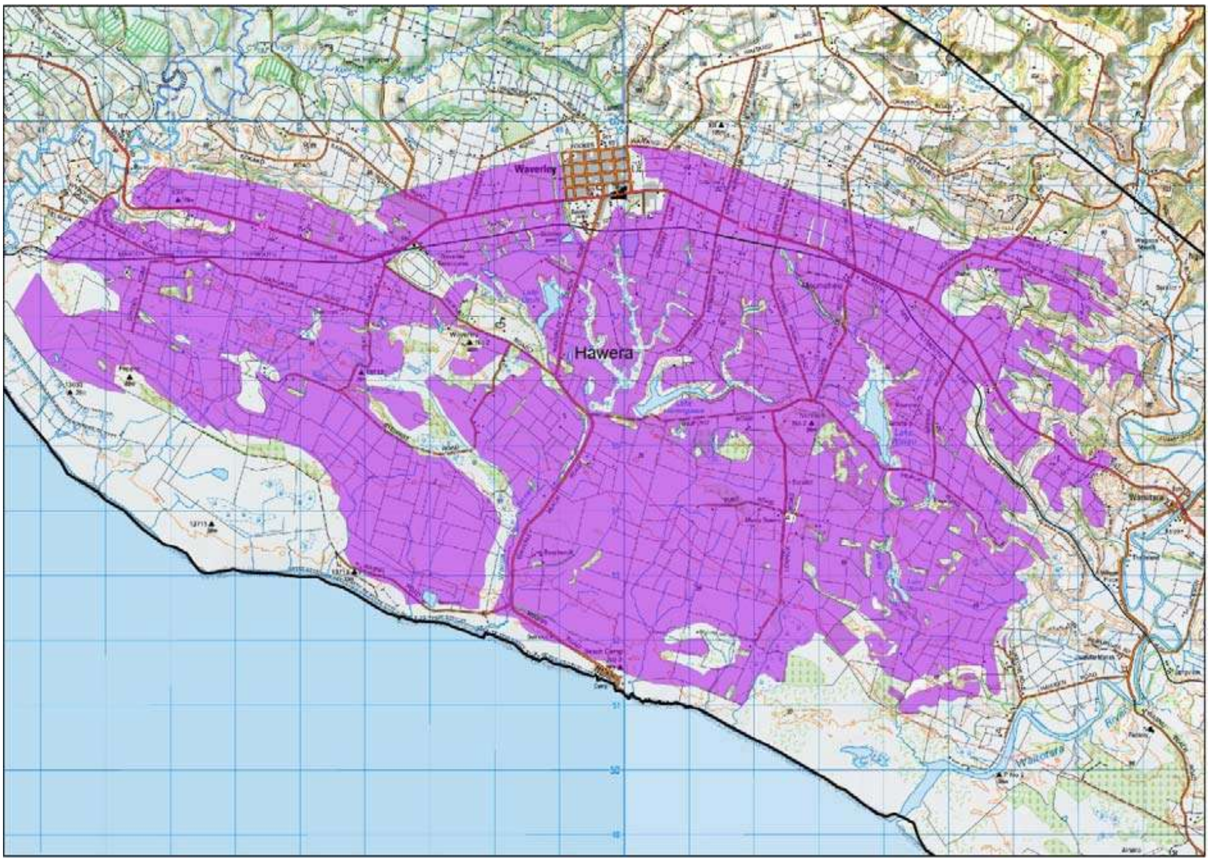

Figure 18: 5,000 ha Hawera Irrigation Scheme

Figure 19: 1,800 ha (light soils only i.e. PAW <80mm) Hawera Irrigation Scheme

7.2 Scheme Description

Analysis indicates that the Hawera Zone can be irrigated by run of river supply without the need for water storage. The run of river irrigation scheme would involve abstracting water from the Waitotara River (near the Waitotara township on State Highway 3), and would include the following components (Refer to Figure 20 for a schematic layout of the irrigation scheme):

- An intake, pumping station, and pipeline to lift the water up from the river to the river terrace (60 m contour for the 1,800 ha scheme or 90 m contour for the 5,000 ha scheme);
- A headrace canal traversing east to west across the Waverley rural area, and discharging any excess flow into the Whenuakura River (the headrace canal will reduce in flow capacity as it runs west); and
- Distribution races (approximately 5) running from the headrace canal (north) to the coast (south).

The 5,000 ha scheme would require a peak flow rate and canal capacity of approximately 2 m^3/s. The headrace canal would traverse approximately the RL 90 m contour for approximately 16 km, but reducing in elevation to the Whenuakura River end. Approximately 7 roads and 1 stream would need to be crossed. The 5 distribution races would be an average of 7 km in length, and cross 2 roads and 1 stream.

The 1,800 ha scheme would require a peak flow rate and canal capacity of approximately 0.75 m^3/s. The headrace canal would traverse at around the RL 60 m contour for approximately 18 km, but reducing in elevation by a few metres at the

Whenuakura River end. Approximately 5 roads and 2 streams would need to be crossed. The 5 distribution races would be an average of 2 km in length, and cross 1 road and 1 stream.

