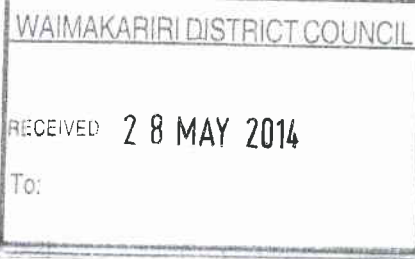




Mahaanui
Kurataiao Ltd



State of the Takiwā 2012

Ruataniwha / Cam River



Cultural Health Assessment of the Ruataniwha / Cam River and its catchment

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mō tātou, ā, mō kā uri ā muri ake nei

for us and our children after us



This cultural health monitoring programme and report was undertaken and produced by Mahaanui Kurataiao Limited in association with a roopu of whānau from Te Ngāi Tūāhuriri Rūnanga.

Mahaanui Kurataiao Ltd and the whānau roopu greatly appreciate the assistance of Te Rūnanga o Ngāi Tahu to establish and support the technical needs of the monitoring programme and database. Mahaanui Kurataiao Ltd and the whānau roopu also acknowledge the vital support of Waimakariri District Council in their funding of this State of the Takiwā monitoring programme.

He mihi nui ki a koutou katoa



Cover Photographs:

Cover Photo: Io Io Whenua. Photo: Mike Lang, MKT.

Above: Ngā Tapuwae o Mua / Kaiapoi Lakes. Photo: Mike Lang, MKT.

Endorsement of State of Takiwā report by Ngāi Tūāhuriri Rūnanga

This report has been prepared by team of representatives from Ngāi Tūāhuriri Rūnanga and staff from Mahaanui Kurataiao Ltd (MKT). Members of the monitoring roopu have been selected and approved by Ngāi Tūāhuriri Rūnanga to undertake the State of the Takiwā assessments as manawhenua representatives. MKT is a company owned by Ngāi Tūāhuriri Rūnanga (and five other Rūnanga) to provide specialist manawhenua environmental services to a range of clients.

In undertaking the State of the Takiwā monitoring programme and preparing this report, MKT staff and the whānau roopu have used their best endeavours to achieve a high standard of assessment and reporting. This includes having sought feedback from wider Ngāi Tūāhuriri whānau to confirm the accuracy and appropriateness of the results reported, whilst recognizing that the monitoring results can only reflect what was observed by the roopu on the day. It is also acknowledged that the State of the Takiwā methodology for this monitoring programme was developed by Te Rūnanga o Ngāi Tahu. This was used as the basis of the approach to monitoring, with some additions made to meet the particular objectives for this Puharakekenui programme, as determined by the roopu. This endorsement represents the final step in the process of gathering feedback and confirming the monitoring results and content needed for this Ruataniwha 2012 State of the Takiwā report.

With the above in mind, we the representatives of the Ngāi Tūāhuriri Rūnanga Executive confirm that we have received and endorse this report prepared by Mahaanui Kurataiao Ltd and the whānau roopu.



Signed on behalf of Ngāi Tūāhuriri Rūnanga



Date

Whakarapopotanga / Executive Summary

This report presents the results of a cultural environmental health assessment of the Ruataniwha / Cam River and its catchment. This was the first cultural health assessment of the catchment using the State of the Takiwā approach developed by Ngāi Tahu, and was undertaken by Ngāi Tūāhuriri Rūnanga in conjunction with Mahaanui Kurataiao Ltd (MKT) between July and August 2012. The programme was based on forty four monitoring sites located across the catchment. These were selected by Ngāi Tūāhuriri Rūnanga representatives to reflect the Ngāi Tahu *Ki Uta Ki Tai* (source to sea) resource management philosophy. The sites chosen included headwaters, tributaries, and main-stem river sites, and artificially created Ngā Tapuwae o Mua / Kaiapoi Lakes which are now a feature of the lower catchment. The catchment is of immense significance for Ngāi Tahu, in part due to its strong connections to Kaiapoi Pa. Māori Reserve 873, known as Te Tuahiwi, also lies within the catchment.

Results from this State of the Takiwā programme establish a cultural health baseline for the catchment. Notable trends include many examples of modified waterway form and function. Many monitoring sites, particularly in the lower catchment, were identified as polluted in visual observations, and through the results of *E. coli* testing. The majority of monitoring sites were deemed unfit to gather mahinga kai by the roopu at the time of the monitoring visit, primarily due to pollution concerns such as those associated with the proximity of unfavourable land use activities.

The diversity and abundance of indigenous vegetation at monitoring sites was found to be low, with farmland and exotic species being dominant throughout the catchment. The exception was at a few sites where efforts have been made to restore the riparian area. Where sites had been the subject of active restoration, many of the assessments used to gauge cultural health returned better results. These results illustrate that although much of the region has been modified for agricultural and residential use, there are opportunities for these activities to co-exist with the traditional Ngāi Tahu values associated with waterways.

Results from this monitoring programme indicate that a variety of management responses would be needed to improve the cultural health of waterways in the catchment. These should be considered on a site specific basis due the considerable variability that exists between sites in terms of both their character and traditional values, and variance in the of actual and potential negative impacts from land use activities in proximity to these sites. Some of the key recommendations to support Ngāi Tahu vales include the need for improved water quality and habitat quality at many sites. In addition, the re-establishment of more natural waterway form and function is an important consideration at many sites, as is the establishment of suitable setbacks and buffer zones and the restoration of indigenous vegetation in riparian areas.

To further develop and implement recommendations from this monitoring programme will require continuing and direct involvement of Ngāi Tūāhuriri Rūnanga in waterways management in their takiwā. Regular, comprehensive and culturally relevant monitoring will be important to establish whether desired aspects of waterways recovery are being achieved. Another important aspect is that additional monitoring programs are needed to target specific cultural values and aspects of cultural health for management purposes. These include that a much greater level of investigation to assess the seasonal cultural health of awa and kai-awa is needed. This will require more frequent and targeted monitoring than that conducted under the State of the Takiwā programme, in which the focus is to establish and monitor against a long term cultural base-line for the entire catchment.

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1. Te Whakatuwheratanga / Introduction

The Ruataniwha (Cam River) and its catchment is a highly significant area for Ngāi Tahu. Within this region lies Maori Reserve 873, known as Te Tuahiwi, which was traditionally a mahinga kai outpost of the Kaiapoi Pa, and was primarily an area of gardens which were guarded by local whānau (Tau et al., 1990). Today this region remains an area of great importance where Ngāi Tahu whānui have a relationship with the land which extends beyond just occupation. There are many archaeological sites, artefacts and other taonga throughout the area in addition to wāhi tapu such as Te Kai a Te Atua Urupā. These are all testament to the traditional associations and level of significance that exists for Ngāi Tahu.

In this report the awa (river) is referred to as the Ruataniwha / Cam River for convenience, although other names have been used including 'Horotueka', and there are several named sections including Ruataniwha, Whakahume and Korotuaheke. In addition to Kaiapoi, the river runs close to several Ngāi Tahu kainga in the area, namely Te Tuahiwi, Te Rakiwhakaputa, Waituere, Pakaika and Kaikanui (Tau et al., 1990). The close association between these kainga the awa is an additional aspect of the relationship that exists in addition to the wider importance of the catchment for mahinga kai for Ngāi Tahu whānui.

The waterways of the Ruataniwha catchment arise from multiple spring-fed sources which provided exceptional water quality and other valued characteristics in their traditional state. Many important cultural values were supported by the awa, puna, and whenua of the catchment. Of particular note was the importance of the waterways for year-round mahinga kai, including in times of siege, for whānau of the area and in particular in connection with the Kaiapoi Pa (Tau et al., 1990). As the stronghold and centre of Ngāi Tahu economic activity the presence and health of the waterways contributed greatly to the strategic position and strength of Kaiapoi Pa; an association which remains unbroken through whakapapa and has never diminished to this day.

Over recent decades the catchment has been subject to modification in the form of development and land-use change under various administrative and governance regimes that continue to evolve today. This includes a shift from indigenous flora and fauna to domination by exotic species, and widespread physical modifications to waterways and drainage patterns in the catchment. For tangata whenua, changes associated with the European colonization and development pattern have had a direct and significant impact on customary relationships with the Ruataniwha / Cam River catchment, particular those derived from mana.

A recent aerial overview of the catchment, including the position of Te Tuahiwi and Māori Reserve 873 is shown in Figure 1.

Figure 1: Overview of the Ruataniwha / Cam River catchment including the position of Te Tuahiwi and Māori Reserve 873.



While some of the effects on cultural values associated with these changes are known, there has been little documentation of the status of the cultural health of the catchment from a tangata whenua perspective, or how important cultural values such as mahinga kai have changed in recent times and what is needed to promote their recovery. Tangata whenua have identified that manawhenua based knowledge and information, including the results of cultural health assessment exercises, is a necessary and ethically important component of contemporary planning and waterways management. This information is especially relevant for the planning and implementation of recovery strategies for the improvement of cultural values in the catchment.

The 2012 State of the Takiwā programme was established to address these needs, and was undertaken by Ngāi Tūāhuriri representatives in conjunction with Mahaanui Kurataiao Ltd and with support from Waimakariri District Council and Te Rūnanga o Ngāi Tahu. This programme represents the first comprehensive cultural environmental health assessment from a tangata whenua perspective for the Ruataniwha / Cam River and its catchment. It is hoped that the results may assist with management planning and the development of restoration strategies, and as a cultural baseline against which long term environmental change can be measured. The purpose of this report is to present findings from the 2012 monitoring programme, and to identify and discuss management recommendations by which cultural concerns and aspirations may be addressed.

2. Tāhuhu Kōrero / Background to the State of the Takiwā monitoring system

The State of the Takiwā monitoring system was developed by Ngāi Tahu to facilitate tangata whenua to gather, store, analyse and report on information relevant to the cultural health of waterways within their Takiwā (tribal areas). The major objective of State of the Takiwā is to enable tangata whenua to generate robust and defensible information on the health of the environment for a variety of purposes, including to inform recommendations for management (Pauling, 2004).

The State of the Takiwā approach to environmental monitoring reflects a Ki Uta Ki Tai (mountains to the sea) framework for natural resource management (Pauling, 2003; Te Rūnanga o Ngāi Tahu, 2003), and builds on other cultural health assessment methodologies such as the Cultural Health Index (Tipa & Tierney, 2003) and the Iwi-SHMAK kit (Ogilvie & Penter, 2001). The approach to data collection is a combination of field assessments measured against cultural criteria, and collection of supporting information on culturally relevant features of monitoring sites, including traditional use (Pauling, 2003, 2004). The range of assessments performed attempts to capture key cultural values and indicators of environmental health, especially those important to mahinga kai (food gathering) and other cultural activities (Pauling, 2008).

3. Ngā Whāinga / Study Aims and Objectives

The major objectives of this monitoring programme are:

1. Provide a current assessment of the cultural health of the Ruataniwha / Cam River and its catchment.
2. Identify recommendations to address cultural health, cultural values, and management issues in the catchment, from a manawhenua perspective.
3. In association with Ngāi Tūāhuriri Rūnanga, consider future needs for State of the Takiwā monitoring in the Ruataniwha / Cam River catchment.

4. Ngā Kauneke / Methods

4.1 Tāngata Arotake / Monitoring Team

The monitoring team consisted of representatives from Ngāi Tūāhuriri Rūnanga, supported by staff from Mahaanui Kurataiao Ltd. Laboratory work conducted by Hills Laboratories for analysis of water samples. Antibiotic resistance testing was conducted by John Aitken.

The Rūnanga roopu with support from Mahaanui Kurataiao Ltd staff involved were:

- Makarini Rupene (Ngāi Tūāhuriri)
- Cherie Williams (Ngāi Tūāhuriri)
- Tui Falwasser (Ngāi Tūāhuriri)
- Nukuroa Tirikatene-Nash (Ngāi Tūāhuriri)
- Tracey Te Karu (Ngāi Tūāhuriri)

- Shane Orchard (Project Manager, Mahaanui Kurataiao Ltd)
- Michael Lang (Project Co-ordinator, Mahaanui Kurataiao Ltd)

4.2 Wāhi Arotake / Monitoring Sites

4.2.1 Site selection

Identification of appropriate sites for the 2012 Ruataniwha / Cam River State of the Takiwā programme began with background research into sites of significance and geographical features of value to tangata whenua. These included known mahinga kai, wāhi tapu and wāhi taonga sites, and other locations of particular significance. All sites and areas identified which were associated with waterways were put forward for consideration as potential monitoring sites for the State of the Takiwā monitoring programme. In addition and in keeping with the *Ngāi Tahu Ki Uta Ki Tai* (mountains to sea) resource management philosophy, it was important that monitoring sites were distributed across the whole catchment to gain a catchment-wide understanding of cultural health.

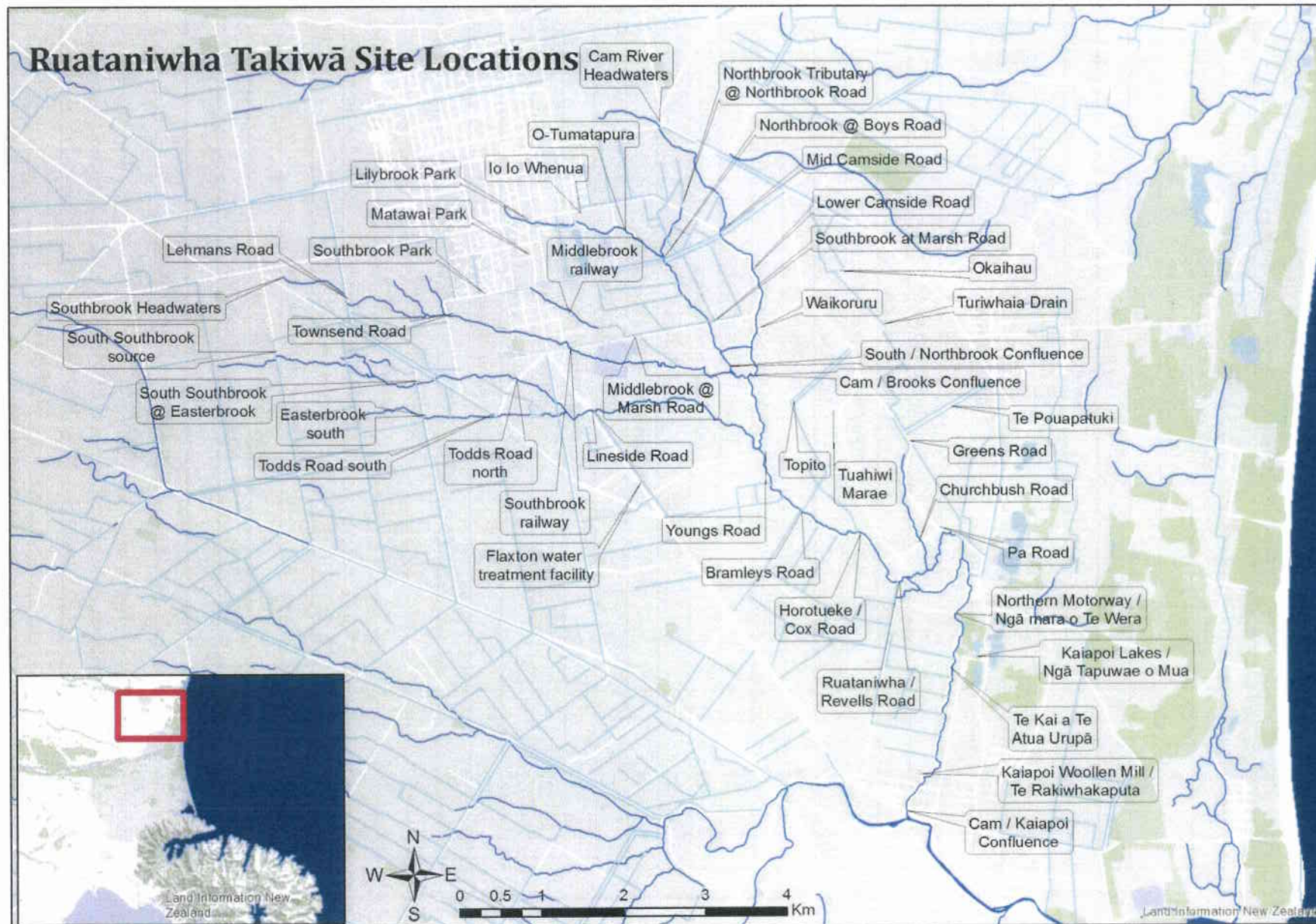
To identify the final set of monitoring sites, a briefing paper was developed and circulated to Ngāi Tūāhuriri Rūnanga with the objective of seeking feedback on the potential sites and areas identified, and to discover any further sites in the catchment which may be of interest as monitoring sites. In addition a hīkoi was conducted with Ngāi Tūāhuriri Rūnanga representatives to establish the suitability of all of the potential monitoring sites identified as above. Aspects considered on the hīkoi sites included logistical issues, site accessibility and safety, and similarity to other sites. For example, some sites of significance to tangata whenua (e.g. some springs) were not selected as State of the Takiwā monitoring sites where a similar monitoring site had been identified nearby or where a site location was inaccessible or prohibited. However, all potential sites were retained unless there was a specific reason for excluding them from the final site selection. From this process a final list of sites was generated and provided to key whānau for approval. This process resulted in the selection of 44 monitoring sites for the 2012 Ruataniwha / Cam River State of the Takiwā programme (Table 1).

Some site names for this study have been chosen on the basis of proximity to areas of historical and traditional association for Ngāi Tahu. The sites chosen included location used for a variety of traditional purposes, as well as providing for appropriate geographical coverage of significant sites throughout the catchment (Figure 2). In some cases the location of the monitoring site chosen does not coincide precisely with such areas for a variety of reasons including logistics, safety, and the location of private property boundaries. In other cases and to maintain the confidentiality of sensitive information, only the approximate location of the monitoring sites is detailed in this report.

Table 1: Monitoring sites used for the 2012 Ruataniwha / Cam River State of the Takiwā programme

Site Number	Proposed Site Name
1	Cam / Kaiapoi Confluence
2	Te Rakiwhakaputa / Kaiapoi Woollen Mill
3	Te Kai a Te Atua Urupā
4	Ngā Tapuwae o Mua / Kaiapoi Lakes
5	Ngā mara o Te Wera / Northern Motorway
6	Ruataniwha / Revells Road
7	Ruataniwha / Cox Road
8	Churchbush Road
9	Pa Road
10	Bramleys Road
11	Youngs Road
12	Greens Road
13	Te Pouapatuki
14	Topito
15	Tuahiwi Marae
16	Turiwhaia Drain
17	Cam / Brooks Confluence
18	Waikoruru
19	Okaihau
20	Mid Camside Road
21	Lower Camside Road
22	Cam River Headwaters
23	Lineside Road
24	Flaxton water treatment facility
25	Todds Road south
26	Easterbrook South
27	Todds Road north
28	South Southbrook @ Easterbrook
29	South Southbrook source
30	South / Northbrook confluence
31	Southbrook railway
32	Southbrook Park
33	Townsend Road
34	Lehmans Road
35	Southbrook Headwaters
36	Middlebrook @ Marsh Road
37	Middlebrook railway
38	Matawai Park
39	Southbrook at Marsh Road
40	Northbrook @ Boys Road
41	O-Tumatapura
42	Io Io Whenua
43	Lilybrook Park
44	Northbrook Tributary @ Northbrook Road

Figure 2: Location of monitoring sites used for the 2012 Ruataniwha / Cam River State of the Takiwā programme.



