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Project summary report – Fresh water Ecosystem Services Project – Phase 1

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Abstract

In the Waikato Regional Policy Statement, objective 3.8 states that the council will take an ecosystem services approach to recognise and maintain or enhance fresh water ecosystem services to enable their ongoing contribution to regional wellbeing. Monitoring ecosystem services and socioeconomic and cultural values could enable better management of these resources and so increase the productivity and efficiency of resource use for community wellbeing. This is because the ecosystem services approach to natural resource management, in principle, considers all services to all sectors of a community.

To facilitate this approach, tools such as maps and a database of ecosystem services are useful at the level of detail at which policy and management decisions are made. This study provides some understanding of services and values of fresh water bodies (rivers, streams, lakes and wetlands) in the Waikato region by assessing the ecosystem services and association values using maps and an underlying database system showing current and potential ecosystem services of a sample of fresh water bodies in the region.

The database system allows structured querying, searching and updating of the database as more information becomes available on these ecosystems. The ecological status and health of the ecosystems provide an indication of the services and values of these natural resources using the Millennium Ecosystem and Assessment (MEA) and the Common International Classification of Ecosystem Services (CICES) frameworks. This will help the regional council's capacity in monitoring the effectiveness of its natural resource management and policies.

Executive summary

In the Waikato Regional Policy Statement, objective 3.8 states that the council aims to recognise and maintain or enhance fresh water ecosystems to enable their ongoing contributions to regional wellbeing. Monitoring ecosystem services and socioeconomic and cultural values could enable better management of these resources, and so increase the productivity and efficiency of resource use for community wellbeing. This is because, in principle, the ecosystem services approach to natural resource management considers the health of ecosystems and the sustainability of supply of all services to all sectors of a community.

To facilitate this approach, tools such as ecosystem maps and a database of services and values are useful at the level of detail at which policy and management decisions are made. This study provides some understanding of services and values of fresh water bodies (rivers, streams, lakes and wetlands) in the Waikato region by developing web-based (online) maps underpinned by interactive database system showing observed and potential ecosystem services and values of a sample of fresh water ecosystems.

In this study, the Millennium Ecosystem Assessment (MEA) framework for assessment of ecosystem services was applied to a sample of fresh water ecosystems in the Waikato region. The ecological integrity (Schallenberg et al*.,* 2011) of each ecosystem was considered. This involves looking at the physical, chemical and biological interactions, which, though they cannot be easily observed, can be indicated by the observable conditions. The conditions are then observed as a reflection of potential or observed service provision from the ecosystem. The highest ecological integrity is assumed when anthropogenic impacts are zero or minimal (Schallenberg et al., 2011).

Monitoring data (biophysical, invertebrate and water quality records) were used together with field observations and desktop studies to assess the ecological conditions of the sampled ecosystems and then provide economic estimates of the values of services where data is available. Based on a literature review, some indicators of fresh water ecosystem services were identified and estimated for a sample of fresh water ecosystems. The data were standardised and harmonised. Where no direct data were available, proxies of potential services were estimated. That is, the indicators are used to map and assess ecosystem conditions and services according to the Common International Classification of Ecosystem Services (CICES v4.3, Haines-Young and Potschin, 2013).

A sample of web-based maps and a database system of ecosystem services are presented in this report. The reports on individual ecosystems that give details and descriptions are referred to in this report. The reports together with the database have been peer-reviewed so that the feedback has been incorporated in this summary report and also considered for further studies in a potential second phase of this project. Ultimately, the web-based maps and database system will be useful for planning and decision making to increase the potential and efficiency of natural resource use, biodiversity strategy, and spatial plans. They will also be accessible to the public, where stakeholders such as land managers will be able to perform searches and structured queries on the database so they can appreciate the value of natural or capital assets that relate to their respective properties.

Future research is needed to cover groundwater ecosystems and interactions with surface water ecosystems, as well as updating and refining the maps and database with up-to-date information. The further research would include studying how economic concepts and tools can help equip society with the means to incorporate the values of nature into decision-making at all levels. More specifically, to capture the position of agriculture in the region, integrating the ecosystem service concepts into agriculture so as to inform agricultural practices while enhancing ecosystem services will allow greater production of both market and non-market goods and services within environmental constraints. This integration will also allow a

comparison of the total economic value of natural resource use with other potential uses in a way that includes the impacts of the activities above and beyond just the commercial value.

1 Introduction

The Waikato region is approximately 9,325km^2 in land area, which accommodates approximately 10% of New Zealand's population and is a medium sized regional economy with significant primary production and energy generation (more than 20% of New Zealand's electricity). This economy relies heavily on its natural resources, including the natural assets of national significance like Lake Taupō and the Waikato River (MBIE, 2016). The region contained approximately 30% of New Zealand's wetlands, including the Whangamarino Wetland and Kopuatai Peat Dome (Swarbrick, 2015). The region consists of valleys and coastal lands separated by ranges. The rich landscapes encouraged the diverse land use, but this also puts pressure on sustainable management of the natural resources in the region.

This pressure warrants a better understanding of the way the 'economic' growth agenda interacts with the management of natural resources. Objective 3.8 of the Waikato Regional Policy Statement relates to Ecosystem Services (i.e. benefits people obtain from nature). Under this objective, the region seeks to 'recognise and maintain or enhance ecosystem services' to enable their ongoing contribution to regional wellbeing (Waikato Regional Council, 2016). In addition, an ecosystem-based approach to managing natural resources has the potential to contribute to the Government's business growth agenda objective of a more productive economy through a number of activities, such as the tourism growth partnership fund to grow tourism infrastructure, and resource management reforms to speed up decision-making (MBIE, 2015).

There are a few existing databases of ecosystem services being compiled by the Ecosystem Services Partnership (ESP)[1]. However, in New Zealand, this concept is relatively new and being developed. Currently there is no database of these ecosystems with their associated services and values. This is a gap between the values the community expects from natural resources and the ecological monitoring data being collected by the Waikato Regional Council (Council). For example, a tourist would benefit from knowing where ecosystems such as lakes, rivers, and wetlands are, as well as their uses, in terms of different types of fish, birds and plants they may see, the length of kayaking trails available, etc. Similarly, ecologists collecting data on the ecological status of water bodies would appreciate knowing not only the environmental benefits of the natural resources, but also the economic, social and cultural values of the resources – that is linking ecological status to socioeconomic and cultural values in terms of how (and how many) people benefit from the ecosystems.

Closing this gap is an important requirement to be able to monitor the effectiveness of the relevant regional policies. It will also provide information that will be useful when objectives and limits are being set to implement the National Policy Statement for Fresh water Management (NPS-FM). An ecosystem services approach to resource management can increase the productivity and efficiency of resource use for community wellbeing because it considers all services provided by ecosystems to all sectors of a community. This approach will also help the region to achieve well-informed natural resource management outcomes and move away from an issue-based approach to resource management where efforts are typically an *ad hoc* corrective approach to particular problems. To facilitate this approach, tools such as ecosystem maps and database of their services are useful at the level of detail at which policy and management decisions are made. Hamilton (2008) and Ausseil et al., (2013) have reported on priorities for an ecosystems approach in NZ and specifically, in the Waikato region.

This project aims to build on earlier research work on this topic (Hart, Rutledge and Greenhalgh, 2012). This work will be useful for well-informed natural resource management, especially for fresh water resources (rivers, streams, lakes, wetlands and ground water bores) in the region. The immediate justification for this project is that the challenge of regional planning is to

[1] http://esp-mapping.net/Home/

spatially describe the landscapes in a manner that allows planning to protect and enhance the ecosystem services that support the wellbeing of the community. Specifically, the NPS-FM (2011, 2014) requires the regional council to set appropriate objectives and targets for fresh water quality and quantity.

1.1 Objectives

The objectives of this project are to:

1. identify the spatial distribution and characteristics of fresh water ecosystems in phase 1 of this project; and
2. examine possible trends in fresh water ecosystem services in the region in terms of comparing and contrasting the demand and supply of these services in the region in phase 2.

1.2 Work activities

In phase 1, the main work activities are presented in Table 1.

Table 1: Main work activities and descriptions of phase 1

#	Main work activity	Description
1	Identification of data to be collected on fresh water ecosystem services	Literature scoping was done to identify dimensions of a database of indicators of fresh water ecosystem services. Initial work in this area is reported in Hart, Rutledge and Greenhalgh, (2013) where ecosystem services generally were identified, classified and prioritised. A blueprint for data collection and presentation of ecosystem services has been identified in the literature (Crossman et al., 2013; United Kingdom - National Ecosystem Assessment, 2011; Drakou et al., 2014; Dominati et al., 2014).
2	Sampling some fresh water ecosystems in the region	A sample of fresh water ecosystems in the region was selected within the scope of this project. After consulting with experts, the following selection criteria were developed and applied: 1. Regional representation (though the sample is limited to Waikato-Waipā River catchment as the study area) 2. Land use representativeness – different land use and land cover adjacent to or within the neighbourhood of a fresh water ecosystem were represented among the sampled ecosystems 3. Ecosystems of significant size are given a higher consideration, e.g. Lake Taupō 4. Sites already researched/monitored by the Waikato Regional Council were also considered especially those that have long term data being collected by the Waikato Regional Council environmental monitoring team
3	Field work and data collection	The data collection exercise was based on the characteristics of the fresh water bodies that we sampled. We also considered the indicators of ecosystem services as identified in the literature. The data collection exercise includes field visits and desktop exercise lead by experts in the ecological sciences and valuation.
4	Development of web-based maps and database system of fresh water ecosystems services	The field work is followed by design of a web-map application. This is a way of organising and presenting the data collected in the form of maps with an associated database of the sampled fresh water ecosystems.
5	Reporting and documentation	The project process will be documented with full details of data collection and metadata.

Based on the objectives above, the final deliverables of phase 1 are presented with a summary in this report. The outputs are

i. Maps of fresh water ecosystems (streams, rivers, lakes and wetlands) with associated services using quantitative indicators;
ii. A database system of the fresh water ecosystems with associated services such that the database can be searched for these indicators; and
iii. A final report (in terms of documentation) of i. and ii. above

The starting point was a literature scoping review specifically to establish context and provide an overview of fresh water ecosystem services and identify dimensions of a database for ecosystem services assessment. From the literature the dimensions of the database were summarised into indicators of data to be collected for the assessment (see Appendix A). The list of fresh water ecosystems in the region was considered before a sample was chosen for assessment (see Appendix B).

The sample was based on the criteria highlighted in Table 1 above. For example, the sources of these fresh water ecosystems include those associated with the Council monitoring sites, ecosystems mentioned in the Waikato Regional Council's regional policy statement, and based on the recommendations of Hart, Rutledge and Greenhalgh (2012). The FENZ and NIWA database of fish values were also considered. The sample was validated with consultants that gave feedback in terms of how the indicators of ecosystem services are appropriate and obtainable in the sampled sites and within the scope of this project. See the report for details in Appendix C.

The literature review also led to the adoption of a database template (referred to as the 'blueprint' of data to be collected). This template was specifically developed for reporting and presenting ecosystem services as an effort to conform to the Common International Classification of Ecosystem Services (CICES v4.3) framework (Haines-Young and Potschin, 2013). Contractors for carrying out the fieldwork were identified, followed by a workshop to discuss the concepts and subsequent field visits to two of the sampled ecosystems. The aim of this was to try out the data collection process and how to use the template in reporting the data for presentation. The experience of the trial field trips indicated most data will be readily collected through a desktop exercise, since most of the data required are difficult to quantify on the field. The desktop data has mostly been collected and processed by other agencies such as NIWA, Fish and Game NZ, etc. The other significant data collection effort involved translating the Council monitoring data into indicators of ecosystem services and parameters.

The data sets, with accompanying reports, were received from the field contractors (see Appendix D for details). The data and reports were reviewed by Council scientists and economists. This has led to cleaning and updating of the database presented in Appendix E. Finally, the dimensions and parameters of the database were used to develop web-maps for the data collected to show spatial distributions of fresh water ecosystem services in the Waikato region. The dimensions are being considered as legends on the maps and also variables against which to search the database.

The rest of this project summary report presents detailed processes of the project. A summary of the knowledge gleaned from literature is provided in Section 2; followed by data collection process (in Section 3) and detailed reports of the field works (in Section 4 with detailed reports in Appendix D). This summary report ends with a conclusion and ideas for future work (in Section 5). The complete database is presented in Appendix E (Attachments E1 and E2), while the web-based maps are available on the Council website.

2 Literature review

Published literature was reviewed to provide an understanding of the concepts of ecosystems and frameworks being used to assess them. The review shows that the idea behind ecosystem concepts is to recognise natural capital (a natural resource) as an ecosystem. The interactions and processes within and between an ecosystem's components performing their functions lead to ecosystem services. There are direct and indirect linkages between the services and human wellbeing. However, most of the resources (ecosystems) are often considered as public goods which are controlled by public entities because there is usually no market for them and they sometimes are not well represented in policies.

There is, however, a growing understanding that ecosystem services can be explored to achieve biophysical, social, cultural and economic values that benefit humanity. Ecosystem services are generated from the stocks of natural capital; as the quality and condition of an ecosystem changes, the provision of the ecosystem services change. The services have been identified and categorised into provisioning, regulating, cultural and supporting which cuts across the provisioning, regulating and cultural categories. Efforts are being made to standardise the indicators for measuring these services, as well as how to present them to inform policy decisions. Fresh water bodies are examples of ecosystems. Specifically, fresh water ecosystems include, broadly, streams, rivers, lakes, wetlands and some groundwater sources such as boreholes or aquifers. The remainder of this section presents further details of knowledge gleaned from the literature.

2.1 Ecosystem services – concepts and assessment framework

An ecosystem is a functional unit of dynamic and complex interaction of plant, animal, and microorganism communities and their non-living environment. These units (ecosystems), when their components do interact, provide some benefits for human wellbeing (MEA, 2005a, b). Ecosystem services are flows of biophysical features, quantities or qualities that directly or indirectly benefit humanity (Boyd and Banzhaf, 2007). Ecosystem services are not commonly considered in land use planning because the tools and information for decision makers have typically not yet been available. This includes information on who the beneficiaries of ecosystem services are, along with their perceptions of the value of ecosystem services.

The importance of understanding functional linkages between ecosystem components, including species, soils and the provision of specific ecosystem services has been indicated in the literature (Kremen and Ostfield, 2005; Sanchirico and Mumby 2009; McDowell, van der Weerden and Campbell, 2011; McDowell et al., 2015; Smith et al., 2015). However, in spite of the large number of publications on ecosystem services assessment frameworks, and the definition of the ecosystem services concepts (e.g. MEA 2005, The Economics of Ecosystems and Biodiversity, 2010, and many others) there is still debate about the 'final' typology of ecosystem services and 'best practice' approaches for putting the concept into practice for the sake of ecosystem conservation and sustainable use.

The *assessment* of ecosystem services is mainly based around the concept that ecosystems perform certain functions (referred to as services), and these provide benefits to human wellbeing. According to Maynard et.al. (2010), quantification and mapping of ecosystem services provides key information mainly to identify: areas that provide a high level of service requiring protection or management; areas that provide specific ecosystem functions or services; and changes in ecosystem service provision over time (i.e. a combination of natural capital status and land use). Spatial representation of the relative provision of ecosystem services across a landscape is critical for incorporating ecosystem services into processes for integrated urban and regional planning.

Previous studies have identified, classified and prioritised a wide range of ecosystem services from natural resources, and also to address some issues based on the requirements of the Resource Management Act 1991 (RMA). These requirements cover the state of resources, effects on climate change, provision for energy demand and the relationship of tangata whenua with the environment and health and wellbeing of the Waikato River catchment (Hart, Rutledge and Greenhalgh, 2012; Hart et al., 2013). Hart et al. (2013) identify some data needs in order to spatially map the identified and prioritised ecosystem services across the region.

Previous ecosystem service mapping approaches have used land use and land use zoning as proxies (Costanza et al., 1997, Costanza et al., 2006, Liu et al., 2010). Based on its biodiversity values, the Waikato River catchment, which comprises Lake Taupō and its catchment, the Waikato River below the Lake Taupō outlet and Waipā River, has been identified as a water resource of national importance (Chadderton et al., 2004; East Harbour Management Services, 2002, 2004; White, Sharp and Reeves, 2004; Fink-Jensen et al., 2004a,b; Kokiri 2004; Ford et al., 2001; Kelly and Greig, 2004; Ministry for the Environment, 2004; Ministry of Tourism, 2004; Richmond, 2004).

Recent work reported in Hart, Rutledge and Greenhalgh (2012) introduced the concept of ecosystem services from a wider number of natural resources in the Waikato Region specifically by incorporating the concept into the Waikato Integrated Scenario Explorer (WISE[2]) model. This is meant to allow the application of WISE to explore, assess and quantify the effects of developments and policies on particular ecosystem services across the region.

In this study, focus was on services that have been used and recognised internationally. These are services that contribute directly or indirectly to biodiversity and human wellbeing. It is, however, acknowledged that there are services that are being debated based on human perceptions or value judgments. The framework for assessing ecosystem services are being developed. The most popular is Millennium Ecosystem Assessment (MAE) framework (MAE, 2005; Cowling et al., 2008; Maynard et al., 2010; Maynard et al., 2012), which has been applied in this study.

2.2 Applications of ecosystems services approach

The ecosystem services approach to managing natural resources has been applied to achieve a number of purposes, such as trade-off analysis and project evaluation, disaster risk reduction (Ganter et al., 2015), planning and management (Henninger et al., 2015), co-investment and reward mechanisms for ecosystem services (Gatner et al., 2015), governance and institutions to manage ecosystems (Hamilton *et al.,* 2008; Maes et al., 2012; Winterbottom et al., 2015), agro-ecosystems (Smethurst, 2014; Ozment, Ranganathan and Reig, 2015) and tourism development (Burke et al., 2015).

In terms of trade-off analysis and project evaluation, it is acknowledged that the capacity of an ecosystem to concurrently provide multiple ecosystem services is inherently limited and trade-offs occur when one ecosystem service is enhanced at the expense of another. This is, however, outside the scope of this study. Nevertheless, it is important to note that this point implies that the values we arrived at in this study cannot necessarily be summed up to indicate the total value of ecosystems. Nor does it necessarily mean one service is more valuable than another, because of different dollar values per unit of a resource. However, where there is a need for trade-off analysis, the data collected in this study can help to achieve that in a further study.

The indicators can also inform disaster risk reduction because ecosystem types, quality, and conditions (e.g. wetlands) play important roles in terms of hazard mitigation and vulnerability reduction. The concept of ecosystem services can provide a useful instrument for more

[2] WISE – Waikato Integrated Scenario Explorer is a spatial decision support system to explore alternative futures for Waikato Region (Research Institute for Knowledge Systems, 2008).

integrated and sustainable planning and management of natural resources as well as provide a powerful argument for investing more in restoration of degraded ecosystems.

In addition, co-investment and reward mechanisms for ecosystem services can be supported with the ecosystem service indicators and dollar values being translated into practical financing instruments and incentives for resource conservation and/or restoration. This is a key reason why it is useful to attempt an economic valuation on top of quantifying ecosystem services: to show benefits in monetary terms so as to justify an investment.

Where agriculture is a predominant source of living, farm intensification can interact with the ecological systems. In that case, the ecosystem services concept can: help to increase productivity per unit area by utilising inputs more efficiently; develop resilience against climatic variability; improve ecosystem functions/services to partially replace non-renewable inputs and minimise impacts on the environment; and contribute to the well-being of rural populations. Applications of these concepts have been reported for European countries (Liquete et al., 2013; Maes et al*.,* 2015); Australia (Baral et al., 2013) and Africa (Willemen et al., 2013).

2.3 Indicators of ecosystem services

There is a wide range of indicators in the literature that are being used to assess ecosystem services (EU 2013, 2014; Haines-Young and Potschin, 2013; UKNAE, 2011), but standard guidelines on social-cultural and economic valuation are still being developed in the literature. The indicators overlap – one indicator can be used for more than one ecosystem, and consequently, for more than one service. Some services have more than one indicator. Some indicators cannot be used as a standalone to assess a service. Contributions of ground water to some fresh water ecosystem services is not well known, e.g. ground water is connected to surface water and exerts indirect effects on the functioning of other ecosystems.

The usual categories of services are, broadly; provisioning, regulating, cultural and supporting services. Most are comprehensive and easily observed either during field visits and or well documented research (literature). However, some are proxies, which are subjective, and limited by lack of detailed information and scale inaccuracies. While these values will be an approximation, they can give an indication of trade-offs, and different values that can be derived from use of a resource. This can contribute to the decision-making process either on investment, raising funds for restoration projects, or exploration of ecosystem services.

In this study, the assessment of ecosystem services is mainly a reflection on the ecosystem's conditions and processes going on in an ecosystem that provide a benefit to the species that inhabit them either for survival or functioning, which in turn are of use to people in some form. The conditions and process do help to maintain biodiversity and the production of goods (e.g., food) and services (e.g., waste assimilation) that contribute to human welfare. These indicators can potentially be useful in enabling markets for ecosystem services. They can also justify regulations to support the establishment and scaling up of payments for ecosystem services.

These are tools that can put an economy in a position to explore how scientists can contribute to the science-policy interface on issues affecting ecosystems and human welfare such as:

- To provide support for global or regional processes such as Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Intergovernmental Panel on Climate Change (IPCC), and the International Sustainable Development Agenda (ISDA) post-2015; and
- To advocate the application of valuation of ecosystem services in decision making processes, especially in development projects.

However, the indicators presented in this study are still valuable because most land use change decisions, population growth and increase in energy uses are based on incomplete information about the consequences for the involved ecosystems, their services and their effects on human

wellbeing. One approach that the region might take is to sustainably manage, conserve and restore ecosystems so that they continue to provide the services that allow society to adapt to global changes.

For each of the Council monitoring sites, associated fresh water ecosystems were observed and surveyed using the indicators of data to be collected. This involved describing their ecological values and services. For example: how an ecosystem has formed and developed over time; the ecological characteristics; how associated land use, land cover, land management practices, water storage, diversion/extraction, commercial eel harvesting, etc. have affected the ecological status of the ecosystem in terms of services and values (e.g. types of plant/animal communities living within the ecosystems, presence of invertebrate fauna, fish species, migratory fish, presence of mahinga kai, etc.) These are detailed in the reports in the Appendix D.

Despite this body of literature on the concept of ecosystem services, the practical application in terms of assessment is still developing. Therefore, in this study, simple approaches have been taken both in data collection and processing, while efforts were made to contribute to the development of standardised measurements. For example the distinction between different valuation methods and frameworks was not considered. However relevant applications of these quantification methods are reported in the literature (Smith, Houtven and Pattanayak, 2002; Shultz, Pinazzo and Cifuentes, 1998; Schuijt, 2002; Costanza 2012; Dominati, 2014; Pinedo-Vasquez, 1992; Pattanayak and Kramer, 2001; Patterson, 1998).

Whether or not distributional issues are considered, a decision maker may also want to know not just the overall picture, but also what the option means for specific stakeholders at multiple scales. Classifying the ecosystem services based on categories, divisions, groups, classes based on the popular MEA (2005) framework was applied in this study. After quantifying the services, we then assigned dollar values based on published data. These values are usually based on benefit transfer[3] rather than any of the more rigorous valuation methodologies in literature (which, despite their rigour, tend to remain controversial). In this study, we have adopted the simpler approach because of limitation in time and scope of this study.

[3] 'Benefit transfer' is a method that takes values estimated in other studies as indicative of the values being considered. While the validity of this method relies on the existence of studies of ecosystem services with sufficiently similar characteristics, it is considered to be a useful indicator within the scope of this study. For more detailed consideration of the ecosystem services of particular sites, a benefits transfer approach may not be sufficient, and other methods should be considered.

3 Fieldworks and data collection

After initial work to define the concepts underpinning the project, the fieldwork contractors were consulted for feedback and advice on scope to ensure the project could achieve its objectives. Two groups of fieldwork consultants were contracted to undertake the fieldwork. One group from the New Zealand Forest Research Institute Ltd (SCION) collected data on the sampled streams and rivers while another group, Kessels Ecology Ltd (Kessels Ecology) collected data on lakes and wetlands. However, a team approach was taken to align ideas, efforts and methodologies for a consistent output. These steps are detailed in this section.

3.1 Fresh water ecosystems in the region

Waikato Regional Council has a number of programmes through which the ecological conditions/status and trends in the region's natural resources are being monitored. These include the Regional Rivers Water Quality Monitoring Programme and the Regional Ecological Monitoring (REM) of streams. Under these programmes, there are a number of sites where Council scientists take samples for analysis for the purposes of monitoring environmental conditions. In the Waikato and Waipā catchments, Council scientists collect aquatic micro-invertebrate samples and basic habitat information at a range of sites:

- Approximately 95 sites on the state of the environment (SOE) network for invertebrate monitoring (each site is visited once every three years).
- There are approximately 15-20 reference condition ("pristine") sites being sampled annually.
- There are 10-20 long term/restoration/urban/peri-urban sites being sampled two out of every three years.
- Fish ecology monitoring is undertaken at around 100 of the above stream monitoring sites.
- For most of the above, the Council has a one-off water quality measurement collected when the site was visited between 2012 and 2014 summers.
- There are four "clean streams" monitoring sites. These are water bodies under the enhancement strategy of the Waikato Regional Council.
- There are about 100 river water quality monitoring sites. The monitoring team sample Regional Ecological Monitoring of Streams (REMS) at or near about seven of these sites (in the Waikato/Waipā catchments).
- From the FENZ dataset, there are approximately 169 lakes and 1,953 wetlands in the Waikato/Waipā catchment. About 10-15 lakes are monitored for water quality on a bi-monthly schedule.

Waikato Regional Council ecological monitoring (excluding water quality) is largely limited to wadeable streams, which are smaller waterways. Some of the wetlands have been surveyed in the past, and some are on-going (e.g. Whangamarino). Given limited resources for monitoring, the number of fresh water bodies and ecosystem services in the region were streamlined such that a manageable sample was selected. Having identified the Council monitoring sites as listed above and discussed with Council scientists, fresh water bodies (river/stream, lakes/ponds, wetlands, etc.) associated with or near those monitoring sites were identified so that a sizeable number of different fresh water bodies were sampled. Within the Waipā zone, efforts were made to ensure ecosystems that have planted forest upstream were represented. However, this was limited by the decision to ensure such ecosystems are within Council monitoring sites, thus providing access to previous biophysical monitoring data on final sites being studied.

Based on the review of the sampled sites by SCION (See the report in Appendix C), the sampled sites were adjusted to include:

- Lakes within vegetation (indigenous forest, manuka/kanuka, or exotic forest) including diverse lake type (volcanic, riverine or peat).
- Wadeable stream sites that have planted forest as a land use nearby.