Figure 20: Schematic layout of possible Hawera Irrigation Schemes

7.3 Hydropower Potential

As part of a detailed design stage, hydropower potential of these schemes could be investigated. This would not be feasible with the design described above due to the requirement to pump water from the Waitotara River and pumping costs being higher than generation revenues. However, if a gravity intake was engineered there would be potential for hydropower generation.

7.4 Tidal Effects On Scheme Intake

It is expected that river water levels at both indicative intake sites would be influenced by the tide. This however, is not significant unless saltwater itself reaches as far inland as the intakes.

The intake for the smaller 1,800 ha scheme would be the one most at risk of saltwater being present. Figure 20 shows the 1,800 ha scheme intake would be in the area upstream of the rail bridge (approximately 10 km upstream of the river mouth).

The Waitotara River Coastal Management Area A boundary is 10 m downstream of the Waitotara-Patea Kapuni gas pipeline crossing, which is approximately 2.4 km upstream of the river mouth.

MWH indicate that a standard desktop rule for the line of the mean high sea water level in rivers, is the lesser of:

- 1 km upstream from the river mouth;
- or a distance upstream 5 times the width of the river mouth.

TRC (1997) Appendix II of the coastal plan (coastal marine area boundary at river mouths) also states these rules, and states that the gas pipeline location is approximately 5 times the width of the river mouth.

From this broad assessment, tidal and saltwater effects will not likely be an issue at the proposed intake locations. However, this matter would require further investigation should a more detailed study be carried out.

7.5 Cost Estimate of Hawera Irrigation Scheme

The indicative estimated cost (main supply infrastructure only) is approximately $13.8M for the 5,000 Ha scheme and $5.1M for the 1,800 Ha scheme, with a breakdown provided in Table 23. The cost estimates exclude engineering fees, contingencies, land purchase costs, and GST. Engineering fees and contingencies are typically 10% and 20% respectively on top of capital cost. With just these two elements included the costs increase to $18.2M and $6.7M.

Table 23: Hawera Schemes Cost Estimate Summary

Scheme	Component	Cost Estimate
5,000 ha	Intake, pump station, pipeline etc	$4.6M
	Headrace canal	$2.7M
	Distribution races	$2.7M
	Intakes and piped distribution*	$3.8M
	TOTAL ESTIMATED CAPITAL COST	**$13.8M**
	Operating costs (per annum)**	**$1.3M**
1,800 ha	Intake, pump station, pipeline etc	$1.5M
	Headrace canal	$1.5M
	Distribution races	$0.7M
	Intakes and piped distribution*	$1.4M
	TOTAL ESTIMATED CAPITAL COST	**$5.1M**
	Operating costs (per annum)**	**$0.35M**

*****Estimate of costs of intakes and reticulation from distribution races to farm turnout based on costs of pipe distribution for BCI scheme in Mid-Canterbury.

****** Operating costs include costs of power plus 30% as allowance for line charges, repair and maintenance, compliance monitoring etc.

Operating costs have been based on an assumption of 100 days per year operation at the maximum flow, and a15 cents per kilowatt hour ($0.15/kWh) power price. The power costs are estimated at $1.0M/year for the 5,000 ha scheme, and $270,000/year for the 1,800 ha scheme.

Depending on the degree of lines upgrade required to supply the pump stations required, the operating costs could be significantly higher than the energy supply cost estimated above. Some allowance has been made for line charges in Table 23, although further investigations are required to provide greater certainty.

Reference was made to The Ritso Society Basis for Estimation of Costs (Ritso 2007) to assist in the preparation of the scheme cost estimate.

To accurately determine the costs of infrastructure to deliver water to all target properties would require further, more detailed design. Because the marginal benefits of irrigation are relatively low, combined with the high level nature of this assessment, this more detailed design work has not been carried out. However, an indicative allowance of $750/ha has been included in the build up of costs shown in Table 23 to allow for the costs of this secondary distribution network.

7.6 Financial Viability of Hawera Schemes

Reliable run-of-river supply means that storage is not needed for irrigation of this zone.

For the larger scheme MWH predict that the development costs for the scheme are approximately $18.2M ($3,640/ha), with operating costs of approximately $1.3M per annum ($260/ha). Although the location of the potential scheme has relatively low mean annual rainfall (1,100 mm/year), there are areas with deeper soils (140 mm and 160 mm PAW). For these soil types the marginal benefits of irrigation (excluding the costs of water supply) are calculated to be $37 and -$118 and $327 and $92 /ha/year for pasture values of $0.20 and $0.30 /kg-DM respectively. These returns are clearly insufficient to offset water supply costs and gain widespread community support at this time.

For the smaller scheme area (1,800 ha) MWH predict scheme development costs to be approximately $6.7M ($3,722/ha), with operating costs of approximately $0.35M per annum ($195/ha). Although the mean annual rainfall remains the same in the smaller scheme i.e. 1,100 mm/year, the soils are predominantly 80mm PAW. The marginal benefit calculated for this soil / rainfall combination for a pasture value of $0.20/kg-DM is $281/ha/year and for a pasture value of $0.30/ha/year it is $701/ha/year. These estimated scheme costs and marginal benefits are summarised in Table 24.