4.3 Kauneke Arotake / Data Collection & Assessment

4.3.1 Overview

Field data collection was conducted over 9 days between the 20th August and 4th of September 2012. Data collection at each site involved a suite of assessments which varied depending upon the nature of the site.

The following types of assessments were utilised:

- Takiwā General Site Assessments (all sites)
- Cultural Health Index (CHI) Waterway Assessment (river and stream sites only)
- Stream Health Monitoring (SHMAK) Assessment (river and stream sites only)
- Fishing surveys (selected sites)
- *E. coli* water testing (all sites with water)
- Antibiotic resistance testing of *E. coli* samples

Prior to the commencement of work at a site, the team gathered for a hui to identify access and safety issues and kōrero on other features of the site supported by appropriate karakia and whakamoemiti/prayer. Roopu members individually completed the Takiwā general site assessments and CHI Cultural Stream Health Assessments at all applicable sites. Other assessments were completed by the roopu as a group.

All data from field monitoring exercises were entered into the Takiwā 2.0 database developed by Ngāi Tahu (Pauling et al., 2007). Takiwā 2.0 is Microsoft Access 2002 runtime application linked to a physically separate database. It includes a site assessment module which provides a range of index calculations to assist tangata whenua analyse assessment data on particular sites, and to facilitate comparisons between sites or monitoring visits.

Index calculations provided by Takiwā 2.0 include an overall site health assessment index, a species abundance index, and indexes for stream health based on both the Cultural Health Index assessment method (Tipa & Tierney, 2003, 2006) and the Stream Health Monitoring and Assessment Kit (Biggs et al., 2000).

4.3.2 Takiwā General Site Assessment

The Takiwā General Site Assessment consists of three forms (Appendix 1). The Site Definition form records the site name, locality, traditional significance and traditional condition of the site amongst other details. As this was a newly established State of the Takiwā programme an assessment of traditional significance and traditional condition of the site was required. This was determined through review of historical documents for information on aspects including ownership, legal protection, landforms, ecosystem types and traditional abundance of indigenous species. This information was augmented with feedback from kaumātua and whānau supported by the field observations of the roopu on aspects such as landforms, waterway morphology, soil type and vegetation type in the area.

The Site Visit form records information on aspects of the monitoring visit. These include the date, time, weather conditions, heritage/archaeological details, land use, and other relevant information. Following completion of the Site Visit form the General Site Assessment form was completed individually by each member of the monitoring roopu. The same set of assessment questions as developed by Pauling et al. (2007) for the original Ihutai programme was used in this programme. These questions address the health of the site in relation to the following:

- The amount of pressure from external factors;
- Levels of modification/change at the site;
- Suitability for harvesting mahinga kai;
- Access issues;
- Willingness to return to the site;
- Overall state/health of the site; and
- Presence and abundance of culturally relevant species.

Information gathered from the General Site Assessment was also entered into the Takiwā 2.0 database and an index score for overall site health calculated. This index reflects the average score from nine individual assessments, all of which are a score on a one to five scale. These assessments include the following six scores taken directly from the Takiwā General Site Assessment form; site pressure, modification, harvest access, willingness to harvest, willingness to return for cultural use, and overall health of the site. The remaining three scores considered are derived from the % cover in indigenous plant cover, an expression of current versus traditional number of species found at the site, and a score based on the Takiwā Abundance Index result (see section 5.7).

4.3.3 CHI Cultural Health Waterway Assessment

The Cultural Health Index (CHI) involves three aspects of the monitored waterway; whether the site is of traditional or contemporary significance to Māori, a mahinga kai assessment, and a cultural stream health assessment (Tipa & Tierney, 2003, 2006). Traditional or contemporary significance is established by the roopu based on feedback from whānau and kaumātua in particular. The remaining two assessments consist of a series of questions to which scores of between 1 and 5 are assigned and averaged to reflect the current condition of the site for these cultural aspects (Appendix 2).

The CHI mahinga kai assessment considers the abundance of mahinga kai species present at the site in relation to the traditional abundance, along with score for access and a score reflecting whether or not Maori would return to use the site in the future. The CHI cultural stream health score is based on a series of questions which score aspects of stream health including water clarity, flow, catchment land use, margin vegetation, riverbed sediments, water quality, variety of habitats, and impression of overall health.

4.3.4 Stream Health Monitoring Assessment (SHMAK)

The Stream Health Monitoring and Assessment Kit (SHMAK) was developed by the National Institute of Water and Atmospheric Research (NIWA) in partnership with Federated Farmers of New Zealand and the Ministry for the Environment (MfE) (Biggs et al., 2000). There are several variations of the SHMAK method in use for waterways assessment including an Iwi-SHMAK kit has also been developed (Ogilvie & Penter, 2001).

The methodology used for this State of the Takiwā programme involved assessment of the SHMAK Stream Bed Life parameters only, which involve assessments of the invertebrate and periphyton communities present (see Figure 6). The invertebrate assessment was based on five randomly selected stones in the stream bed which were scored for presence or absence of 17 invertebrate taxa as per the standard SHMAK method (Appendix 3). The same five stones were also assessed for periphyton presence/absence using the standard SHMAK method (Biggs et al., 2001). Scores from all SHMAK assessments conducted contributed to the SHMAK Stream Habitat Health index score calculated in Takiwā 2.0.

4.3.5 Indigenous vegetation and bird surveys

A survey was conducted to characterise the indigenous vegetation species present within a 100m radius of the monitoring site. Using the methodology established in Pauling et al. (2007), this survey considered only selected species of importance to Ngāi Tahu and was therefore not a comprehensive botanical survey. Plant species were recorded against a schedule of important species recognised within the Takiwā 2.0 database (Appendix 4). In this schedule some related species are referred to by a same Ngāi Tahu name, and where this occurs those species are therefore lumped and appear as a record of a single taxonomic group. The percentage cover in indigenous plant species for the total site area was also estimated to the nearest 5% or to the nearest 1% for cover estimated to be less than 5%.

Bird species observed during the monitoring visit within the same 100m radius were also recorded with particular emphasis on identifying any native bird species present.

4.3.6 Fish surveys

Fish surveys were conducted at a total of 24 sites using two different fishing techniques; Electric fishing and Hīnaki (fyke nets). The combination of methods allowed a greater number of sites to be surveyed to provide information on fish communities in the catchment, including some of the non-wadeable sites.

Electric Fishing

Electric fishing involves using an electric current delivered into the water which temporarily stuns fish so they can be gathered for inspection, identification and measurements. This method of surveying is suitable in freshwater locations which are wadeable (NIWA, 2012).

This study utilised the Kainga EFM 300 packset in-conjunction with a hand held scoop net and larger mesh net. The EFM300 consists of a battery-powered backpack generator unit, a fibreglass wand with cathode, and an earthing wire. Both machine and net operators wear full length neoprene waders and rubber safety gloves, with cotton inners during surveying (Figure 3). Surveying was conducted over varying distances, but typically between 10 and 30 metres with a single pass over each bank. The total time taken to complete electric fishing surveys was typically 10 to 20 minutes.

Figure 3: Electric fishing at O-Tumatapura.



Hīnaki

Traditionally hīnaki were constructed with natural resources of aka/vine, kareao pirita/supple jack pātaka/hoops and harakeke/flax korari/flower stalk (Beattie, 1994). Muka/fibre was extracted and prepared for the netting around the frame work and braided for the taura/securing rope. As this method often utilised the natural resources of the area where the activity was carried out, Ngāi Tahu whānui would also utilise any suitable natural resources present including aka/ vines and tororaro (a vine which grows on the flats). With the introduction of man-made resources including fencing wire, synthetic nylon, and aluminium and galvanised steel frames, the traditional structures for hīnaki are now frequently modified. Though less use is now made of traditional materials for hīnaki, though these techniques remain important.

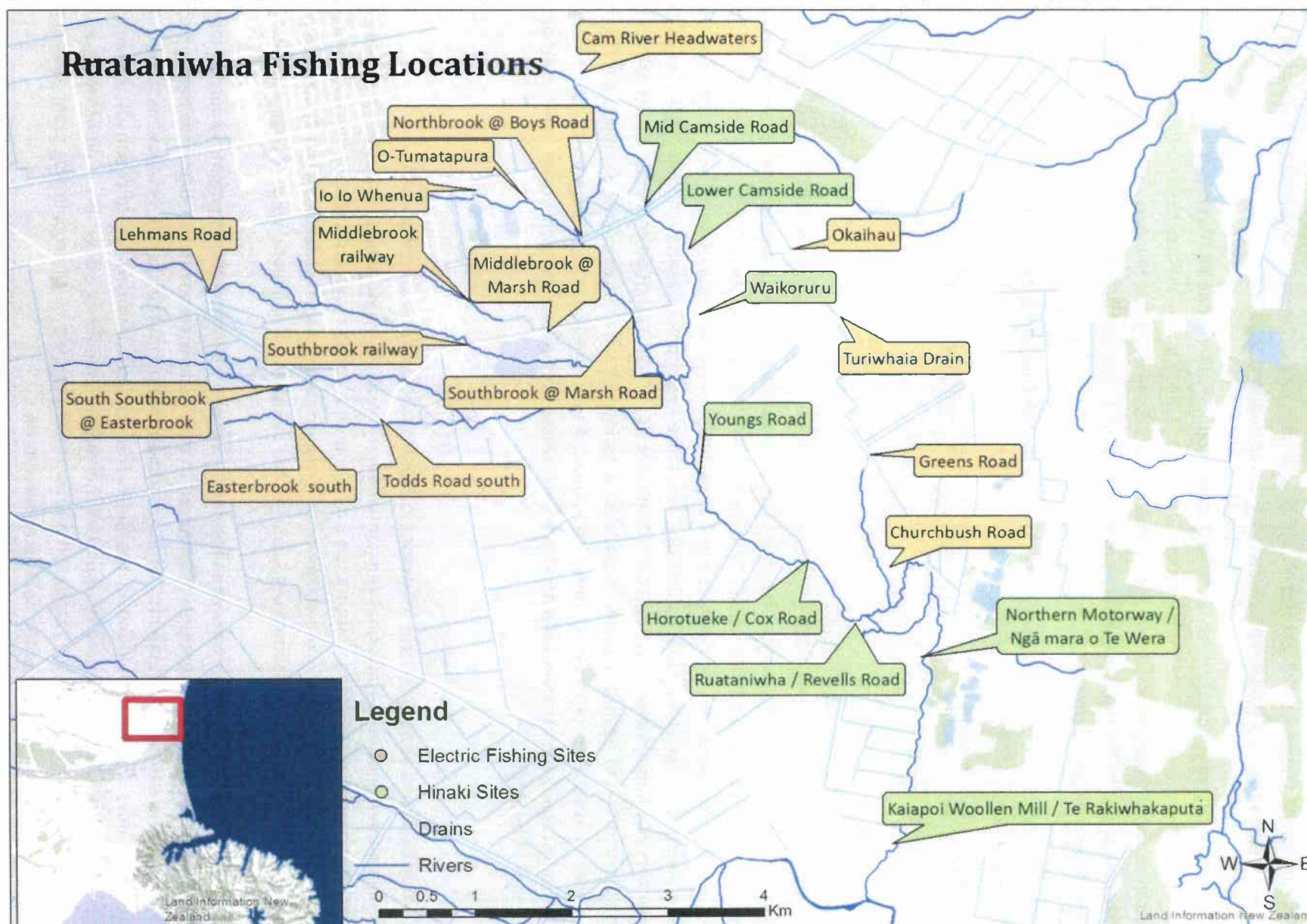
A single hīnaki baited with fish frames and scraps was set at each of nine locations over two days on the 26th and 30th September. These sites were selected on the basis of being not amenable to electric fishing, and where ease of access and safety of team members and equipment was acceptable for the setting of hīnaki. In each case the hīnaki remained set overnight and was collected on the following morning and their contents assessed (Figure 4).

Figure 4: Setting a hīnaki at the Ruataniwha / Revells Road site.



Electric fishing was undertaken at 16 sites and Hīnaki at nine sites (Figure 5).

Figure 5: Location of fishing sites by method used for the 2012 Ruataniwha / Cam River State of the Takiwā programme.



4.3.7 *E. coli* testing

E. coli is a subset of the group of faecal coliform group which commonly live inside the intestinal tract of healthy warm blooded animals and will survive but not duplicate in aquatic environments. *E. coli* itself does not typically cause illness on its own, but its presence in water is used as an indicator of faecal contamination. Therefore the occurrence of *E. coli* suggests a greater risk of other pathogens such as campylobacter that cause health problems (Ministry of Health, 2009).

Water samples were collected from all freshwater and estuarine sites at which water was present using plastic screw top vials. These samples were labelled and stored during the day in ice and subsequently hand delivered to Hills Laboratory at the end of each day for analysis of *E. coli* levels. These were assessed and recorded as the MPN (most probable number) count of *E. coli* per 100ml using standard procedures, for comparison against relevant standards (Table 2).

Table 2: Standards for *E. coli* levels (Source: Ministry for the Environment & Ministry of Health 2003; Ministry of Health, 2008).

Standard	Drinking water	Recreational - Alert	Recreational - Action
<i>E. coli</i> / 100ml	<1	260	550

4.3.8 *E. coli* antibiotic resistance

In addition to *E. coli* levels in water samples it is also necessary to determine the likely sources of the contamination due to the impact of human faecal contamination on cultural values (Te Rūnanga o Ngāi Tahu, 1999). Specific antibiotics (e.g. Apramycin) are uniquely associated with the agricultural use of antibiotics and therefore the detection of *E. coli* which may be resistant to these antibiotics suggests contamination of agricultural origin. Similarly, resistance to antibiotics used on humans (e.g. Ampicillin) are indicators of human faecal contamination (Pauling et al., 2005). To obtain this information samples were isolated and tested against a panel of antibiotics to identify resistances of the samples, and from here patterns of resistance can help identify the source of contamination. Where possible, 10 isolates being different *E. coli* colonies, were obtained from each water sample tested. Each isolate was tested against a panel of 14 antibiotics.

4.4 Background research and information on traditional associations

An understanding of both traditional and contemporary Ngāi Tahu associations with the catchment was an important aspect of the study. Information was gathered through review of relevant literature and kōrero with key persons with specific knowledge of these associations. Aspects included Ngāi Tahu presence and patterns of occupation and resource use, underpinned by the Ngāi Tahu world view, tikanga and kawa.

Understanding the relationship between tangata whenua and the natural environment is a further important dimension. Background information was gathered to address how these relationships have been affected by changes to the natural environment. This included information on the species, ecosystems, landforms and other resources traditionally found in the area. This research included identification of the indigenous species which traditionally would be found at the various monitoring sites. This is an essential aspect of index calculations performed in Takiwā 2.0 and was also required by the monitoring team as background information relevant to some of the field assessment tasks.

4.5 Taputapu Arotake / Summary of monitoring equipment

- Takiwā forms, Cultural Health Index forms, SHMAK Kit, manual and forms
- Electric Fishing Machine, probe and nets
- Waders and protective gear
- Hīnaki nets and bait (fish frames and scraps)
- *E. coli* kit (vials, ice packs, chilly bin, forms)
- First Aid kits
- Private vehicles
- GPS unit, digital camera
- Species identification resources
- Maps
- Laptops and Takiwā software

Figure 6: The roopu engaged in a SHMAK assessment at the Flaxton water treatment facility site.



5. Ngā hua / Results

5.1 Ngāi Tahu associations with the Ruataniwha / Cam River catchment

This cultural health assessment was carried out within the traditional boundaries of Ngāi Tūāhuriri who, as kaitiaki/environmental guardians of this area, are committed to assess any effects on our cultural, and customary traditional values and interests. The Kaiapoi Māori Reserve 873, commonly known as Te Tuahiwi, is an outcome of the 1848 Canterbury Purchase, placed aside as settlement land for Ngāi Tahu and their descendants to live upon (Evison & Adams, 1993).

NGĀI TŪĀHURIRI

Ngāi Tūāhuriri is one a primary hapū of Ngāi Tahu whose tribal boundaries (takiwā) centre on Tuahiwi. Tūāhuriri is our ancestor, from whom we all descend and we take our name from him. The following is a traditional Ngāi Tūāhuriri *pepehā*, or tribal statement of identity.

Ko Maunga Tere te Maunga
Our mountain, Maunga Tere (Mount Grey) stands above us;

Ko Waimakariri, ko Rakahuri ngā Awa
Our rivers – the Waimakariri and Rakahuri (the Ashley) – flow below;

Ko Tūāhuriri te Tangata
Tūāhuriri is our ancestor.

CULTURAL VALUES

Traditionally, Tuahiwi was a mahinga kai outpost of Kai-a-poi pā. It was primarily an area of gardens and was guarded by a number of local whānau (Tau et al., 1990). There are a number of *mahinga kai* sites in and around this area.

The Cam River has several named sections including Ruataniwha, Whakahume and Korotuaheke (Tau et al., 1990). The river runs close to several Ngāi Tahu kainga in the Kaiapoi district, namely Tuahiwi, Waituere, Pakiaka, Kaikanui and Te Rakiwhakaputa. Because of the close proximity of the kainga to the river, the Cam was an important source of food for the local Ngāi Tahu people. Figures 7 and 8 depict scenes as captured by early European visitors to the area. The close association between the Ngāi Tahu way of life and the awa is very obvious.

Figure 7: "Scene on the Horotueka or Cam / Kaiapoi Pa / Canterbury", 1855, by Charles Haubroe (Reproduced with permission from Canterbury Museum).