- A river along the Waipā Catchment; the Waipā River being a main tributary in the Waikato River Catchment.
- Lakes that are within indigenous and planted forest catchments so that more land uses are represented

The list of the indicators and sampled sites (ecosystems) were reviewed by the experts. Based on the recommendation of the reviewers' report, the number of the sites and the mix were adjusted to allow for different land use and regional representation. Figure 1 shows the spatial distribution of the sampled sites with respect to all the sites that Council does monitor, i.e. all the ecosystems sampled are in Council's monitoring sites. These sites (representing a river, wadeable stream, wetland or lake are currently sampled or have been in the past).

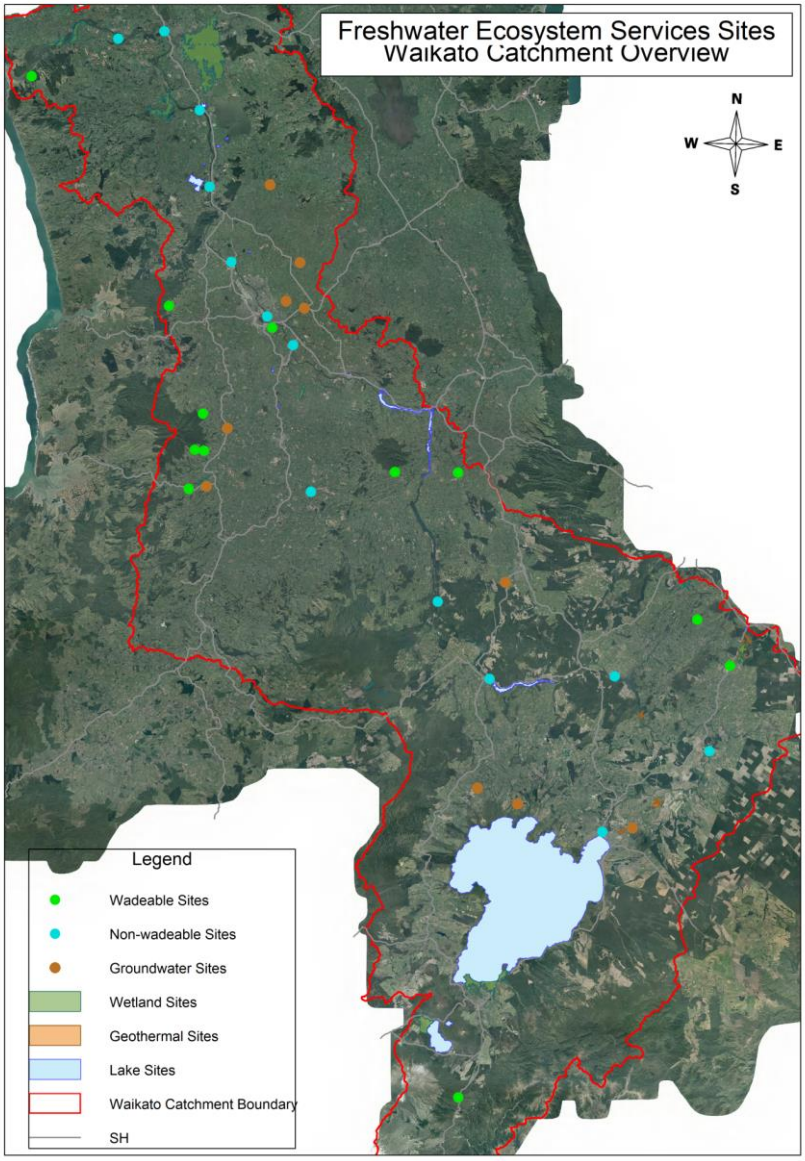

Figure 1: Sampled sites (ecosystems)

3.2 Data collection and ecosystem assessment

The fieldwork contractors were provided with the Council monitoring data sets on the sample sites and "blueprint" spreadsheet template for data collection and reporting. The data sets include trends in hydrology, habitat, invertebrates, water quality, geothermal features, etc. For each of the Council's monitoring sites selected, associated fresh water ecosystems were observed and surveyed using the indicators of data to be collected.

This involved describing their ecological values and services. The fieldwork contractors undertook desktop research and went on field visits to the selected sites to identify, observe and collect relevant data on associated fresh water ecosystem services (rivers, lakes, wetlands, ground water bores), using the document “indicators of data to be collected” in Appendix A. Data collected include land use, land cover, biodiversity data, etc. to indicate certain ecosystem services by populating the “blueprint” spreadsheet template. Where there is an absence of a service that we thought likely to be critical, we indicate no data in the records so as to identify gaps in data collection and to provide feedback for other areas of work that collect biophysical data.

The fieldwork contractors also applied appropriate relationships between land use and provision of ecosystem services to quantify ecosystem services by supplementing information with other local/regional information to estimate the level and or value of ecosystem services (including $-value) in populating the “blueprint” spreadsheet template. The contractors used the ‘comment/reference’ column in the blueprint template to present a note on each ecosystem service indicator. This might include describing methodology, limitations, key assumptions, general field visits experience that is relevant to each site. It also includes brief remarks on each ecosystem.

4 Fieldwork reports

In this project, we conducted targeted field surveys of a sample of fresh water ecosystems (streams, rivers, lakes and wetlands) within the Waikato region. Data was collected from published literature, unpublished reports and the Council's monitoring databases to assess fresh water ecosystem services in the proximity of Council's monitoring sites. These data sets were presented in excel spreadsheets which have been summarised in the database presented in Appendix E and also mapped as presented in the next section. The detailed field reports are presented in Appendix D.

5 Project summary

The fieldwork data sets and reports were reviewed by Council scientists and economists. The fieldwork contractors then responded to the reviewer's comments with updated data sets and reports. The data sets have been cleaned and formatted to requirements for mapping. The database is being used to develop web-maps that will be hosted on the Council's website for public access. Forty-two out of the 75 sites (representation of ecosystems) sampled have enough data to assess the services they provide (potential or observed). Of all various possible indicators, as compiled in Tables A1 to A3 (in Appendix A), 202 of those indicators are presented in the summary database in Table E2 in Appendix E.

5.1 Database of ecosystem services

In this study, the available monitoring data, geographic information system (GIS) data sets and research findings reported in the literature were used together with observations during field visits. While most of the indicators were fully developed with data readily available, a number of the ecosystem service indicators required extrapolation of regional data, literature data and aggregated statistics. The data were organised into a database system that can be queried (searched) based on the different categories, types and classification of ecosystem services. The web-based maps are being produced to describe each of the 202 ecosystem services across the 42 ecosystems based on the Framework.

Based on the Framework, ecosystem services are derived from the ecological conditions of the biological, chemical and physical states and characteristics of the ecosystem. The conditions are presented in Attachment E1 in the Appendix E. The conditions reflect the stock of potential services one could expect from these ecosystems. This is in line with published literature (Maynard, James and Davidson, 2010:6; TEEB, 2010; Watson and Albon, 2011) as a proxy where services are not directly quantified. Quantification of the services where possible was based on actual observation of services (field visits) and records of benefits as found in literature (desktop studies). The quantified services are presented in Attachment E2 in the Appendix E. These data represent the flow of ecosystem services in terms of the temporal units for each indicator. It is acknowledged that some data that were used as a proxy of ecosystem services were reviewed or refined in order to adjust for the uncertainties and similarity of ecosystem sites.

The blueprint of presenting an ecosystem services assessment as reported in Crossman *et al.* (2013) was applied to the data with some adjustment to accommodate the types of ecosystem in this study as well as maintaining the international standard of reporting being established in the field of ecosystem services assessment. Specific methods, references, the rationale for each estimate, the caveat about a particular indicator as well as future recommendations for updating the estimates are presented in the comment/reference column. Most of the estimates were also standardised to metric units to produce a common unit to facilitate comparisons where appropriate. To capture the scale of the extent of the services, the estimated services were extrapolated to the size of the ecosystem.

5.2 Web-maps of ecosystem services

The maps being developed were prepared using ArcGIS software. A sample of examples of the web-based maps with an underlying database reflected in the legend is presented in the figures that follow in this section. Specifically, figure 2 shows the repository for the maps and database in the Council's website. The database and maps are subject to ongoing refinement and review as new information and data sets become available especially in the second phase of this project. Figures 3 to 13 show examples of how clicking on an ecosystem on the map will bring up a pop-up to show the quantity and value of a specific ecosystem service. These maps and the database together with the field reports will be hosted on the Council's website for public access. The pop-up will also include a link to the report and photos showing details about a particular ecosystem.

The maps will be user-friendly and interactive such that clicking on an ecosystem will give a pop-up of key attributes showing the conditions of ecosystems (Attachment E1) representing the stock of the ecosystem services. The pop-up will also show the services in both quantity and monetary values (Attachment E2) as a measure of the flow of the ecosystem services where available. These figures are not exact but have been extrapolated from past studies. These are direct benefits rather than total value which would capture the flow on impacts in the economy.

The database behind the maps will be a relational database that can be sorted or searched for any of the attributes like type of ecosystem (streams, rivers, lakes, wetlands), categories of ecosystem services (e.g. provisioning, regulating, etc.), etc.

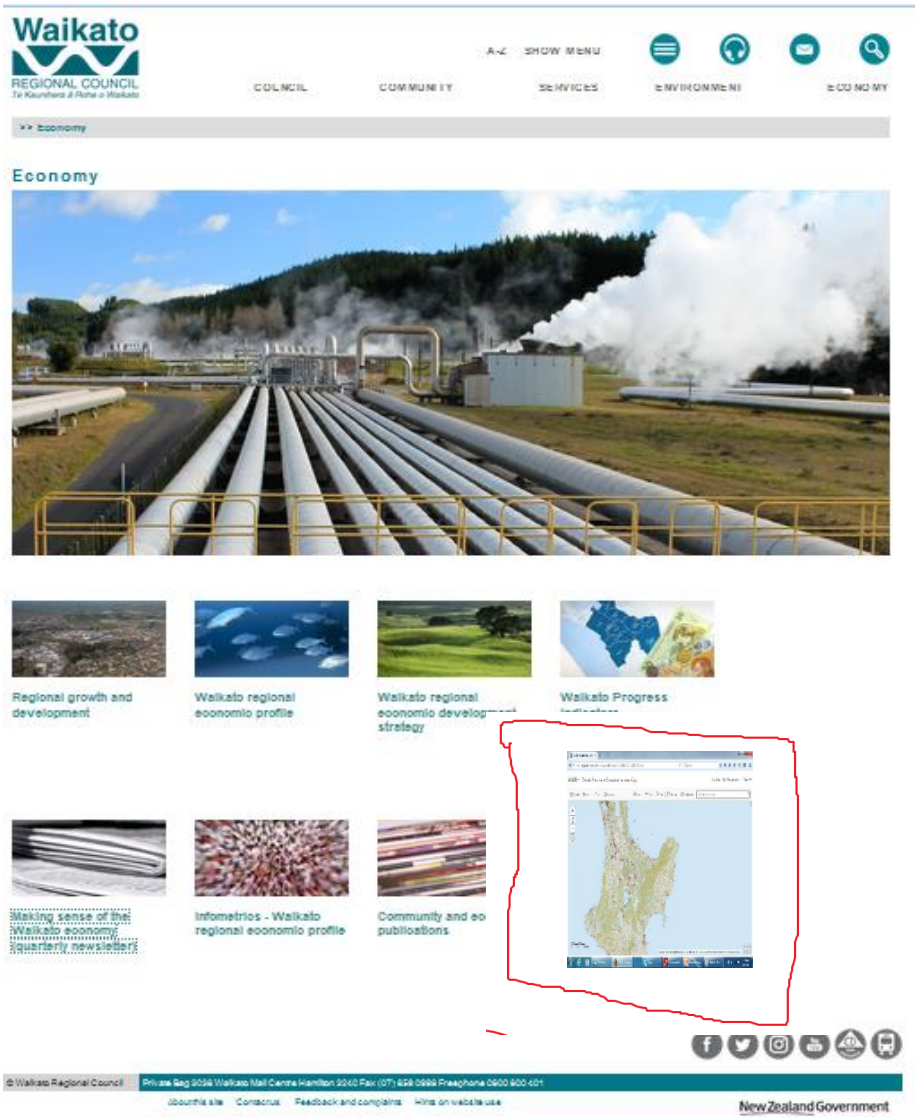

Figure 2: Repository of the Database and web-maps of the Fresh water Ecosystem Services

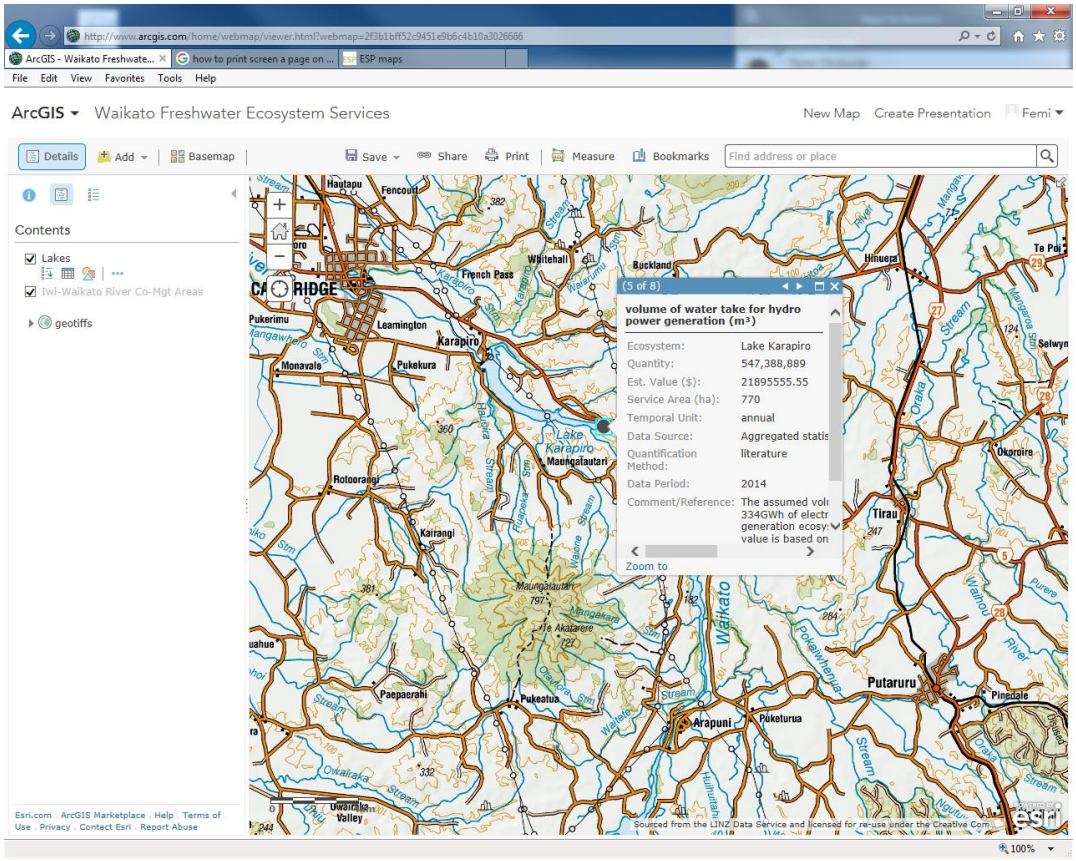

Figure 3: **Web-map showing an indicator of water provision for hydro power generation in the Lake Karapiro**

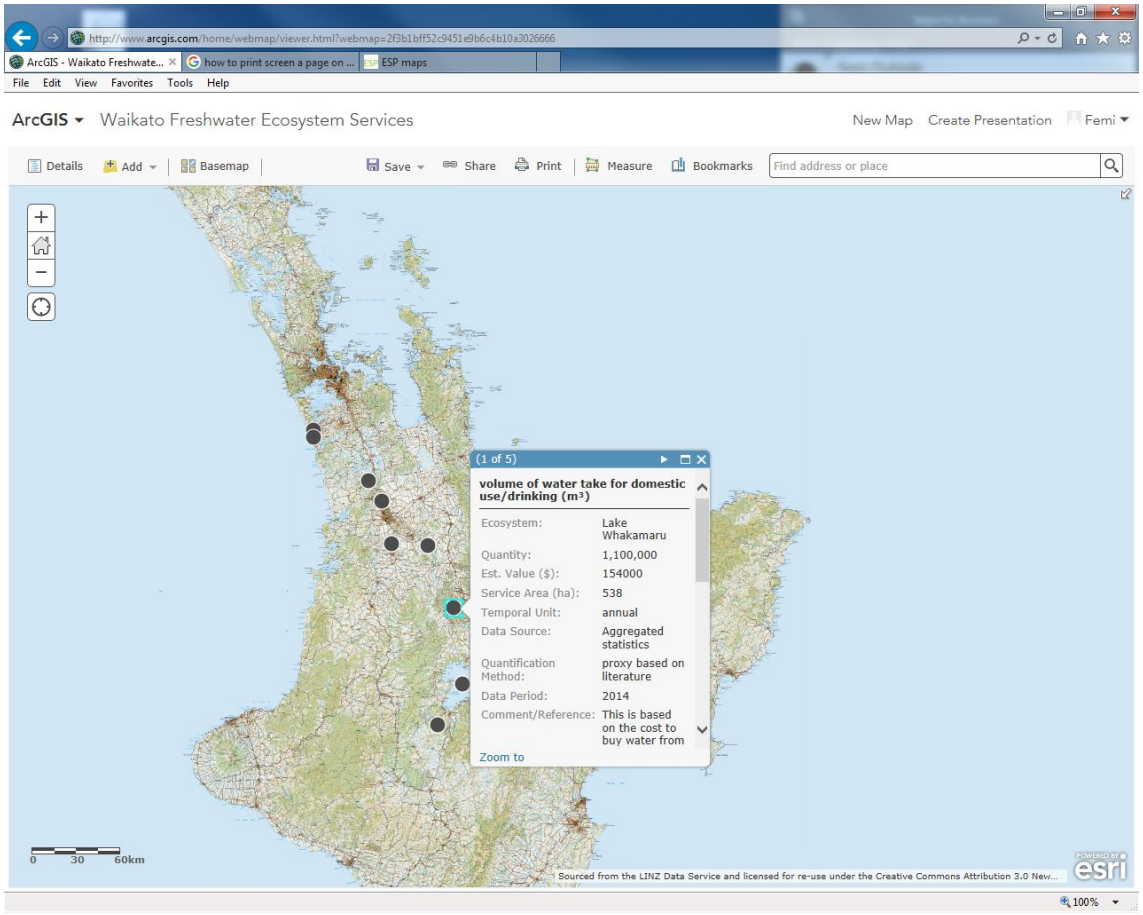

Figure 4: **Web-map showing an indicator of water provision for domestic water take in the Lake Whakamaru**

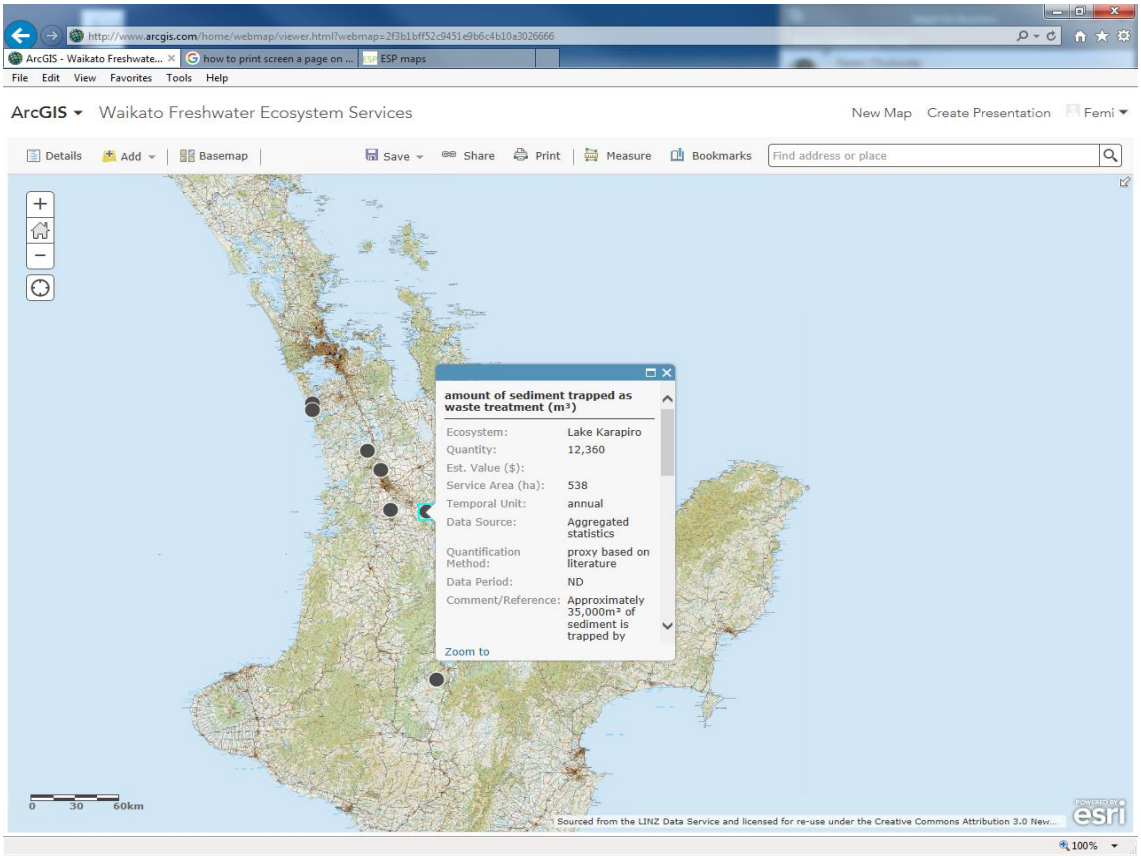

Figure 5: **Web-map showing an indicator of sediment trapped as waste treatment in the Lake Karapiro**

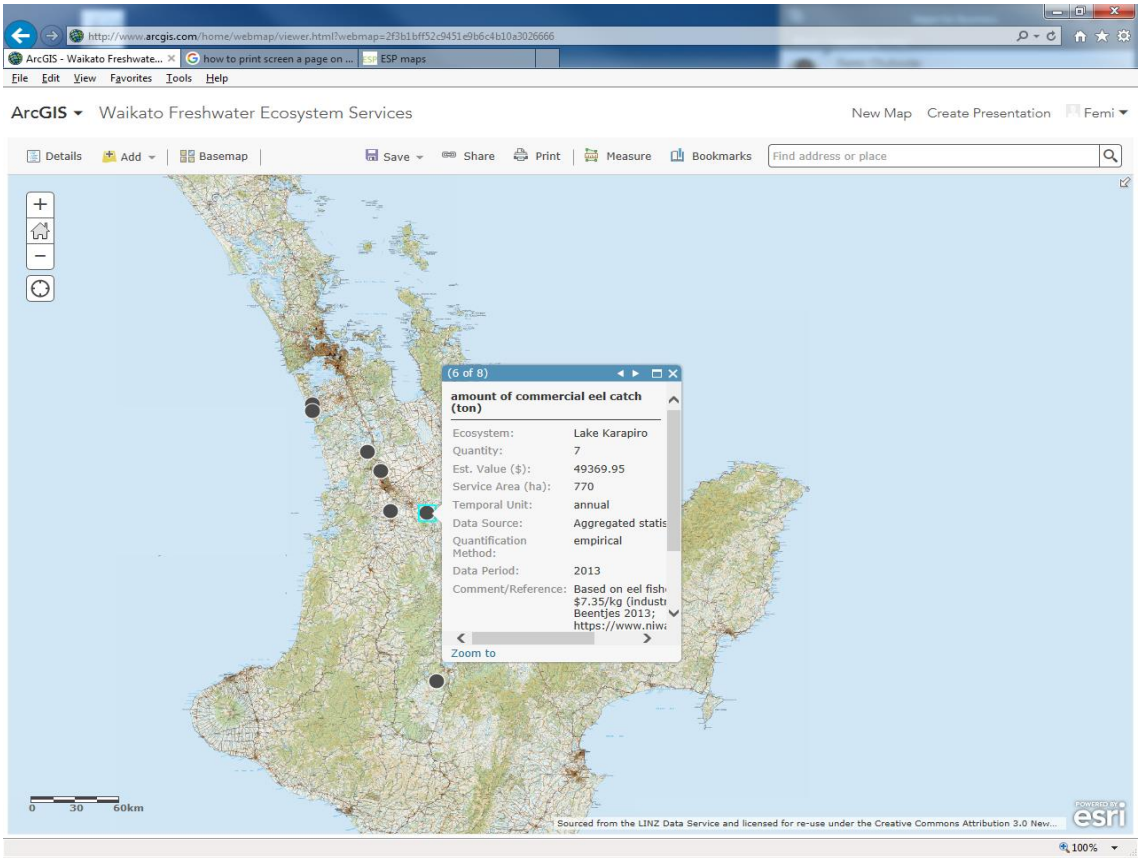

Figure 6: **Web-map showing an indicator of commercial eel catch in the Lake Karapiro**