Table 24: Hawera Scheme Summary of Costs and Marginal Benefits

Scheme Area >	5,000 ha	1,800 ha
Development costs inc. fees and contingencies	$18.2M	$6.7M
Development costs per ha	$3,640	$3,722
Annual operating costs	$1.3M	$0.35M
Annual operating costs per ha	$260	$195
Marginal benefit for soil PAW 140mm and pasture value $0.20/kg-DM	$37	-
Marginal benefit for soil PAW 160mm and pasture value $0.20/kg-DM	$-118	-
Marginal benefit for soil PAW 140mm and pasture value $0.30/kg-DM	$327	-
Marginal benefit for soil PAW 160mm and pasture value $0.30/kg-DM	$92	-
Marginal benefit for soil PAW 80mm and pasture value $0.20/kg-DM	-	$281
Marginal benefit for soil PAW 80mm and pasture value $0.30/kg-DM	-	$701

Assuming a finance rate of 8% and a 35 year loan period for $6.7M and with annual operating expenses of $0.35M/yr the annual water charge/ha for the scheme would be approximately $539. This “cost of community supply” suggests that with a pasture value approaching $0.30/kg-DM a community scheme may be viable serving properties with shallow soils in the Hawera zone.

Once again it needs to be stressed that, for a community scheme to be successful, good community support is required. As such, the limited marginal benefits of such a scheme (i.e. $162/ha maximum modelled) may not be sufficient to secure the necessary support without either significant net increases in the value of pasture or climatic changes.

7.7 Areas Outside Those Considered

Although irrigation marginal benefits within the Opunake zone are lower than for the Hawera zone, marginal benefits are sufficient to attract some irrigation. Two streams within the Opunake zone have been assessed (Kapoaiaia and Punehu streams). The land areas that can be reliably irrigated from the run-of-stream supply of these two streams is not high, being just 152 ha and 39 ha respectively. Whilst supply reliability can be improved by harvesting and storage of water from the B and C Blocks, storages are economically unattractive.

It is not practical to assess the reliability of supply and the economic viability for other rivers. In many cases there is insufficient long-term flow data available and the majority of streams within the Opunake zone are likely to have similar characteristics to the Kapoaiaia and Punehu streams, as most of these streams are also flowing from Mount Taranaki. The areas that can reliably be irrigated from run-of-stream supply are likely to be relatively small. As shown by Table 9, the irrigation marginal benefits for these areas are not high. Therefore, it is unlikely that storage would be economically viable within these zones.

8 COMPARISONS WITH OTHER SCHEMES IN NEW ZEALAND

It is useful to compare the schemes identified within this study with similar schemes elsewhere in the country. This can provide an indication of possible costs that have been developed through detailed design processes. The following provides a brief description of such schemes allowing comparisons to be made.

8.1 Waimea Water Augmentation Scheme – Tasman

This scheme is comparable to that outlined in this study to serve the Inaha Zone.

This proposed scheme will involve the construction of a dam on the Lee River in the Tasman District. The scheme will capture excess water for storage, releasing water into the Waimea River system during periods of high water demand and/or low natural water flows.

The dam storage will be in the order of 13 million cubic metres. The reservoir would extend approximately 4 km upstream of the dam and cover an area of 65 ha of the Lee Valley.

The Waimea Water Augmentation will address existing over-allocation and environmental issues associated with the river, while also meeting the needs of both the urban and rural water users for the next 50 to 100 years.

The scheme would provide water for:

- Supply to the existing irrigation area of the Waimea Plains;
- Adjoining irrigable land potential;
- Existing urban and industrial water supply;
- Future urban and industrial demand; and
- Future regional demand.

The estimated capital cost of the proposed Waimea Water Augmentation is $41.6M. This is made up of $38.1M for the design and construction of the dam, $2M for land purchase and access replacement, $1M for environmental mitigation and $0.5M to obtain resource consents. This cost excludes any costs associated with piped delivery from dam or any other water distribution infrastructure. This is based on an irrigated area of 5,786 ha and equates to $7,190/ha.

The estimated annual operating cost of the augmentation is $400,000. This is made up of $300,000 for repairs and maintenance and $100,000 for scheme administration. This equates to $69/ha.

For the Inaha zone the costs indicated above are >$50M for the community storage and infrastructure ($7,692/ha). It is estimated that operating costs for the Inaha schemes would be similar to Waimea i.e. approximately $400,000/yr.

8.2 Tarras Irrigation Scheme – Otago

The proposed Tarras scheme is a pressurised piped scheme that will provide water for approximately 7,700 ha. Part of the command area is already irrigated under historic mining privileges which will expire in 2021.

Water will be taken from the Clutha River via two intakes. Booster pump stations will be situated downstream of major off-takes and junctions in the pipe network to ensure that pumping energy requirements are minimised.