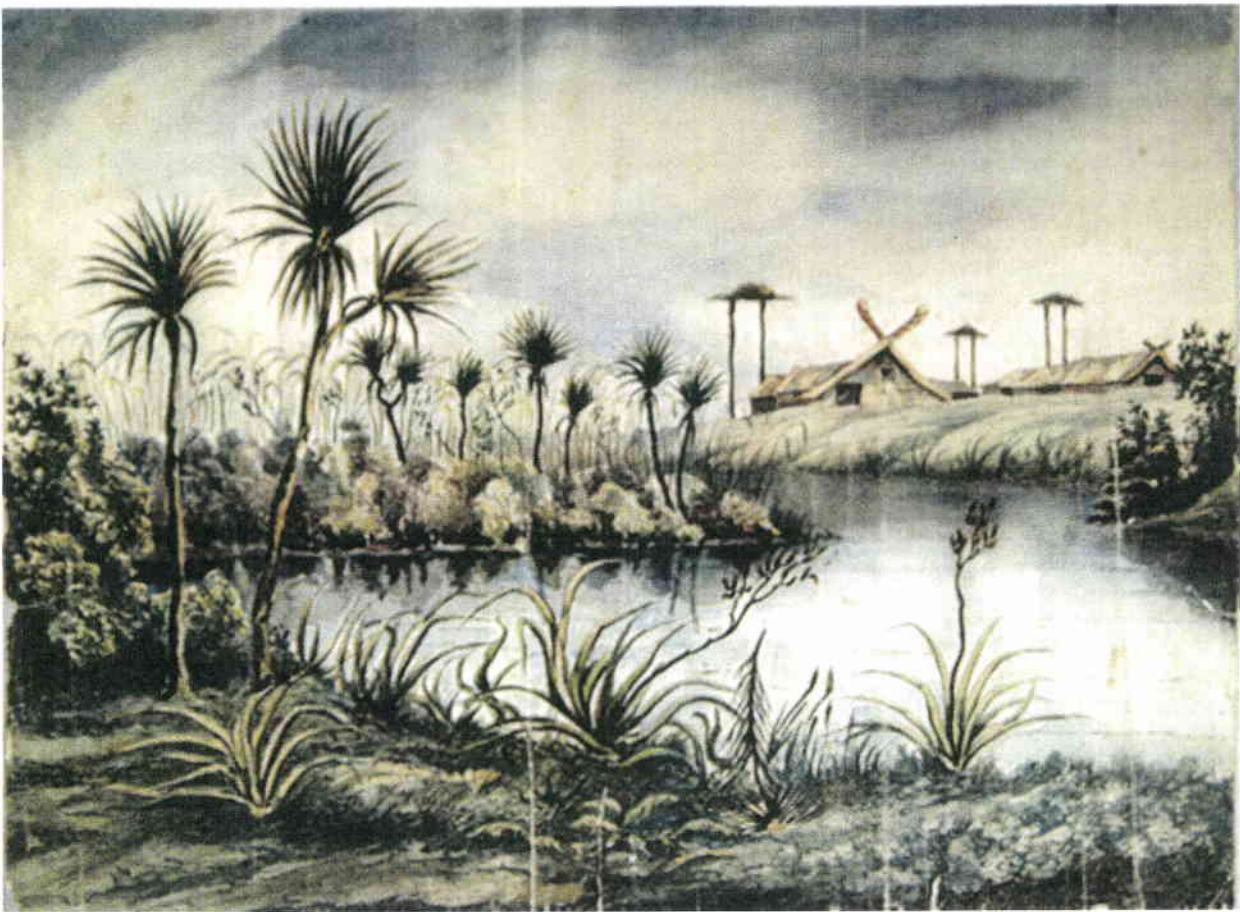
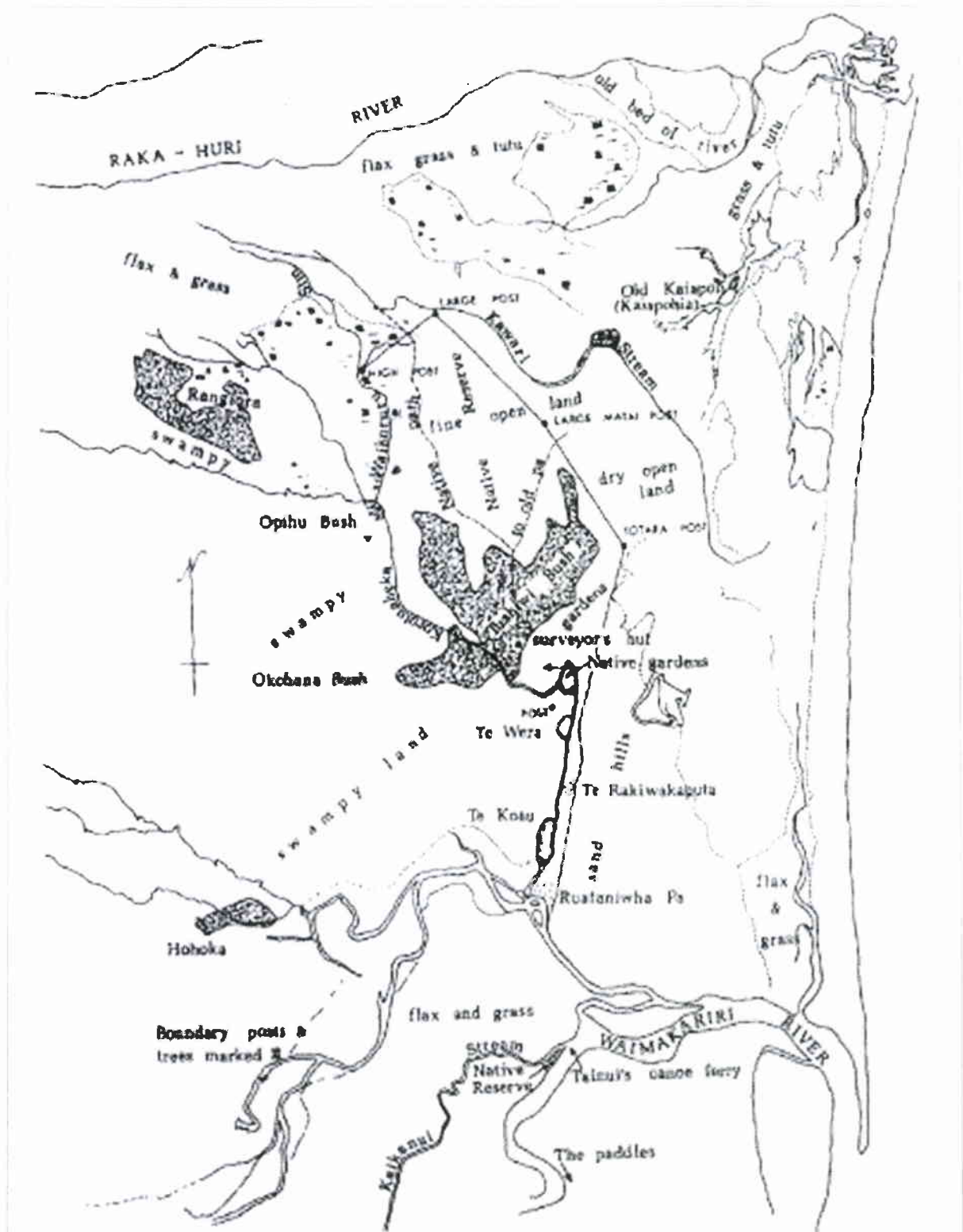


Figure 8: "Eeling in the Cam Creek, Kaiapoi", 1855, by Charles Haubroe. (Reproduced with permission from Canterbury Museum).



Early maps of the area provide a useful reference to the vegetation and habitat types which existed at the time (Figure 9). All of these indigenous habitats supported and were important for mahinga kai.

Figure 9: The Waimakariri-Rakahuri Lowlands 1848-50, showing the landscape as Charles Torlesse and John Boys found it, and the native reserve which Alfred Wills surveyed in 1848. (Source: Hawkins, 1983).



The kai-awa traditionally taken from the Ruataniwha are: waikoura (freshwater crayfish), waikakahi (freshwater mussel), patiki (flounder), inanga (whitebait), marearea (adult whitebait), tuna (eel), kanakana lamprey), and [wai]tuere (Tau et al., 1990). The awa supports two types of eel which act as kaitiaki (guardians) of the river. The first is the [wai]tuere, a blind lamprey which is a creamy spotted colour. The second is the koiro, a large black eel. These eel travel between Kaiapoi and Te Taumutu via underground waterways. The waterways also supported many species of flora that were associated with mahinga kai including harakeke, ti kouka, aruhe/fern root, puha, and waikirihi / watercress. In addition to the abundant river resources, there were a number of important gardens in this area. The gardens are known as "Ngā mara o Te Wera" (Tau et al., 1990).

Today the Ruataniwha is mainly used by Ngāi Tahu whānui for catching whitebait during certain parts of the season. Although Kaiapoi Ngāi Tahu are known to still catch pātiki / flounder in the river, the catch may not necessarily be for human consumption. However it is important to recognise that mahinga kai is central to Ngāi Tahu culture and our traditional way of life.

WĀHI TAPU

Waituere is sited on the banks of the Ruataniwha / Cam River. Within this site is an ūrupa which is now unfenced and unmarked. The Pa of Te Rakiwhakaputa, an important ancestor of the Kaiapoi and Peninsula Ngāi Tahu, is sited behind the Kaiapoi Woollen Mills on the banks of the Cam River (Figure 10). Kai-a-Te-Atua is an urupā which lies on the banks of the Ruataniwha section. It is an old urupā which is still used by Ngāi Tahu whānui. Where sites are of special significance, Tangata Whenua may wish to restrict some activities, access, and information about their location.

Figure 10: "Te Rakawhakaputa, P. Cooper Plains", 1848, by William Fox. (Reproduced with permission from Hocken Library).

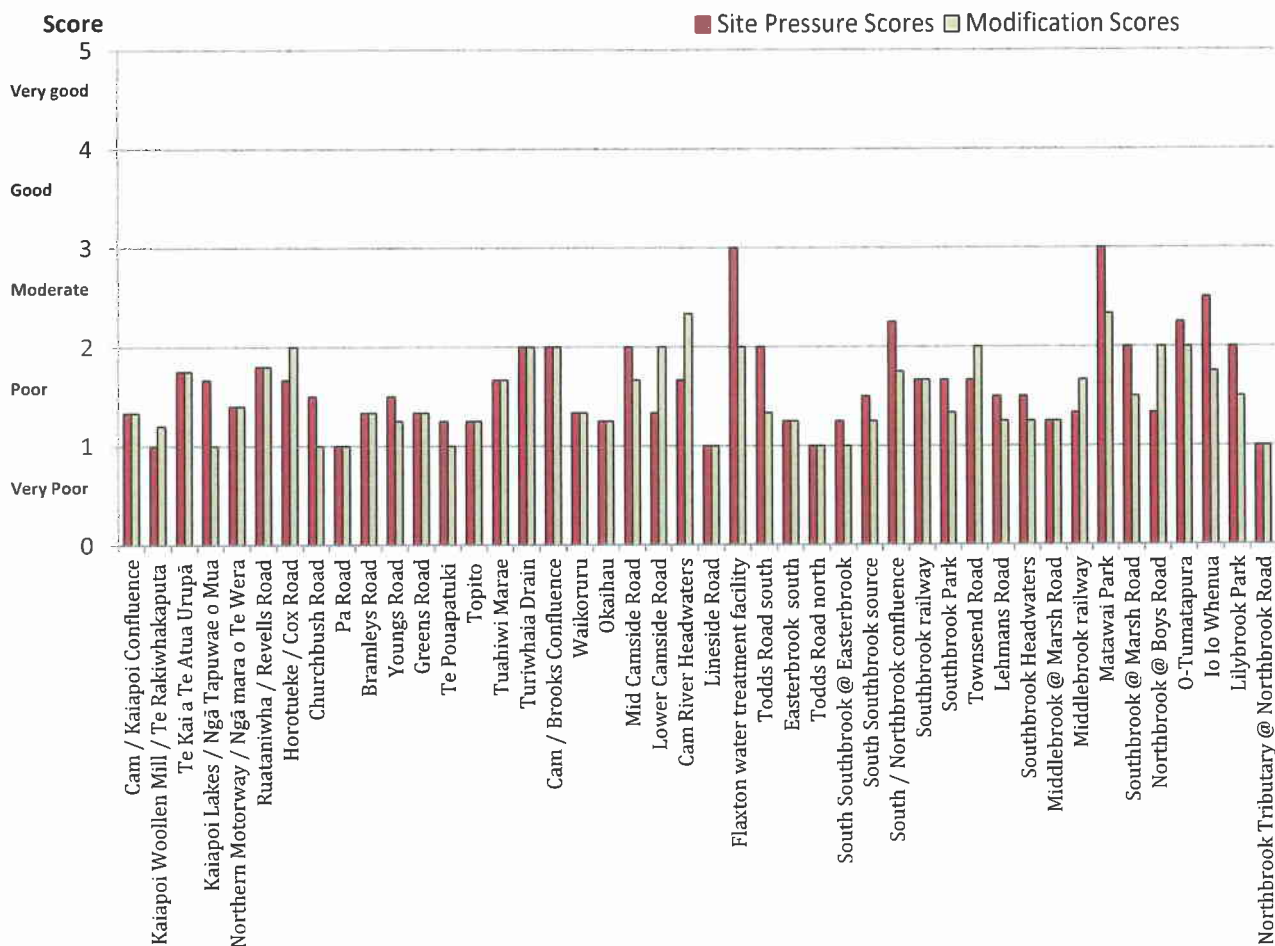


5.2 Takiwā General Site Assessments

5.2.1 Modification and Pressure

Takiwā assessment scores relating to the amount of pressure and the degree of modification at each sites show that most sites in the catchment are in poor condition in respect to these criteria, with just a small number of sites in moderate condition. The majority of sites were considered to be highly modified (relative to traditional condition) and also currently experiencing a high level of pressure with respect to the maintenance of cultural values (Figure 11).

Figure 11: Scores for levels of modification and pressure on monitoring sites.



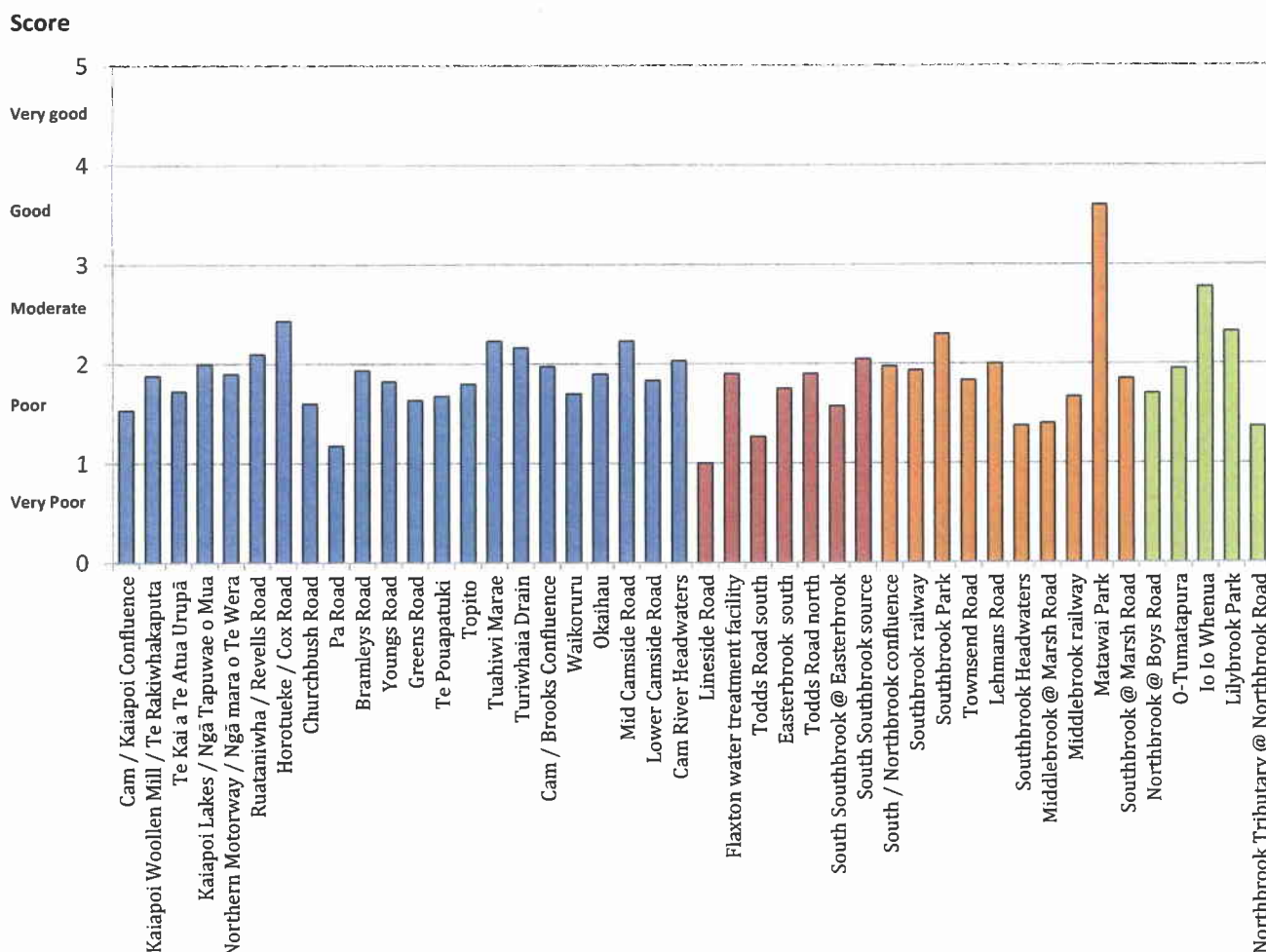
Sites which were scored as having high levels of pressure and modification were typically sites where exotic species were abundant or where agriculture dominated, and where there was a lack of native riparian species within the waterways and their margins.

These sites at which moderate scores were achieved typically have undergone restoration of native plant species or where there is a reasonable buffer between the waterways and unfavourable adjacent land uses.

5.2.2 Takiwā 2.0 Overall Health Index

Results from the Takiwā 2.0 Overall Health Index calculation returned scores indicating that cultural health of the majority of sites in the catchment was poor. The average score across the catchment was 1.9 out of a possible score of five. On the one to five scale, no sites were assessed as being in 'very good' condition, only a single site in 'good' condition, nine sites (20.5%) in 'moderate' condition, and 34 sites (77.3%) in either 'poor' or 'very poor' condition (Figure 12).

Figure 12: Takiwā 2.0 Overall Health Index scores.



Blue = Cam River/Cam Drains, Red = South-Southbrook, Orange = South & Middle brooks, Green = Northbrook

The site at Matawai Park scored the highest (3.6/5), with Io Io Whenua scoring the next highest with 2.8, followed by Horotueke / Cox Road (2.4/5) and Lilybrook Park (2.3/5). In contrast, many sites across the catchment were rated poorly. The lowest of which was Lineside Road with the lowest possible score of 1.0 / 5, with Pa Road scoring 1.2 / 5 and Todds Road south scoring 1.3 / 5.

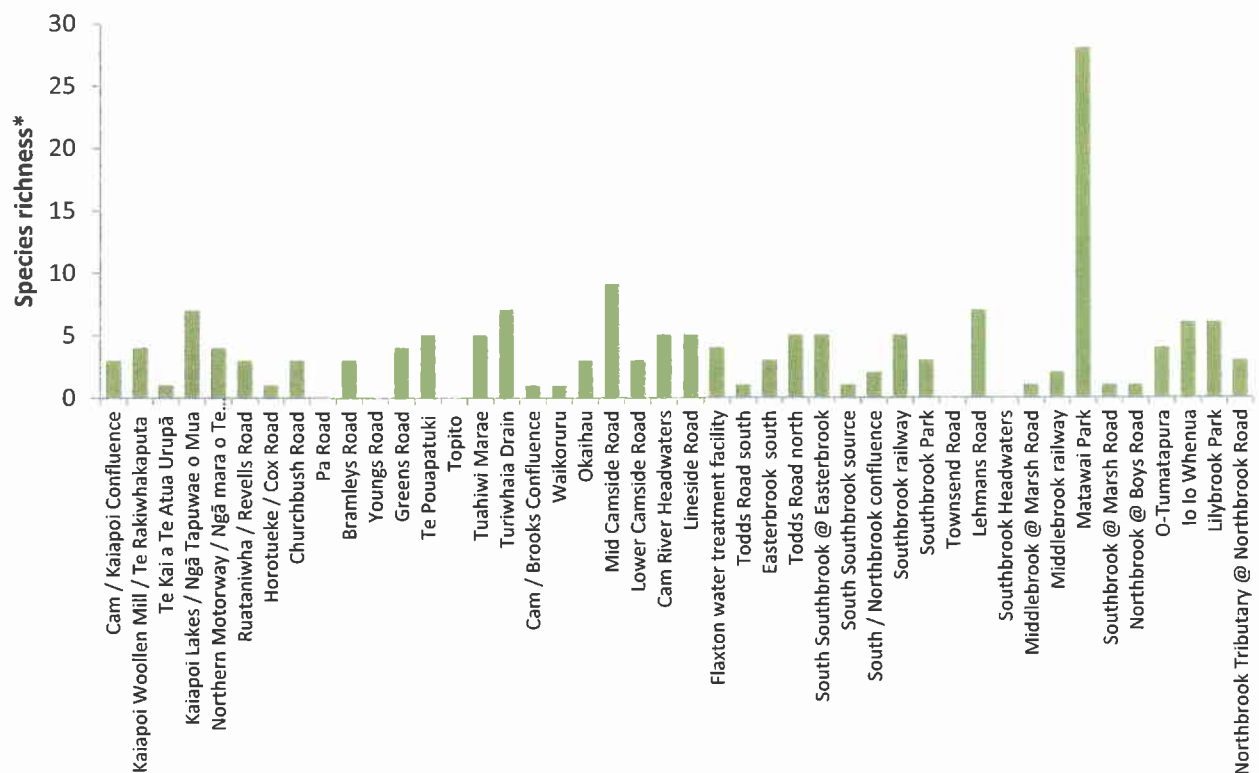
5.3 Indigenous vegetation

5.3.1 Indigenous vegetation richness

Indigenous vegetation richness for species of interest varied across the catchment with the highest score being recorded at Matawai Park. A few sites included areas of restored native wetland vegetation, particularly Io Io whenua and Kaiapoi Lakes. There were also occasional pockets of restored riparian vegetation along sections of the Cam River. The Turawhaia Drain site had good riparian planting and had been fenced off (Figure 13). However, by far the majority of sites were dominated by exotic species, including along the margins of the water way in many cases.