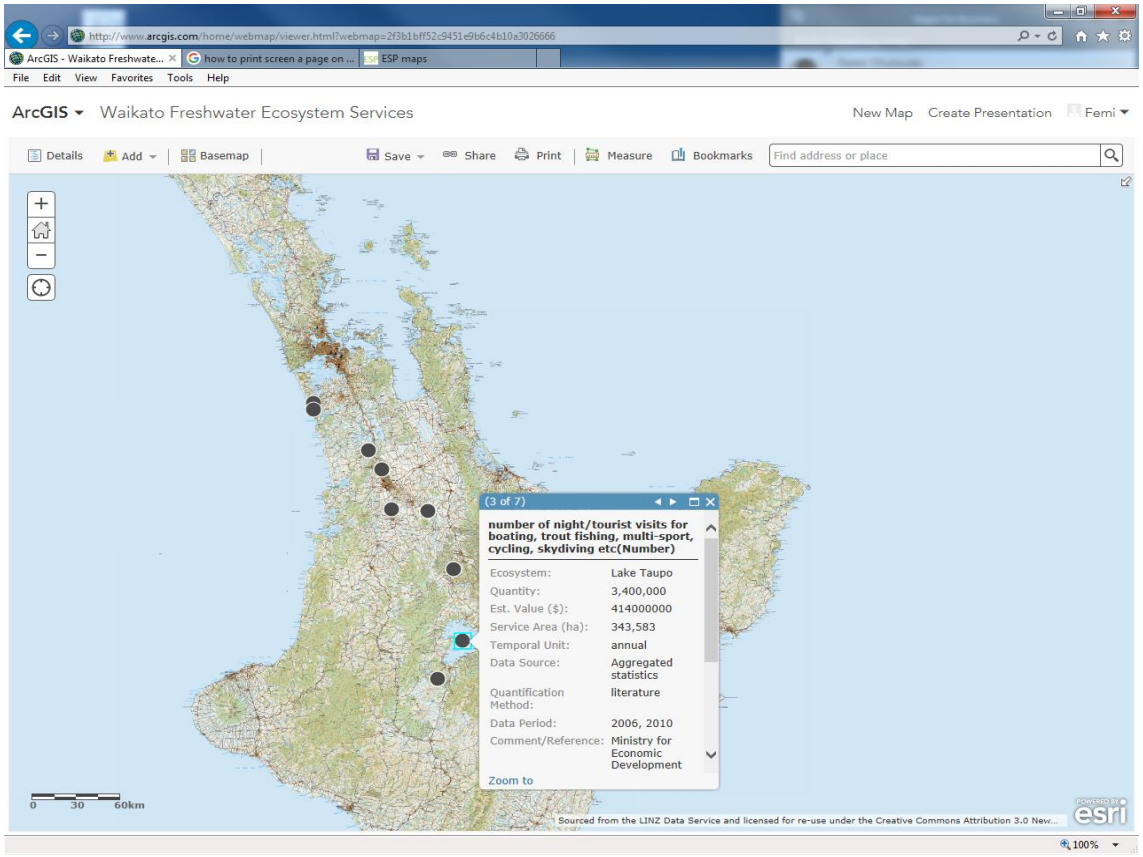

Figure 7: Web-map showing an indicator of number of night/tourist visit in the Lake Taupō

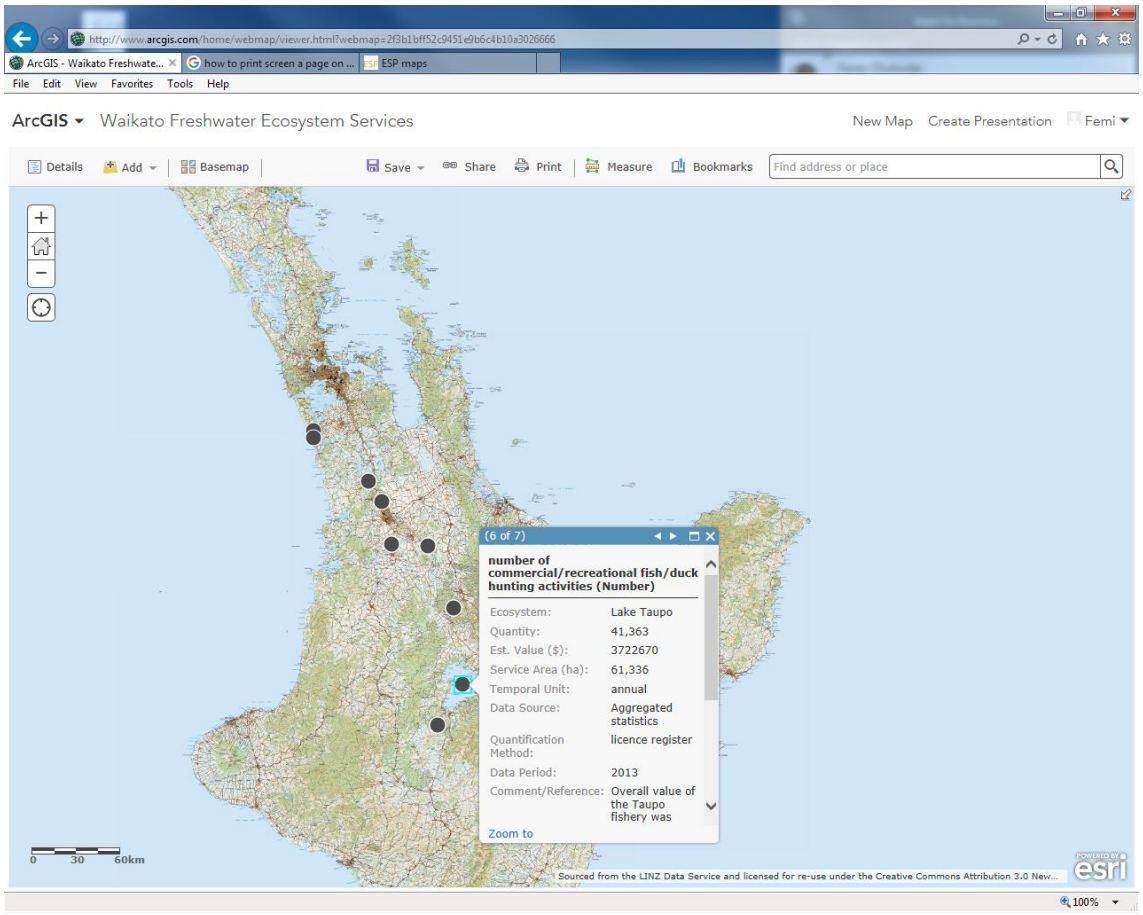

Figure 8: Web-map showing an indicator of hunting in the Lake Taupō

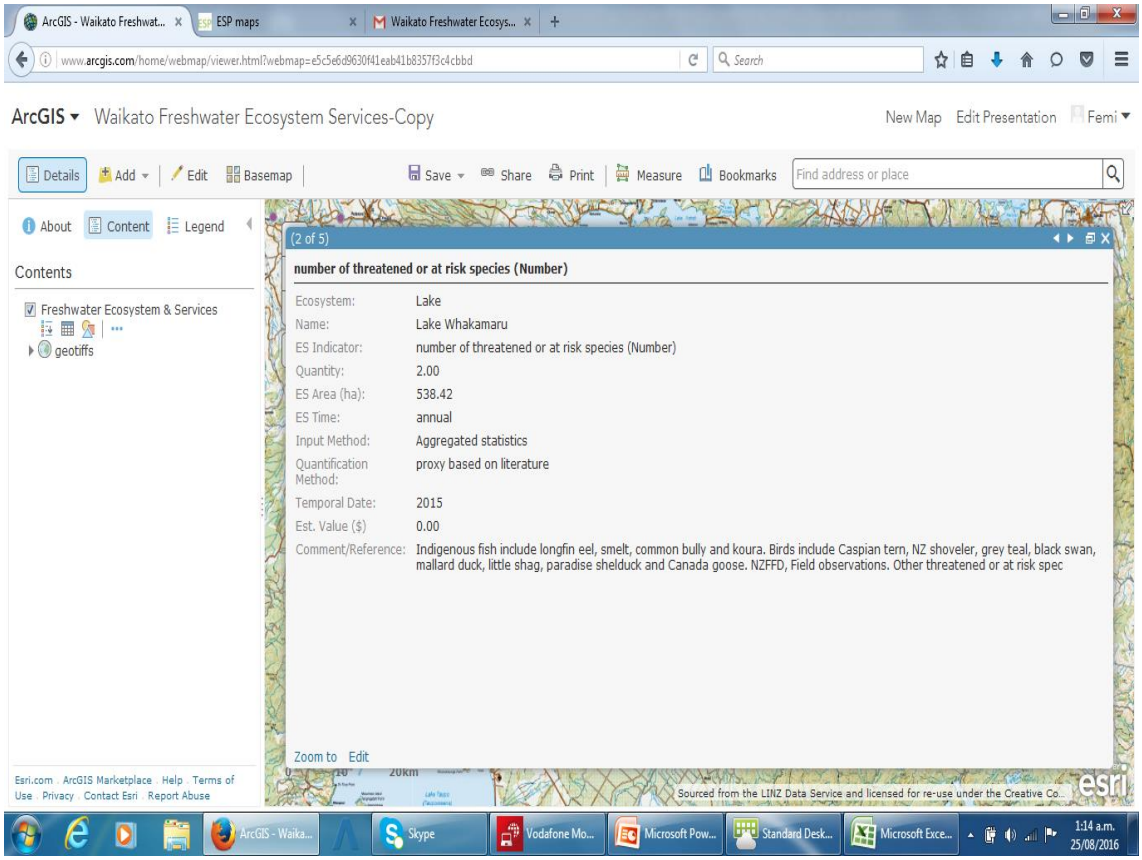

Figure 9: Web-map showing an indicator of number of at risk or threatened species being provided with habituated in the Lake Whakamaru

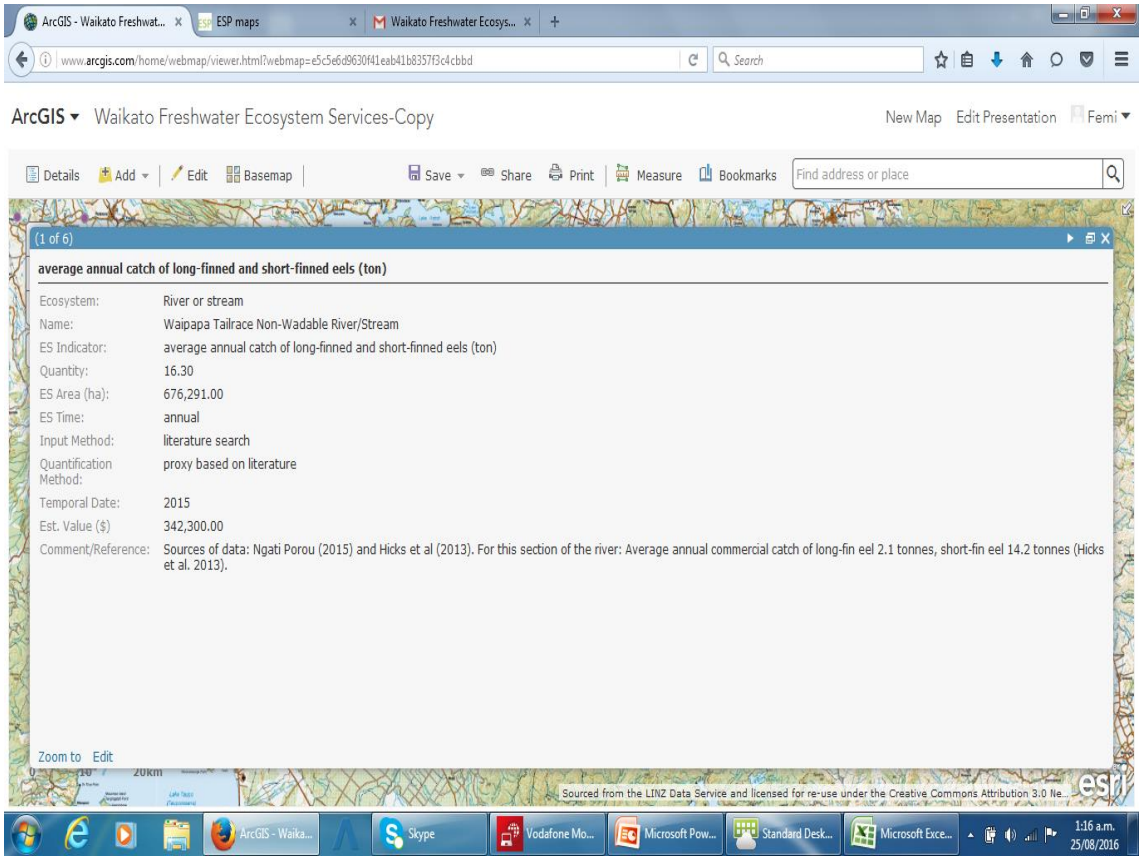

Figure 10: Web-map showing an indicator of long-fined and short-fined eels catch in the Waipapa Tailrace River

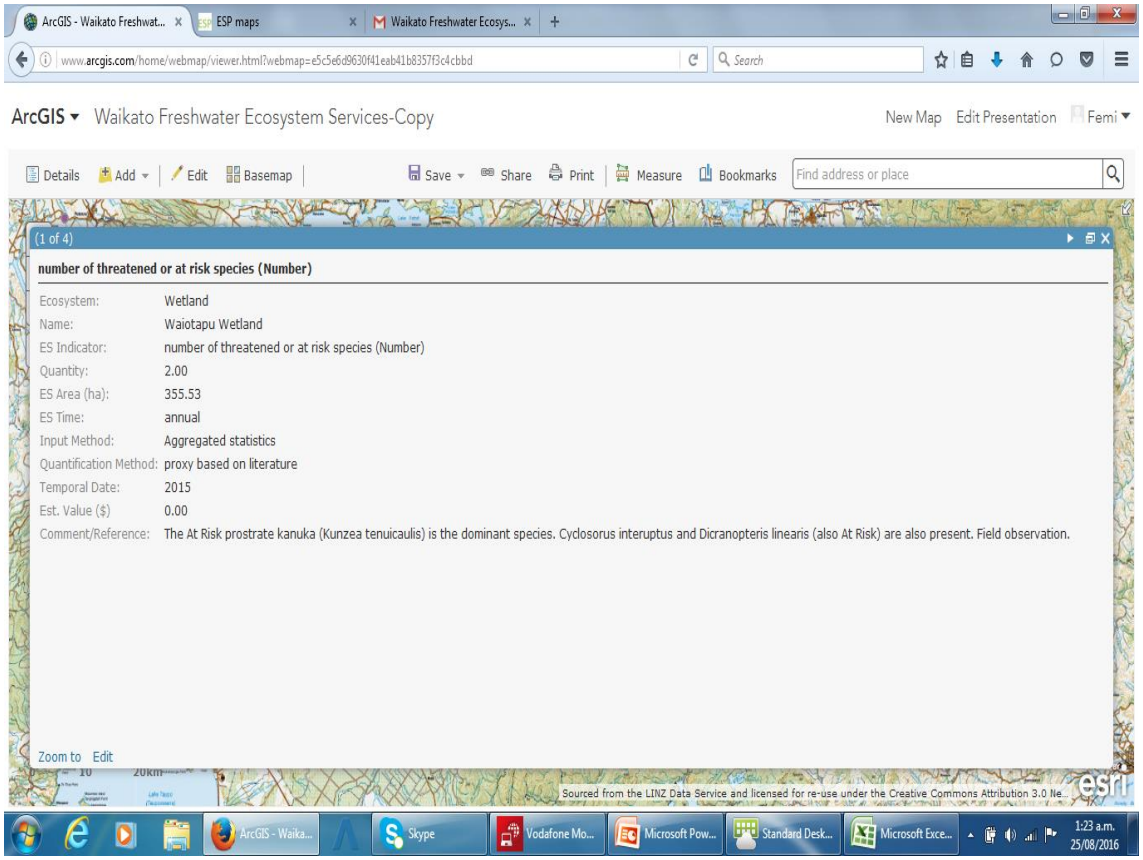

Figure 11: Web-map showing an indicator of at risk or threatened species having habitat in the Waiotapu Wetland

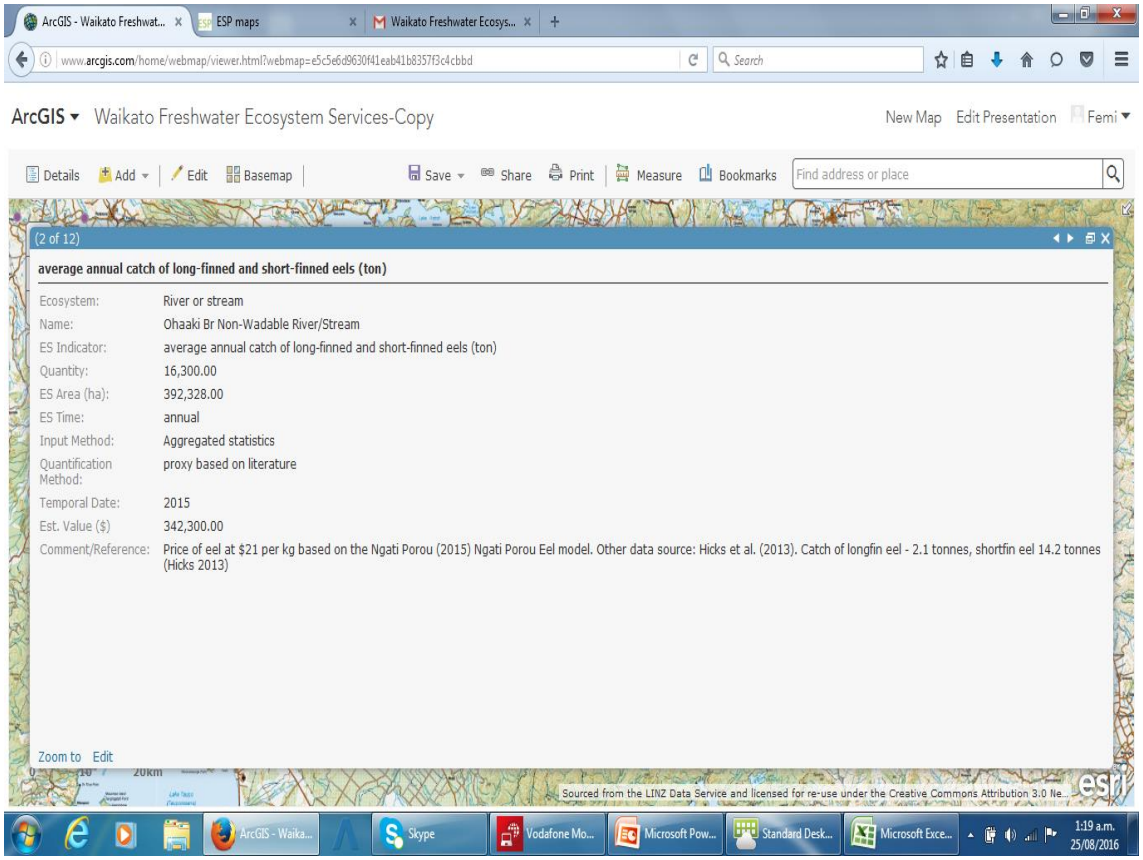

Figure 12: Web-map showing an indicator of long-fined and short-fined eel catch in the Ohaaki Bridge River

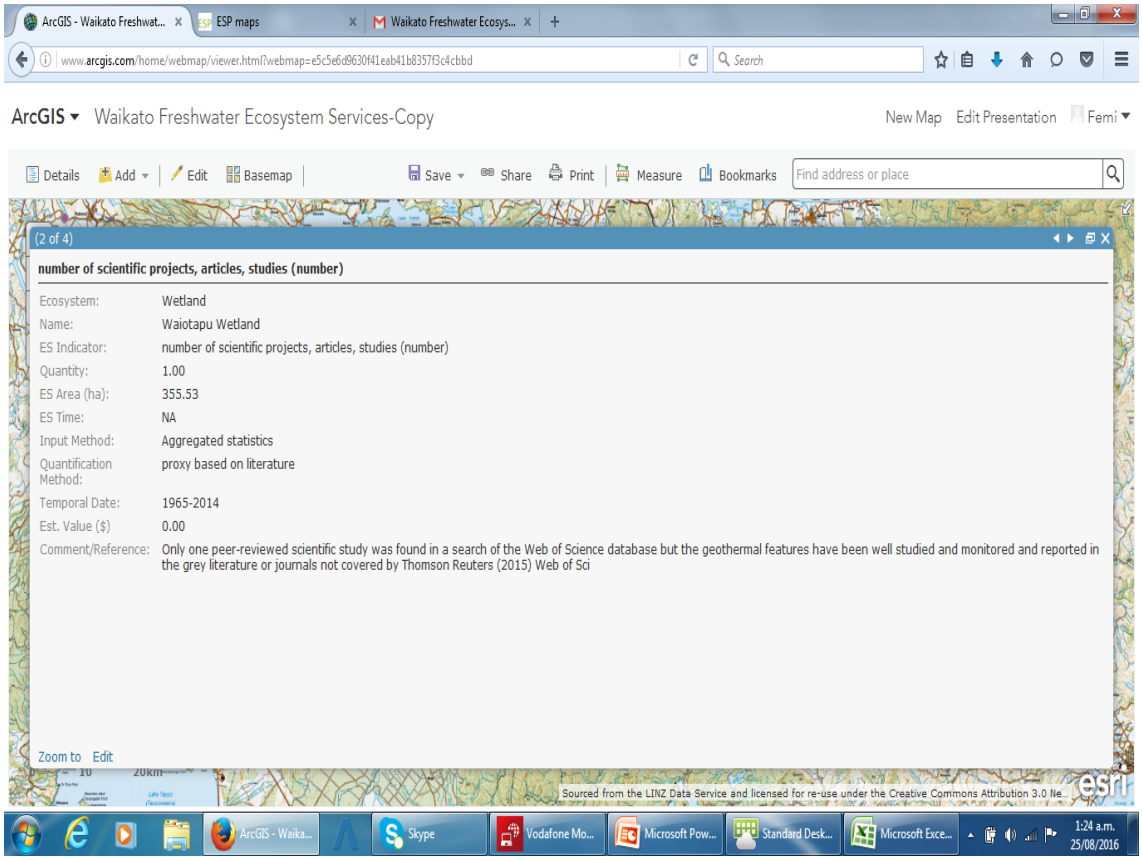

Figure 13: Web-map showing an indicator of scientific projects, articles and studies being carried out using the Waiotapu Wetland

6 Conclusion and recommendations

6.1 Conclusions

In this study, the Millennium Ecosystem Assessment (2005) has been applied with expert judgement to identify the presence of ecosystem services and to quantify the service. Dollar values were also assigned where practicable. We have used the fresh water ecosystem service concepts to characterise the region's fresh water resources. This is an advancement of Council's work programme to better understand and account for natural resources in the region. The first phase of this project has focused on the fresh water ecosystems namely rivers, streams, wetlands and lakes of the Waikato-Waipā catchment.

Scaling the field data to catchment level provides a significant conceptual problem, so the estimates are based on where there were enough data to approximate the values. This project benefits from a high level of professional expertise both within the organisation, and from independent consultants and research professionals. It is recognised that the data are likely to contain estimation and proxy bias, so are non-prescriptive. They are nevertheless considered to be a good starting point for appreciating the services from the environment. The database and the maps provide opportunities for discussion and further research work to establish more accurate and useful information to inform policy on natural resource management. Another application will include climate change mitigation and adaptation strategies and guiding the development of a regional offsetting programmes.

6.2 Recommendations

The fieldwork reports contain their own direct recommendations. These recommendations are valid and will be useful areas to explore in ongoing work. This work programme should incorporate the concepts of ecosystem services in the state of the environment monitoring such that the states of the resources and changes in trends are monitored along with the services they provide.

Since the concepts and frameworks for assessing ecosystem services are still being developed, it is recommended that the Council consistently develop this programme of work as this approach is promising as a long term solution to the issues critical to the region. These issues include nutrient use management and the associated challenges of setting objectives and limits on resource use in collaboration with stakeholders. This approach will also provide vital information to inform the region's biodiversity strategy and spatial plan. These are evidence based education materials for land managers taking the perspective of ecosystem services and wider benefits of conservation practices, rather than focusing on biodiversity issues and reactions to those issues. This type of work, with the information presented here, is a useful evidence base with which to engage land managers in discussions on setting outcomes of ecosystem services and biodiversity.

6.3 Limitations of the study and future work areas

It is acknowledged that this study is not a full ecological impact assessment, as the framework being applied is strictly within the concept of ecosystem assessment rather than the guidelines and framework provided by the Environmental Institute of Australia and New Zealand (EIANZ) detailed in the EIANZ (2015). However, the monitoring programmes that generated the biophysical data, and the published national and regional databases being used in this study were assumed to have complied with those guidelines.

Also, the expertise of the ecological scientists involved in the study has been a key part of this study. This project is a first phase in a proposed work programme. In the second phase, the plan is to study the trends in supply of ecosystem services *vis-a-vis* demand. However, a regular

exercise or part of further work would be an iterative process of data collection, analysis, review and refinement.

In this study, we have not gone into the argument about the differences between the terms and concepts of benefits, services, ecological functions, and ecological structures and processes that underpin the links between natural capital and human well-being, although an attempt was made in recognising the fourth category of ecosystem services, supporting services which some literature regards as intermediate services. We have rather focused on a utilitarian perspective of the obvious benefits that people directly or indirectly enjoy from ecosystems. These are things that can be valued either in monetary or social terms. This limitation may have implications for double counting, overestimation or underestimation in some instances.

This study has also refrained from laying emphasis on cultural values as described in the general literature because this may not directly apply to the local people who benefit from the ecosystems. This is simply because while some ecosystems obviously and directly provide some cultural services, different groups might attach different values to those benefits. Future research should address the specific values of tangata whenua in the region.