The Clutha River is not currently under any allocation pressure and the proposed scheme's water supply reliability will be very high.

The estimated capital cost of the proposed Tarras Scheme is $36.5M. This is based on an irrigated area of 7,700 ha and equates to $4,740/ha.

The estimated annual operating cost of the scheme is $4.1M which equates to $532/ha.

This scheme is comparable to the schemes outlined in this study for the Hawera Zone. They both take relatively reliable surface water and have to pump that water over the river terrace. Tarras did not lend itself to open channel distribution as well as Hawera and so piped distribution was preferred for that scheme. Also, the maximum pump lift for Tarras will be higher than for Hawera.

For the Hawera schemes outlined above the capital cost of development is estimated at $18.2M ($3,640/ha) for the 5,000ha and $6.7M ($3,722/ha) for the 1,800ha scheme. The operating costs are $1.3M per annum ($260/ha) and $0.35M per annum ($195/ha) respectively.

Note that these comparisons with other proposed schemes are provided only as a matter of interest. There will be variations in the build up of costs and each scheme will have its own unique issues that impact upon both development and operating costs. One point of interest however, is that these example schemes have been on the table for some time and getting the necessary support and financing hasn't been easy. Yet the marginal benefits of irrigation in these areas will be higher than Taranaki because of lower mean annual rainfall. This suggests that it would be extremely difficult to obtain the necessary backing for similar value schemes in Taranaki.

9 IMPLICATIONS FOR IMPROVING / DEVELOPING WATER SUPPLIES FOR NON-IRRIGATION USES

At the outset of this project feedback was sought from the three district councils in Taranaki about the issues faced with regard to providing reliable water supplies for non-irrigation uses, serving both the rural and urban communities. The following provides an indication of the verbal responses from senior District Council officers.

9.1 New Plymouth District Council

Meeting with Brent Manning (NPDC Manager Water and Wastes) provided the following comments:

- Exploratory work being carried out to determine extent to which groundwater may by used to provide water supplies;
- Currently looking into potential to serve Egmont Village and other smaller settlements from the Inglewood supply;
- Water modelling being used to forecast water use in various areas;
- Steps being taken to improve the New Plymouth supply;
- Had investigated serving the whole of the districts area on the ring plain from Inglewood, although investigations determined that this may be cost prohibitive;
- District working hard to improve the efficiency and reduce water losses from the existing water supply schemes with good results to date;
- All NPDC treated water supplies are fully compliant with New Zealand drinking water standards;
- NPDC is intending to retain the untreated water supply on the Waiongana Stream as a contingency supply.

There is currently very little irrigation in the district.

9.2 Stratford District Council

Meeting with Mike Oien (SDC Services Asset Manager) provided the following comments:

- The district has three main public supply schemes;
- There is one small scheme that uses a groundwater supply. All other supplies are from surface water. Consideration is being given to replacing the groundwater supply with surface water;
- All schemes are to drinking water standards;
- Michael indicated that the district did not have major problems with supply reliability or water allocation;
- There is currently no irrigation demand in the district.

9.3 South Taranaki District Council

Meeting with Neil McCann (Group Manager, Engineering Services) and Howard Wilkinson (Engineering Assets and Planning Manager) provided the following comments:

- There is significantly higher demand for irrigation in this district than the other two Taranaki districts;
- There are numerous community water supply schemes that exist in the district. The locations of existing schemes are identified in Appendix A;
- All water supplies are in the process of being systematically upgraded across the district to meet the drinking water standards. Significant investment has already been made starting with the largest supplies and the remainder will be completed within the next few years to meet the timetable set in the drinking water standards;
- Water supplies in the south of the district (Patea, Waverley, Waverley Beach and Wai-inu) are sourced from groundwater. A recent comprehensive ground water exploration programme across the district searched for other sources as potential replacements for surface water sources. However, only one location was suitable at Kapuni where a production borehole has been developed to supplement surface water;
- Water demand management has been a business focus for several years and significant reductions in demand have been made, particularly in rural water supplies. This work was recognized nationally as a finalist in the Ministry for the Environment Green Ribbon Awards; and
- If community scale irrigation water supply schemes are being considered, the STDC would like non-irrigation water uses to be incorporated into the feasibility studies.

10 INCORPORATING NON-IRRIGATION WATER SUPPLY WITHIN COMMUNITY IRRIGATION SCHEMES

This project has considered the irrigation demand and economic feasibility of providing irrigation supplies to the Taranaki Region. The results of this work have indicated that community scale irrigation schemes are unlikely to be feasible within the areas administered by the New Plymouth District Council or the Stratford District Council.

With the focus of this project being a review of irrigation potential, these results have meant that no further assessment has been made of the potential for new schemes to supplement or replace existing water supply schemes in these two districts.

The potential for community scale irrigation development is highest within the area administered by the South Taranaki District Council.

10.1.1 Inaha Zone

The scheme concept outlined in this report to provide irrigation water to the Inaha Zone, considers various options for introducing storage. This concept could be extended to include providing non-irrigation water supplies to properties within, or beyond the suggested irrigation command area.