Figure 13: Vegetation richness* of indigenous vegetation recorded at monitoring sites.

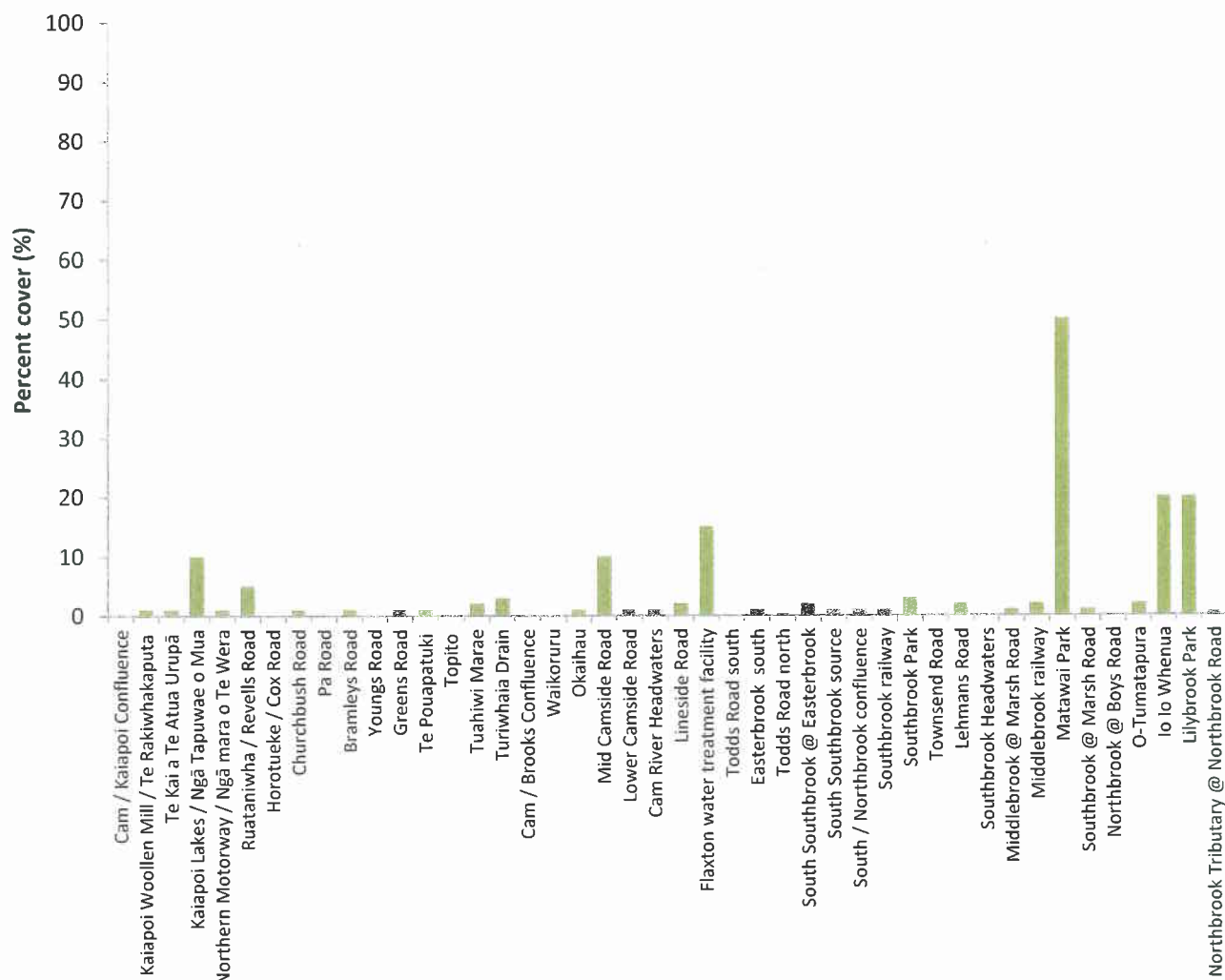
* refers to selected taxonomic groups of interest to Ngāi Tahu as recorded in the Takiwā 2.0 database



5.3.2 Indigenous vegetation cover

Although the vegetation richness results indicate the presence of some indigenous plant species of importance to Ngāi Tahu, the overall density of indigenous vegetation was extremely low at nearly all monitoring sites in the catchment (Figure 14). With the exception of a few sites, the majority of the catchment is dominated by exotic grasses and weeds.

Figure 14: Percent cover of native vegetation recorded at monitoring sites.

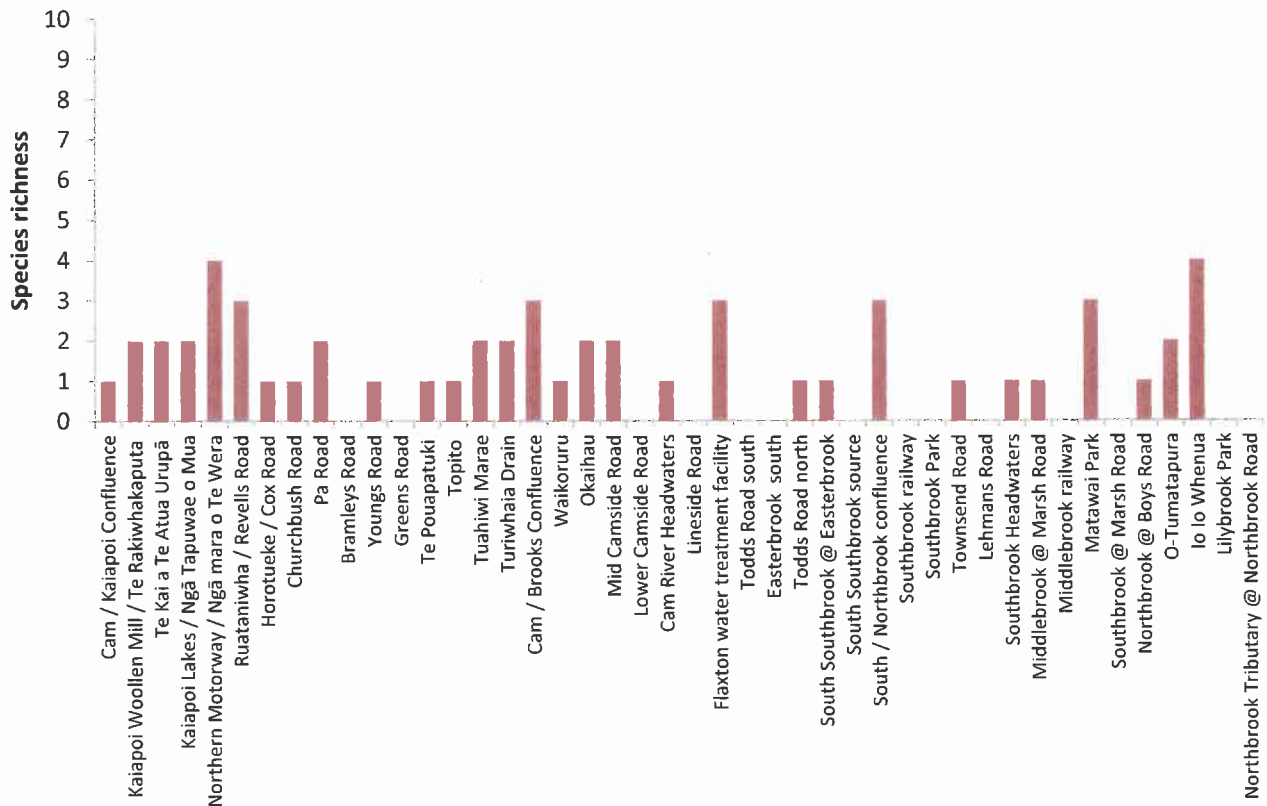


5.4 Indigenous bird species

The catchment contained a variety of indigenous bird species. Pukeko were identified at 15 of the 44 sites, with Putangitangi (Paradise Shelduck) also common throughout the catchment and recorded at 11 monitoring sites. In addition to these, Kahu (Harrier Hawk) was recorded at nine sites and the New Zealand Scaup (Black Teal) was recorded at two sites.

Overall the species richness and native species abundance was considered by the roopu to be reasonably good (Figure 15). However many sites also contained relatively high numbers of introduced bird species, such as sparrow, blackbird, and mallard ducks.

Figure 15: Species richness of indigenous birds recorded at monitoring sites.



5.5 Indigenous fish species

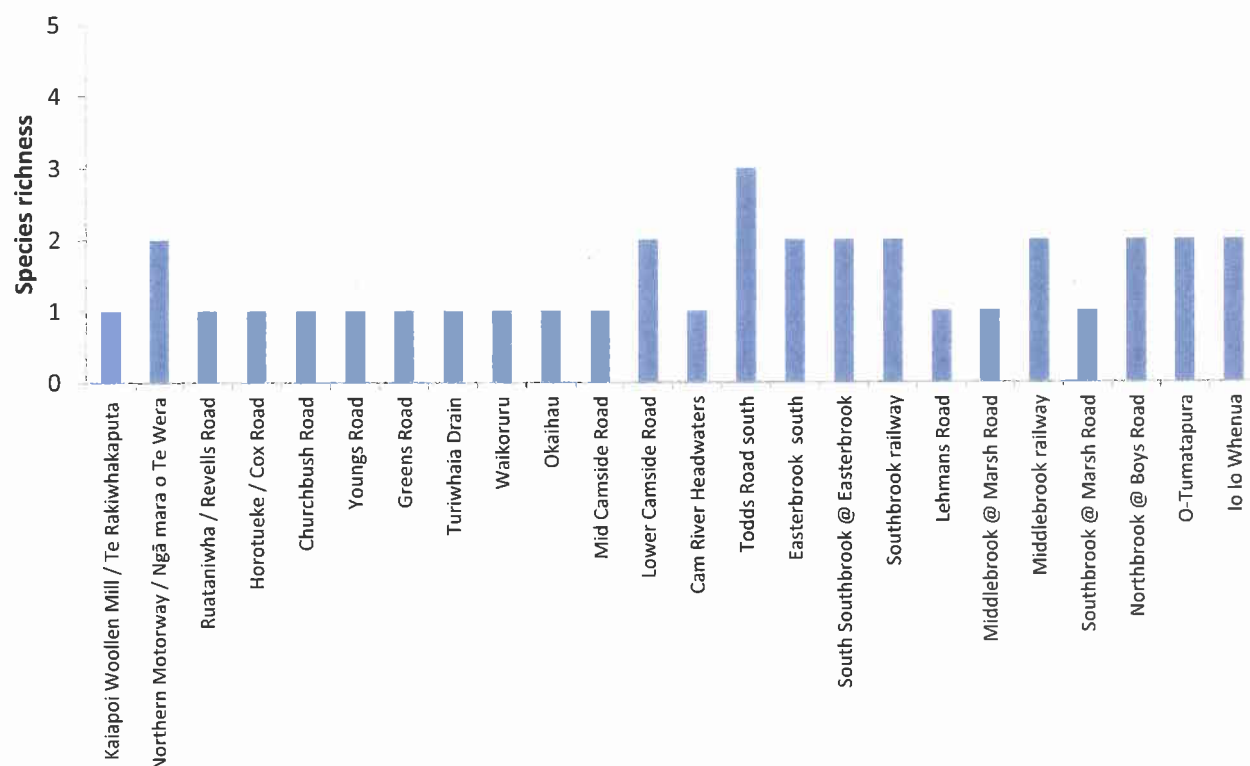
5.5.1 Fish species richness

The combined use of two individual fish survey techniques provided fish species abundance and diversity information at 24 sites across the catchment.

Tuna Roa (Short-finned eel) and Tuna Paku (Long-finned Eel) were the most common fish species recorded, with Short-finned eel present at 16 sites and Long-finned eel at 10 sites. Also commonly identified were giant bully, shrimp, and introduced species of trout and salmon. A single waikoura (freshwater crayfish) was also recorded.

Species richness for indigenous species at each site was low, with typically just a single species recorded at many sites (Figure 16).

Figure 16: Species richness of indigenous fish species recorded at monitoring sites.



5.5.2 Electric fishing results

Electric fishing was conducted at 16 freshwater sites across the catchment and native freshwater fish were identified at all sites, of which Tuna Paku was the most common species identified, found at 14 electric fishing sites, with Tuna Roa identified at three sites. Common bully was recorded at six sites, and shrimp at two. In addition to these native fish species, Trout and Salmon species were recorded from two sites. The most diverse site amongst electric fishing sites was Todds Road south where tuna roa, tuna paku and common bully were all recorded.

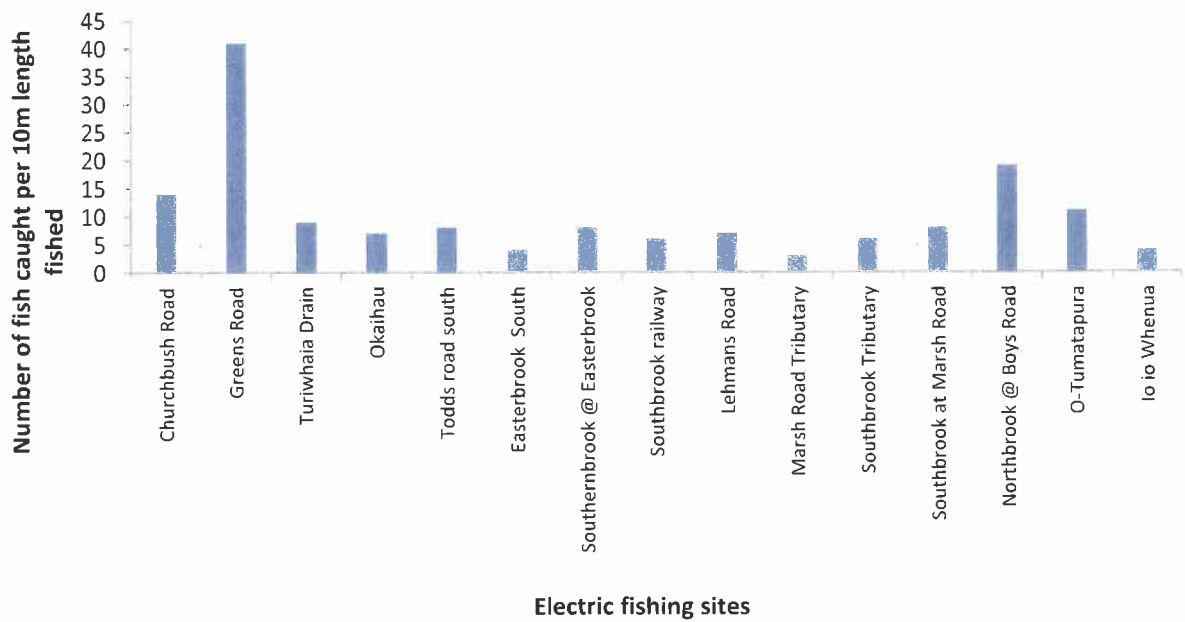
Although throughout the catchment species richness was reasonably low, some sites did contain large quantities of these few species. This variability is evident in the catch per unit effort results (Figure 17). Although the majority of electric fishing sites contained two to ten individual fish in the given survey distance, 41 fish were recorded from Greens Road.

5.5.3 Hīnaki fishing results

Hīnaki were set at eight sites and results indicated a good presence of Tuna Roa in some areas of the catchment. Tuna Roa was recorded at seven of the eight Hīnaki sites, the largest of which was caught at Lower Camside Road and measured 1.05m in length (Figure 18). A single freshwater crayfish was also recorded from this site.

Figure 17: Total catch quantities per unit of effort for each of the fishing methods used.