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Appendices

Appendix A: Ecosystem Services Indicators

Table A1: Indicators/data for measuring condition/status of Lake fresh water ecosystems and quantity of their services

MEA Classification[4]	Division[5]	Group/Product[6]	Class[7]	Indicators of data to be collected	Class type[8]	Examples[9]
Provisioning	Nutrition	Biomas	Wild plants, algae and their outputs	● Wild plants used in gastronomy, cosmetic, pharmaceutical uses (data on industries collecting the plants)	*Plants, algae by amount, type*	Wild berries, fruits, mushrooms, water cress, salicornia (saltwort or samphire); seaweed (e.g. Palmaria palmata = dulse, dillisk) for food
			Wild animals and their outputs	● Fish production (catch in tonnes by commercial and recreational fisheries) ● Number of fisherman and hunters of waterfowls (anglers, professional and amateur fishermen) ● Status of fish population (Species composition, Age Structure, Biomass (kg/ha)	*Animals by amount, type*	Game, fresh water fish (trout, eel etc.), marine fish (plaice, sea bass etc.) and shellfish (i.e. crustaceans, molluscs), as well as equinoderms or honey harvested from wild populations; Includes commercial and subsistence fishing and hunting for food
			Animals from in-situ aquaculture	● Fresh water aquaculture production (e.g. sturgeon and caviar production)		In-situ farming of fresh water (e.g. trout) and marine fish (e.g. salmon, tuna) also in floating cages; shellfish aquaculture (e.g. oysters or crustaceans) in e.g. poles
		Water	Surface water for drinking (Water Exploitation Index)	●Water consumption for drinking ● Surface water availability ● Water abstracted	*By amount, type*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for drinking (This include nutrition and non-nutrition elements)
	Materials	Water	Surface water for non-drinking purposes (Water Exploitation Index)	● Water use per sector ● Surface water availability ● Water abstracted ● Volume of water bodies	*By amount, type and use*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.
Regulating services	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	● Indicators on water quality (microbiological data for bathing waters, BOD5 nitrate concentration, phosphate	*By amount, type, use, media (land, soil, fresh water, marine)*	Bio-chemical detoxification/decomposition/mineralisation in land/soil, fresh water and marine systems including sediments;

Footnotes apply to Tables A1-A3

[4] This column lists the three main categories of ecosystem services
[5] This column divides section categories into main types of output or process
[6] The group level splits division categories by biological, physical or cultural type or process
[7] The class level provides a further sub-division of group categories into biological or material outputs and bio-physical and cultural processes that can be linked back to concrete identifiable service sources
[8] Class types break the class categories into further individual entities and suggest ways of measuring the associated ecosystem service output
[9] Note: this section is not complete and for illustrative purposes only. Key components could change by region or ecosystem

				concentration, oxygen conditions, saprobiological status) ● Nutrient loads ● Ecological status ● Trophic status ● Area occupied by riparian forests		decomposition/detoxification of waste and toxic materials e.g. waste water cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation etc.
			Filtration/sequestration/storage/ accumulation by micro-organisms, algae, plants, and animals	● Number and efficiency of treatment plants		Biological filtration/sequestration/storage/accumulation of pollutants in land/soil, fresh water and marine biota, adsorption and binding of heavy metals and organic compounds in biota
		Mediation by ecosystem	Filtration/sequestration/storage/ accumulation by ecosystems	● Waste treated		Bio-physicochemical filtration/sequestration/storage/accumulation of pollutants in land/soil, fresh water and marine ecosystems, including sediments; adsorption and binding of heavy metals and organic compounds in ecosystems (combination of biotic and abiotic factors)
	Mediation of flows	Mass flows	Buffering and attenuation of mass flows	● Sediment retention	*By reduction in risk, area protected*	Erosion / landslide / gravity flow protection; vegetation cover protecting/stabilising terrestrial, coastal and marine ecosystems, coastal wetlands, dunes; vegetation on slopes also preventing avalanches (snow, rock), erosion protection of coasts and sediments by mangroves, sea grass, macroalgae, etc.
		Liquid flow	Hydrological cycle and water flow maintenance	Hydrological flow data	*By depth/volumes*	Capacity of maintaining baseline flows for water supply and discharge; e.g. fostering groundwater; recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects.
			Flood protection	● Holding capacity flood risk maps ● Conservation of river and lakes banks	*By reduction in risk, area protected*	Flood protection by appropriate land coverage; coastal flood prevention by mangroves, sea grass, macroalgae, etc. (supplementary to coastal protection by wetlands, dunes)
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	● Biodiversity value (Species diversity or abundance, endemics or red list species and spawning location) ● Ecological status Morphological status	*By amount and source*	Habitats for plant and animal nursery and reproduction e.g. seagrasses, microstructures of rivers etc.
		Pest and disease control	Pest control	● Alien species (Introduced riparian and aquatic plants ● Number of introduced aquatic invertebrates	*By reduction in incidence, risk, area protected*	Pest and disease control including invasive alien species

				● Number of introduced vertebrates in rivers and riparian areas		
		Soil formation and composition	Weathering processes	● Fluvisols surface	*By amount/concentration and source*	Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure; includes biological, chemical, physical weathering and pedogenesis
		Water conditions	Chemical condition of fresh waters	● Chemical status ● Ecological status		Maintenance / buffering of chemical composition of fresh water column and sediment to ensure favourable living conditions for biota e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.
		Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	● C sequestration (Annual increase) ● Carbon sequestration in living biomass of riparian forest ● Carbon sequestered by plantations of *Populus* ● Organic carbon stored in fluvisols)	*By amount, concentration or climatic parameter*	Global climate regulation by greenhouse gas/carbon sequestration by terrestrial ecosystems, water columns and sediments and their biota; transport of carbon into oceans (DOCs) etc.
Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Experimental use of plants, animals and land/seascapes in different environmental settings	● Number of visitors (to National Parks including lakes or rivers) ● National Parks ● Known bird watching sites Waterfowl	*By visits/use data, plants, animals, ecosystem type*	In-situ whale and bird watching, snorkelling, diving etc.
			Physical use of land-/seascapes in different environmental settings	● Number of visitors ● bathing areas and Number beaches ● Fishing reserves ● Fish abundance ● Fish monetary value from angling, ● Number fishing licenses, ● Quality of fresh waters for fishing		In-situ whale and bird watching, snorkelling, diving etc.
		Intellectual and representative interactions	Scientific	● Monitoring sites (by scientists) ● Number of scientific projects, articles, studies ● Classified sites (world heritage)		Subject matter for research both on location and via other media
			educational	● Number of visitors ● National Parks		Subject matter for research both on location and via other media
			Heritage, cultural	● Number of visitors ● Natural heritage and cultural sites ● Number of annual cultural activities organised		Subject matter for research both on location and via other media

			Entertainment	● Number of visitors (surface or number of wetlands located next to a bike path)		Ex-situ viewing/experience of natural world through different media
			Aesthetic	● Number of visitors ● Contrasting landscapes (lakes close to mountains) ● Proximity to urban areas of scenic rivers or lakes		Sense of place, artistic representations of nature
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	● National species or habitat types	*By use, plants, animals, ecosystem type*	Emblematic plants and animals e.g. national symbols such as American eagle, British rose, Welsh daffodil
			Sacred and/or religious	● sacred/religious sites (catastrophic events, religious places)		Spiritual, ritual identity e.g. 'dream paths' of native Australians, holy places; sacred plants and animals and their parts
		Other cultural outputs	Existence	● Number of visitors (to National Parks including lakes) ● Number of fishing licenses	*By plants, animals, feature/ecosystem type or component*	Enjoyment provided by wild species, wilderness, ecosystems, land-/seascapes
			bequest	● Number of association registered on animals, plants, environment, naturism		Willingness to preserve plants, animals, ecosystems, land-/seascapes for the experience and use of future generations; moral/ethical perspective or belief

Table A2: Indicators/data for measuring condition/status of Wetlands fresh water ecosystems and quantity of their services

MEA Classification	Division	Group/Product	Class	Indicators of data to be collected	Class type	Examples
Provisioning	Nutrition	Biomas	Wild plants, algae and their outputs	● Wild plants used in gastronomy, cosmetic, pharmaceutical uses (data on industries collecting the plants)	*Plants, algae by amount, type*	Wild berries, fruits, mushrooms, water cress, salicornia (saltwort or samphire); seaweed (e.g. Palmaria palmata = dulse, dillisk) for food
			Wild animals and their outputs	● Fish production (catch in tonnes by commercial and recreational fisheries) ● Number of fisherman and hunters of waterfowls (anglers, professional and amateur fishermen) ● Status of fish population (Species composition, Age Structure, Biomass (kg/ha)	*Animals by amount, type*	Game, fresh water fish (trout, eel etc.), marine fish (plaice, sea bass etc.) and shellfish (i.e. crustaceans, molluscs), as well as equinoderms or honey harvested from wild populations; Includes commercial and subsistence fishing and hunting for food
		Water	Surface water for drinking (Water Exploitation Index)	● Nitrate-vulnerable zones	*By amount, type*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for drinking
	Materials	Biomas	Fibres and other materials from plant, algae and animals for direct us or processing	● Wood produced (tons or volume) by riparian forest ● Surface of exploited wet forests (e.g. poplars) and reeds	*Material by amount, type, use, media (land, soil, fresh water, marine)*	Fibres, wood, timber, flowers, skin, bones, sponges and other products, which are not further processed; material for production e.g. industrial products such as cellulose for paper, cotton for clothes, packaging material; chemicals extracted or synthesised from algae, plants and animals such as turpentine, rubber, flax, oil, wax, resin, soap (from bones), natural remedies and medicines (e.g. chondritin from sharks), dyes and colours, ambergris (from sperm whales used in perfumes); Includes consumptive ornamental uses.
		water	Surface water for drinking (Water Exploitation Index)	● Surface of flood-prone areas	*By amount, type and use*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.
	Energy	Bioma-based energy sources	Plant-based resources	● Firewood produced by riparian forests		Wood fuel, straw, energy plants, crops and algae for burning and energy production
Regulating services	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	● Carbon storage per unit of area	*By amount, type, use, media (land, soil, fresh water, marine)*	Bio-chemical detoxification/decomposition/mineralisation in land/soil, fresh water and marine systems including sediments; decomposition/detoxification of waste and toxic materials e.g. waste water

						cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation etc.
			Filtration/sequestration/storage/ accumulation by micro-organisms, algae, plants, and animals	● Potential mineralization or decomposition		Biological filtration/sequestration/storage/accumulation of pollutants in land/soil, fresh water and marine biota, adsorption and binding of heavy metals and organic compounds in biota
			Filtration/sequestration/storage/ accumulation by ecosystems	● Ecological status ● Nutrient concentration ●Nutrient retention		Bio-physicochemical filtration/sequestration/storage/accumulation of pollutants in land/soil, fresh water and marine ecosystems, including sediments; adsorption and binding of heavy metals and organic compounds in ecosystems (combination of biotic and abiotic factors)
	Mediation of flows	Mass flow	Buffering and attenuation of mass flows	● Sediment retention	*By reduction in risk, area protected*	Transport and storage of sediment by rivers, lakes, sea
		Liquid flow	Hydrological cycle and water flow maintenance	Surface of wetlands	*By depth/volumes*	Capacity of maintaining baseline flows for water supply and discharge; e.g. fostering groundwater; recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects.
			Flood protection	● Water holding capacity of soils ● Floodplains areas (and records of annual floods) ● Area of wetlands located in flood risk zones ● Conservation status of riparian wetlands	*By reduction in risk, area protected*	Flood protection by appropriate land coverage; coastal flood prevention by mangroves, sea grass, macroalgae, etc. (supplementary to coastal protection by wetlands, dunes)
		Gaseous/air flows	Storm protection	● Conservation status of wetlands Area of wetlands Vegetation cover?		Natural or planted vegetation that serves as shelter belts
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	Beekeeping value of wetlands	*By amount and source*	Pollination by bees and other insects; seed dispersal by insects, birds and other animals
			Maintaining nursery populations and habitats	Biodiversity value?		Habitats for plant and animal nursery and reproduction e.g. seagrasses, microstructures of rivers etc.
		Soil formation and composition	Pest control	● Alien species (Introduced riparian and aquatic plants ● Number of introduced aquatic invertebrates ● Number of introduced vertebrates in rivers and riparian areas	*By reduction in incidence, risk, area protected*	Pest and disease control including invasive alien species
			Weathering processes	● Hydromorphic soils (Presence/absence) Surface of floodplains	*By amount/concentration and source*	Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure;

						includes biological, chemical, physical weathering and pedogenesis
			Decomposition and fixing processes	• Potential mineralization, decomposition, etc.		Maintenance of bio-geochemical conditions of soils by decomposition/mineralisation of dead organic material, nitrification, denitrification etc.), N-fixing and other bio-geochemical processes;
		Water conditions	Chemical condition of fresh waters	• Chemical status • Ecological status • Potential of water purification of wetlands		Maintenance / buffering of chemical composition of fresh water column and sediment to ensure favourable living conditions for biota e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.
		Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	• C sequestration (Annual increase) • Carbon sequestration in living biomass of riparian forest • Carbon sequestered by plantations of *Populus* • Organic carbon stored in fluvisols)	*By amount, concentration or climatic parameter*	Global climate regulation by greenhouse gas/carbon sequestration by terrestrial ecosystems, water columns and sediments and their biota; transport of carbon into oceans (DOCs) etc.
Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings)	Physical and experimental interactions	Experimental use of plants, animals and land/seascapes in different environmental settings	• Number of visitors (waterfowl hunters and fishermen • Visitors to National Parks or protected areas including wetlands) • Known bird watching sites • Waterfowl • Tourism revenue	*By visits/use data, plants, animals, ecosystem type*	In-situ whale and bird watching, snorkelling, diving etc.
			Physical use of land-seascapes in different environmental settings	• Number of visitors (waterfowl hunters and fishermen) • Number of fishing licenses • Tourism revenue		In-situ whale and bird watching, snorkelling, diving etc.
		Intellectual and representative interactions	Scientific	• Monitoring sites (by scientists) • Number of scientific projects, articles, studies • Classified sites (world heritage)	*By use/citation, plants, animals, ecosystem type*	Subject matter for research both on location and via other media
			educational	• Number of visitors • National Parks		Subject matter of education both on location and via other media
			Heritage, cultural	• Number of visitors • Natural heritage and cultural sites • Number of annual cultural activities organised		Historic records, cultural heritage e.g. preserved in water bodies and soils
			Entertainment	• Number of visitors (surface or number of wetlands located next to a bike path); Geothemal tourism		Ex-situ viewing/experience of natural world through different media
			aesthetic	• Number of visitors • Contrasting landscapes (lakes close to mountains); Geo-diversity • Proximity to urban areas of scenic rivers or lakes		Sense of place, artistic representations of nature
	Spiritual, symbolic and other interactions with	Spiritual and/or emblematic	Symbolic	• National species or habitat types	*By use, plants, animals, ecosystem type*	Emblematic plants and animals e.g. national symbols such as American eagle, British rose, Welsh daffodil

	biota, ecosystems, and land-/seascapes [environmental settings]		Sacred and/or religious	● sacred/religious sites (catastrophic events, religious places)		Spiritual, ritual identity e.g. 'dream paths' of native Australians, holy places; sacred plants and animals and their parts
		Other cultural outputs	Existence	● Number of visitors (to National Parks including lakes) ● Number of fishing licenses	*By plants, animals, feature/ecosystem type or component*	Enjoyment provided by wild species, wilderness, ecosystems, land-/seascapes
			bequest	● Number of association registered on animals, plants, environment, naturism Social perception of wetlands		Willingness to preserve plants, animals, ecosystems, land-/seascapes for the experience and use of future generations; moral/ethical perspective or belief

Table A3: Indicators/data for measuring condition/status of Rivers and Streams fresh water ecosystems and quantity of their services

MEA Classification	Division	Group/Product	Class	Indicators of data to be collected	Class type	Examples
Provisioning	Nutrition	Biomas	Wild plants, algae and their outputs	● Wild plants used in gastronomy, cosmetic, pharmaceutical uses (data on industries collecting the plants)	*Plants, algae by amount, type*	Wild berries, fruits, mushrooms, water cress, salicornia (saltwort or samphire); seaweed (e.g. Palmaria palmata = dulse, dillisk) for food
			Wild animals and their outputs	● Fish production (catch in tonnes by commercial and recreational fisheries) ● Number of fisherman and hunters of waterfowls (anglers, professional and amateur fishermen) ● Status of fish population (Species composition, Age Structure, Biomass (kg/ha)	*Animals by amount, type*	Game, fresh water fish (trout, eel etc.), marine fish (plaice, sea bass etc.) and shellfish (i.e. crustaceans, molluscs), as well as equinoderms or honey harvested from wild populations; Includes commercial and subsistence fishing and hunting for food
			Animals from in-situ aquaculture	● Fresh water aquaculture production (e.g. sturgeon and caviar production)	*Animals by amount, type*	In-situ farming of fresh water (e.g. trout) and marine fish (e.g. salmon, tuna) also in floating cages; shellfish aquaculture (e.g. oysters or crustaceans) in e.g. poles
			Plants and algae from in-situ aquaculture		*Plants, algae by amount, type*	In situ seaweed farming
		Water	Surface water for drinking (Water Exploitation Index)	●Water consumption for drinking ● Surface water availability ● Water abstracted	By amount and type	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for drinking *(Note: This include nutrition and non-nutrition elements)*
	Materials	Water	Surface water for non-drinking purposes (Water Exploitation Index)	● Water use per sector ● Surface water availability ● Water abstracted ● Volume of water bodies		
Regulating services	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	● Indicators on water quality (microbiological data for bathing waters, BOD5 nitrate concentration, phosphate concentration, oxygen conditions, saprobiological status) ● Nutrient loads ● Ecological status ● Trophic status ● Area occupied by riparian forests	*By amount, type, use, media (land, soil, fresh water, marine)*	Bio-chemical detoxification/decomposition/mineralisation in land/soil, fresh water and marine systems including sediments; decomposition/detoxification of waste and toxic materials e.g. waste water cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation etc.
		Mediation by ecosystem	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	● Number and efficiency of treatment plants	*By amount, type, use, media (land, soil, fresh water, marine)*	Biological filtration/sequestration/storage/accumulation of pollutants in land/soil, fresh water and marine biota, adsorption and binding of heavy metals and organic compounds in biota
			Filtration/sequestration/storage/accumulation by ecosystems	● Waste treated		
	Mediation of flows	Mass flows	Buffering and attenuation of mass flows	● Sediment retention	*By reduction in risk, area protected*	Transport and storage of sediment by rivers, lakes, sea

MEA Classification	Division	Group/Product	Class	Indicators of data to be collected	Class type	Examples
		Liquid flow	Hydrological cycle and water flow maintenance	Hydrological flow data	*By depth/volumes*	Capacity of maintaining baseline flows for water supply and discharge; e.g. fostering groundwater; recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects.
			Flood protection	● Holding capacity flood risk maps ● Conservation of river and lakes banks	*By reduction in risk, area protected*	Flood protection by appropriate land coverage; coastal flood prevention by mangroves, sea grass, macroalgae, etc. (supplementary to coastal protection by wetlands, dunes)
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	● Biodiversity value (Species diversity or abundance, endemics or red list species and spawning location) ● Ecological status Morphological status	*By amount and source*	Habitats for plant and animal nursery and reproduction e.g. seagrasses, microstructures of rivers etc.
		Pest and disease control	Pest control	● Alien species (Introduced riparian and aquatic plants ● Number of introduced aquatic invertebrates ● Number of introduced vertebrates in rivers and riparian areas	*By reduction in incidence, risk, area protected*	Pest and disease control including invasive alien species
		Soil formation and composition	Weathering processes	● Fluvisols surface	*By amount/concentration and source*	Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure; includes biological, chemical, physical weathering and pedogenesis
		Water conditions	Chemical condition of fresh waters	● Chemical status ● Ecological status	*By amount/concentration and source*	Maintenance / buffering of chemical composition of fresh water column and sediment to ensure favourable living conditions for biota e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.
		Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	● C sequestration (Annual increase) ● Carbon sequestration in living biomass of riparian forest ● Carbon sequestered by plantations of *Populus* ● Organic carbon stored in fluvisols)	*By amount, concentration or climatic parameter*	Global climate regulation by greenhouse gas/carbon sequestration by terrestrial ecosystems, water columns and sediments and their biota; transport of carbon into oceans (DOCs) etc.
Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Experimental use of plants, animals and land/seascapes in different environmental settings	● Number of visitors (to National Parks including lakes or rivers) ● National Parks ● Known bird watching sites Waterfowl	*By visits/use data, plants, animals, ecosystem type*	In-situ whale and bird watching, snorkelling, diving etc.
			Physical use of land-/seascapes in different environmental settings	● Number of visitors ● bathing areas and Number beaches ● Fishing reserves ● Fish abundance ● Fish monetary value from angling ● Number fishing licenses ● Quality of fresh waters for fishing		Walking, hiking, climbing, boating, leisure fishing (angling) and leisure hunting
		Intellectual and representative interactions	Scientific	● Monitoring sites (by scientists) ● Number of scientific projects, articles, studies ● Classified sites (world heritage)	*By use/citation, plants, animals, ecosystem type*	Subject matter for research both on location and via other media
			educational	● Number of visitors ● National Parks		Subject matter of education both on location and via other media

MEA Classification	Division	Group/Product	Class	Indicators of data to be collected	Class type	Examples
			Heritage, cultural	• Number of visitors • Natural heritage and cultural sites • Number of annual cultural activities organised		Historic records, cultural heritage e.g. preserved in water bodies and soils
			Entertainment	• Number of visitors (surface or number of wetlands located next to a bike path)		Ex-situ viewing/experience of natural world through different media
			aesthetic	• Number of visitors • Contrasting landscapes (lakes close to mountains) • Proximity to urban areas of scenic rivers or lakes		Sense of place, artistic representations of nature
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	• National species or habitat types	*By use, plants, animals, ecosystem type*	Emblematic plants and animals e.g. national symbols such as American eagle, British rose, Welsh daffodil
			Sacred and/or religious	• sacred/religious sites (catastrophic events, religious places)		Spiritual, ritual identity e.g. 'dream paths' of native Australians, holy places; sacred plants and animals and their parts
		Other cultural outputs	Existence	• Number of visitors (to National Parks including lakes) • Number of fishing licenses	*By plants, animals, feature/ecosystem type or component*	Enjoyment provided by wild species, wilderness, ecosystems, land-/seascapes
			bequest	• Number of association registered on animals, plants, environment, naturism		Willingness to preserve plants, animals, ecosystems, land-/seascapes for the experience and use of future generations; moral/ethical perspective or belief

Notes apply to Tables A1-A3

Source: *Adapted from Hart, Rutledge and Greenhalgh (2013) & European Union (2014)*

Note:

- • Green bullet — *indicator/data easily available and easily understood by non-technical audiences*
- • Yellow bullet — *indicator/data easily available but less easy to understand by non-technical audiences*
- • Red bullet: — *indicator/data easily available but not easy to understand by non-technical audiences*
- • Grey bullet — *indicator/data not sure of available and/or not sure of ease to understand by non-technical audiences*
- Red print — *indicator/data being proposed and may not be readily available*
- Numbered — *The numbered indicators are related to geo-thermal bores*

There is overlapping in the use of indicators - one indicator can be used for more than one ecosystem so also for more than one service

Some services have more than one indicator. Some indicators cannot be used as a standalone to assess a service

Appendix B: Sampled sites (Ecosystems)

Table B: Sampled sites (ecosystems)

N	ID	Name	Address	NZMG		
				Easting	Northing	
	Headwater/Wadeable streams (orders 1-3)					
1	240_5	KAWAUNUI STM	SH5 BR	2802100	6308100	RERIMP + REMS
2	1323_1	WHIRINAKI STM	CORBETT RD	2795702	6317097	RERIMP + REMS
3	786_2	POKAIWHENUA STM	ARAPUNI - PUTARURU RD	2749051	6345843	RERIMP + REMS
4	398_1	MANGAKOTUKUTUKU STM (RUKUHIA)	PEACOCKES RD	2712745	6374200	RERIMP + REMS
5	477_14/10	MANGAUIKA STM	TE AWAMUTU BOROUGH W/S INTAKE	2697800	6350300	RERIMP + REMS
6	*1888_4*	*OTAUTORA STM*	*INSIDE MAUNGATAUTARI ENCLOSURE*	*2736681*	*6346017*	*REMS REFERENCE*
7	*379_1*	*MANGAKARA STM (PIRONGIA)*	*BUSHLINE*	*2699203*	*6357477*	*REMS REFERENCE - requested to be replaced with exotic forest*
8	*458_1*	*MANGATAWAI STM*	*OFF SH1 U/S BRIDGE*	*2748969*	*6223909*	*REMS REFERENCE*
9	*1132_67*	*WAIKATO RIVER TRIB*	*TUAKAU/PORT WAIKATO RD 2.2 KM EAST PORT*	*2665837*	*6423399*	*REMS REFERENCE*
10	*1968_1*	*WHAKAKAI STREAM*	*WHATAWHATA RESEARCH STATION*	*2692600*	*6378500*	*REMS REFERENCE*
11 or 7	*477_17*	*MANGAUIKA STM*	*UPSTREAM OF WATER TREATMENT PLANT*	*2699405*	*6350244*	*REMS in exotic forest*
12 or 7	*582_12*	*NGUTUNUI STM*	*SH3 PIRONGIA*	*2696400*	*6342800*	*REMS in exotic forest*
Waikato River (non wadeable)						
1	1131_64	HAMILTON TRAFFIC BR	Hamilton Traffic Bridge, Bridge Street, Hamilton	2711800	6376400	WARIMP
2	1131_69	HOROTIU BR	Horotiu Bridge	2704815	6387066	WARIMP routine
3	1131_77	HUNTLY-TAINUI BR	Huntly-Tainui Bridge	2700546	6401768	WARIMP routine
4	1131_91	MERCER BR	Mercer Bridge/Recorder	2691787	6433612	WARIMP routine
5	1131_101	NARROWS BR	Narrows Bridge	2716814	6370783	WARIMP routine
6	1131_105	OHAAKI BR	Ohaaki Bridge	2798071	6291450	WARIMP routine
7	1131_107	OHAKURI TAILRACE BR	Ohakuri Tailrace Bridge	2779596	6306083	WARIMP routine
8	1131_127	TAUPŌ CONTROL GATES	Taupō Gates	2777133	6275733	WARIMP routine
9	1131_133	TUAKAU BR	Tuakau Bridge	2682750	6432184	WARIMP routine
10	1131_143	WAIPAPA TAILRACE		2745012	6320697	WARIMP routine
11	1131_147	WHAKAMARU TAILRACE		2755134	6305593	WARIMP routine
12	1131_117	RANGIRIRI BR	Rangiriri Bridge	2698700	6416700	WARIMP routine
13	*476_7*	*MANGATUTU STM (WAIKERIA)*	*WALKER RD BR*	*2720300*	*6342200*	*WARIMP Waipā Catchment*
Wetlands						
1	5295	Whangamarino wetland		2699723	6428580	FENZ WL Site
2	5296	Waikato river wetland		2671774	6431916	FENZ WL Site
3	5317	Opuatai stream		2691660	6417210	FENZ WL Site
4	5380	Moanatuatua		2718497	6361550	FENZ WL Site
5	5390	`		2699531	6344677	FENZ WL Site
6	5394	Kapenga Swamp		2793370	6323954	FENZ WL Site
7	5408	Waiotapu		2804394	6310756	FENZ WL Site
8	5415			2731635	6304210	FENZ WL Site
9	5419			2734196	6302789	FENZ WL Site

N	ID	Name	Address	NZMG		
				Easting	Northing	
10	5433	Forest Rd		2770226	6291018	FENZ WL Site
11	5456	Turangi swamp		2754064	6246272	FENZ WL Site
12	5463	Lake Rotoaira wetland		2742357	6238181	FENZ WL Site
Lakes						
1	NONE	Rotoaira		1833846	5675664	*SNA lake w/ vegetated catchment*
2	321_43	Taupō		2768000	6260000	LOCATED_LAKES
3	329_6	Whakamaru		2767700	6304800	LOCATED_LAKES
4	294_2	Karapiro		2743700	6353500	LOCATED_LAKES
5	1456_14	Rotopiko (Serpentine)		2713900	6358800	LOCATED_LAKES
6	1457_5	Kaituna		2708578	6389098	LOCATED_LAKES
7	324_9	Waahi		2699000	6402400	LOCATED_LAKES
8	307_1	Ohinewai		2702600	6409700	LOCATED_LAKES
9	312_2	Puketi		2658927	6434522	LOCATED_LAKES
10	310_3	Otamatearoa		2659863	6432786	LOCATED_LAKES

Appendix C: Feedback on Sample Sites and Ecosystem Service Indicators

Attachment C: Site Selection Feedback

Report for the Waikato Regional Council

Review of the proposed sites and indicators for the Waikato Regional Council freshwater ecosystems services project

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REPORT INFORMATION SHEET

REPORT TITLE	[REVIEW OF THE PROPOSED SITES AND INDICATORS FOR THE WAIKATO REGIONAL COUNCIL FRESHWATER ECOSYSTEMS SERVICES PROJECT]
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Review of the proposed sites and indicators for the Waikato Regional Council freshwater ecosystems services project

This project aims to get a better understanding of the services provided by freshwater ecosystems in the Waikato region. At the moment, there seem to be a divide between the society and those people in charge of collecting and analysing ecological data. Most field data collected are usually analysed by scientists to report ecosystem health and less emphasis has been placed on processing those data to reflect the impact of the changes in levels of environmental quality to the economy, society and the neighbouring environment. For example, a person who regularly visits Lake Taupo would appreciate knowing the impact of a reduction in nutrients (e.g. P, N) in Lake Taupo on the quality of his/her recreational visit. The person collecting data on the ecological status of the lake would appreciate knowing the importance of those data not just for economic planning but also in terms of environmental, social and cultural values.