Information provided by STDC indicates that the most significant existing water supply scheme within this area is the Waimate West Rural Water Supply. This scheme supplies approximately 527 properties and requires 17,700m^3/day. There are also smaller schemes to the east. The area modelled for irrigation potential, only covers approximately 20% of the area served by the Waimate West scheme, this being only the coastal strip.

The STDC (2003) survey of farmers carried out by BECA gauged the level of interest in reticulated water supplies in areas not currently supplied by water. The survey asked a variety of questions about water use, desire for water supply and the price people were prepared to pay. The results of the survey, with regard to interest in gaining access to reticulated supplies, is shown in graphical form in Appendix B. The survey indicated interest both inland of, and within the eastern end of the Inaha irrigation scheme identified in this report.

If a community irrigation scheme was considered to serve the Inaha Zone area in the future, the degree to which that scheme (or some variation thereof) could also be used to serve or supplement the Waimate West scheme, or those areas currently not served by reticulated supply, would depend upon the extent of that scheme and the location of the storage facility i.e. it will depend upon the elevation of the storage facility.

10.2 Hawera Zone

The scheme concepts outlined in this report to provide irrigation water to the Hawera Zone consider two scheme concepts, one serving 1,800 ha and the other 5,000 ha. The STDC information indicates that there are two existing community supplies within the irrigation command area. These are the Waverley urban water supply with approximately 400 connections and the Waverley beach supply with 35 connections. These are both relatively small community urban supplies.

The results of the farmer survey conducted by BECA in 2003 (Appendix B) indicated very little interest in new reticulated water supplies within the proposed scheme areas.

The irrigation design requirements for this area have been assessed as being 0.4l/s/ha. This equates to approximately 35 m^3/ha/day. The requirements for stock, domestic and dairy sheds are approximately 0.45m^3/ha/day (PGG Wrightson, 2007). This equates to approximately 1.3% of the water required for irrigation.

The amount of water required for non-irrigation purposes is significantly less than irrigation. Incorporating such uses into a community irrigation scheme of any significance, will be relatively straight forward. The majority of new community scale irrigation projects would tend to also be designed to make provision for other water uses within the irrigated area being served by the scheme. Significant industrial water uses can be an exception to this rule. Provision of water for such uses would tend to be location specific and so is not considered further for this project.

Non-irrigation water uses do have specific requirements that mean that these uses do need to be considered as part of the concept planning and detailed design stages. Although the volumes and flow rates required are a relatively small proportion of irrigation supplies, thought needs to be given to how supplies can be maintained outside of the irrigation season. With pressurised piped schemes this is not usually a major issue as small pumps can be used to lift water and maintain appropriate pressure. However, this becomes much more of a problem where open channels are used to convey water (especially where water is being pumped into those channels) and significantly higher flows will be required in order to maintain a reliable supply to all areas.

Provision of water for non-irrigation purposes needs to be given careful consideration within the design of community schemes. Due to the strategic and conceptual nature of this project no further or more detailed assessments have been carried out.

10.3 Opunake Zone

Reticulated water supplies already serve a reasonable proportion of the Opunake Zone where irrigation marginal benefits are shown to be highest. The schemes serving this area include a part of Waimate West, Cold Creek, Opunake Urban and Oaonui water supplies. G J Mullett STDC Water Supply Strategy Study (2003) indicates that these schemes at that time were generally sufficient to meet demands, although there were some issues with meeting peak demand, security of supply and water quality. However, that report also identified forecasted demand increase by 2025 of between 22% and 35% within these rural zones.

This study has indicated that large scale community irrigation schemes to serve this area are unlikely to be economically viable. However, a continuation of small scale development is likely where land owners have direct access to rivers or streams that have spare allocation. If such small scale development occurs, potential exists for water to be used for purposes other than irrigation which would go some way towards reducing the pressure upon the existing rural supply schemes.

11 POTENTIAL REGIONAL ECONOMIC IMPLICATIONS

The introduction of community scale irrigation schemes into an area can lead to relatively large impacts upon the regional economy. Typically, the aspects that can change include:

- Increased total direct farm output (i.e. value of sales);
- Increased output from local processing;
- Increase in total regional output, including flow-on impacts;
- Significant contributions to regional GDP;
- Direct increase in farm jobs;
- Direct increase in processing jobs; and
- Increases in household income as a result of the business returns and employment associated with the scheme(s).

The regional economic impacts of a community scale irrigation scheme (or schemes) being developed in the Taranaki Region are however, likely to be limited. The reason for this is that such schemes in Taranaki are unlikely to lead to a significant change in land use or significant increases in farm profitability and production.

The majority of the areas where irrigation may be viable are currently used for dairy production. Irrigation is unlikely to change this land use. It will lead to some additional production and it will reduce the risks caused by drought. Because of this, there will be benefits to the regional economy. However, with land use changes unlikely, the returns of irrigation are marginal in most locations and with a limited chance of large scale community schemes, any such benefits are likely to be limited.