(a) Electric Fishing – total number of fish caught per 10m length fished.



b) Hīnaki – total catch per hīnaki set

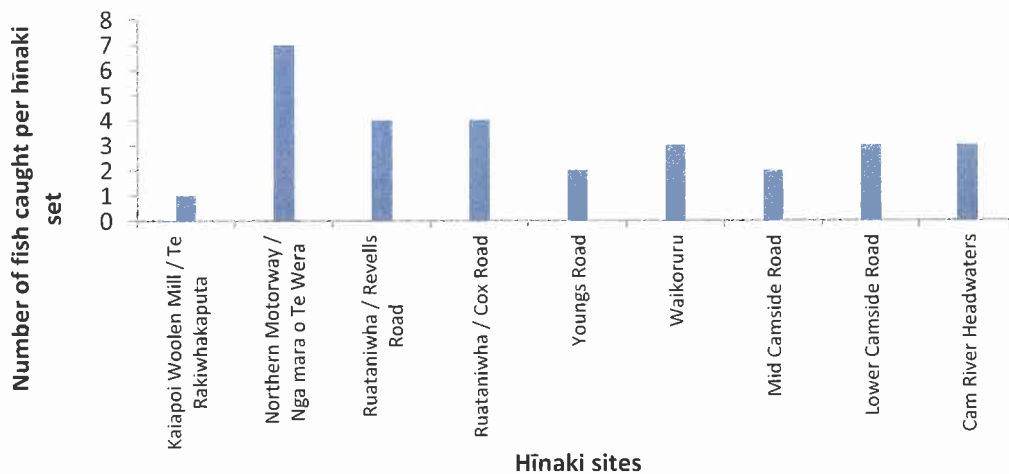
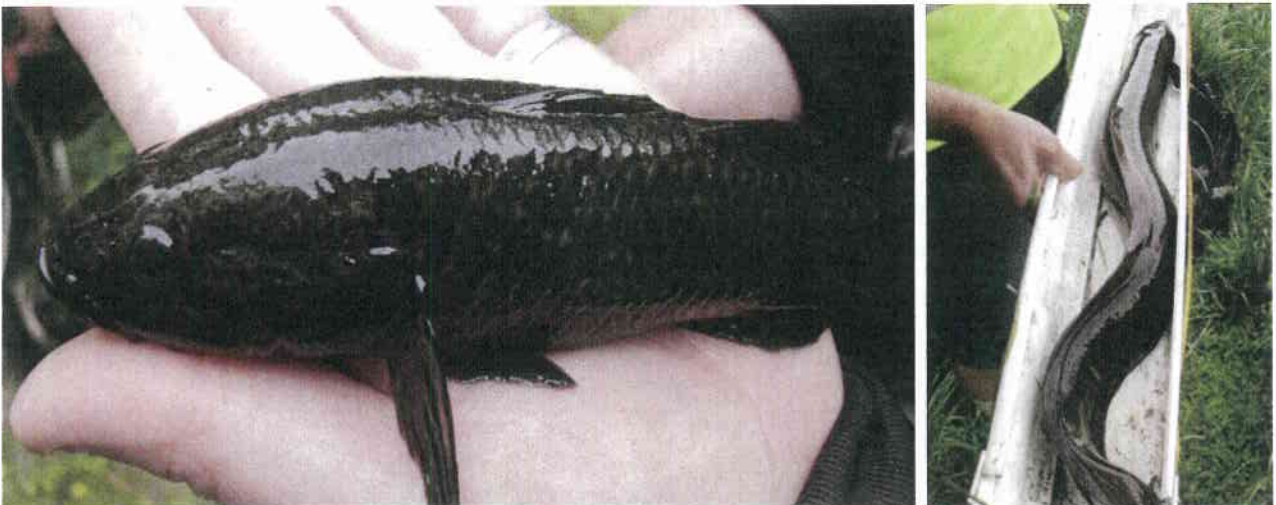


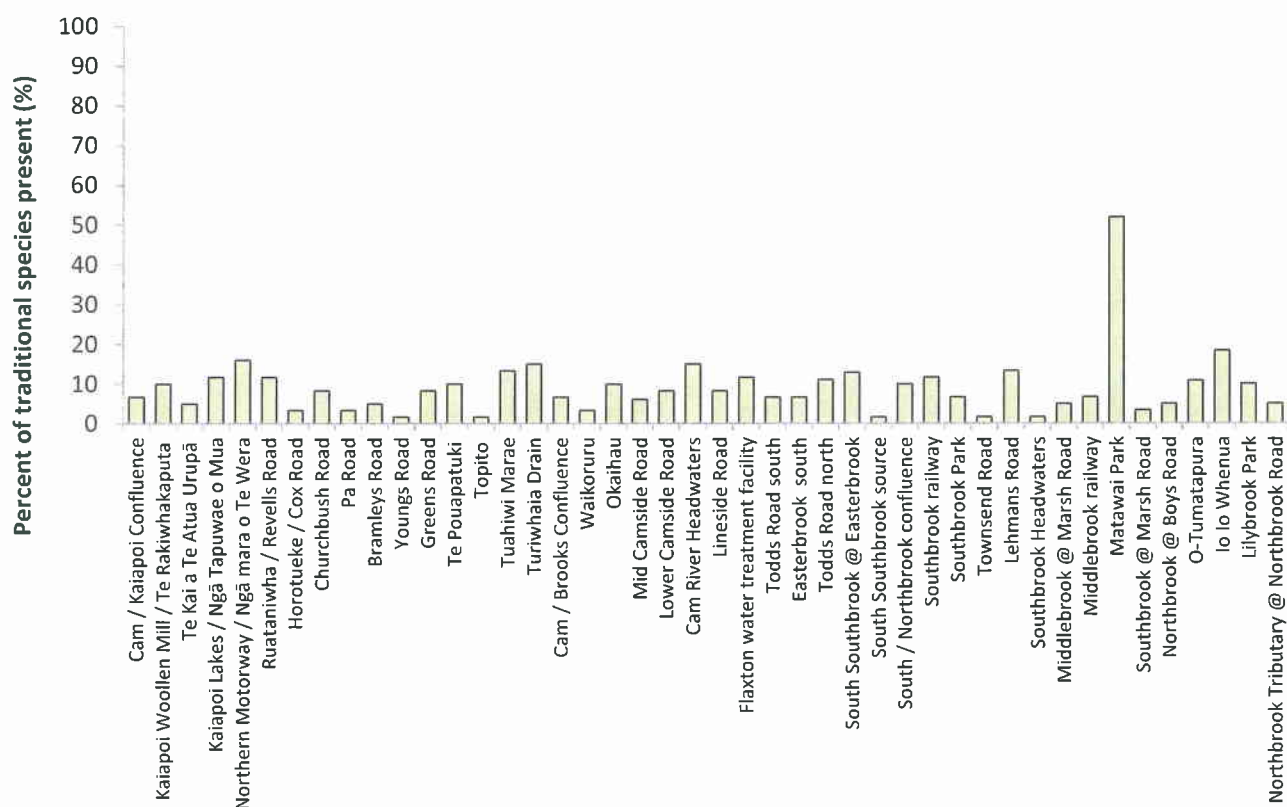
Figure 18: Giant Bulli from the Kaiapoi Woollen Mill / Te Rakiwhakaputa site (left) and Tuna Roa (Long-finned eel) from Lower Camside Road (right).



5.6 Current versus traditional presence of indigenous species

A comparison of the number of taxonomic groups of indigenous species recorded during the monitoring visit versus the number regarded as being traditionally present provides an indication of the ability of the site to sustain traditional Ngāi Tahu values. Although not all species traditionally present would be expected to be present and recorded during a single monitoring visit, the comparison provides useful information for tangata whenua in the development management objectives. Assessments were completed for plant, bird and fish species and the combined results are presented below (Figure 19).

Figure 19: Number of species recorded during monitoring as a percentage of those traditionally present at each site for selected taxonomic groups.



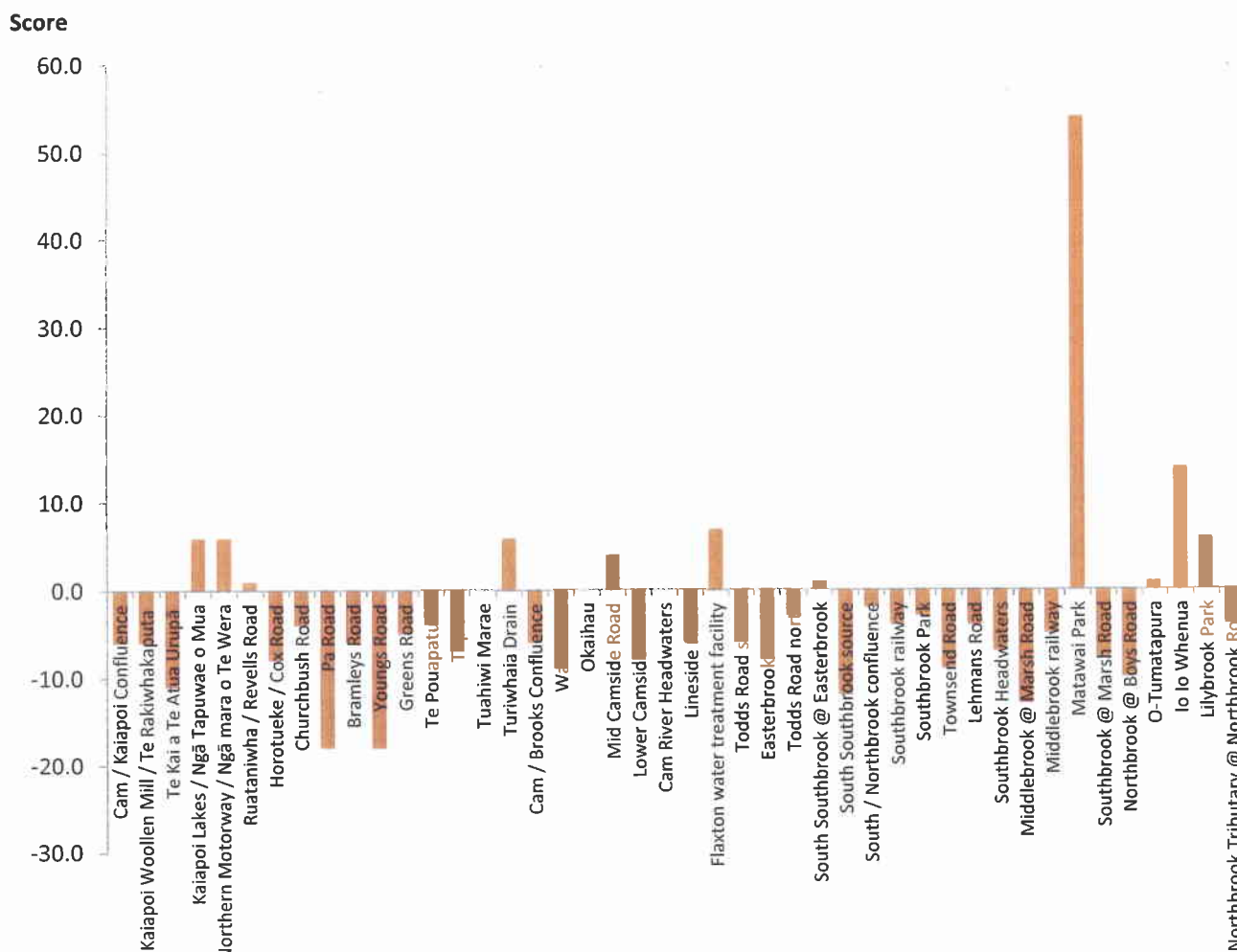
** note: this assessment is based on a Ngāi Tahu traditional species list of 60 species

These results show that between zero and 60% of species traditionally present were recorded during monitoring activities. The sites at which higher percentages were recorded were typically those with remnant or restored indigenous vegetation in the riparian zone.

5.7 Takiwā Abundance Index

Takiwā 2.0 calculates an Abundance index which considers the abundance of native species as a positive value and the abundance of exotic species as a negative value. The results show a catchment-wide trend of a high dominance of exotic species compared with native species (Figure 20).

Figure 20: Takiwā Abundance Index scores as calculated in Takiwā 2.0.



These index scores provide an indication of the dominance of indigenous species versus exotics. However, only vegetation, bird and fish species are considered in the calculation.

The results show that few sites returned positive scores and Matawai Park was the only site which returned a significant positive score. Although there is no maximum score to the index, higher scores indicate greater dominance of native species versus exotics while negative values suggest a high number of exotic species.

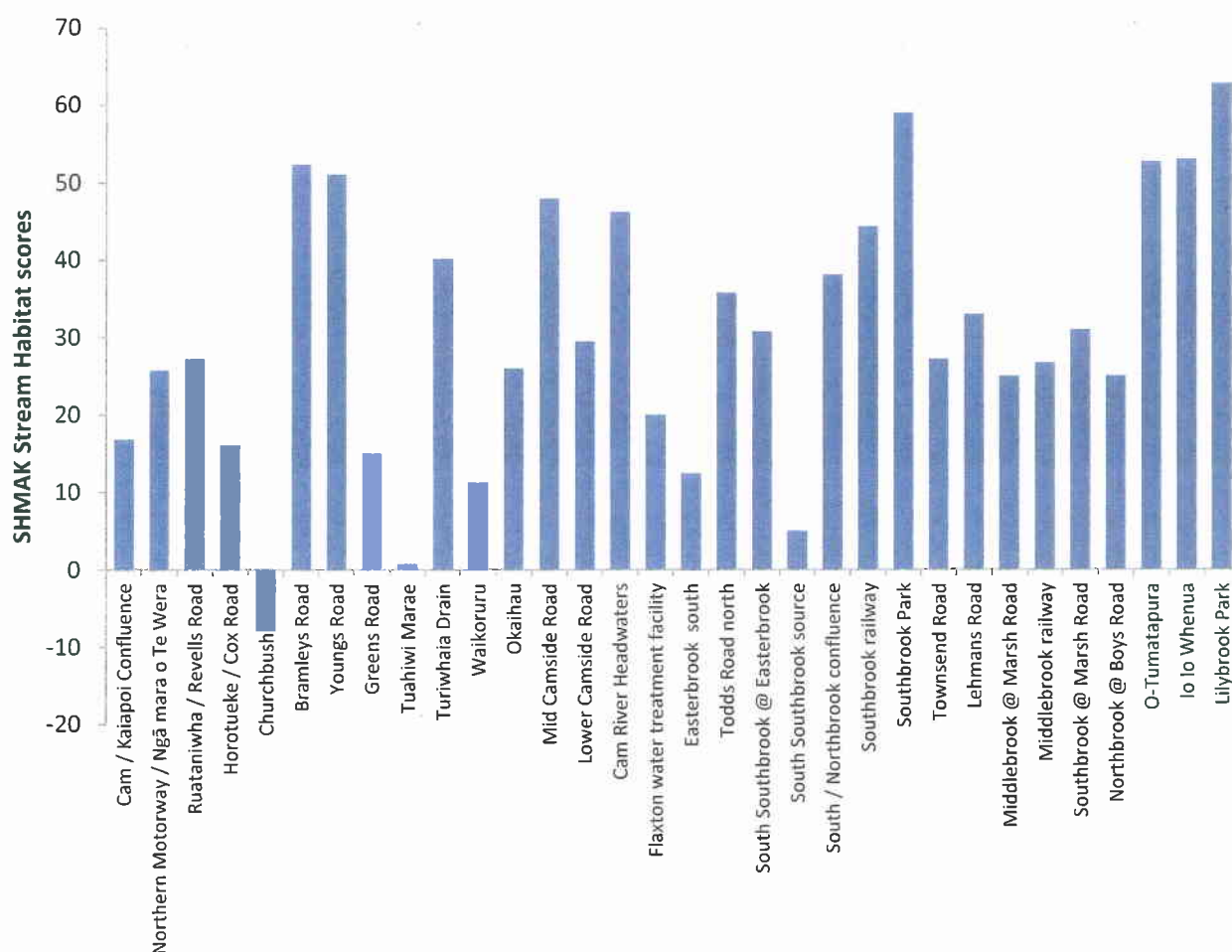
5.8 SHMAK Stream Habitat and Stream Bed Life Assessments

SHMAK Stream Habitat assessments were completed at a total of 33 sites which were those that had flowing water. SHMAK Stream Bed Life assessments consisting of periphyton and invertebrate measurements were also conducted at 18 of these sites where stream bed substrate was suitable.

5.8.1 SHMAK Stream Habitat Assessment

Results from the SHMAK Stream Habitat Assessments were variable across the catchment with a slight trend towards improved habitat conditions towards the headwaters/source of the catchment, which typically had better water clarity due to the proximity to freshwater springs (Figure 21). The highest scores were found at Lilybrook Park (43) and Southbrook Park (32) whilst the lowest scoring site was Churchbush Road (-8).

Figure 21: SHMAK Stream Habitat scores.



5.8.2 SHMAK Stream Bed Life Assessment

The scores obtained in this assessment are based on the presence of various invertebrates and periphyton located on rock samples (Figure 22) which are scored based on NIWA's invertebrate and periphyton assessment kit. Both the invertebrate and periphyton scores are based on a scale from 1 – 10, with 10 being the highest score possible.

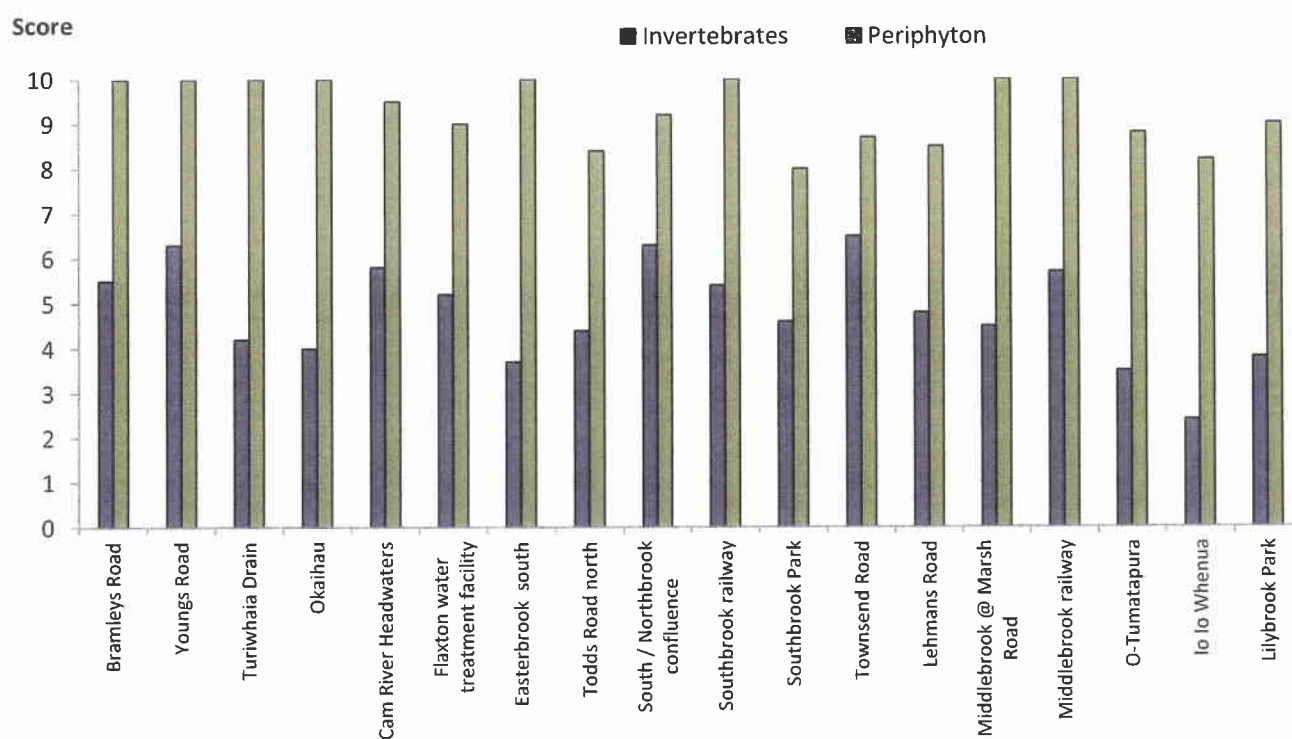
Figure 22: Periphyton and invertebrates on a rock sample at the South / Northbrook confluence.



Scores from the Invertebrate assessment ranged from 2.4 to 6.5 with the average score from all sites measured being 4.8. The best score was recorded at Townsend Road and the lowest score at Io Io Whenua which likely reflected the lack of flowing water at that site.

Scores from the periphyton assessment ranged between 8 and 10 indicating relatively healthy in-stream conditions for periphyton (Figure 23).