Background and Scope

The Waikato Regional Council has contracted Scion to undertake an ecosystem services assessment of the freshwater resources in their region. The proposed pilot study will assess the ecosystem services provided by a select range of freshwater ecosystems in the Waikato River catchment.

Project brief: Objective 3.7 of the proposed Waikato Regional Policy Statement (RPS) relates to Ecosystem Services (i.e. benefits people obtain from nature). Under this objective, the region seeks to 'recognise and maintain or enhance ecosystem services' to enable their ongoing contribution to regional wellbeing (Waikato Regional Council, 2012). Currently there is no database of these ecosystems with their associated services and values. This is needed to monitor the effectiveness of the relevant regional policies. The ecosystem services approach to resource management considers all services provided by ecosystems to all sections of a community. To facilitate this approach, tools such as ecosystems maps and database of their services are useful at a level of detail at which policy and management decisions are made (Hamilton 2008; Ausseil et al. 2013). The objectives of the proposed project are:

1) To identify, characterise and classify freshwater ecosystems in terms of their services and value; and

2) To examine spatial distribution and possible trends of freshwater ecosystem services in Waikato-Waipa River Catchment.

The Waikato Regional Council have engaged Scion to undertake a review of the proposed list of sites (Appendix 1) and the proposed list of indicators to assess the freshwater ecosystems services provided by wadeable streams, non-wadeable rivers, lakes and wetlands.

Proposed freshwater ecosystem sites

The Waikato Regional Council proposes to assess the freshwater ecosystem services at 69 sites throughout the Waikato River catchment, covering non wadeable rivers, wadeable streams, wetlands, groundwater bores, geothermal ecosystems, geothermal bores and lakes. As a full range of geothermal bores has yet to be decided, Scion's review has focused on the remaining types of freshwater ecosystems: wadeable streams sites

(10), non-wadeable river sites (12), wetland sites (12), groundwater bore sites (10), geothermal ecosystem sites (6) and lake sites (10).

Wadeable Streams: The map provided by Waikato Regional Council shows a reasonable spread of sites throughout the Waikato River catchment. The sites cover a range of land uses including pasture, indigenous forest and urban. Although there are extensive areas of planted forest within this catchment, this land use appears to be absence in the sites selected for this study. There are currently two sites in the Pirongia area (both native). We recommend removing one of these sites, (preferably Site 7 as it appears that Site 5 provides a drinking water supply and therefore a useful ecosystem service to include in this assessment), and including a planted forest site.

Non-wadeable river sites: With the exception of Site 12, these sites are located along the main stem of the Waikato River system. Site 12 is at the Waitomo Stream, but it does not appear on the map and its status needs clarification. The Waipa is a main tributary in the Waikato River catchment and is currently not in the sampling programme. We recommend the addition of at least one site on the Waipa River.

Wetlands and groundwater bores: These sites are located throughout the Waikato region and cover a range of wetlands and bore sites across a range of land uses.

Geothermal ecosystems: These sites are clustered in an area between Taupo and Rotorua and reflect the natural occurrence of these types of freshwater ecosystems in the landscape.

Lakes: the lake sites are located throughout the region and have been selected to cover the different types of lakes present in the region (volcanic, hydro, peat riverine & dune). With the exception of Lake Taupo which has a mixed land use catchment and Lake Rotoaira which has a large component of forests and conservation land in its catchment, most of the lakes appear to be in catchments predominantly in agriculture. If there are any lakes within indigenous and/or planted forest catchments, that maintain the range of lake types and could replace some of the pasture sites, it would improve the representation of different land uses in the region. For example Lake Rotopounamu is in an indigenous forest catchment (although we appreciate that this lake is not as accessible as others) and Lake Hinemaiaia is within a planted forest catchment.

Proposed indicators to assess freshwater ecosystem services

The Waikato Regional Council has provided Scion with a series of spreadsheets containing a comprehensive list of potential freshwater indicators to use in the assessment of ecosystem services provided by the freshwater resources in the Waikato River catchment.
We have used this spreadsheet to provide a brief desktop critique within the time constraints of this part of the project. We have provided comment on the feasibility of reporting on each indicator. For many indicators, this will be influenced by the availability of the underlying data required.

General comments about the indicators:

- Some measures of ES (e.g. ecological and chemical status) already follow the ecosystem services approach described in Maltby et al. (2011) and Morris and Camino (2011) which is a good starting point.
- Quantification of Freshwater ES, should also:
    - be reported in trends over the years, whether they are improving, deteriorating or about the same. This would allow prioritisation given the limited resources;

  - recognise the navigation services provided by lakes and rivers;
  - analyse the impact of the change in the level of nutrients on key activities such as individual recreation (jet skiing), major events (rowing competition) and cruising services (Waipa Delta, steamboat, jet boat, scenic cruise); and
  - look at both services and disservices from each freshwater ecosystem. In terms of human health regulation, a lake can increase well-being and quality of life by providing a swimming amenity but it can also serve as source of waterborne diseases.
- We suggest that the data that should be collected, analysed and reported to the public are those that could describe the impact on the final ecosystem services because those information can show the status of the economic, environmental and cultural values. Examples of final ecosystem services are listed on Figure 1 which we adopted from the UK National Ecosystem Assessment report (UKNEA 2011).

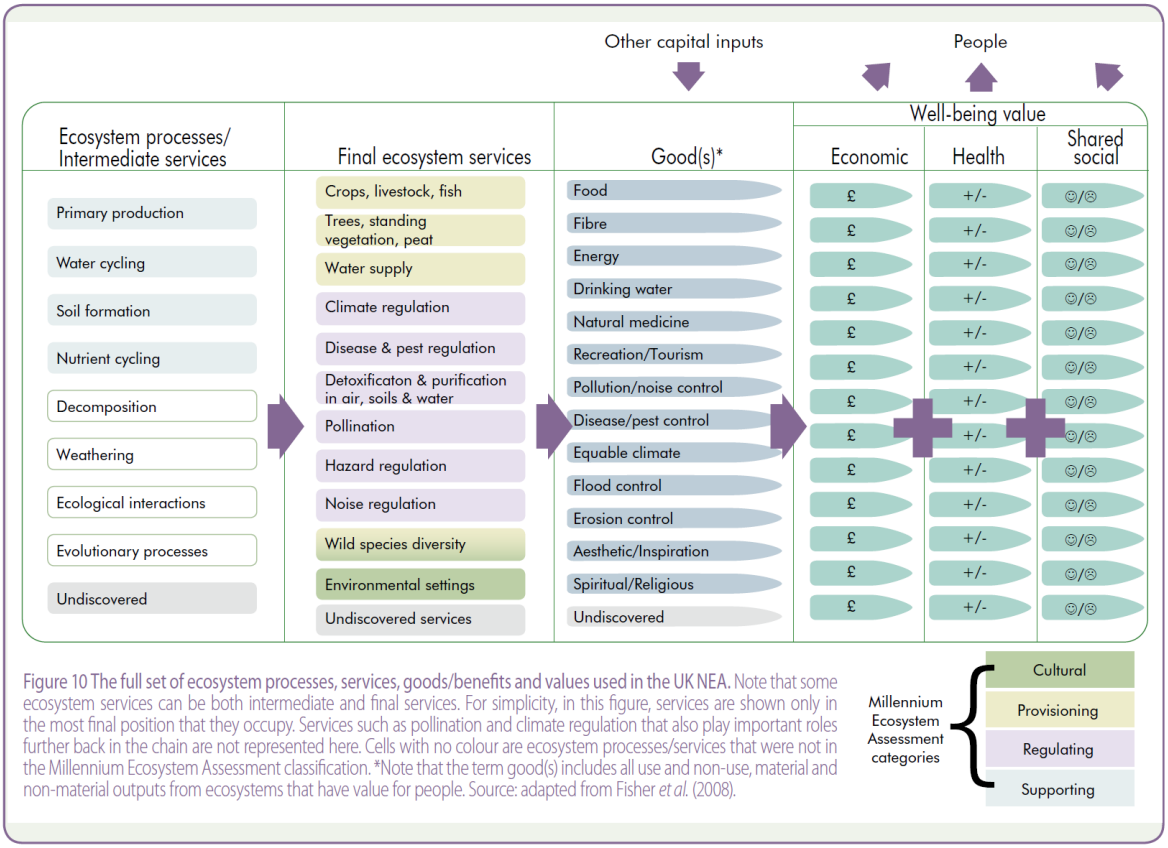

Figure 10 The full set of ecosystem processes, services, goods/benefits and values used in the UK NEA. Note that some ecosystem services can be both intermediate and final services. For simplicity, in this figure, services are shown only in the most final position that they occupy. Services such as pollination and climate regulation that also play important roles further back in the chain are not represented here. Cells with no colour are ecosystem processes/services that were not in the Millennium Ecosystem Assessment classification. *Note that the term good(s) includes all use and non-use, material and non-material outputs from ecosystems that have value for people. Source: adapted from Fisher *et al.* (2008).

Figure 1. List of final ecosystem services from the UKNEA (2011 p. 16)

- Several services provided by freshwater ecosystems have been quantified. For instance, services provided by rivers, lakes, wetlands, flood plains and groundwater in the United Kingdom have been quantified by Morris and Camino (2011) and Maltby et al. (2011).
- Not all ecosystem services can be quantified in monetary terms or in ecological units such as those indicators under cultural values (e.g. *Mauri*, *Mana*, *Tapu*). However, those services can be described qualitatively or can be expressed in index terms (e.g. Tipa and Teirney 2006).
- A measurement unit should be categorised into levels such as Excellent, Very Good, Good, Not very good, Bad, Very bad – e.g. impact on drinkability, for better communication to everyone
- Data for collection should include those that can be used for tradeoffs or scenario analysis (e.g. what will be the overall ecosystem value of a catchment if we increase the area of wetlands by retiring less productive dairy farms). A small study on this has been completed by Yao and Velarde (2014) which provided indicative values of ecosystem services across different land uses in the Ohiwa catchment in the Bay of Plenty region.
- Data that should be collected and information reported should also include the indicators for connectedness or connectivity to neighbouring freshwater ecosystems.

Discussion and Future Directions

This work provides an initial review of the list of indicators identified by the Waikato Regional Council. The review has identified some of the gaps and future directions of the project towards the assessment of freshwater ecosystems in the region. The future work includes field reconnaissance in selected freshwater ecosystems to provide a high level characterisation of each site, estimation of key ecosystem system services values using economic valuation techniques (e.g. benefit transfer) and spatial economic modelling.

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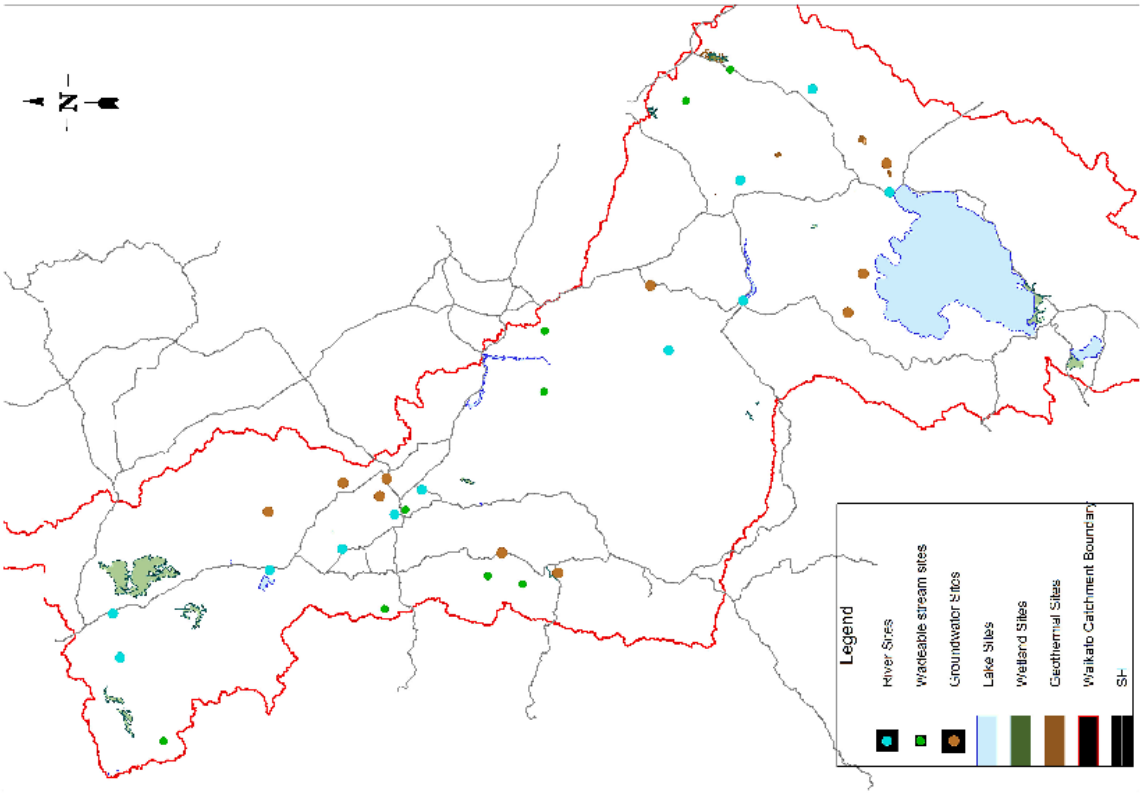
Appendix 1: Proposed freshwater ecosystem sites for the freshwater ecosystem services project



Appendix 2: Proposed indicators for the freshwater ecosystem services project

The proposed indicators for the rivers and streams, lakes, and wetlands are in three Excel spreadsheet files (Indicators_of_data_to_be_collected_-_Rivers_and_Streams–Scion comments; Indicators_of_data_to_be_collected_-_Lakes–Scion comments; Indicators_of_data_to_be_collected_-_Wetlands–Scion comment). For each freshwater ecosystem, we provided two sets of comments: field work and ecosystem valuation.

Appendix D: Fieldwork Reports

Attachment D1: Kessels Report

Attachment D2: Scion Report

Waikato Regional Council

Waikato Ecosystem Services Assessment:

Lakes and Wetlands Data Collection & Scoping Study

KesselsEcology
SURVEY, ASSESSMENT AND RESTORATION

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Executive Summary

Waikato Regional Council (WRC) has contracted Kessels Ecology to conduct a scoping study of ecosystem services provided by selected freshwater (lake and wetland) sites around the Waikato region. This scoping study is intended to inform future, more detailed studies of the ecosystem services provided by freshwater ecosystems in this region. The overall aim of this ecosystem services study is to map out an appropriate methodology to describe and assess ecosystem services provided by freshwater ecosystems through desktop study and site surveys, taking into consideration diverse datasets covering hydrology, ecology, catchment land use, water quality, economic, demographic and all other relevant data available for collection for each site. A secondary objective is to describe the relationship between land use in the catchment and provision of ecosystem services where possible, in order to ascertain how land use may impact levels of ecosystem services provision and, if applicable, what role restoration of the ecosystem to a more healthy ecological state may play in increasing levels of ecosystem services provision.

This study provides a general description of the ecosystem services provided by the twenty-two lake and wetland sites that were surveyed. Some economic values are also identified, as well as a general scoring of level of ecosystem services provided for each site. Where possible, ecosystem services provision is ranked reflecting surrounding existing land use, and its potential impacts on reducing ecosystem services provisions by compromising ecological health, including reduced habitat provision and ecosystem integrity. However, more detailed studies, as well as more detailed data, would be required in order to conduct a more all-encompassing study that quantifies all relevant ecosystem services for each site, including a detailed economic assessment. These details were beyond the scope of this study, but wherever possible, comments were included in the 'blueprint' template and the master spreadsheet of what data would be required in order to complete this more detailed quantification of ecosystem services. The function of the blueprint furthermore was to allow for comparison with ongoing and future studies within the Waikato region and beyond. The blueprint is based on a current international template for ecosystem services modelling and assessment studies.

Cultural values were not included in this assessment aside from general educational and recreational values. The reasons for that include the complexities inherent to socio-cultural values, the lack of data or detailed information on these values, and the in-depth investigation required to establish these values. In addition, and importantly, the study team do not have the appropriate expertise and cultural background to assess tangata whenua values. All these aspects mean that assessing and accounting for cultural values were beyond the scope of this study. Similar reasons prevented the inclusion of any spiritual values that might be associated with a site. Nevertheless, they would be of vital importance to be included in future studies of this kind.

As a project at the complex intersection of ecological and economic values, many aspects and indicators used here were found to be data deficient which thus does not allow for a robust assessment of the true value of the ecosystems services provided for each of the natural features studied. While areas such as hydropower and tourism at iconic sites such as Lake Taupo are relatively well studied and quantified, lesser known and studied sites are data deficient in regards to many ecosystem services that they provide.

. Thus, a robust assessment of the true value of the ecosystems services provided for each of the natural features studied is limited by this lack of data. Given these limitations of data deficiencies, it is recommended that certain indicators for ecosystem services are added to the annual monitoring of lakes and wetlands, which would provide more detailed information for any future ecosystem services studies, allowing for more quantitative and specific assessments of ecosystem services provisions and associated values.

1 Introduction

Waikato Regional Council (WRC) has contracted Kessels Ecology to conduct a scoping study of ecosystem services provided by selected freshwater (lake and wetland) sites around the Waikato region. This scoping study is intended to inform future, more detailed studies of the ecosystem services provided by freshwater ecosystems in this region. The overall aim of this ecosystem services study is to map out an appropriate methodology to describe and assess ecosystem services provided by freshwater ecosystems through desktop study and site surveys, taking into consideration diverse datasets covering hydrology, ecology, catchment land use, water quality, economic, demographic and all other relevant data available for collection for each site. A secondary objective is to describe the relationship between land use in the catchment and provision of ecosystem services where possible, in order to ascertain how land use may impact levels of ecosystem services provision and, if applicable, what role restoration of the ecosystem to a more healthy ecological state may play in increasing levels of ecosystem services provision.

This study encompasses provides a general description of the ecosystem services provided by the twenty-two lake and wetland sites that were surveyed, by employing both a background desktop study and field surveys to collect data on ecosystem services provided by each site. All data has been collated in a master spread sheet, and then entered in a provided 'blueprint' template to allow for a more global comparison to other existing ecosystem services studies, as well as potential future studies that may be conducted for the same purpose.

Some economic values were also identified, as well as a general scoring of level of ecosystem services provided for each site. Where possible, ecosystem services provision has been ranked in review of the impact of the surrounding land use and its potential impacts on reducing ecosystem services provisions by compromising ecological health, including reduced habitat provision and ecosystem integrity. However, more detailed studies, as well as more detailed data, would be required in order to conduct a more all-encompassing study that quantifies all relevant ecosystem services for each site, including a detailed economic assessment. These details were beyond the scope of this study, but wherever possible, comments have been included in the 'blueprint' template and the master spreadsheet of what data would be required in order to complete this more detailed quantification of ecosystem services. The function of the blueprint furthermore was to allow for comparison with ongoing and future studies within the Waikato region and beyond. The blueprint is based on a current international template for ecosystem services modelling and assessment studies (Crossman et al. 2013).

Cultural values were not included in this assessment, aside from general educational and recreational values. The reasons for that include the complexities inherent to socio-cultural values, the lack of data or detailed information on these values, and the in-depth investigation required to establish these values. In addition, and importantly, the study team do not have the appropriate expertise and cultural background to assess tangata whenua values. All these aspects mean that cultural values were beyond the scope of this study. Similar reasons prevented the inclusion of any spiritual values that might be associated with a site. Nevertheless, they would be of great importance to be included in future studies of this kind.

2 Methodology

2.1 Lake and wetland sites

In total, ten lake sites and twelve wetland sites were included in this scoping study. Figure 1 below shows the locations of all twenty two freshwater sites. Table 1 below outlines all sites including location information, area, catchment size and ecosystem type. The range of sites was chosen by WRC to represent a diverse set of site of different origin, ecological status and catchment characteristics such as land use.

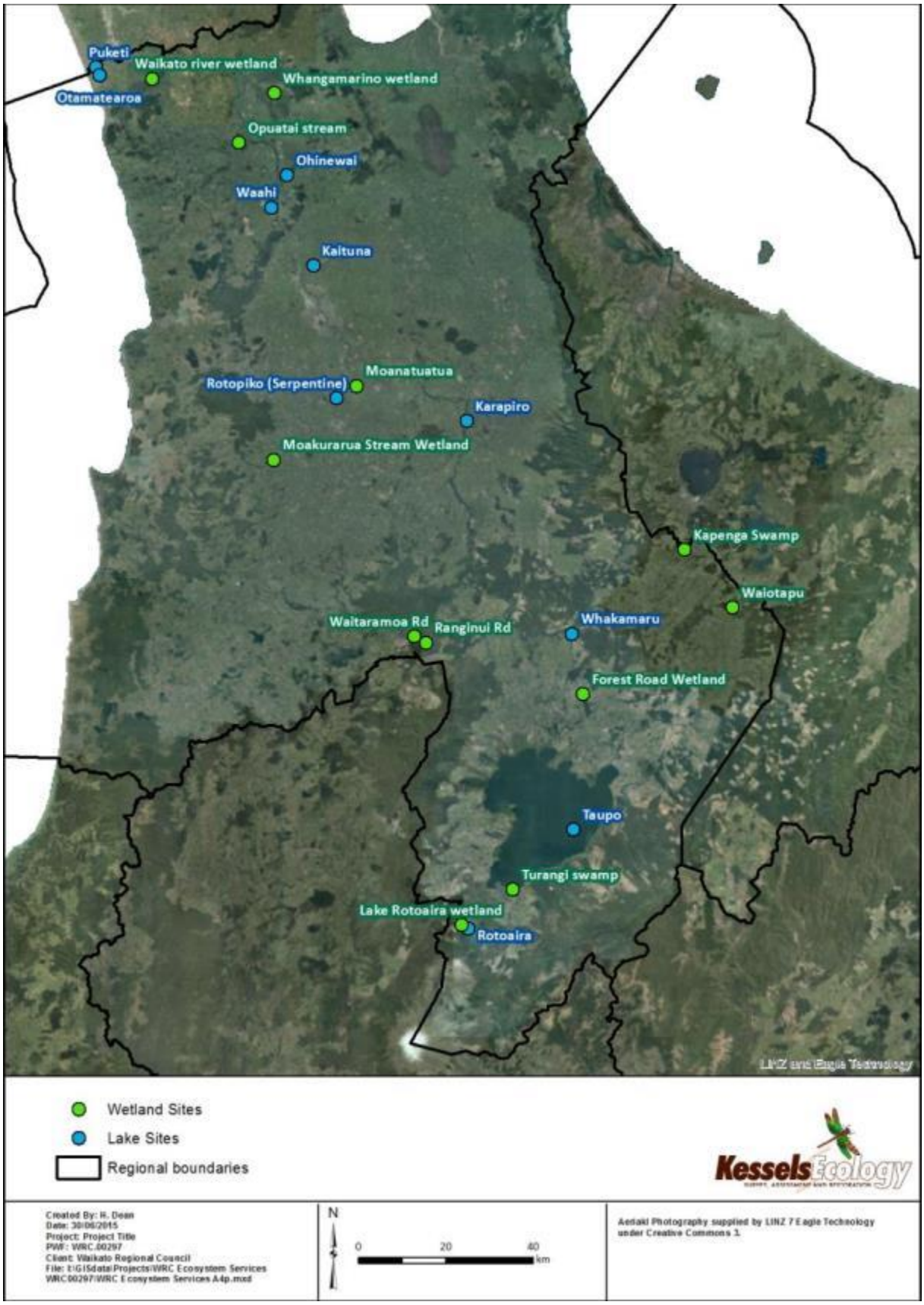


Figure 1: Locations of the 22 freshwater sites covered by this survey.

Table 1. Lake and wetland sites, location information, area, catchment size and ecosystem type.

Site Name	*Easting*	*Northing*	*Area (ha)*	*Type*	*Lake Type*
Rotoaira	1833846	5675664	1584.50	Lake	Volcanic
Taupo	1857924.597	5698390.106	61336	Lake	Volcanic
Whakamaru	1857578.252	5743217.007	538.4206	Lake	Hydro
Karapiro	1833502.164	5791911.543	769.6121	Lake	Hydro
Rotopiko (Serpentine)	1803683.668	5797170.805	10.3	Lake	Peat
Kaituna	1798314.341	5827468.294	9.65	Lake	Peat
Waahi	1788712.861	5840757.203	444.57	Lake	Riverine
Ohinewai	1792301.187	5848064.442	17.07	Lake	Riverine
Puketi	1748582.891	5872811.466	5.90	Lake	Dune
Otamatearoa	1749521.91	5871077.261	4.87	Lake	Dune
Whangamarino Wetland	1789390.736	5866942.298	6137.67	Wetland	
Waikato river Wetland	1761434.064	5870228.488	837.02	Wetland	
Opuatai Stream	1781346.783	5855556.721	660.95	Wetland	
Moanatuatua	1808277.983	5799928.265	128.56	Wetland	
Moakurarua Stream Wetland	1789330.9	5783024.2	51.71	Wetland	
Kapenga Swamp	1883242.279	5762415.435	109.36	Wetland	
Waiotapu	1894291.407	5749220.692	335.53	Wetland	
Waitaramoa Rd	1821495.589	5742585.117	47.45	Wetland	
Ranginui Rd	1824059.247	5741166.465	17.04	Wetland	
Forest Road Wetland	1860121.252	5729429.397	46.35	Wetland	
Turangi Swamp	1843992.49	5684642.249	1115.93	Wetland	
Lake Rotoaira Wetland	1832286.075	5676537.777	553.68	Wetland	

2.2 Flow chart of methodological steps

Waikato Regional Council set out the blueprint template to be completed as a final step of the data collection and ecosystem services assessment. The blueprint provides context for this study by offering a template to be used in concurrent as well as future studies of ecosystem services provision in the Waikato region and beyond. It also offers a platform for a gap analysis that shows up missing or insufficient datasets that can be addressed by regional council. In order to achieve this endpoint, an intermediate step of collating all data within a detailed master spreadsheet was required. This step also served the purpose of collecting all necessary attributes that informed the gap analysis to show missing information for each of the study sites. The detailed master spreadsheet containing all collected data, and the completed blueprint for both wetland and lake sites have been submitted to Waikato Regional Council alongside this report.