12 POTENTIAL ENVIRONMENTAL IMPLICATIONS

There are many potential environmental implications of both developing and using water from an irrigation scheme. For any proposed scheme it will need to be demonstrated that these environmental impacts are within acceptable limits.

The two aspects of the potential effects on the environment of further irrigation development that require specific mention here are:

- Water quantity; and
- Water quality.

12.1 Water Quantity

Because the groundwater resources are unlikely to support any significant level of irrigation water for irrigation will need to be sourced from the region's rivers and streams.

Minimum flow guidelines have already been set by TRC for rivers and streams in the region. These aim to maintain minimum in-stream flows that provide for a river's natural character and life-supporting capacity in low flow conditions. The minimum flow is the most important part of a flow management regime for protecting ecological and mahinga kai values. Fish, and other aquatic life, like irrigators, like certainty. If the minimum flow is too low to sustain the various aquatic populations, then the duration of time that flow remains at the minimum flow becomes important. The duration of time between large flow events that scour or clean the river bed can also be important. However, for most streams and rivers, flow allocation has little impact on the frequency and magnitude of these large events.

The allocation regime proposed in this report is likely to be an acceptable trade-off that allows for the potential for economically viable irrigation, while ensuring the ecological, recreational and aesthetic values of affected water ways are protected. This opinion is based on experience in similar situations. However, scientific studies would need to be undertaken to support the proposed water allocation approach for each particular river or stream considered.

12.2 Water Quality

The introduction of irrigation can lead to intensification of farming activities and increased drainage through the soil profile. It can also lead to increased surface run-off, although this can usually be minimised by appropriate management of the irrigation system.

These changes pose potential risks to both groundwater and surface water quality.

The latest TRC State of the Environment Report (2009) states that water quality in the upland parts of rivers and streams is generally good, although the lower reaches of many show signs of being adversely impacted by agriculture. There have been efforts made in recent years to improve this situation with the implementation of a riparian management programme.

Any proposed irrigation scheme will need to have regard to the potential for further reducing water quality. Whether potential impacts will be considered to be any more than minor will depend upon the specifics of the location(s) in question. However, given the current status of water quality in the coastal areas of the region (where irrigation is most likely to occur) some mitigation to minimise the impact upon water quality can be expected. Such mitigation may take the form of fencing waterways, riparian planting, specific riparian management and the requirement for robust farm management plans.

13 POTENTIAL SOCIAL AND CULTURAL IMPLICATIONS

13.1 Social Impacts

The introduction of community scale irrigation schemes into an area can lead to relatively large impacts upon the social fabric of the local community. Typically, the aspects that can change include:

- Changes upon population numbers;
- Effects upon the socio-economic make up of the population;
- Changes to the ethnic mix of the population;
- Changes to the populations qualifications;
- Effects on income levels;
- Effects upon local infrastructure, such as schools, social services, community organisations, transportation, roading etc; and
- Effects on employment and business.

The social impacts of a community scale irrigation scheme (or schemes) being developed in the Taranaki Region will be significantly less than for the majority of such schemes located elsewhere in New Zealand. The reason for this is that such schemes in Taranaki are unlikely to lead to a significant change in land use.

The majority of the areas where irrigation may be viable are currently used for dairy production. Irrigation is unlikely to change this land use. It will lead to some additional production and it will reduce the risks caused by drought. However, with land use changes unlikely, irrigation is unlikely to lead to significant changes in the workforce population.

13.2 Cultural Impacts

There are eight iwi whose rohe or tribal area falls either wholly or partially within the Taranaki region (Figure 21).