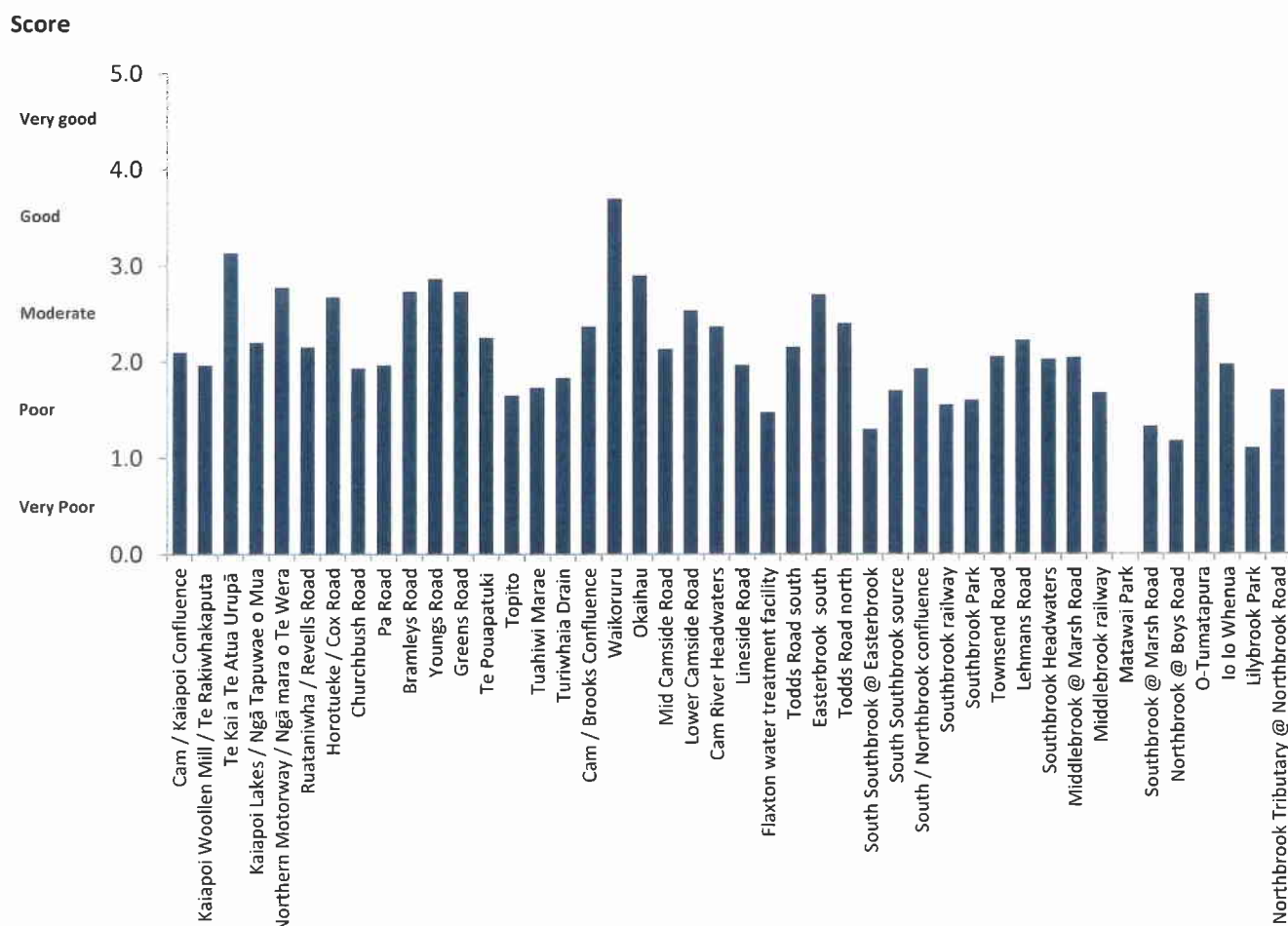
Figure 23: SHMAK Invertebrate and Periphyton scores.



5.9 CHI Stream Health Assessment

Results from the CHI Stream Health Assessment indicate that stream health is degraded across the catchment with average score across the 42 sites assessed being 2.1 on the one to five scale used (Figure 24). Of those sites, 50% scored two or less and 40 sites returned scores of three or less. The two best scores were recorded at the Head of the Cam and Matawai Park sites, both of which are located near the source of the respective streams / tributaries and are in close proximity to springs.

Figure 24: CHI Cultural Stream Health Assessment scores.

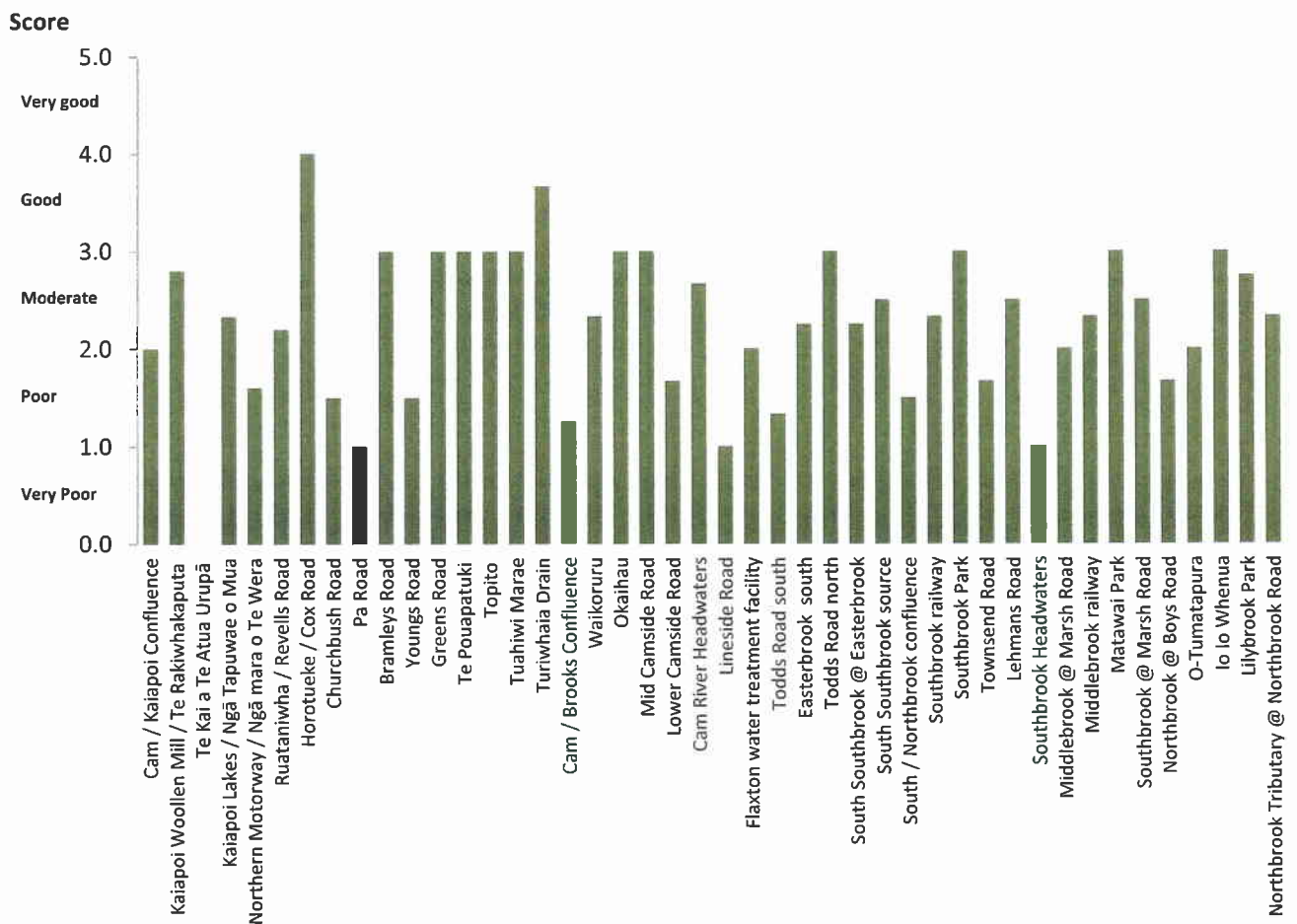


5.10 Mahinga Kai Assessments

5.10.1 Accessibility for mahinga kai

Access was typically assessed as being poor to moderate, with access to some sites being restricted by private property or where access was deemed to be unsafe for various reasons (Figure 25). Sites which scored well had reasonable proximity to a road or path, and where access to the water or other mahinga kai resource was not restricted or obstructed. As a wāhi tapu, the site close to Te Kai a Te Atua Urupā was not included in mahinga kai assessments.

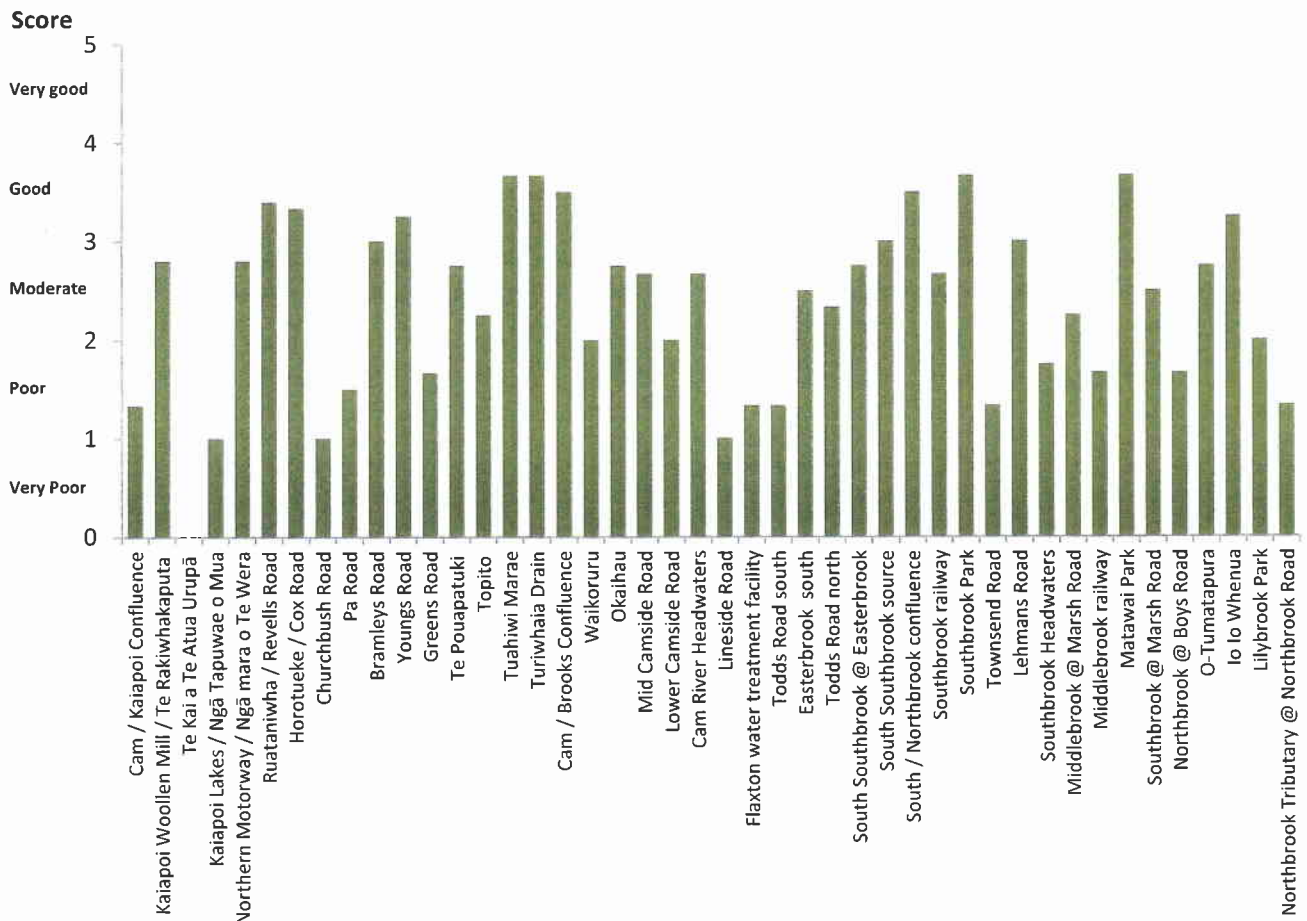
Figure 25: Accessibility for harvesting mahinga kai.



5.10.2 Willingness to harvest / Suitability for harvesting mahinga kai

Across the catchment scores for the 'Willingness to harvest' assessment averaged 2.4/5 and just nine sites reached scores in excess of 3/5 suggesting that there was overall an unwillingness to harvest at many sites throughout the catchment. Three sites were scored at 1/5 which is the lowest possible score, indicating that these sites were highly degraded in terms of mahinga kai (Figure 26). At many sites there were no current culturally harvestable resources, or where the area appeared to be too polluted to be suitable for harvesting.

Figure 26: Willingness to harvest / suitability for harvesting mahinga kai from the site.



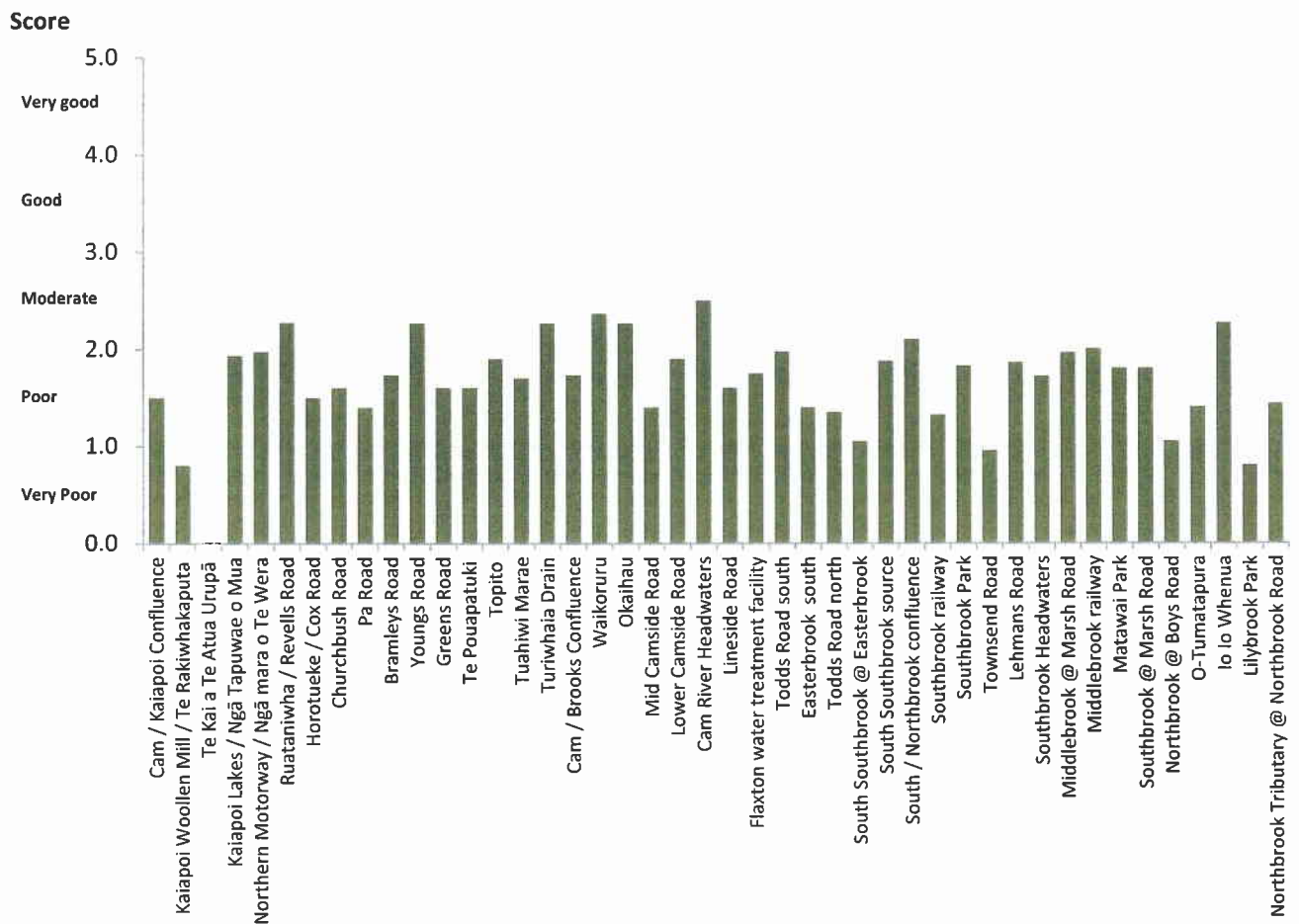
5.10.3 CHI Mahinga Kai Index

A range of factors were considered by the roopu in the CHI Mahinga Kai Index assessment, including the presence and abundance of mahinga kai resources, condition of those resources, and health of the overall site including exposure to pollution sources and other sources of degradation. As a wāhi tapu, the site close to Te Kai a Te Atua Urupā was not included in these assessments.

Overall the assessment returned low scores across the catchment. No sites were assessed as having good or very good mahinga kai values on the one to five scale used, and sites with dominant exotic species and farm land typically returned the lowest scores. Three sites returned very low scores being Lineside Road, Todds Road south, and Middlebrook @ Marsh Road, whilst no sites were assessed as having good or very good mahinga kai values. (Figure 27).

However, the roopu noted that there was potential for future mahinga kai activities at almost all sites if the abundance of resources increased and improvements in other aspects of cultural health were made.

Figure 27: CHI Mahinga Kai Index scores.

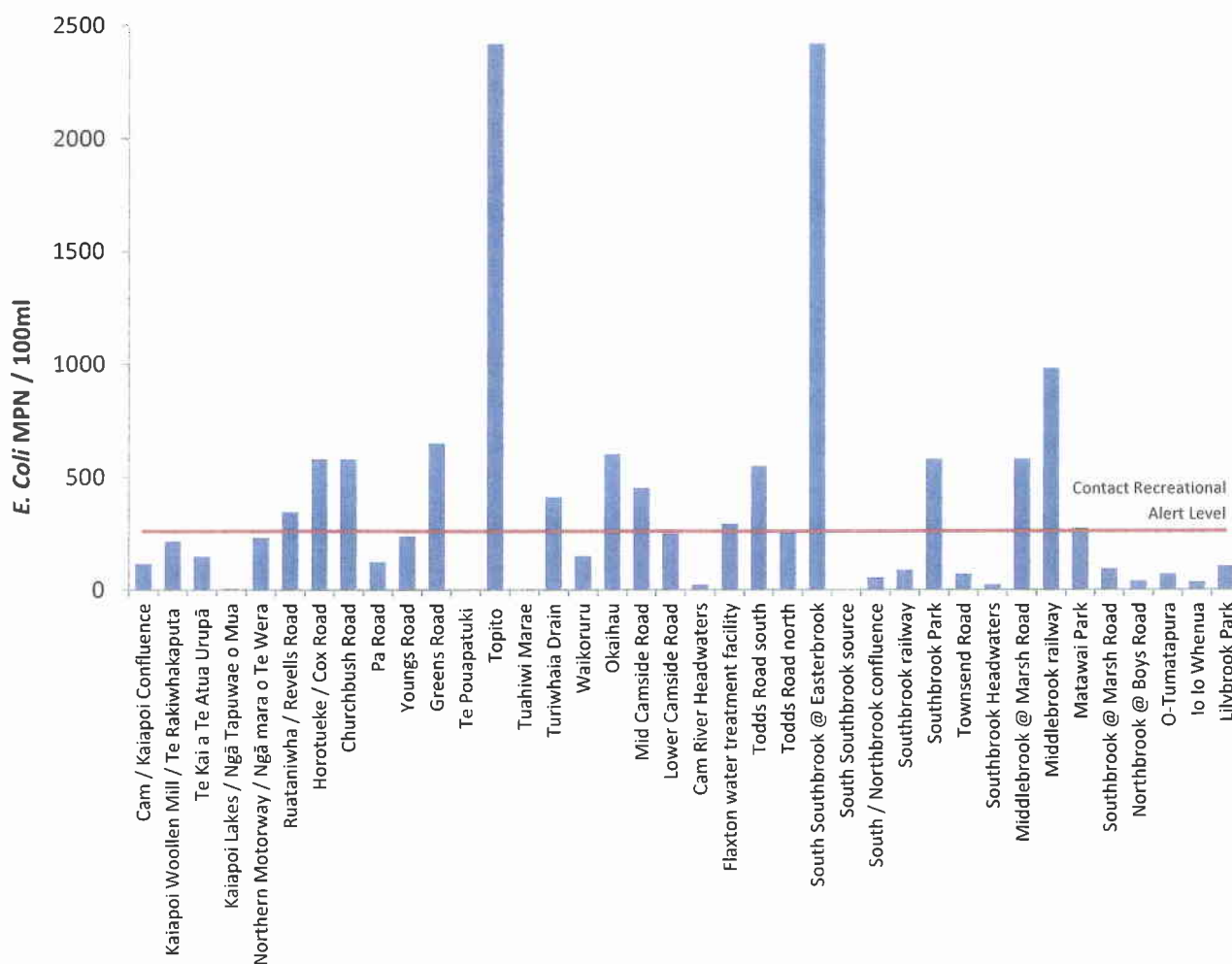


5.11 *E. coli* levels and antibiotic resistance

5.11.1 *E. coli* levels

Sampling and testing of *E. coli* indicated that levels of faecal pollution were highly variable across the catchment (Figure 28). Although recreational standards were exceeded at many sites, very low *E. coli* levels were recorded at other sites at the time of sampling, likely reflecting the very high water quality typical of spring-fed sources.