The flowchart in Figure 2 below outlines the major methodological steps for this ecosystem services study. All ecosystem services relevant to each ecosystem (lake and wetland) were identified based on existing ecosystem services literature, using both national and international studies. Background information on each site was collected using input from sources including GIS data, monitoring data, technical reports, and peer reviewed literature. A site visit was used to expand this information, make opportunistic land management and ecological observations, and document important features.

As a next step, ecosystem services provided by each site were assessed, as well as the overall ecological status. Where possible, ecosystem services provision was quantified, including an economic value (where available and applicable). Impacts of land use on ecosystem services were also taken into consideration where possible; however, a precise quantification of these impacts is

beyond the scope of this study, and will need to be investigated in more detail for any future assessments. Informed by an ecosystem services provision ranking for each site and ecosystem services (see section 2.5 below), ecosystem services for each site were assessed. Lastly, the master spreadsheet and the 'blueprint' template were populated, and a site summary for each lake and wetland site is presented as part of this report.

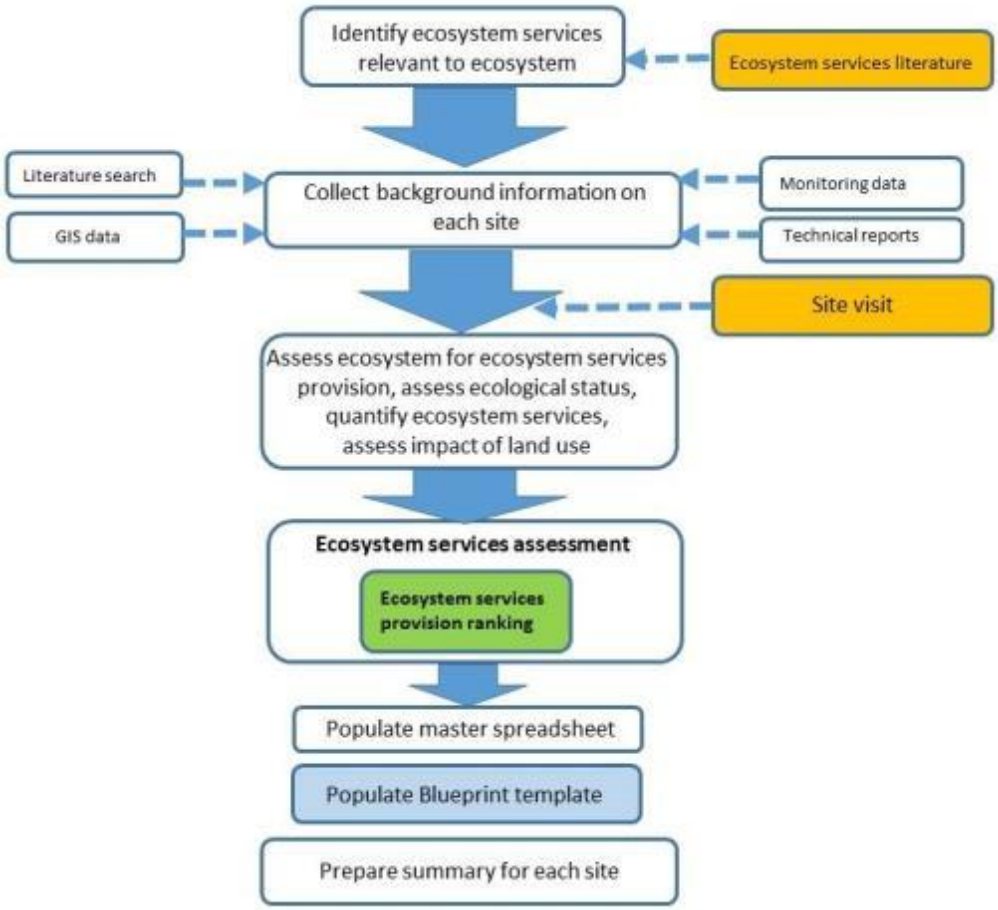


Figure 2 Flowchart outlining methodological steps and data inputs for ecosystem services assessment

2.3 Desktop study

Existing data, reports and other literature were gathered in order to gain an understanding of past and current ecological and socio-economic features of all twenty two study sites. Searches were conducted of relevant library, Waikato Regional Council and Crown Research Institute publication catalogues including the National Library of New Zealand, Waikato libraries, crown research institutes, as well as general searches on Google and Google Scholar. To fill any gaps of missing data where possible, external key information providers such as tourism information and commercial operators were consulted to complement the desktop study data collection.

2.3.1 Ecosystem services

Ecosystem services refer to the goods and services provided by natural (or semi-natural) ecosystems, and generally provided to the benefit of humans (de Groot et al 2002). The concept links ecological and economic systems and be used to describe values humans derive from ecosystems. As a classification system, ecosystem services are broadly categorised into supporting services (e.g. primary production), provisioning services (e.g. food, water, fuel, fibre), regulating services (e.g. flood regulation, climate regulation) and cultural services (e.g. aesthetics, recreational, educational services) (MEA 2005).

Ecosystem services that are provided by lake and wetland ecosystems are listed in Table 2 and 3 below. The tables also summarises a brief description of each service, as well as suggestions of indicators that can be collected to assess and quantify the provision of each ecosystem service.

For each site, ecosystem service provision was assessed based both on a preliminary desktop study, and a site visit to allow for more detailed observations including surrounding land management practices (such as plantings of riparian margins and stock management), evidence of recreational use (such as boat ramps and near-shore recreational areas), scientific monitoring stations, and notable ecological features.

Table 2. Ecosystem services provided by lakes, including description and indicators for quantification.
Adapted from Schallenberg et al. (2013).

Type	*Ecosystem service*	*Description*	*Quantification*
Provisioning	Water	Drinking water supply, stock water, irrigation	Litres of water abstracted; generic price per litre for drinking water
	Fisheries	Commercial fishing	Tonnes of fish harvested (estimate per ha)
		Spawning habitat	Number of species using lake for spawning
	Food	Wild food provision	Estimate of food taken from lake (estimate per ha)
	Waterfowl	Habitat	Number of species using system as habitat
	Biodiversity	Species, habitat, ecological functions	Number of species present; low to high level of biodiversity
Regulating	Nutrient processing	Removal of nutrients (e.g. denitrification); water filtering	Levels of nutrient concentration (monitoring data), trophic status/Trophic Level Index
	Sediment processing	Water filtering (e.g. kakahi)	Relevant species present
	Hydrological regulation	Flood control, landscape water retention	Flood risk areas, status of riparian margins
	Climate change mitigation	Carbon cycling/sequestration	Carbon storage per ha, carbon cycling studies
Cultural	Recreation	Contact recreation	Lake usage, visitor numbers
		Sport fishing	Fishing licences
		Hunting	Hunting permits
		Tourism	Tourism revenue, tourism numbers
	Aesthetics	Amenity values	Visitor numbers, lakefront properties
	Cognitive information	Science, research, environmental education	Research projects, monitoring sites, education signage

Table 3. Ecosystem services provided by wetlands, including description and indicators for quantification.
Adapted from Clarkson et al. (2013).

Type	*Ecosystem service*	*Description*	*Quantification*
Provisioning	Food	Wild food provision	Estimate of food taken from lake (estimate per ha)
	Water	Fresh water supply	Litres of water abstracted; generic price per litre for drinking water

	Materials	Raw materials, fibre provision, ornamental	Tonnes of fibre taken (estimate per ha); percentage area of plants with potential ornamental use
	Medicinal	Resources with medicinal use	Percentage area of plants with potential medicinal use
	Biodiversity	Species, habitat, ecological functions	Number of species present; level of biodiversity
Regulating	Air	Air quality	
	Climate	Climate regulation, carbon cycling	Carbon storage (general wetland studies, estimate per ha)
	Hydrological	Flood regulation, water flow regulation	Area of wetland within flood zones (ha)
	Waste	Water filtration, waste regulation	Ecological/trophic status
	Sediment & soils	Erosion control Soil fertility	
	Reproduction	Pollination	Bee hives/numbers of pollinating species using area
		Genetic resources, lifecycle maintenance	Species using habitat for reproduction
Cultural	Recreation	Contact recreation	Wetland usage, visitor numbers
		Hunting	Hunting permits
		Tourism	Tourism revenue, tourism numbers
	Aesthetic	Amenity value	Visitor numbers, lakefront properties
	Cognitive information	Science, research, environmental education	Research projects, monitoring sites, education signage

2.3.2 Land use

Land use within the catchment of each site was assessed by collecting data on land cover, predominant types of land use, as well as land management practices, where available. Restoration activities within the catchment, such as plantings of riparian margins, was also noted where available.

A detailed investigation was undertaken of any available spatially referenced data. Several of the existing GIS layers were used to identify the character and values of the catchment and lake/wetland area. These layers were then used to identify any information gaps. Freshwater Ecosystems of New Zealand (FENZ) is a geodatabase of biodiversity values and pressures of New Zealand's lakes, rivers and wetlands (Department of Conservation 2010, Leathwick et al. 2010). A search of FENZ was carried out to gain an understanding of broad patterns in biodiversity values and pressures within the study catchments.

2.3.3 Ecology

For the background study, available ecological data was collected for each site. This included, where applicable, information on biodiversity, plant and animal communities, threatened species, and the formation of the ecosystem. Ecological health of the ecosystem was also recorded where this data was accessible, including water quality parameters and Trophic Level Index for lakes. Trophic Level Index (TLI) is a proxy to indicate the trophic level of a lake, and consists of measurements of total nitrogen, total phosphorus, chlorophyll *a* and clarity (indicated by Secchi depth) (Burns et al. 1999).

Information collected for wetlands included a range of site specific reports, species lists, and management plans. The DOC BioWeb database was used for threatened plant records and the New Zealand Freshwater Fish Database (NZFFD 2015) was queried for each site.

2.3.4 Socio-economic aspects

For socio-economic aspects of the sites, firstly economic data was collected where available. This includes aspects such as recreational income data (tourism revenue), water take consents and information on electricity generated by hydropower. Further data collected included recreational use information, hunting licences issued, visitor numbers for recreational sites, fishing licences, existing scientific projects and monitoring stations and projects for environmental education. Scientific importance of each site was in addition assessed by the number of research publications. A number of research publications were obtained by a keyword search for each site name using Web of Science, covering the time period 1965-2014.

Demographic information, such as population within the catchment, age groups, ethnicity, and major occupations, was suggested in the project specifications as a subset of data to be collected. However, given the unavailability of this data with regards to the specific project sites and their catchments, demographic data was not included in this study. Any specific inquiries to obtain such catchment-specific data was beyond the scope of this pilot study.

2.3.5 Restoration activities and potential

Background research also focused on past and present restoration activities of the lake and wetland sites, including each site's catchment area. Restoration of land features, such as plantings of riparian margins, mitigation strategies of intense land uses (e.g. on-farm practice mitigation by reduced stocking numbers, feed pads, etc.) and restoration activities, such as pest control for animal and plant pests, were collected where available.

2.4 Field survey

Each site was visited for a visual inspection, observation of notable features for ecosystem services assessment and documentation of any other characteristics. A survey sheet for the ecosystem services assessment was developed and used during the site visits. The field sheets for the lakes and wetland sites are attached in Appendix I.

Opportunistic observations for the field survey part of the assessment included land management practices, biodiversity observations for example of threatened fauna and flora species, and any other notable ecological features not covered in the background review. All visible signs of ecosystem service provision were also collected. This included visible ecosystem use, including evidence of boating, and existence of ecosystem service provisions such as water takes.

Lastly, where applicable any potential for restoration activities, in addition to any restoration already in progress as described by the background study, was noted in the field sheets to allow for comments on the potential restorability of those ecosystem services that are potentially, but not currently provided by the ecosystem.

2.5 Site assessment

Following background studiers and site visits, each lake and wetland site was assessed by entering all available data and collected field data into a master Excel data spreadsheet ('ecosystem services blueprint'). The assessment included all spatial details, quantification of ecosystem services provided (where applicable and sufficient data available), the assignment of a dollar value to each ecosystem service where possible, a scoring of the overall provision of ecosystem services provided (see scoring description below), relevant references and any further comments and limitations applicable to each ecosystem service for each site.

Factors that were taken into consideration for this assessment included the ecological status of the site, any land use impacts that may negatively influence the provision of ecosystem services, an assessment of the use of the ecosystem and recreational activities, and lastly, an assessment of the damages to ecosystem services provision due to a potentially degraded state of the ecosystem.

Where possible, quantifications of ecosystem services were also assessed in economic terms. A value was estimated where sufficient data was available for a site. This assessment includes, for example, estimates of electricity generated by hydro lakes, economic values of recreational and commercial fisheries and consented water takes. More detailed studies are recommended for each of the sites in order to get better estimates of the economic value of each ecosystem service, for each site. A detailed quantification of all ecosystem services provided and associated economic values was the scope of this survey.

Possibilities for restoration and assessment of restoration actions (where applicable) were also included.

2.6 Scoring of ecosystem services provision

In order to assess the provision of ecosystem services provided by each site in comparison to what level of ecosystem services each lake or wetland in a reference condition could provide, a scoring system for each ecosystem service was developed. As a basic underlying assumption, the provision of ecosystem services was assessed to be of a low, medium of high level depending on whether only aspects of services were provided compared to what the ecosystem could provide (low score), moderate amounts of services were provided (medium score), or ecosystem services were fully provided (high score).

This scoring approach was modelled into the provision ranking detailed below (Tables 4 and 5 for lake and wetland sites respectively), which encompasses a ranking of 1- 3 or <30%, 30-70%, >70%.

Table 4. Provision ranking for lake sites for assessment of ecosystem services provision

Type	*Ecosystem service*	*Quantification*	*Ranking*
Provisioning	Water		
		Volume of water used for potable or irrigation purposes	0 = No water supplied or not applicable 1 = no or very little water supplied 2 = Some water supplied 3 = Large volume of water supplied
	Fisheries	Number of fishers using the lake	0 = no fishing or not applicable 1 = no or very little fishing 2 = Some fishing 3 = Popular for recreational fishing or used for commercial fishing
	Food	Number of fishers using the lake	1 = no or very little fishing 2 = Some fishing 3 = Popular for recreational fishing or used for commercial fishing
	Waterfowl	Number of Hunters	0 = no hunting 1 = very few hunters use the site 2 = Some hunters use the site 3 = Popular with duck hunters
	Biodiversity	Number of Threatened or At Risk species	0 = No threatened species 1 = <3 threatened species 2 = 3 - 5 threatened species 3 = > 5 threatened species

Regulating	Nutrient Processing	Trophic State	0 = Hypertrophic 1 = Supertrophic 2 = Eutrophic 3 = Mesotrophic or better
	Sediment processing	Quantity of sediment trapped	1 - 3, High, Medium, Low, subjective
	Hydrological regulation	Flood storage volume	Subjective
	Climate change mitigation	Carbon sequestered	
Cultural	Recreation	Recreational use	Subjective (1= Low, 2= Medium, 3= High)
	Aesthetics	Density of lakeside properties	Subjective (1= Low, 2= Medium, 3= High)
	Cognitive information	Number of Scientific studies	0 = No published papers in Web of Science search 1 = < 5 published papers 2 = 5 - 10 published papers 3 = > 10 published papers

Table 5. Provision ranking for wetland sites for assessment of ecosystem services provision

Type	***Ecosystem service***	***Quantification***	***Ranking***
Provisioning	Food	Number of Hunters	0 = no hunting 1 = very few hunters use the site 2 = Some hunters use the site 3 = Popular with duck hunters
	Biodiversity	Number of Threatened or At Risk species	0 = No threatened species 1 = <3 threatened species 2 = 3 - 5 threatened species 3 = > 5 threatened species
	Water	Volume of water used for potable or irrigation purposes	0 = No water supplied or not applicable 1 = no or very little water supplied 2 = Some water supplied 3 = Large volume of water supplied
	Materials	Ability to provide flax or other materials	0 = No flax present or flax not harvested 1 = Very little flax harvested 2 = Flax commonly harvested 3 = Important flax/materials source for business
	Medicinal	Unknown	Subjective (1= Low, 2= Medium, 3= High)
Regulating	Air	Wetland area	Subjective (1= Low, 2= Medium, 3= High)
	Climate	Carbon sequestration	Subjective (1= Low, 2= Medium, 3= High)
		Climate regulation	Subjective (1= Low, 2= Medium, 3= High)
	Hydrological	Flood storage	Subjective (1= Low, 2= Medium, 3= High)
	Waste	Nitrate removal	Subjective (1= Low, 2= Medium, 3= High)

Cultural	Sediment & soils	Nil	Subjective (1= Low, 2= Medium, 3= High)
	Reproduction	Nil	Subjective (1= Low, 2= Medium, 3= High)
	Recreation	Number of duck hunters	Subjective (1= Low, 2= Medium, 3= High)
	Aesthetic		Subjective (1= Low, 2= Medium, 3= High)
	Cognitive information	Number of Scientific studies	0 = No published papers in Web of Science search 1 = < 5 published papers 2 = 5 - 10 published papers 3 = > 10 published papers

3 Results

3.1 Site Summaries

This section includes summaries of each of the twenty two sites. Each site summary includes a description of the site and its ecological values along with an outline of the key ecosystem services it provides. All data and details collected have been collated in a master datasheet. The content of this datasheet specifying data for each site surveyed is included in Appendix II.

3.1.1 Lake Taupo

Lake Size	61,336 ha	**Catchment Area**	343,583 ha
Easting (NZTM)	1857924	**Northing (NZTM)**	5698390

Site Description

Lake Taupo is New Zealand's largest lake and is extremely important for tourism, both international and domestic. The lake lies in a volcanic caldera and provides habitat for a range of indigenous species, including birds such as New Zealand dabchick, little shag, black shag, little black shag, Australasian bittern, grey teal, mallard, paradise shelduck, black swan, spotless crake, red- and black-billed gulls, coot, banded rail and Caspian tern (Cromarty & Scott 1996). Indigenous fish species include koaro and koura. The lake retains relatively high water quality and a considerable amount of work is being done to maintain this. The high water clarity allows significant populations of submerged plants to thrive and marginal wetlands are a feature of the south-eastern shore. The catchment is large and while some of it remains in natural vegetation the majority is now farmland or exotic forestry.

Summary of Ecosystem Services

Being the largest lake in the region and the source of the Waikato River Lake Taupo is an extremely valuable resource and provides significant ecosystem services to the local area, the region, and the country. The lake has an outlet control structure which allows it to be used as header storage for the Waikato River hydro system, which comprises eight hydro dams and their associated power stations. Lake Taupo stores up to 862,400,000 m^3 of water for this purpose. The lake's water is also used extensively for domestic, agricultural and industrial purposes which jointly amount to 19,177,830 m^3 annually. Waste water from several small townships around the lake as well as numerous farms is filtered through the lake after treatment or irrigation on to land. At least 192,000 t of sediment enters the lake annually and much of this is stored in lake sediments.

Lake Taupo also provides valuable tourism and recreation services. The trout fishery is world-renowned and is estimated to bring around $3.7million into the local economy (Taupo Fishery Review 2013). The fishery provides both recreational opportunities and food. The lake is the centre of an area which is rich in scenic beauty and although information is not available on the number of visitors that visit just for the lake the Taupo area receives some 3.4 million visitors each year, contributing $414 million to the economy.

Although the Lake's ecology has been significantly altered since human occupation of the area it supports a wide range of birds, as well as indigenous fish and plants and at least 12 nationally listed Threatened or At Risk species utilise habitat provided by the lake.

Figure 3: Lake Taupo is very scenic and this is one of its significant ecosystem services (top left). It provides a range of recreational opportunities (top right, bottom right) and habitat for threatened fauna (bottom left).

3.1.2 Lake Karapiro

Lake Size	769.6121	**Catchment Area**	785,389
Easting (NZTM)	1833502.164	**Northing (NZTM)**	5791911.543

Site Description

Lake Karapiro is a hydro lake that formed in 1947 by damming the Waikato River to create the header reservoir for the 96 MW Karapiro power station. Lake Karapiro provides habitat for dabchick, Caspian tern, spotless crake, shags (black, little black, little) black swan and other wetland and waterfowl. Fish include longfin eel and koura. The lake lies within a sub-catchment dominated by intensive land use including dairy and dry stock farming. While the exact trophic level index is data deficient, the lake is potentially in a eutrophic state and weed growth compromises recreational usage as well as aesthetic values. Lake Karapiro is of regional importance for various recreational uses, including international rowing events, boating, sailing, kayaking, water skiing and fishing. The lake shore is also used for various activities including running, walking, cycling, beach volleyball and triathlons.

Summary of Ecosystem Services

Approximately 38,000m^3 of sediment is trapped by Lake Karapiro annually. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the majority of course sediment (Hicks et.al. 2010). The lake provides the header reservoir for the 90MW Karapiro Power station. Consented potable and irrigation water takes from the lake amount to 7555500m3 annually. Karapiro is an important lake for boating, trout fishing, and duck hunting. It is part of Auckland-Waikato trout fishing region, which attracts some 3,500 anglers each year. The lake is the venue for numerous national and international rowing events. There are at least eight public boat ramps along with numerous private jetties. Several reserves are located along the entire length of the lake. The Waikato River Trail starts on Horahora road and follows the lake edge. The lake is utilised by duck hunters, but exact numbers are not known. Lake Karapiro is a desirable location to own property. A number of large houses overlook the lake. Also provides a scenic backdrop to SH1. For environmental, scientific, and cultural education, signage about the lake and hydro schemes are present in several places, including along the Waikato River Trail.

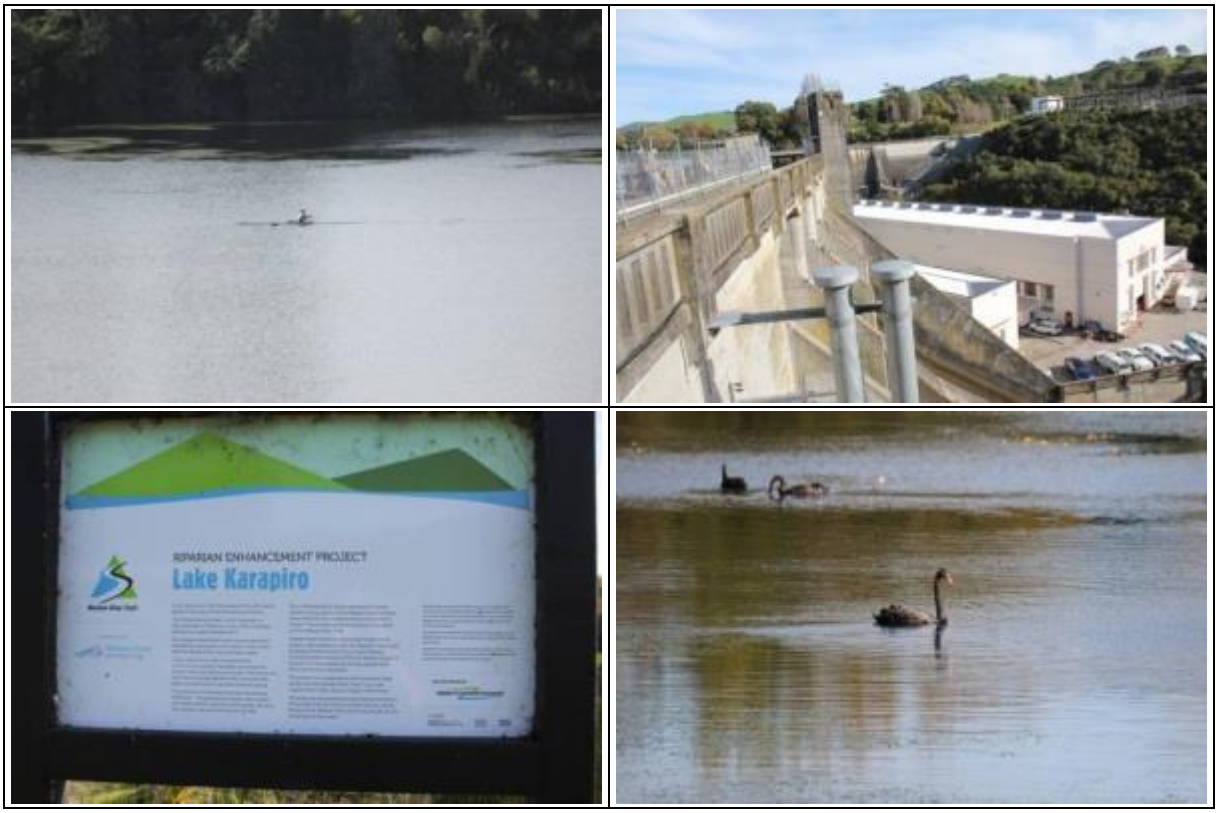


Figure 4: Lake Karapiro provides a range of recreational opportunities (top left), water for electricity generation (top right), learning opportunities through information panels (bottom left) and habitat for fauna and flora (bottom right).

Figure 5: Lake Whakamaru provides the header for a 100MW power station (top left). It supports indigenous animals and plants (top right) and provides significant recreational opportunities including boating biking and camping (bottom).

3.1.3 Lake Whakamaru

Lake Size	538.4206 ha	**Catchment Area**	586,192 ha
Easting (NZTM)	1857578.252	**Northing (NZTM)**	5743217.007

Site Description

Lake Whakamaru is a hydro lake that forms the header reservoir for the Whakamaru power station, formed by damming the Waikato River. Trophic state of the lake is unknown, but water quality is generally good. However, important characteristics such as total nitrogen are reported to be declining. Lake Whakamaru provides habitat for indigenous freshwater species including longfin eel, smelt, common bully, and koura. Land use within the catchment includes intensive agriculture and forestry.

Summary of Ecosystem Services

Lake Whakamaru provides the header reservoir for the 100MW Whakamaru Power station and is used to regulate flows to the downstream hydro-dams. Approximately 1,100,000m^3 of water is taken from the lake for irrigation purposes. The lake is used for duck hunting and trout fishing. Recreational use also includes boating. Approximately 35,000m^3 of sediment is trapped by Lake Whakamaru annually. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the majority of course sediment (Hicks et.al. 2010). There is some information posted along the Waikato River trail as part of environmental and cultural education. The lake provides an important scenic backdrop to State Highway 30 and the Waikato River Trail.