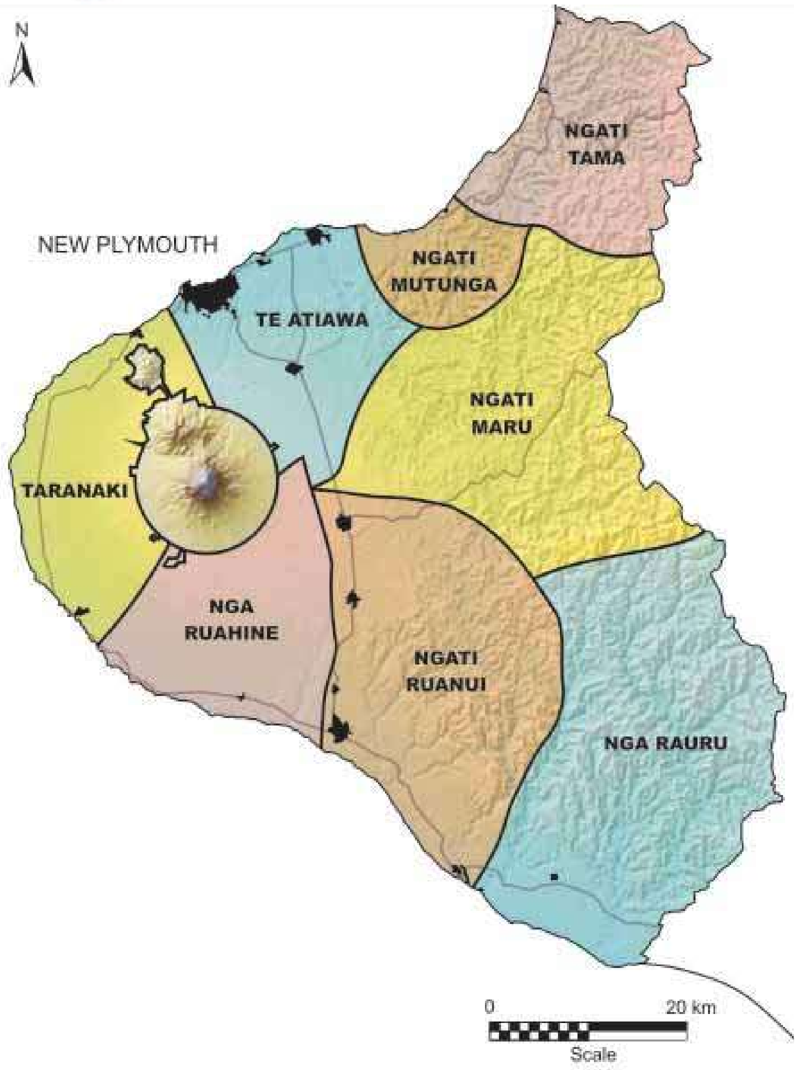

Figure 21: Iwi boundaries

The rohe of Ngati Ruanui, Nga Ruahine, Taranaki, Te Atiawa and Ngati Mutunga are located entirely within the region, while that of Ngati Tama overlaps the Waikato region in the north and those of Ngati Maru and Nga Rauru overlap the Manawatu-Wanganui region to the east and south.

The areas that show the higher marginal benefits of irrigation fall within the boundaries of four iwi. These are Taranaki (Opunake Zone), Nga Ruahine (Inaha Zone), Ngati Ruanui (north western Hawera Zone) and Nga Rauru (south eastern Hawera Zone).

13.3 Tangata Whenua And The Environment

Maori view themselves as an integral part of the natural world. The spiritual beliefs held by all Maori link tangata whenua to their original parents Papa-tu-a-nuku (Earth Mother) and Ranginui (Sky Father) as part of a complete living system. The close attachment of tangata whenua to their ancestral lands and resources stems from this belief in their common origins and from occupation and use. The relationship of Maori with the environment provides links with both ancestors and future generations, and establishes tribal identity and continuity. Some of the relationships of Maori and their culture and traditions to land and water (being the most likely matters to be affected by potential irrigation) are briefly outlined below.

13.4 Land

Ancestral lands are not restricted to land currently owned by Maori but also include lands traditionally occupied by iwi and hapu. In managing the effects of the use of land resources in Taranaki, recognition must be given to the relationship Maori have with their ancestral lands, and of the need to protect sites and resources of particular cultural and spiritual value from the adverse effects of land use and development.

Mount Taranaki is of particular significance to all iwi in Taranaki.

13.5 Water

To Maori, water (wai) in all its forms is descended from Papa-tu-a-nuku and Ranginui. Rivers (awa) represent the tupuna (ancestors) of the tangata whenua. Water and every river therefore have their own mana.

Water also has its own mauri (life force) and wairua (spirituality) which are linked to mana. If the mauri or wairua of a water body is interfered with through over-exploitation, pollution or desecration, then the spirits of the tupuna are affected and the water body loses its mana.

Spiritual qualities can be adversely affected by the taking, use or diversion of water, and discharges of contaminants to land or water. Tangata whenua also value water for the provision of physical sustenance through the gathering of kai - for example, watercress, tuna (eel), piharau (lamprey), kahawai, inanga and other whitebait species.

Particular rivers have special significance to those iwi and hapu in whose rohe they are located. For example, the Stony (Hangatahua) River has special value for the Taranaki iwi, the Waiwhakaiho, Waiongana and Waitara rivers are of particular significance to Te Atiawa, the Kapuni Stream is of special value to Nga Ruahine and the Manganui and Waitara rivers are of special value to Ngati Maru.

13.6 Impacts Of Irrigation Development On Cultural Values

If irrigation development is proposed, consultation with the appropriate iwi and hapu for that area is recommended at an early stage of the project’s feasibility.

Consultation with iwi has not been undertaken in preparing this report. However, based on tangata whenua issues identified in TRC policy documents and experience elsewhere in New Zealand, the following issues are likely to be of interest/concern to the iwi and hapu of Taranaki:

- recognition of the kaitiakitanga role and responsibilities of iwi and hapu in relation to rivers, streams and other water bodies within their rohe, and opportunities for incorporating customary knowledge in project assessment, design and monitoring;
- protection of wahi tapu and other sites, features or taonga of cultural and spiritual significance to iwi and hapu that might be affected by the project including actions required if cultural material is discovered during construction and installation of the irrigation system;
- effects of the project on mahinga kai and habitats of species harvested by iwi and hapu, and access to mahinga kai;

- effects of the mixing of waters from different rivers on the mauri and wairua of the waterbody; and
- the aspirations of iwi and hapu themselves to use and develop freshwater resources within their rohe.