Figure 28: *E. coli* levels at monitoring sites.



Fifteen sites (39%) exceeded the Recreational Alert level of 260 *E. coli* /100ml at the time of sampling. There were also several sites where *E. coli* levels were very low. The lowest level recorded was three (3) *E. coli* / 100ml at the South Southbrook source. Other sites of note included Te Pouapatuki (5 *E. coli* / 100ml), a roadside drain, Tuahiwi Marae (4 *E. coli* / 100ml), a small drain behind the marae, Kaiapoi Lakes / Nga Tapuwae o Mua (7 *E. coli* / 100ml) and the Cam River Headwaters site (22 *E. coli* / 100ml). Many of these sites are characterised by springfed sources nearby.

Sites along the mainstem of the Ruataniwha / Cam River were typically found to have higher levels of *E. coli* pollution compared to Northbrook and Southbrook sites at the time of sampling, and some sites contained extremely high *E. coli* levels.

An interesting finding was the spatial proximity of sites which had markedly different *E. coli* levels at the time of sampling. For example the *E. coli* result at Southern Southbrook source was 3 *E. coli* / 100ml whereas the result for the Southbrook @ Easterbrook was 2420 *E. coli* / 100ml on the same day, and despite being not far downstream.. A value of 2420 *E. coli* / 100ml is the upper limit of measurement method used and therefore actual *E. coli* levels at such sites could be even greater. In this example results from antibiotic resistance testing indicate that the source of *E. coli* pollution measured at the Southbrook @ Easterbrook was livestock.

In another example, a drain site with good flow (Turiwhaia Drain) returned a result of 4 *E. coli* / 100ml despite being downstream from the Okaihau site which measured 602 *E. coli* / 100ml. These examples demonstrate the variable nature of *E. coli* inputs and illustrates that a better understanding of *E. coli* sources is essential to reduce *E. coli* pollution in waterways. Efforts by local land owners to reduce impacts from adjacent land use activities is likely to be an important mechanism for the reduction of contaminant inputs to waterways.

5.11.2 *E. coli* antibiotic resistance

Antibiotic resistance testing was conducted on *E. coli* isolates from 38 of the 44 monitoring sites. As a general rule, single resistances (eg ampicillin) are more likely to be associated with stock, whereas multiple resistances are more likely to be associated with human sources (John Aitken, pers. comm.).

Of the 38 sites tests, isolates from 13 sites showed no antibiotic resistance traits. Isolates from 15 sites exhibited resistance to Ampicillin only and this indicates livestock as the likely source. These sites included the two sites at which very high *E. coli* levels were found, being the Topito and South Southbrook @ Easterbrook sites. There was one site (Todds Road South) which returned resistance to apramycin in all isolates tested. This resistance trait is uncommon, and is specifically associated with livestock.

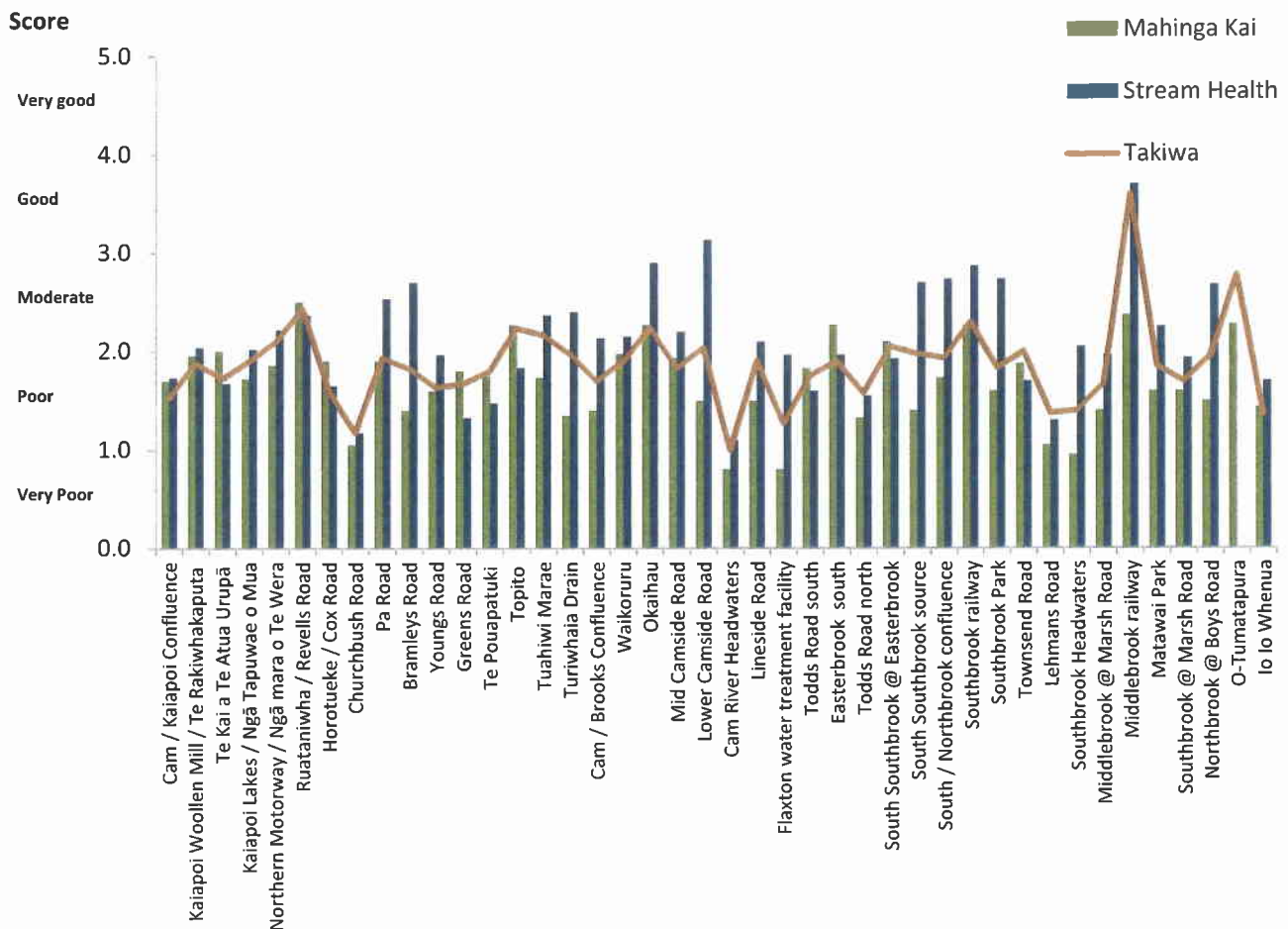
There were also several human “hotspots” seen in the results, where multiple resistances were found. These sites were typically in close proximity to towns, and included a number of sites in the lower catchment. At the Flaxton Water Treatment Facility one isolate showed resistance to sulphonamide, streptomycin, tetracycline and ampicillin, and at the Ruataniwha / Cox Road site one isolate was resistant to ampicillin and tetracycline. These patterns are common in human isolates and a human origin is suggested given the multiple resistances present.

At the South / Northbrook Confluence site an isolate was found with trimethoprim, sulphonamide streptomycin, ampicillin, and tetracycline resistance, and at the Waikoruru site an isolate was resistant to streptomycin, sulphonamide, tetracycline and ampicillin. These are human associated resistance groupings. Results from four sites in the lower catchment also suggested that *E. coli* of human origin was present. At the Te Kai a Te Atua Urupā site resistance to tetracycline and ampicillin was found, and the Northern Motorway / Ngā mara o Te Wera site, Kaiapoi Lakes / Ngā Tapuwae o Mua site, and Cam / Kaiapoi Confluence site all returned resistance to streptomycin, trimethoprim, sulphonamide, tetracycline and ampicillin.

5.12 Comparison between results of different assessment modules

Differences and similarities in results from the different assessment modules used in the State of the Takiwā approach can assist understanding of the condition of monitoring sites from various perspectives. There was much similarity in the results from CHI Stream Health, Mahinga Kai scores, and Takiwā 2.0 overall site health scores (Figure 29). Although a different range of parameters are addressed in these assessment modules they are all culturally-relevant.

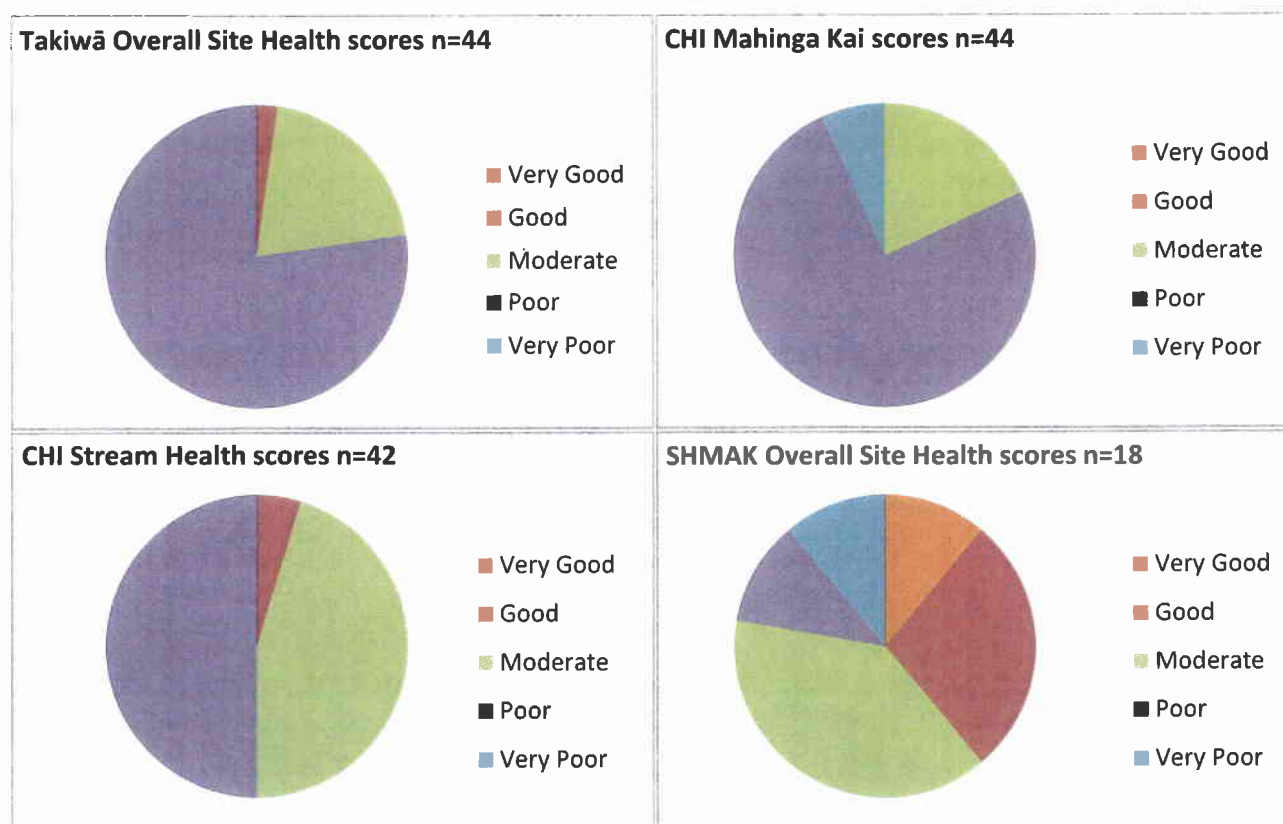
Figure 29: Comparisons between CHI Stream Health, Mahinga Kai scores, and Takiwā 2.0 overall site health scores.



It should be noted that the SHMAK module also includes a calculation for overall site health. However the SHMAK module used is not based on parameters specific to cultural health. In this study a SHMAK overall site health score could be calculated only for the 18 sites for which both SHMAK modules were assessed, being those with suitable substrate and flowing water.

However, a comparison of the four different index scores available provides an indication of the differences in overall 'health' of a site that may be derived from different methods (Figure 30).

Figure 30: Comparison between the results from four different assessments used in the State of the Takiwā approach.



This comparison clearly shows that results from the SHMAK module tend to indicate that sites are in a better state of health than the results from the other three modules. This is consistent with the methodology of the SHMAK module being not based on parameters specific to cultural health, and this comparison may be further biased by the limited number of sites for which SHMAK method may be applied. Within the SHMAK calculations, the weighting applied to the periphyton assessment component is a major influence on the overall result. By comparison, periphyton measurements are not a major component of the other three index calculations, reflecting that it is not a culturally specific indicator of stream health.

6. Kōrero / Discussion

6.1 Overview of the catchment

Results from many of the assessment modules indicated that key aspects of cultural health are in poor condition. Results from the CHI Mahinga Kai assessment are particularly notable since this addresses a key cultural value and scores were consistently low across the catchment. However at almost all sites there was considerable potential to improve cultural health and provide significant benefits to wildlife, and to create an environment where traditional practices can once again thrive.

A feature of the State of the Takiwā approach is the performance of a variety of assessments at the same site. This increases the robustness of any conclusions drawn on the 'overall' cultural health of monitoring sites in addition providing information on a range of topics important from which more specific management recommendations can be made. Several modules within the State of the Takiwā assessment approach provide an expressions of the overall health of monitoring sites. These include the Takiwā Overall Site Health scores, CHI Stream Health Assessment, CHI Mahinga Kai Assessment, and SHMAK overall stream health results.

As identified in section 5.12 the SHMAK method consistently indicated better stream health than did other assessments; likely reflecting the effect of the periphyton component of the overall stream health score. Similar results were also found in recent State of the Takiwā programmes conducted in the Ihutai and Puharakekenui / Styx River catchments (Lang et al., 2012; Orchard et al., 2012). When considering the components of each of these assessment modules it is evident that the range of attributes informing the SHMAK assessment are not culturally specific indicators of health. By contrast both of the CHI methods takes a wider range of attributes of a site into account, and importantly the range of assessment topics used are culturally-specific. Although using a different range of questions, the Takiwā General Site Assessment from which the Takiwā Overall Site Health score is derived also employs a suite of cultural specific assessment questions.

A strong finding from this study was the similarity of 'overall site health' results from the Takiwā Overall Site Health, CHI Mahinga Kai Index, and CHI Stream Health assessments. Whilst the SHMAK module produced further useful information, it does not provide a culturally relevant expression for the overall health of monitoring sites.

When taking into account the results of all assessment modules, the cultural health of the majority of monitoring sites in the Ruataniwha / Cam River catchment is considered to be poor. To better understand these results, information from individual assessment exercises within the various assessment modules is useful to identify contributing factors, and these are likely to be a useful focus for management responses. Some of the key factors important to degraded cultural health in the catchment are discussed in the following sections.

6.2 Modification of waterway form and function

One of the State of the Takiwā assessment tasks addresses the degree of modification at each site, relative to traditional condition. The majority of sites were assessed as being highly modified and also currently experiencing a high level of pressure with respect to the maintenance of cultural values. Comments made by the roopu indicated that contributing factors were typically domination of the landscape by agricultural activities and associated with this, the presence of exotic species which were often abundant. In addition to there being a lack of native plant species present in riparian areas, it was also noted that many water

channels have been physically modified away from their natural form (Figures 31 and 32). These include diversions away from the natural Ruataniwha / Cam River system such as found on the Sothern Southbrook, blocked waterways such as found at Pa Road, and other physical modifications such as realignments and straightened associated with drainage and associated land use activities such as agriculture and roading.

Sites which scored better in the modification assessment were typically those where a reasonable buffer existed between the waterway and unfavourable adjacent land uses; sufficient to permit a more natural form for the waterway channel and riparian area and maintain some indigenous vegetation cover.

Figure 31: An example of a diverted waterway at the Todds Road south site where the stream has been diverted away from its natural alignment (adjacent to the line of trees in background). This stream also no longer feeds into the Ruataniwha / Cam River having been diverted into the Cust Main Drain catchment.



Figure 32: An example of a site which has undergone recent modification to block a natural waterway and convert land for agricultural use at Pa Road.



6.3 Indigenous vegetation

A key finding was the very low number of indigenous plant species recorded at monitoring sites, and in addition, very low percentage cover in indigenous plant species. The majority of monitoring sites were characterised by a lack of indigenous vegetation in the riparian zone and the observations of the roopu also confirmed that there are few examples of remnant native vegetation in the catchment (Figure 33).

Figure 33: The South Southbrook source site which is typical of many sites across the catchment. The waterway is surrounded by farmland and dominated by exotic species with little native vegetation present. Habitat conditions for many indigenous and mahinga kai species are poor.



6.4 Indigenous bird and fish species

Although the occurrence of native vegetation was sparse throughout the catchment, considerable native bird life was observed including good numbers of Pukeko which were recorded throughout the region. In addition to bird life, the presence of Long-finned eel in the catchment was regarded by the roopu as being particularly important.

The presence of Long-finned eel / tuna roa (*Anguilla dieffenbachii*) is notable since it is New Zealand's only endemic freshwater eel and was once a common species in New Zealand waterways (Burnet, 1952). Recently numbers have been decreasing (Jellyman et al., 2000) and Long-finned eel is now listed as a threatened species (Hitchmough & Cromarty, 2005). It is therefore important that remaining populations are maintained and preferably enhanced in the Ruataniwha / Cam River catchment. As a long-lived migratory species (Graynoth & Taylor, 2004; McDowall, 1990) a long term approach is required. A particular issue for Long-finned eels is the risk of losing breeding stock since these eels take many years to mature in their fresh water habitat before migrating to spawning grounds at unknown locations in the South Pacific (Ministry of Fisheries, 2008).

6.5 Current versus traditional presence of indigenous flora and fauna

The current versus traditional presence of indigenous flora and fauna results (Section 5.6) are a further indicator of degradation. Although limited to vegetation, fish and bird species these results show that only 2 – 15% of the estimated 60 species traditionally found in the area are present today.

Taken together with the indigenous vegetation findings, these results confirm the highly modified character of monitoring sites in the catchment. This level of modification supports few cultural values when compared to the historical state.

6.6 Mahinga kai values

The CHI Mahinga Kai assessment considers a range of factors important to mahinga kai and returned low scores across the catchment indicating that mahinga kai values are substantially degraded. Access was typically assessed as being poor to moderate, with access to some sites being restricted by private property or where access was deemed to be unsafe for various reasons. The 'Willingness to harvest' assessment returned variable scores across the catchment though just nine of the 44 sites reached scores in excess of 3/5 suggesting that there was overall an unwillingness to harvest at many sites. This result indicates that aspects of environmental health need to be addressed in respect of mahinga kai values in addition to factors influencing the abundance of mahinga kai species.

As discussed in sections 6.3 and 6.4 the typically low abundance of mahinga kai species is a major feature of the catchment. At many sites there are currently few cultural resources to harvest. Thus the presence and abundance of mahinga kai species is a critical aspect to address for the improvement of mahinga kai values in the catchment, alongside other factors such as the health and condition of mahinga kai sites and resources, and their accessibility (Figure 34).