3.1.4 Lake Waahi

Lake Size	460.94 ha	**Catchment Area**	9,215 ha
Easting (NZTM)	1788713	**Northing (NZTM)**	5840757

Site Description

Lake Waahi is a riverine lake associated with the Waikato River and is the fourth largest lake in the Waikato Region after Lake Taupo, Waikare, and Whangape. It is heavily degraded due to the effects of landuse changes including drainage, vegetation clearance, and agricultural practices. Longfin eel and black mudfish have been recorded from the lake and its wetlands. Australasian bittern, spotless crake, Caspian tern, black shag, little black shag, pied shag, North Island fernbird, NZ dabchick, and banded dotterel all utilise this habitat. Lake Waahi is very degraded and is currently supertrophic with a 5-year TLI (2008 - 2012) of 5.8. It is likely to have limited ability to process nutrients.

Summary of Ecosystem Services

Approximately 4.3 tonnes of eels are fished from the Lake each year. Customary and recreational fishing may also occur. Hunting is popular in the area and a number of maimais are situated on the lake or on the margins. The popularity of the site may be affected by the poor water quality but there is no data to show this. The lake and its surrounding wetlands undoubtedly provide sediment filtration to the catchment. However, because the lake is shallow bottom sediments will be constantly re-suspended with the potential of release into the Waikato River. Significantly altered hydrology due to drainage and diversion. Nevertheless provides significant water storage to regulate flows in heavy rain and a drainage point for surrounding land. Flood storage is at least 23.8M m^3. Waahi is used for fishing, hunting and boating although all of these are likely to be affected by poor water quality. The lake is not particularly scenic although it is overlooked by several houses. A number of peer reviewed scientific papers have been published about Lake Waahi and there is also a considerable grey literature of technical reports and plans.

Figure 6: A boat ramp at Lake Waahi (left) and the LERNZ automated water quality buoy with wetlands beyond (right).

3.1.5 Rotopiko Lakes

Lake Size	10.3 ha	**Catchment Area**	164 ha
Easting (NZTM)	1803683.668	**Northing (NZTM)**	5797170.805

Site Description

Lake Rotopiko (Serpentine) is considered one of the most ecologically healthy peat lakes remaining in the Waikato region. The lake provides habitat for several threatened bird species (bittern, dabchick, Caspian tern, crake, and shags), as well as longfin eel. It has healthy submerged native plant communities. Rotopiko East has a pest-proof fence. The lake's trophic level is estimated at eutrophic to supertrophic (TLI between 4 and 5.2). Land use within the catchment is dominated by intense pastoral farming and some residential land use.

Summary of Ecosystem Services

No water, food or fish are taken from the lake. The lake has a significantly altered hydrology due to drainage and diversion. Nevertheless they provide water storage to regulate flows in heavy rain and a drainage point for surrounding land. It is likely to remove coarse sediment and some suspended sediment from inflows but not quantified. There is no known fishing activity at Rotopiko although some eels may be caught for recreation or customary purposes. It provides breeding habitat for ducks and other water fowl. The number of hunters using the lakes is not known but there are a few maimais. Recreational use of the lake is estimated to be minor. There might be some use for walking and possibly hunting. This could perhaps increase significantly if the planned National Wetland Centre is built at this site. The lake is highly visible from SH3. The National Wetland Centre will capitalise on the scenic value of the lakes when built. Some houses overlook the lakes, with several new lifestyle properties off Jary Road. Rotopiko has been the subject of a considerable amount of scientific study.

Figure 7: The Rotopiko Lakes provide recreation and sightseeing opportunities (top left). A predator-proof fence surrounds East Lake (top right) which includes high-quality wetland habitat (bottom left). A number of interpretive panels provide learning opportunities (bottom right).

3.1.6 Lake Kaituna

Lake Size	9.65311 ha	**Catchment Area**	410 ha
Easting (NZTM)	1798314.341	**Northing (NZTM)**	5827468.294

Site Description

Lake Kaituna is a small hypertrophic peat lake north-east of Hamilton city. The lake used to form part of the by now drained Kaituna peat bog. The catchment of the lake is dominated by intense agricultural land use. Restoration activities are being undertaken, including willow removal and other pest plant removal, installation of sediment traps at the inflows (farm drains), animal pest control and restoration planting of natives along the lake edge. Restoration has increased usage by native birds, including grey teal, dabchick and Australasian bittern. Habitat is also provided for freshwater species including eels and common bullies.

Summary of Ecosystem Services

No water is taken directly from the lake. Food provision is limited to occasional recreational eel fishers. The lake provides breeding habitat for ducks and is a popular hunting site; 7 maimais were observed around the lake. It also provides habitat for bittern, dabchick, spotless crake, longfin eel, black mudfish (Reeves et. al. 2011).

The lake provides a nutrient processing service through its marginal wetlands and within the water column and bottom sediments. This capacity has been increased recently with the installation of specific nutrient processing wetlands at the lake inflows. The lake itself is at least eutrophic and as it is completely non-vegetated its ability to filter nutrients may be impaired.

The lake and its surrounding wetlands undoubtedly provide sediment filtration to the catchment and treatment wetlands installed on the main drains filter both fine and course sediment from the inflowing water.

Significantly altered hydrology due to drainage and diversion. Nevertheless provides water storage to regulate flows in heavy rain and a drainage point for surrounding land. There is a walking track around the lake and it is used by duck hunters during the season. A nice example of a restored wetland and lake but only visible from the road and a few houses nearby.

No peer reviewed scientific studies were found but Kaituna has been the site of at least one PhD project as well as a model for lake restoration.

Figure 8: Lake Kaituna is managed for conservation purposes by DOC (top left) It is fully fenced and marginal vegetation has been restored (top right). Floating wetlands are part of a treatment wetland system installed on the major drains flowing into the lake (bottom left). Duck hunting is popular and several maimais are situated on the lake edge (bottom right).

3.1.7 Lake Rotoaira

Lake Size	1584.5 ha	**Catchment Area**	14281 ha
Easting (NZTM)	1833846	**Northing (NZTM)**	5675664

Site Description

Lake Rotoaira is a very scenic volcanic lake in the Central Volcanic Plateau, south of Lake Taupo and just to the north of Mt Tongariro. The lake is in a mesotrophic state (2001). It is privately owned. The lake level was raised by a metre as part of the wider hydro-electricity scheme in the 1980s. The surrounding land use is dominated by native vegetation, adding to the very high scenic value of the lake. There are some small settlements in the catchment.

Summary of Ecosystem Services

It is not known whether hunting is permitted on Lake Rotoaira but waterfowl are abundant and it is likely to be a source of birds for hunting in other areas. Koaro present in the lake (NZFFD). Bittern, dabchick, fernbird, pied stilt, spotless crake, and marsh crake reported (Reeves et. al. 2011)

The lake provides the header reservoir for the 240MW Tokaanu Power station and as part of the Tongariro power scheme it provides some flood regulation for the Tongariro catchment. There are regular fluctuations in water level of about 300mm. There is trout fishing in the lake.

Lake Rotoaira is very scenic and provides nice views from the main road between Turangi and National Park - lake views with the mountains behind. The historic maōri village on the northern shore is signposted, adding to the cultural value of the lake.

Figure 9: Lake Rotoaira has significant scenic value (top left) and provides habitat for large numbers of waterfowl (top right). It is culturally significant (bottom left) and provides the header supply of water to the Tokaanu power station (bottom right).

3.1.8 Lake Ohinewai

Lake Size	17.07112 ha	**Catchment Area**	331 ha
Easting (NZTM)	1792301	**Northing (NZTM)**	5848064

Site Description

Lake Ohinewai is a riverine lake to the east of the Waikato river near Huntly. The lake has one outlet (drain) to Lake Waikare. Water quality is degraded due to high nutrient inputs from the catchment, and was in a hypertrophic state in 2012 with a TLI of 6.3 (WRC shallow lakes indicator data). No submerged plants survive in the lake; instead it is often dominated by algal blooms. Predominant land use in the catchment is intense agricultural, including dairy. The lake also suffers from invasive pest fish such as koi carp. However, eels and kakahi can still be found.

Summary of Ecosystem Services

There are no known water takes from the lake. Commercial eel fishers may utilise Lake Ohinewai but it is unlikely as there is no formal access or any boat ramps. Ohinewai is used for duck hunting but is unlikely to be used for fishing. Hunter numbers are not known.

A number of maimais are located around the lake edge but hunter numbers are not known. It provides habitat for a number of target species including mallard, swans, and geese. A number of bird species utilise Ohinewai, mostly as part of a larger habitat which will include other nearby lakes and wetlands. Species include Caspian tern, black shag, little black shag, and probably Australasian bittern and spotless crake. Fish species include longfin eel. Freshwater mussels are also present.

The lake provides some nutrient processing for the surrounding catchment and is likely more effective at phosphorus removal than nitrogen.

Although there are no dedicated sediment traps the lake margins are well vegetated in planted natives and it is likely that the majority of sediment entering the lake is stored there rather than transported downstream. Ohinewai provides flood storage to the 331 ha catchment. No water level data for the lake is available but it is likely that the water regulation service provided by Ohinewai is significant.

Lake Ohinewai has no marked public access and hunters during the game bird season are likely to be the only visitors. No visitor assets. A large parcel of adjacent land is recreation reserve but this is leased for grazing and there is no indication that it is public land. Ohinewai is visible from the Ohinewai-Tahuna Road for a short stretch and no houses overlook the lake. Aesthetic value is relatively low.

Waikato University have trialled koi carp control methods at Ohinewai (Daniel & Morgan 2011), including the use of a one-way fish barrier at the outlet, electro-fishing, pod traps, and fyke nets (Dean-Spiers et al 2014). However, no peer-reviewed papers were found.

Figure 10: Lake Ohinewai has been fenced and has had marginal vegetation restored (top left). The inflowing drains are fenced to reduce nutrient inflows (top right). Duck hunting is popular and maimais are located around the margin of the lake (bottom left).

3.1.9 Lake Puketi

Lake Size	5.9 ha	**Catchment Area**	78 ha
Easting (NZTM)	1748583	**Northing (NZTM)**	5872811

Site Description

Lake Puketi is a 5.9 ha dune lake located 1.8 km from Karioitahi beach near Waiuku. The lake sits on Crown land but is surrounded by a small catchment of private farmland and there is no public access. The lake is approximately 7m deep and retains good water clarity and a submerged flora and although this is dominated by the exotic *Egeria densa* a number of indigenous species are also present (Burton et. al. 2014). Very little information about the fauna of the lake exists but Threatened or At Risk birds known to be present include NI fernbird, Australasian bittern and NZ dabchick (J Efford, WRC, *pers. comm.*). A narrow margin of wetland surrounds the lake and includes beds of raupo, harakeke, *Machaerina articulata* and in deeper water *Eleocharis sphacelata*. Occasional grey willows are also present. The lake has recently been completely fenced and the riparian area has been planted in native species as part of a WRC catchment management project (J Efford, WRC, pers. comm.).

Summary of Ecosystem Services

Lake Puketi has a very small catchment area and the ecosystem services it provides are relatively limited. It is an ecologically significant lake which provides habitat for a number of threatened species. Water filtration is limited to surface runoff and groundwater but relatively good water quality suggests that natural processes are keeping up with nutrient inflows. The lake also provides recreational opportunities and food provision through duck hunting but because there is no public access to the lake these services are somewhat limited.

Figure 11: Lake Puketi with new fence and plantings (left). The catchment is dominated by pasture but the lake retains some indigenous wetland vegetation (right).

3.1.10 Lake Otamatearoa

Lake Size	4.87 ha	**Catchment Area**	68 ha
Easting (NZTM)	1749521	**Northing (NZTM)**	5871077

Site Description

Lake Otamatearoa is a 8.87 ha dune lake situated approximately 2 km inland from Karioitahi Beach, south-west of Waiuku. The lake is 5 m deep and has a catchment area of approximately 68 ha (Dean-Spiers *et. al.* 2014). It is surrounded by privately-owned farmland but the lake bed is Crown land. The lake is not fenced but it is surrounded by a band of emergent macrophytes comprising mostly *Eleocharis sphacelata* as well as raupo (*Typha orientalis*) and *Machaerina articulata*. Pasture species occur right to the lake shore but there are also likely to be a range of wetland turf species. The lake has good water quality and clarity and is vegetated with submerged plants (Burton *et. al.* 2014). Hornwort has been an issue and is likely to continue to be despite a considerable control effort in the past (Dean-Spiers *et. al.* 2014). Shortfin eel and common bullies are present in the lake, along with exotic goldfish, catfish and trout (Dean-Spiers et. al. 2014). No records of the bird species that utilise the lake could be found but it is likely that species such as mallard, black swan, Canada goose, NZ dabchick, Australasian bittern, and shags visit the site periodically.

Summary of Ecosystem Services

Lake Otamatearoa provides relatively limited ecosystem services. Perhaps the most significant are its intrinsic ecological and biodiversity values, high water quality and potential for restoration. It may provide limited food provision and recreational services in the form of duck hunting but these do not appear to be a significant. Otamatearoa may also provide nutrient and sediment processing services and hydrological regulation but these are limited by the small catchment size and lack of permanent inflows or outflows.

Figure 1: Lake Otamatearoa is unfenced but features a band of emergent native macrophytes. Photos Jackson Efford, WRC.

3.1.11 Opuatia Wetland

Wetland Size	660.95 ha	**Catchment Area**	2,631.4 ha
Easting (NZTM)	1781347	**Northing (NZTM)**	5855557

Site Description

Opuatia Wetland is situated west of Rangiriri adjacent to the Opuatia Stream which is a tributary of the Waikato River. Opuatia comprises a mosaic of wetland types including 180 ha of peat bog as well as fen and swamp (Wildland Consultants 2011). The wetland is partly owned by Waikato Regional Council for soil and river control, partly by the Department of Conservation as a Wildlife Management Reserve, and is partly privately owned. The northern part of the wetland is adjacent to the Opuatia Stream and is eutrophic and dominated by willows. A central peat bog area includes wire rush-dominated communities and fen habitats are dominated by manuka/*Machaerina* communities. The wetland supports an array of Threatened or At Risk plant species as well as black mudfish and longfin eel. Australasian bittern, North Island fernbird and spotless crake have also been recorded at Opuatia. The wetland is actively managed by DOC and Waikato Regional Council and there has been a considerable amount of weed control and hydrological restoration work undertaken over the last 10 - 15 years (Wildland Consultants 2011).

Summary of Ecosystem Services

Opuatia provides a range of ecosystem services typical of a lowland Waikato wetland. Perhaps its chief value is its intrinsic ecological value as habitat for at least 18 Threatened or At Risk plants and animals. It also provides a significant flood storage service. When the Waikato River is in flood the Opuatia Stream backs up and over-flows its banks into the Opuatia wetland which provides in excess of 3 million cubic metres of water storage. The wetland also provides a water supply service through groundwater to adjacent farmland. Phosphorus and nitrates in sediment and in groundwater are likely to be filtered by the wetland although no specific data is available to quantify this service. Using generic filtration figures from Tanner & Sukias (2012) it is estimated that the wetland has the potential to filter around 603 tonnes of nitrate from water annually. Other ecosystem services include sediment removal and aesthetics.

Figure 12: Opuatia wetland includes high-quality bog habitat (top left) as well as fen and swamp (top right). Some of the inflowing drains have been fenced and planted (bottom left). The Opuatia Stream flows through the northern part of the wetland (bottom right)

3.1.12 Moanatuatua Bog

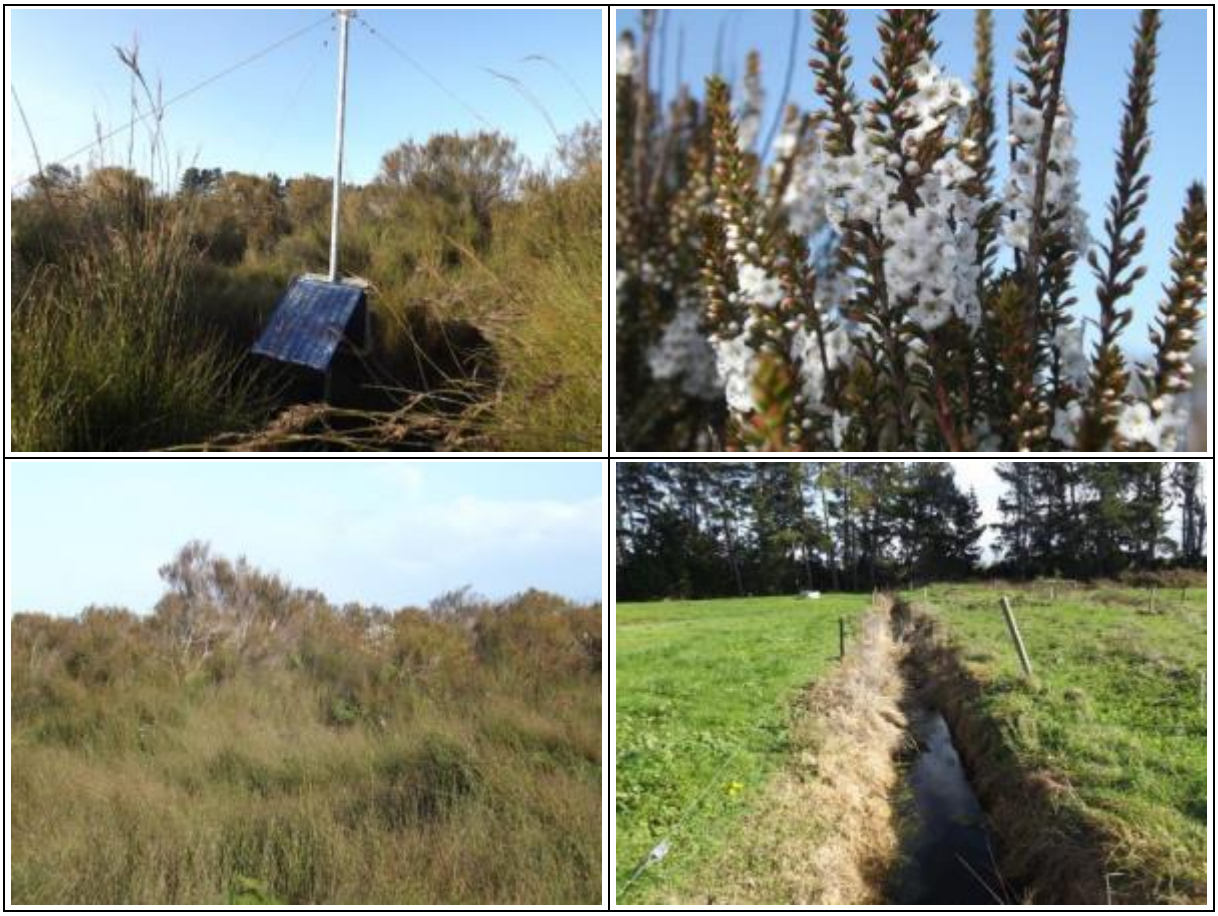
Wetland Size	128.56 ha	**Catchment Area**	416 ha
Easting (NZTM)	1808278	**Northing (NZTM)**	5799928

Site Description

Moanatuatua is a remnant peat bog located approximately 5km east of Ohaupo in the Waipa District. The remaining area is all that remains of a more than 7,000 ha bog which has been drained and cleared for agricultural use. The wetland sits on deep bog peat and the vegetation is generally high quality bog vegetation dominated by *Empodisma robustum* with *Leptospermum scoparium, Epacris pauciflora,* and *Sporadanthus ferrugineus.* This is one of only four sites where *Sporadanthus ferrugineus* grows naturally. Moanatuatua is surrounded by intensive dairy farms and a network of drains.

Summary of Ecosystem Services

Moanatuatua's value is primarily based on its rarity and biodiversity values although these are difficult to quantify. The wetland has been the subject of a number of scientific studies and reports although this was not well reflected in the Web of Science search used as an indicator. The wetland stores water which helps with hydrological regulation for surrounding farmland and is likely to be sequestering carbon. However this is likely to be offset by the surrounding drained peat emitting carbon.



3.1.13 Moakurarua Stream Wetland

Wetland Size	837.02 ha	**Catchment Area**	144,564,857 km²
Easting (NZTM)	1761436	**Northing (NZTM)**	5870228

Site Description

Moakurarua Wetland is a riparian wetland on a floodplain of the Moakurarua Stream south of Pirongia. It is primarily an agricultural system and although the whole site was not viewed much of the site appears to be dominated by pasture with an area of crack willow (*Salix fragilis*) treeland at the western end. Parts of the stream have been fenced but the floodplain remains grazed.

Summary of Ecosystem Services

This wetland has been highly modified as a result of land clearance, drainage, and grazing and is now dominated by exotic species. As a result many ecosystem services are also impaired and are not being provided to the level that a more intact wetland might provide. In its current state it provides nutrient and sediment removal services although these may be offset by grazing on the floodplain. It is also likely to provide a limited climate regulation function. The stream flowing through the wetland does not appear to have been channelized and can still flood into the riparian wetland in times of high flow. This flood storage and regulation function is likely to be impaired by the lack of wetland vegetation to help slow flood waters.


3.1.14 Waikato River Wetlands

Wetland Size	837.02 ha	**Catchment Area**	144,564,857 km²
Easting (NZTM)	1761436	**Northing (NZTM)**	5870228

Site Description

The Waikato River Wetlands are situated within the Waikato River delta south of Waiuku. They comprise more than 830 ha of riverine swamp and a range of vegetation types. The vegetation and hydrology have been highly modified and much of the site is now dominated by exotic species such as crack willow (*Salix fragilis*), black alder (*Alnus glutinosa*) and reed sweetgrass (*Glyceria maxima*). However significant areas of indigenous vegetation including kahikatea (*Dacrycarpus dacrydioides*) forest and *Phormium tenax* - sedge communities still remain and the wetland has very high biodiversity value. The wetland includes several islands.

Summary of Ecosystem Services

The Waikato River Wetlands provide a range of provisioning, regulating and cultural ecosystem services. The wetlands are situated within the tidal influence and provide habitat for a diverse range of fish and birds, some of which are more commonly associated with coastal or estuarine habitats. At least 15 Threatened or At Risk species utilise this wetland habitat and it is an important spawning area for inanga, one of the main constituents of the whitebait fishery which yields approximately 2 tonnes of fish from the Waikato River each year (NIWA 2010). At least 500 whitebait stands dot the margin of the wetland indicating a significant recreational service. Commercial eel fishers also utilise this part of the Waikato River and eel and mullet are commonly taken by recreational fishers. Although the fisheries are technically based on the river the wetlands are important components of the habitat that these species utilise for feeding and spawning.

Regulating services provided by the Waikato River wetlands include flood regulation which is likely to be impaired by the wetlands location at the downstream end of the Waikato catchment. Carbon sequestration is likely to be significant although specific data is not currently available. Based on generic figures the climate regulation service provided by these wetlands is likely to be valued at around $700,000 p.a.

The Waikato River is culturally significant and provides limited aesthetic values. The wetlands have been reasonably well studied and supply the basis of a number of scientific studies and technical reports.




3.1.15 Whangamarino Wetland

Wetland Size	6137.67 ha	**Catchment Area**	79997.5 ha
Easting (NZTM)	1789391	**Northing (NZTM)**	5866942

Site Description

Whangamarino wetland totals around 7,000 ha of palustrine swamp, fen, and peat bog east of Rangiriri. A 5,690 ha area of Whangamarino became formally recognised as a wetland of international importance under the Ramsar convention in 1989. Whangamarino supports a diverse range of indigenous flora and fauna including at least 19 Threatened or At Risk species. The wetland is habitat for the largest known breeding population of Australasian bittern (*Botaurus poiciloptilus*) and is the only known location of swamp helmet orchid (*Anzybas carsei*) (Duggan *et. al.* 2013). Whangamarino retains good quality peat bog dominated by wire rush (*Empodisma robustum*) but swamp and fen habitat has been degraded by eutrophication and invasion by exotic plants. The wetland is mostly managed by the Department of Conservation which spends considerable resources on threat management and restoration. Other parts of the wetland are owned by Fish and Game and managed for game bird hunting, or are privately owned.

Summary of Ecosystem Services

The economic value of Whangamarino was estimated at US$9.88 million (2003 equivalent) by Schuyt & Brander (2004), the majority of which was non-use value. I.e. the intrinsic value of the wetland rather than exploitable value. This equates to approximately NZ$18.6 million in 2015 terms. Whangamarino provides a range of ecosystem services, the most significant of which are provisioning and regulating biodiversity and flood protection. The wetland is part of a large drainage scheme and along with Lake Waikare provides storage for more than 90 million cubic metres of water when the Waikato River is in flood. This service is valued at more than $6 million annually (DOC 2007). It also provides a significant climate regulation function which is estimated to be worth more than $5 million annually. In addition Schuyt & Brander (2004) estimated that the recreational services provided by the wetland were valued at around $3.8 million annually.

Commercial eel fishers utilise the rivers running through the wetland. No specific data on eel catch for the wetland is available as MPI group Whangamarino with Waikare and the Waikato River delta. Koi carp fishing, unquantified takes. Whangamarino was a highly significant food source for Maori and is still considered a taonga for this reason. The resource and percieved value of the resource has declined significantly since drainage and clearance of the catchment. Whangamarino has a very high biodiversity value and provides habitat for a range of threatened species and ecosystems. It includes a range of wetland types from mineralised swamp to domed peat bog. Threatened fauna includes the Australasian bittern ,black mudfish, inanga, torrentfish, longfin eel, spotless crake, and North Island fernbird. Threatened plant species include swamp helmet orchid, *Utricularia delicatula, U. australis, Myriophyllum robustum, Cyclosorus interruptus, Pterostylis micromega, Pterostylis paludosa, Juncus holoschoenus, Prasophyllum hectorii, Gratiola concinna, Lycopodium serpentinum* and *Spiranthes novae-zelandiae.* Whangamarino is a significant hunting site and provides habitat for all main game birds. Fish & Game own and manage around 730 ha of the wetland primarily for waterfowl habitat and hunting and other parts of the wetland are also open to hunters. Whangamarino has been extensively studied both in the peer-reviewed literature and in technical reports and grey literature. The wetland also provides ecosystem services related to cognitive endeavour and is culturally significant.

Figure 13: Whangamarino is surrounded by pasture (top left). The wetland is well managed and is completely fenced (top right). A number of weeds including willow and *Glyceria maxima* occur in large areas of the wetland (bottom left) but high-quality bog habitat is also present (bottom right).