In broader or more general terms tangata whenua interests are likely to include:

- Effects of abstraction upon the quantity of stream flow;
- Effects of abstraction upon the variability of stream flow;
- Maintenance of fish passage through in-stream structures;
- Prevention of fish passage into water supply systems;
- Confirmation that the use of water is appropriate and efficient;
- Effects of water take and use on surface and groundwater quality.

Further work would be required in order to quantify the effects of any proposed scheme. The one issue outlined in the above list that the proposed schemes would not comply with, is the mixing of water from different catchments. All of the designs outlined in this report would lead to this occurring and any large-scale community scheme in this area (especially around the ring plain) is likely to require some degree of mixing. Feedback from the relevant iwi about this matter should be sought early in any feasibility or pre-feasibility assessment.

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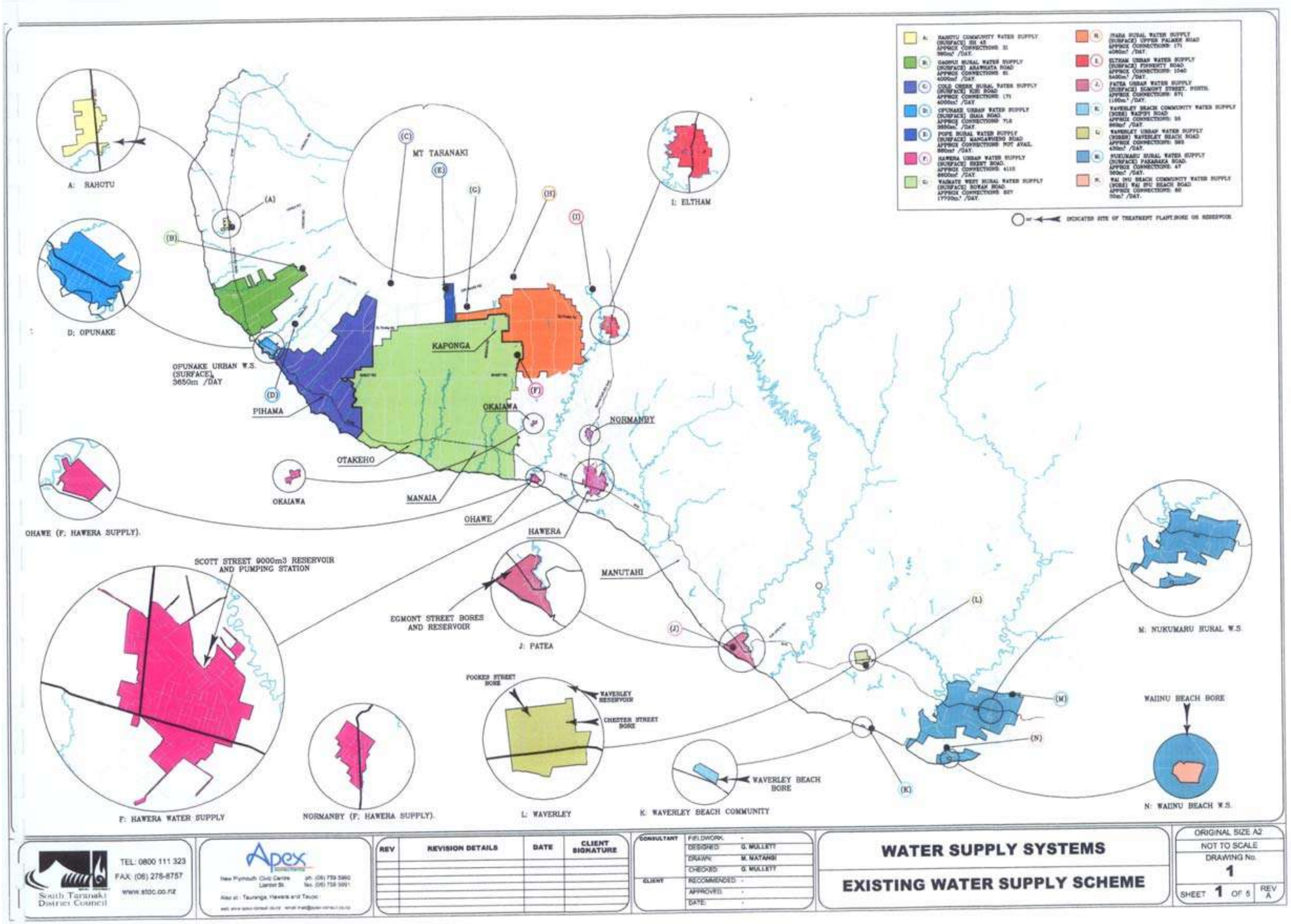
Appendix A: South Taranaki District Council existing community water supply schemes



Appendix B: Graphical representation of BECA 2003 survey results