Figure 34: The condition of many monitoring sites for mahinga kai was assessed as being low. A lack of mahinga kai resources, poor condition of resources, and presence of pollution sources were contributing factors observed at many sites. Here cattle are seen freely entering a waterway at the Pa Road site.



6.7 Pollution of waterways

Throughout the region it is apparent that waterways are being directly affected by roadside and farmland drains, many of which provide no buffer between the waterway and intensive land use activities. The roopu frequently noted that the water in these drains appeared to be polluted. Results from *E. coli* testing showed that levels of faecal pollution is highly variable across the catchment. The Recreational Alert level of 260 *E. coli* / 100ml was exceeded at many sites at the time of sampling, whilst at other sites very low *E. coli* levels were recorded.

It is important to note that different classes of water need to be managed to different water quality parameters. Whilst established Ngāi Tahu policy requires that water quality in all waterways be fit for the use of such waterways as a mahinga kai resource, water quality in other waterways may need to be managed to higher standards because they are wāhi taonga or wāhi tapu (Te Rūnanga o Ngai Tahu, 1999; Tau et al., 1990). Of the note for the Ruataniwha / Cam River catchment is the high number of puna (springs) giving rise to waterways characterised by waipuna (spring water). As a wāhi taonga the water quality of such waterways must not be degraded. To achieve this requires control of all contaminants of concern such as those that may originate from adjacent land uses. This is consistent with the established Ngāi Tahu “no discharge” policy as articulated in the Ngāi Tahu Freshwater Policy Statement (Te Rūnanga o Ngai Tahu, 1999).

Results from this State of the Takiwā programme illustrate that a variety of management concerns for water quality do exist in the catchment and these should be addressed on a case by case basis. In particular instances of direct stock access to waterways was noted, in addition to several situations where run-off from land-use activities into farm and roadside drains appeared to be a source of pollution. These are obvious targets for improved management, for example by preventing stock access to waterways, and by ensuring that setbacks accommodating buffer and filter strips or other run-off interception devices are present and are sufficient to control the contaminant load from the land use activities present. In cases where more intensive and potentially polluting land use activities are present, larger buffers and higher performing

stormwater management solutions are likely required to deliver the cultural outcomes sought in the receiving environment.

6.8 Riparian restoration

The State of the Takiwā monitoring sites included some examples of well-established restoration initiatives, notably at Io Io Whenua and Matawai Park. These sites scored well in a number of assessment modules illustrating the positive impact of restored riparian areas for cultural health (Figures 35 and 36).

Figure 35: An example of ecological restoration at the Io Io Whenua site.



Figure 36: The Matawai Park site.



Although as discussed above there were few examples of stream and drain sites with restored or remnant indigenous vegetation in the riparian zone, an exception was the Turiwhaia Drain site where an appropriate area had been fenced off and well established indigenous plant cover was present (Figure 33).

Figure 33: The Turiwhaia Drain site; an example where riparian planting has been undertaken and the waterway fenced off to provide a buffer zone to the surrounding land uses.



6.9 Fencing and the maintenance of stream form and function

As discussed above there were many sites at which fencing was either absent or provided an insufficient buffer from adjacent land uses. This includes examples where fence-lines were too close to waterways to create an effective buffer or allow a more naturally meandering stream form to be accommodated within the area set aside (Figure 34). This was noted as an important consideration by the monitoring team.

Figure 34: Ineffective riparian management at the South / Northbrook confluence site.



However at some sites such as the Southbrook Railway site, the fencing arrangement was designed to allow a more sinuous stream form to persist (Figure 35).

Figure 35: The Southbrook Railway site.



7. Te Whakamutunga / Conclusions

Results from this State of the Takiwā programme establish a cultural health baseline for 44 sites across the Ruataniwha / Cam River catchment. Notable trends include that instances of modified form and function of waterways are widespread throughout the catchment. The diversion and/or blocking of several natural waterways in the catchment is of particular note. These modifications are in direct conflict with established Ngai Tahu Policy such as that contained in the Mahaanui Iwi Management Plan (IMP) 2013 and Ngai Tahu Freshwater Policy Statement 1999, especially in relation to maintaining the *mauri* of freshwater bodies. Water abstractions and diversions also affect the potential of the waterways to sustain habitat for mahinga kai and taonga species.

Many monitoring sites, particularly through the lower catchment, were identified as polluted in visual observations, and through the results of *E. coli* testing. Several sites exceeded the recreational guideline for *E. coli* levels, and the majority of sites were deemed unfit to gather mahinga kai by the roopu at the time of the monitoring visit, primarily due to pollution concerns such as those associated with the proximity of unfavourable land use activities.

The diversity and abundance of indigenous vegetation at monitoring sites was found to be low, with farmland and exotic species being dominant throughout the catchment. The exception was at a few sites where efforts have been made to restore the riparian area. Where sites had been the subject of active restoration, many of the assessments used to gauge cultural health returned better results. These results illustrate that although much of the region has been modified for agricultural and residential use, there are opportunities for these activities to co-exist with the traditional Ngāi Tahu values associated with waterways.

Results from this monitoring programme indicate that a variety of management responses would be needed to improve the cultural health of waterways in the catchment. These should be considered on a site specific basis due the considerable variability that exists between sites in terms of both their character and traditional values, and variance in the of actual and potential negative impacts from land use activities in proximity to these sites.

Key recommendations that apply to many of the State of the Takiwā monitoring sites are provided below in Section 8. Outstanding issues include the need for improved water and habitat quality at many sites. In addition, the re-establishment of more natural waterway form and function is an important consideration at many sites, as is the including the establishment of suitable setbacks and buffer zones and the restoration of indigenous vegetation in the riparian zone.

To further develop and implement recommendations from this monitoring programme will require the continuing and direct involvement of Ngāi Tūāhuriri Rūnanga in waterways management in their takiwā. Regular, comprehensive and culturally relevant monitoring will be important to establish whether desired aspects of waterways recovery are being achieved. This programme also identified that other monitoring programs are needed to target specific cultural values and aspects of cultural health for management purposes. These include that a much greater level of investigation to assess the seasonal cultural health of awa and kai-awa is needed. This will require more frequent and targeted monitoring than that conducted under the State of the Takiwā programme, in which the focus is to establish and monitor against a long term cultural base-line for the entire catchment.

Lastly, the roopu wish to acknowledge and appreciate the opportunity to have been involved in this State of the Takiwā programme and hope that the results presented here will be of use to all whānau in achieving their objectives and aspirations for waterways in this area.

Figure 36: A typical view of the lower Ruataniwha / Cam River, showing highly modified riparian and surrounding areas and a lack of the indigenous vegetation which was formerly present (above), and the roopu at work at the Cam / Brooks Confluence site (below).



8. Recommendations

Controls on the modification of waterways

Further controls to prevent the modification of waterways appear to be required since substantial modifications of waterway form and function including the diverting of waterways into other catchments was observed at several State of the Takiwā monitoring sites and elsewhere in the catchment. This situation is in conflict with established Ngāi Tahu policy. Management interventions to control the following are particularly important to protect Ngāi Tahu values:

- Damming of rivers and streams;
- Abstraction of water from natural water bodies;
- The mixing of waters of discretely different ecosystems; and
- The diverting of waters in other cases where tangata whenua values may be adversely affected.

It is also important that river protection and bank stabilisation works are designed correctly to avoid adverse effects on tangata whenua values, and where possible to take opportunities to enhance values relative to the status quo.

Protection of wāhi taonga and wāhi tapu and protection and enhancement of puna (springs) and waipuna (spring water)

Waterways and sections of waterways of particular significance to tangata whenua because they are wāhi taonga need to be recognised separately from any other waterways classes proposed, and appropriate management objectives identified for these waterways. Puna and waipuna are present in the area and their significance must be established in consultation with tangata whenua. Established Ngāi Tahu policy includes some management objectives for puna and waipuna including that further management needs are established in consultation with Papatipu Rūnanga. In general the establishment of reserves or other forms of buffer zones around these sites is preferred. There must be no discharges of contaminants in the vicinity of springs and separation of spring water from stormwater run-off and other pollution sources to the greatest possible extent. It is also important that an adverse effects on base flows are avoided.

Although not the specific focus of the State of the Takiwā monitoring programme, there may be other types of wāhi tapu and wāhi taonga in the area and in some case these may be associated with waterways or their margins. The nature of these and appropriate management objectives need to be established in consultation with the relevant whānau.

Restoration of water quality to a level at which mahinga kai can be safely gathered

A fundamental resource management principle for Ngāi Tahu is that the quality and quantity of water in all waterways must be improved to the point where it supports mahinga kai species that were sources from them in the past, and this mahinga kai must be fit for human consumption. This recommendation applies to all sites in the State of the Takiwā programme except those that may be wāhi tapu for various reasons and thus may not have been traditionally used for mahinga kai purposes. At these sites, other specific water quality objectives would be applicable (as determined by tangata whenua) and these are likely to require very high levels of control over contaminant concentrations and sources.

In general, achievement of these management objectives requires the progressive elimination of contaminant inputs throughout the catchment, including from wastewater infrastructure and from

stormwater runoff and rural land use practices. To provide assurance that water quality is able to support and maintain mahinga kai values, it is also essential that regular monitoring is conducted against all relevant parameters.

Control of pollution sources

The roopu noted that further investigation into the sources of faecal pollution as indicated by the high *E. coli* levels recorded at some sites is required, which may include monitoring of *E. coli* by source. Measures to reduce or eliminate these *E. coli* sources from waterways are also required, once this information is known. Likely targets for management interventions include ensuring that stock do not have direct access to waterways, and ensuring that all human effluent is effectively disposed to ground and cannot enter any waterways. This includes in flood events and that wastewater systems in the area are sufficient resilience to natural disasters through their design and location with respect to the potential to cause overflows to waterways.

It is also important the pollution control measures address all contaminants of concern such as those that may originate from adjacent land uses, and to an appropriate level for different waterways including those that are wāhi taonga and wāhi tapu. This includes ensuring that setbacks accommodating buffer and filter strips or other run-off interception devices are present and are sufficient to control the contaminant load from the land use activities present.

To provide assurance that faecal pollution levels are appropriate regular monitoring is vital. Such monitoring needs to adopt appropriate methodologies to be useful. A key recommendation is that monitoring is required against the Ministry for the Environment and Ministry of Health shellfish gathering standard as a regular feature of monitoring activities. This will provide essential information to support Ngāi Tahu objectives for mahinga kai including determination of whether that standard has been met.

Fencing

Fencing stock out of waterways was considered to be of high importance by the roopu and was lacking at some State of the Takiwā monitoring sites. Important aspects include the effectiveness of fencing and the setback distance away from waterways established by the position of fences. There were also examples of adequate fencing at some sites.

Riparian planting using appropriate local indigenous species

Planting was identified as needed at the majority of State of the Takiwā monitoring sites to restore riparian areas, improve connectivity aspects within the catchment, and for its relevance to the cultural landscape. Recommendations for planting include using appropriate local indigenous species including Ngāi Tahu taonga species as a matter of priority. It is also important the riparian zone is accorded sufficient width to support and maintain cultural values, and this in part influenced by the nature of the adjacent land uses, particularly those which are the source of pressure on the cultural values associated with waterways. These aspects are best determined in consultation with tangata whenua since the significance of the waterway at each location may differ, and hence the level of protection required. Specific Ngāi Tahu policy on these aspects can be found in the Mahaanui IMP 2013. This includes that a buffer width of at least 10m and up to 30m either side of waterways is provided for as a minimum set-back from adjacent land activities, and up to 50m where there is space such as towards river mouths and in greenfield areas (see Policy WM12.5). The use of appropriate fencing, buffer, and setback areas are particularly important to protect wetlands, waipuna and riparian areas from intensive land use (see Policies WM13.2 and WAI2.4).

Control of pest and exotic species

This was noted as an important aspect of the restoration of waterways in the State of the Takiwā programme. Despite that agricultural land use will continue to be prominent in the area, it is particularly important that exotic species with the ability to out-compete indigenous species are controlled to an appropriate level in restored areas, and in waterways.

Signage and naming

Where possible, the correct Māori name associated to the waterways should be used. In addition, the roopu recommend that signage be erected at some sites, where appropriate, that have historical or traditional associations or significance for local whānau/ hapū. In both instances the correct approach and wording should be established in consultation with the whānau and hapū with interests in the site.

Additional management recommendations

- Implementation of methods to ensuring that urban development does not further encroach on waterways, and that all developments are consistent with or enable riparian restoration activities.
- Create environments where all resources can be attained in close proximity for tangata whenua to actively participate in cultural practices.
- Specific enquiry into all heavily degraded sites and identification and implementation of remedial actions to improve the health of those sites.
- Restoration of areas known to be of high significance, particularly those in relation to MR873 and the Cam River.

Implementation aspects

A range of stakeholders will need to be involved to successfully implement the above recommendations, and it is noted that these recommendations affect many different land tenures. Although in some cases external agencies may be responsible for the land and waterways that would be affected by these recommendations, in other cases private property is involved. It is likely that incentives will be required for private land owners to pursue activities such as native riparian plantings and fencing on their land. Access issues will also be important to resolve in consultation with land owners.

Monitoring

In addition to the points raised above on monitoring in connection with individual topics, cultural monitoring and reporting on a regular basis throughout the catchment is recommended. It is especially required to address catchment-wide issues and specific management concerns. Progress against baseline measurements made in the 2012 State of the Takiwā programme is a key aspect and it is recommended that this be provided for by ensuring the State of the Takiwā Ruataniwha programme can be repeated at regular intervals, ie. every 4-5 years.

It is also important to recognise that there is a the need for other monitoring programs that will target specific cultural values and aspects of the cultural health for management purposes. A number of particularly important topics that require more frequent and targeted monitoring were identified by the roopu. These include a much greater level of investigation to specifically monitor the seasonal cultural health of awa and kai-awa. For example, information is needed for practical use by whānau, on the abundance and likelihood of obtaining a catch of mahinga kai species, particularly at important mahinga kai sites. This will require a purpose built monitoring program sampling at much greater frequencies than that of the State of the Takiwā approach, in which the sampling methods, locations and frequency are designed to establish and monitor against a long term cultural base-line across an entire catchment.

9. References

- Beattie, J.H. (1994). *Traditional Lifeways of the Southern Maori. The Otago University Museum Ethnological Project 1920*. (Edited by Atholl Anderson). Dunedin: Otago University Press.
- Biggs, B.J., Kilroy, C. & Mulcock, C.M. (2000). *New Zealand Stream Health Monitoring and Assessment Kit*. Christchurch, NZ; NIWA.
- Burnet, A.M.R. (1952). Studies on the ecology of the New Zealand longfinned eel, *Anguilla dieffenbachii* Gray. *Australian Journal of Marine and Freshwater Research* 3:32-63.
- Evison, H. & Adams, M. (1993). *Land of Memories*. Tandem Press.
- Graynoth, E. & Taylor, M. J. (2004). Growth of juvenile eels (*Anguilla* spp.) in lowland streams in New Zealand. *Fisheries Research* 66: 95-106.
- Hawkins, D. N. (1983). *Rangiora: the passing years and people in a Canterbury country town*. Rangiora: Rangiora Borough Council. 479pp.
- Hitchmough, R. & Cromarty, P. (2005). New Zealand Threat Classification System lists. *Threatened Species Occasional Publication 23*. Wellington: Department of Conservation. 210 pp.
- Jellyman, D.J., Graynoth, E., Francis, C.R.I.C., Chisnall, B. L. & Beentjes, M.P. (2000). A review of the evidence for a decline in the abundance of longfinned eels (*Anguilla dieffenbachii*) in New Zealand. *Report No. EEL9802*. Wellington: Ministry of Fisheries. 76 pp.
- Lang, M., Orchard, S., Falwasser, T., Rupene, M., Williams, C., Tirikatene-Nash, N. & Couch, R. (2012). *State of the Takiwā 2012 -Te Āhuatanga o Te Ihutai. Cultural Health Assessment of the Avon-Heathcote Estuary and its Catchment*. Christchurch, NZ: Mahaanui Kurataiao Ltd. 43pp.
- McDowall, R. M. (1990). *New Zealand Freshwater Fishes: A Natural History and Guide*. Auckland: Heinemann Reed. 553 pp.
- Ministry for the Environment and Ministry of Health (2003). *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*. Wellington: Ministry for the Environment.
- Ministry of Fisheries (2008). *Fisheries Plenary Report*. Wellington: Ministry of Fisheries. 243-255 pp.
- Ministry of Health (2008). *Drinking-water Standards for New Zealand 2005 (Revised 2008)*. Wellington: Ministry of Health.
- Ministry of Health (2009). *Environmental Health Indicators for New Zealand 2008*. Wellington: Ministry of Health.
- NIWA (2012). *Electric Fishing Machines*. Retrieved 27 June 2012 from <http://www.niwa.co.nz/our-services/instruments/instrumentsystems/products/accessories-and-parts/kainga-electric-fishing-machine-efm300>
- Ogilvie, S. & Penter, B. (2001). *Stream Health Monitoring Assessment Kit for Māori*. Christchurch: NIWA.

- Orchard, S., Sarson, R., Lang, M., Falwasser, T., Rupene, M., Williams, C. & Tirikatene-Nash, N. (2012). *State of the Takiwā 2012 Puharakekenui - Cultural Health Assessment of the Puharakekenui / Styx River, Brooklands Lagoon / Te Riu o Te Aika Kawa and catchment*. Christchurch: Mahaanui Kurataiao Ltd.
- Pauling, C. (2003). *Ki Uta Ki Tai – Mountains to the Sea Natural Resource Management: A scoping document for developing Mountains to the Sea Natural Resource Management Tools for Ngai Tahu*. Christchurch: Te Rūnanga o Ngāi Tahu.
- Pauling, C. (2004). *State of the Takiwa - Cultural Monitoring and Reporting on the Health of our Environment: A scoping document for developing a culturally based environmental monitoring and reporting system*. Christchurch: Te Rūnanga o Ngāi Tahu.
- Pauling, C. (2007). *State of the Takiwa: Introducing a culturally based environmental monitoring and reporting system for Ngai Tahu*. Christchurch: Te Rūnanga o Ngāi Tahu.
- Pauling, C. (2008). *Ngā Wai Pounamu: Cultural Health Assessment of South Island Waterways*. Paper presented at the Environmental Defence Society Conference: Conflict in Paradise: the Transformation of Rural New Zealand. June 2008. 15pp.
- Pauling, C., Lenihan, T., Rupene, M., Tirikatene-Nash, N., & Couch, R. (2007). *State of the Takiwā - Te Āhuatanga o Te Ihutai. Cultural Health Assessment of the Avon-Heathcote Estuary and its Catchment*. Christchurch: Te Rūnanga o Ngāi Tahu.
- Tau, T., Goodall, A., Palmer, D. & Tau, R. (1990). *Te Whakatau Kaupapa: Ngai Tahu resource management strategy for the Canterbury region*. Wellington: Aoraki Press.
- Tipa, G. & Tierney, L. (2003). *A Cultural Health Index for Streams and Waterways: Indicators for recognising and expressing Māori values*. Wellington: Ministry for the Environment.
- Tipa, G. & Tierney, L. (2006). *Using the Cultural Health Index: How to assess the health of streams and waterways*. Wellington: Ministry for the Environment.
- Te Rūnanga o Ngāi Tahu (1999). *Te Rūnanga o Ngāi Tahu Freshwater Policy Statement*. Christchurch: Te Rūnanga o Ngāi Tahu.
- Te Rūnanga o Ngāi Tahu (2001). *Ngāi Tahu Vision 2025*. Christchurch: Te Rūnanga o Ngāi Tahu.