3.1.16 Kapenga Swamp

Wetland Size	109.52 ha	**Catchment Area**	1,842.8 ha
Easting (NZTM)	1789331	**Northing (NZTM)**	5783024

Site Description

Kapenga Swamp is a palustrine wetland located approximately 10 km south of Rotorua. The swamp is a Wildlife Management Reserve owned by the Kapenga M Maori trust and leased by the Department of Conservation. Management of the reserve is split between DOC and Fish & Game. The swamp is the largest in the Atiamuri Ecological District and has been fenced and intensively managed to control willow (Cashmore 2014). The vegetation comprises *Phormium tenax* / *Carex spp.* flaxland and *Coprosma propinqua* is common. Several Threatened or At Risk birds utilise this site including spotless crake, NI fernbird, pied stilt, and pipit. The surrounding catchment is predominantly dairy farms with small areas of radiata pine plantation. Although the whole perimeter was not viewed it appears that most inflowing streams and drains have been fenced.

Summary of Ecosystem Services

Kapenga Swamp is largely intact and provides a significant nutrient and sediment processing service for surrounding farmland. Suspended sediment and phosphorus are likely to be very well processed and a very approximate estimate of nitrate removal suggests the wetland can remove up to 151 tonnes of nitrate each year. Kapenga provides significant habitat for indigenous plants and animals including at least nine Threatened or At Risk species. It also provides habitat for ducks and other common waterfowl which provide the basis for recreational hunting and food supply. Fish & Game have installed ponds in the northern part of the wetland to improve habitat for ducks and therefore improve the service for the 20 - 30 hunters who utilise the site each season. The climate regulation service has been estimated to be worth approximately $138,000 annually based on generic figures, with around 500 tonnes of carbon sequestered.

Figure 14: Clockwise from top left: Fish & Game have created ponds for waterfowl at Kapenga. High quality natural wetland vegetation. The wetland is jointly managed by DOC and F&G. Maimais provide facilities for hunters.

3.1.17 Waiotapu

Wetland Size	353.5 ha	**Catchment Area**	4,126.5 ha
Easting (NZTM)	1894291	**Northing (NZTM)**	5749220

Site Description

Waiotapu comprises a large geothermal field which includes features such as geysers, fumaroles, mud pools and geothermally heated water. The dominant vegetation in the area is geothermal kanuka (*Kunzea tenuicaulis*) and where soil is less influenced by geothermal heating a mixed scrub of *Kunzea*, *Dicksonia fibrosa, Pteridium esculentum,* and *Cytisus scoparius*. The site is highly significant ecologically and geologically and provides habitat for several threatened species including the fern *Cyclosorus interruptus*, *Kunzea tenuicaulis* and *Dicranopteris linearis*. The land is a Scenic Reserve and some is Maori owned. It hosts the well-established tourist attraction Wai-o-Tapu Thermal Wonderland.

Summary of Ecosystem Services

Waiotapu provides a range of ecosystem services. Of these the most significant is tourism. Tourism is an important part of the Rotorua economy and Waitapu receives around 160,000 paying visitors each year which equates to around $3.9 million in gross income. The Waiotapu geothermal features have been well studied although this was not well reflected in a Web of Science search. They are regularly monitored by GNS science as part of national monitoring of volcanic activity.

Waiotapu also provides habitat for a range of indigenous species including plants and vegetation associations that specialise in geothermal areas. Other provision and regulating services are very minor although geothermal groundwater is taken from nearby.

Figure 15: Clockwise from top left. Specialist geothermal vegetation. Large geothermal features. More than 160,000 visitors pay to see Waiotapu each year. Interpretive signs provide learning opportunities.

3.1.18 Waitaramoa Road (Waipa Mires)

Wetland Size	47.45 ha	**Catchment Area**	415.4 ha
Easting (NZTM)	1821496	**Northing (NZTM)**	5742585

Site Description

This wetland is part of the Waipa Mires and is situated within the Waipapa Ecological Area near Pureora. The wetlands are in very good condition and are dominated by indigenous sedges and harakeke. A number of threatened plants and birds occur in the wetland including *Myriophyllum robustum, Pimelea tomentosum, Epilobium insulare,* and North Island fernbird. The site is part of a much larger natural areas which is habitat for a diverse range of indigenous species including kokako and NZ falcon. The catchment is approximately half indigenous forest and wetland and half radiata pine plantation.

Summary of Ecosystem Services

Waitaramoa Road wetland provides very few ecosystem services because of its location however functions such as nutrient processing and particularly sediment processing are important for downstream water quality. The wetland is also likely to be sequestering carbon from the atmosphere and its climate regulation function is valued at approximately $39,600 annually using generic figures. While visitors are unlikely to visit the wetland specifically they do visit the wider Pureora area for recreation including bush walking, mountain biking, and hunting. No water is taken from the wetland, although it is the head waters of the Waipa which is an important water source further downstream.

Figure 16: Waitaramoa Road wetlands retain high-quality indigenous vegetation and re ecologically significant.

3.1.19 Ranginui Road Wetlands

Wetland Size	17.04	**Catchment Area**	198.21 ha
Easting (NZTM)	1824059	**Northing (NZTM)**	5741166

Site Description

Like the Waitaramoa Road wetlands this wetland is part of the Waipa Mires and is situated within the Waipapa Ecological Area near Pureora. However, this site drains into the Waikato River rather than the Waipa. This site was not visited but was discussed with DOC staff. The wetlands are in very good condition and are dominated by indigenous sedges and harakeke. A number of threatened plants and birds occur in the wetland including *Pimelea tomentosum, Epilobium insulare,* and North Island fernbird. The site is part of a much larger natural areas which is habitat for a diverse range of indigenous species including kokako and NZ falcon. The catchment is entirely in indigenous forest and wetland.

Summary of Ecosystem Services

Ranginui Road wetland provides very few ecosystem services because of its location but similarly with the nearby Waitaramoa Road wetland the nutrient and sediment processing functions are important for downstream water quality. The wetland is also likely to be sequestering carbon from the atmosphere and its climate regulation function is valued at approximately $14,200 annually using generic figures. While visitors are unlikely to visit the wetland specifically they do visit the wider Pureora and Waipapa area for recreation including hunting, camping, bush walking and mountain biking. No water is taken from the wetland, although it is the head waters of a tributary of the Waikato River which is an important water source further downstream.

3.1.20 Forest Road Wetland

Wetland Size	46.35 ha	**Catchment Area**	1110.5 ha
Easting (NZTM)	1860121	**Northing (NZTM)**	5729429

Site Description

Forest Road wetland is a 46 ha palustrine swamp situated approximately 17 km northwest of Taupo near Mokai. It is privately owned and its 1,110 ha catchment is around 70 % dairy farm with the remaining area in forestry. This entire area was part of Kinleith forest until the mid-2000s when it was converted to dairy farming. The wetland is fenced and although there was considerable effort put into willow control prior to dairy conversion the re-growth of willow is significant. However, the vegetation is still predominantly indigenous with *Phormium tenax, Carex secta* and *Coprosma propinqua* being the dominant species. The At Risk North Island fernbird is present, along with *Ranunculus macropus*.

Summary of Ecosystem Services

This wetland provides a range of ecosystem services. Probably the most significant of these are the nutrient and sediment regulation services provided to surrounding farmland. It is estimated that the wetland can process around 40 tonnes of nitrate annually and is likely to retain all sediment and most phosphorus entering the system. The wetland is likely to sequester around 139 tonnes of carbon each year and its climate regulation services are estimated to be worth around $38,000 annually. The wetland also has intrinsic value and provides habitat for indigenous plants and animals.

Figure 17: Forest Road wetland is completely fenced and has high-quality indigenous vegetation.

3.1.21 Turangi Swamp (South Taupo Wetlands)

Wetland Size	1,115.93 ha	**Catchment Area**	82,226.8 ha
Easting (NZTM)	1843992	**Northing (NZTM)**	5684642

Site Description

Turangi Swamp is more commonly referred to as South Taupo Wetlands and comprises 1,115 ha of palustrine, lacustrine, and riverine swamp and fen north and east of Turangi and on the margins of Lake Taupo. The wetland includes areas of high-quality sedge and flax vegetation as well as more degraded willow carr and forest. A number Threatened or At Risk species occur in the wetlands including NZ dabchick, banded rail, and spotless crake. The wetlands formed as a result of sediment deposition from the three rivers that flow through them to Lake Taupo, but principally the Tongariro. The lake level rise associated with the installation of the control structure increased the size of the wetlands and altered the hydrology.

Summary of Ecosystem Services

These wetlands are very large and provide a range of important ecosystem services to the area. The sediment retention process that helped to form the wetlands continues to be a valuable service provided by the swamp and nutrient processing is also important. It is estimated that the wetlands are capable of removing at least 1018 t of nitrate each year although actual figures are not known. Carbon sequestration and climate regulation are also important services provided by this wetland and these are valued at around $0.93 million annually, based on generic figures. The wetlands provide habitat for at least 11 Threatened or At Risk plants and animals as well as valuable habitat for more common species. Duck hunting and trout fishing occur with and adjacent to the wetlands and they provide a scenic backdrop to State Highway 1.

Figure 18: Turangi Wetlands.

3.1.22 Rotoaira Wetlands

Wetland Size	553.68 ha	**Catchment Area**	4840.67 ha
Easting (NZTM)	1832286	**Northing (NZTM)**	5676537

Site Description

The Rotoaira wetlands are situated on the northern shore of Lake Rotoaira, 10 km south-west of Turangi. The wetlands are owned by the Lake Rotoaira Trust. These large wetlands are in a relatively pristine condition and comprise extensive areas of harakeke, toetoe, *Carex* sedges, and *Coprosma propinqua*. Higher land is dominated by manuka. Threatened plants and birds occur at the site and it is part of a much larger area of indigenous vegetation that includes the lake and adjacent National Park.

Summary of Ecosystem Services

The Rotoaira wetlands provide water filtration, habitat provision, and climate regulation services. It is estimated that the climate regulation service is worth up to $465,000 annually in part through sequestration of carbon. The manuka within the wetland is likely to be harvested for honey and this service was estimated to be worth around $33,000 each year. The site includes a significant source of harakeke although it is not known if it is harvested. The wetlands may provide hydrological regulation for the neighbouring lake and are likely to help remove nutrients from both surface water and inflowing groundwater.

Another significant service is the scenic value of the wetland which is visible from State Highway 47 and is part of a highly scenic landscape which includes Tongariro.

Figure 19: Rotoaira Wetlands.

4 Conclusions and recommendations

This freshwater ecosystem services study assessed ten lake sites and twelve wetland sites in the Waikato region. Its main objective was to assess the ecosystem services provided by each ecosystem, quantify these services where possible, and assess the impact of catchment land use and restoration activities on the provision of ecosystem services. A scoring system was developed to assess the provision of each ecosystem service for each site compared to its potential of provision.

As a project at the complex intersection of ecological and economic values, many aspects and indicators used here were found to be data deficient which thus does not allow for a robust assessment of the true value of the ecosystems services provided for each of the natural features studied. While areas such as hydropower and tourism at iconic sites such as Lake Taupo are relatively well studied and quantified, lesser known and studied sites are data deficient in regards to many ecosystem services that they provide.

Quantitative data of secondary industries, such as information around recreational use (including passive and active use of the ecosystem), is often not available. For example, the use for hunting and fishing of ecosystems is not quantified for each individual site, as recreational and industry surveys generally cover regions rather than specific ecosystems. Therefore, details such as the precise level of hunting and fishing at lesser known lakes and wetlands, as well as specific takes of commercial operations, are unknown. For these ecosystem services, site specific data is unavailable as it is predominantly not collected.

For some of the surveyed sites, the lack of information also includes basic ecosystem information such as regularly monitored water quality parameters (including nutrient concentrations, clarity, chlorophyll *a* and bacterial counts). Specific biodiversity condition, particularly of terrestrial ecosystems, is another gap in information that could be filled with additional surveys and the ongoing monitoring plans.Where applicable, comments have been made within the master spread sheet and the 'blueprint' for each site and ecosystem services to point out further data requirements, including what data could be collected to allow for better quantification of the ecosystem services, including a more detailed economic value assessment. Both spreadsheets show up the areas where gaps in information exist, and show a range of ecosystem services that are currently unquantified. Given the current data deficiencies, many estimates in this study are based on data that was available for similar sites, but are often not site specific.

Given these limitations of data deficiencies, it is recommended that certain indicators for ecosystem services could be added to the annual monitoring of lakes and wetlands, which would provide more detailed information for any future ecosystem services studies, allowing for more detailed and more site-specific assessments of ecosystem services provision and a better quantification of its values.

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Appendix I

Ecosystem services field data collection sheet

LAKES

Study Site	
Site type	
GPS location	
Date visited	
Site area (km^2)	
Catchment area (km^2)	

Ecological Status Observations

Aspect	**Description, status**
Ecological features *Biodiversity observations*	
Adjacent land use/land cover	
Land management practices	
Comments on restorability of the ecosystem	
Other relevant observations	

Ecosystem Services

Ecosystem Service	Estimated level of provision/ features observed
Water e.g. water takes	
Fisheries e.g. boats, boat ramps	
Food e.g. fish harvesting gear	
Waterfowl	
Biodiversity	
Nutrient processing	
Sediment processing e.g. evidence of erosion, riparian plantings	
Hydrological regulation	

Climate change mitigation	
Recreation	
Aesthetics e.g. lake front properties, lookouts, rest areas	
Cognitive information e.g. explanatory signage, school projects, monitoring stations	

Ecosystem services field data collection sheet

WETLANDS

Study Site	
Site type	
GPS location	
Date visited	
Site area (km^2)	
Catchment area (km^2)	

Ecological Status

Aspect	**Description, status**
Ecological features *Biodiversity observations*	
Adjacent land use/land cover	
Land management practices	
Comments on restorability of the ecosystem	
Other relevant observations	

Ecosystem Services

Ecosystem Service	Estimated level of provision/features observed (e.g. hunting features, public access)
Food	
Water e.g. water takes	
Materials e.g. removed materials	
Medicinal	
Air	
Climate	
Hydrological	
Waste	

Sediment & soils e.g. evidence of erosion, riparian plantings	
Reproduction	
Recreation e.g. evidence of recreational use	
Aesthetic e.g. nearby properties, lookouts, rest areas	
Cognitive information e.g. explanatory signage, school projects, monitoring station	

Appendix II

Master Datas

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status	Overall social/cultural/spiritual value	Overall health value (+/-)
Whangamarino	1789390.736	5866942.298	6137.67	Wetland	79997.5478	Oligotrophic - Eutrophic	High	+

		Quantification			Spatial details		Scoring		Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Commercial fishing	Commercial eel fishers utilise the rivers running through the wetland. No specific data on eel catch for the wetland is available as MPI group Whangamarino with Waikare and the Waikato River delta.	No data available	Ongoing	N/A	Regional	6137.67	2		Could be improved with specific survey or improved reporting by MPI.	
	Customary fishing	Whangamarino was a highly significant food source for Maori and is still considered a taonga for this reason. The resource and percieved value of the resource has declined significantly since drainage and clearance of the catchment.	N/A	Ongoing	N/A	Local	0.00	2			http://www.wrrt.co.nz/waikato-river-fisheries-bylaw-3/
Biodiversity	Number of threatened species	Whangamarino has a very high biodiversity value and provides habitat for a range of threatened species and ecosystems. It includes a range of wetland types from mineralised swamp to domed peat bog. Threatened fauna includes the Australasian bittern ,black mudfish, inanga, torrentfish, longfin eel, spotless crake, and North Island fernbird. Threatened plant species include swamp helmet orchid, *Utricularia delicatula, U. australis, Myriophyllum robustum, Cyclosorus interruptus, Pterostylis micromega, Pterostylis paludosa, Juncus holoschoenus, Prasophyllum hectorii, Gratiola concinna, Lycopodium serpentinum* and *Spiranthes novae-zelandiae.*	19 Threatened or at risk species	Ongoing	N/A	National	6137.67	3		Many of the species present are uner threat within the wetland by pests, weed invasion, and eutrophication. DOC spends considerable amounts of money managing these threats.	DOC Bioweb, NZFFD
Water	Water Supply	No water is taken form the wetland for irrigation or domestic pruposes but the surrounding farmland benefits from the high water table especially during summer.	N/A	N/A	N/A	Local	N/A	1			WRC consents data
Materials	Ability to provide flax	Historically harakeke was taken from Whangamarino and may still be in small quanitities.	No data available	Ongoing	N/A	Local	N/A	1			DOC 2007
medicinal	Nil	No medicinal uses known.	N/A	N/A	N/A	N/A	N/A	0			
Air	Air filtering/oxygen production	Air purifying function is not known	n/a	n/a	N/A	Local		0			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	18,413 t C	Annually		National	0.00	3	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	6137.67 ha	Annually	$5,124,954.45	National	0.00	3	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood storage	Whangamarino plays an important role in flood regulation in the lower Waikato. It recieves water from Lake Waikare via canal and flood waters from the Waikato River are preented from entering the wetland by flood gates. The Whangamarino-Waikare system provides 94.8 million m^3 of flood storage.	94,800,000 m^3	Ongoing	$6,100,000.00	Regional	79997.5478	3	Based on flood storage for the Waikare-Whangamarino system rather than just the wetland. Data is now relatively old.	Based on a study by DOC on the economic value of Whangamarino with values converted to 2015 dollars.	DOC 2007
Waste	Nitrate removal	Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service.	5601 t nitrate	Annually	Unknown	Local	6137.67	3		based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Removal of sediment from water	Likely to remove the majority of course sediment and a significant quantity of fine sediment from inflowing water.	N/A	Ongoing	N/A	Local	6137.67	2			
Reproduction	Nil	This is a large and diverse wetland which is important habitat for a range of indigenous species including threatened birds, eels, and plants.	N/A	Ongoing	N/A	Regional	6137.67	3		This indicator has been scored subjectively but could be based on species richness or similar if that data was available.	Subjective
Recreation	Duck hunting	Whangamarino is a significant hunting site and provides habitat for all main game birds. Fish & Game own and manage around 730 ha of the wetland primarily for waterfowl habitat and hunting and other parts of the wetland are also open to hunters.	No data on hunter numbers available	Ongoing	$3,817,474.00	Regional	6137.67	3		Converted from Schuyt & Brander (2004) value for recreation to 2015 NZ$.	Schuyt & Brander (2004)
Aesthetic	Nil	A number of houses overlook the wetland but it is not a major scenic drawcard for the area. A wetland scenic drive follows the edge of the wetland.	N/A	Ongoing	N/A	Local	6137.67	1			Field observations.
Cognitive information	Number of peer-reviewed scientific studies	Whangamarino has been extensively studied both in the peer-reviewed literature and in technical reports and grey literature.	4 peer-reviewed papaers in Web of Science	Since 1965	N/A	National	6137.67	2		Not a particularly strong indicator as it is based on peer-reviewed journal articles in one online databse.	Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status	Overall social/cultural/spiritual value	Overall health value (+/-)
Waikato River Wetland	1761434.064	5870228.488	837.02	Wetland	14,456,485,741	At least eutrophic	High	+

		Quantification			Spatial details		Scoring		Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Commercial fishing	Commercial eel fishers utilise the lower Waikato River. No specific data on eel catch for the wetland is available as MPI group the Waikato River delta with Whangamarino and Lake Waikare.	No data available	Ongoing	N/A	Regional	837.02	2		Could be improved with specific survey or improved reporting by MPI.	Beentjes 2013
	Customary and recreational fishing	The Waikato River delta is a source of food for many local people. Eel, mullet and whitebait are the main species caught. In 2000 there was an estimated 2t of whitebait caught from the Waikato River (NIWA 2010).	No data available	Ongoing	N/A	Regional	837.02	3		Available data is very broad-scale.	Cromarty & Scott 1996; NIWA 2010
Biodiversity	Number of threatened species	The lower Waikato River and its wetlands are important breeding grounds for inanga and other diadromous fish as well as many birds. Threatened or At Risk fish species include inanga, longfin eel and black mudfish. Birds include banded rail, NZ dabchick, NI fernbird, Australasian bittern, grey duck, spotless crake, pied stilt, white-fronted tern, Caspian tern, black shag, little black shag and pied shag.	15 Threatened or At Risk species	Ongoing	N/A	National	837.02	3			Cromarty & Scott 1996; NIWA 2010
Water	Water Supply	Consents are in place to take at least 47,000m³ water per day from the Waikato River where it passes through the wetlands. Consents are for irrigation, agricultural and industrial use including 40,000 m³ per day for Glenbrook Steel Mill.	47,000m³	daily	$6,580.00	Local	837.02	3	This water is being supplied by the river rather than the wetland		Reese & Borrie 2014
Materials	Ability to provide flax	It is not known whether harakeke is harvested from this swamp although it is common in some areas.	N/A	N/A	N/A	N/A	N/A	0			
medicinal	Nil	No medicinal uses known.	N/A	N/A	N/A	N/A	N/A	0			
Air	Air filtering/oxygen production	Air purifying function is not known	n/a	n/a	N/A	Local		0			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	2,511 t C	Annually		National	837.02	2	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	837.02 ha	Annually	$698,911.70	National	837.02	3	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood storage	May provide limited flood storage or slowing of flood flows but difficult to quantify for this site.	N/A	Ongoing	N/A	Local	837.02	1		May be able to be improved with modelling.	
Waste	Nitrate removal	Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service.	764 t nitrate	Annually	Unknown	Local	837.02	2		based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Removal of sediment from water	Likely to remove the majority of course sediment and a significant quantity of fine sediment from inflowing water but not from the Waikato River.	N/A	Ongoing	N/A	Local	837.02	2			
Reproduction	Nil	This is a large and diverse wetland which is important habitat for a range of indigenous species including threatened birds and fish.	N/A	Ongoing	N/A	Regional	837.02	3		This indicator has been scored subjectively but could be based on species richness or similar if that data was available.	Subjective
Recreation	Number of whitebait stands	At least 542 consented whitebait stands are situated along the margins of this wetland.	542 stands	Ongoing	N/A	Regional	837.02	3		Technically whitebait are fished from the Waikato River but the wetlands play an important role In supporting the fishery.	WRC consents data
Aesthetic	Nil	A number of houses overlook the delta wetlands and they provide some scenic value.	N/A	Ongoing	N/A	Local	837.02	1			Field observations.
Cognitive information	Number of peer-reviewed scientific studies	The Waikato River wetlands have been the subject of anumber of scientific studies but particularly of technical reports produced by Regional Council and other government agencies.	11 peer-reviewed studies	Since 1965	N/A	Regional	837.02	3			Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status	Overall social/cultural/spiritual value	Overall health value (+/-)
Opuatia sStream Wetland	1781346.783	5855556.721	660.95	Wetland	2631.408301	Oligotrophic - eutrophic	Moderate	+

	Quantification			Spatial details		Scoring		Comments	Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Commercial & recreational fisheries	Commercial or recreational fishing for eels occurs in the Opuatia Stream but they are unlikely to occur in the wetland itself.	N/A	N/A	N/A	N/A	N/A	0			
Biodiversity	Number of Threatened or At Risk species	Australasian bittern, NI fernbird, black mudfish and giant kokopu have been recorded from Opuatia. Threatened plants include *Ophioglossum petiolatum* , *Lycopodiella serpentina, Juncus holoschoenus, Myriophyllum robustum, Pterostylis paludosa, Pterostylis micromega, Utricularia australis, Utricularia delicatula, Prasophyllum hectorii, Amphibromus fluitans, Pterostylis foliata, Sporodanthus ferrugineus, Pomaderris pylicifolia* and *Ranunculus macropu* s. The wetland also has oligotrophic peat bog which is now uncommon as well as a range of other wetland types.	18 species	Ongoing	N/A	Regional	660.95	3		There appears to be very little data on the birds of Opuatia.	Moynihan 1986; NZFFD
Water	Water takes	There are no consented water takes from the Opuatia wetland although there is a consent for 26,400m^3 of water to be taken from the Opuatia stream within the wetland. The wetland also provides groundwater to adjacent farmland which is valuable during dry periods.	N/A	Ongoing	N/A	Local	660.95	1			WRC consents data.
Materials	Nil	It is unlikely that any materials are supplied by this wetland.	N/A	N/A	N/A	N/A	N/A	0			
medicinal	Nil	No medicinal uses known.	N/A	N/A	N/A	N/A	N/A	0			
Air	Air filtering/oxygen production	Air purifying function is not known	n/a	n/a	N/A	Local		0			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	1,983 t C	Annually		National	660.95	3	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	660.95 ha	Annually	$551,893.25	National	660.95	3	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood water storage	In 2004 a large flood event caused the water level in the wetland to rise by an average of 0.464m (Browne & Campbell 2005) which equates to a volume of approximately 3,066,808m^3 based on wetland size.	N/A	Ongoing	N/A	Local	660.95	3			Browne & Campbell 2005
Waste	Nitrate removal	Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service.	603 t nitrate	Annually	Unknown	Local	660.95	3		based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Removal of sediment from water	Likely to remove the majority of course sediment and a significant quantity of fine sediment from inflowing water and from floodwater from the Opuatia Stream.	N/A	Ongoing	N/A	Local	660.95	2			
Reproduction	Nil	This is a large and diverse wetland which is important habitat for a range of indigenous species including threatened birds, eels, and plants.	N/A	Ongoing	N/A	Regional	660.95	3		This indicator has been scored subjectively but could be based on species richness or similar if that data was available.	Subjective
Recreation	Nil	Opuatia is not used for recreation although the stream may be hunted during duck season.	N/A	N/A	N/A	N/A	N/A	0			Field observations
Aesthetic	Nil	Several houses overlook the wetland and it is visible from two roads.	N/A	Ongoing	N/A	Local	660.95	1			Field observations
Cognitive information	Number of peer-reviewed scientific studies	Opuatia has been studied for biodiversity and hydrology but a web of science search did not yield any results	0 peer-reviewed papers	Since 1965	N/A	N/A	660.95	0			Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)
Moanatuatua	1808277.983	5799928.265	128.56	Wetland			416.144228		

		Quantification			Spatial details		Scoring	Comments			Input data
Ecosystem service	Ecosystem Service Indicator	Description	Quantification	Time	$ value	Scale of provision (extent of the impact of provision)	Area (of ecosystem service provision)	Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)	Limitations	Comments	References etc.
Food	Nil	Nil									
Biodiversity	Number of threatened species	A valuable remnant of a highly under-represented raised peat bog ecosystem which include the Threatened *Lycopodiella serpentina* and At risk *Sporodanthus ferrugineaus*, *Utricularia delicatula* and North island Fernbird	4	n/a	N/A	Regional	128.6 ha	3		The site also has one of the last natural populations of *Sporodanthus ferrugineus* and is the only significant example of a peat bog in the Hamilton basin.	Clarkson 1997. Bioweb
Water	Water supply	No water is taken from the wetland but there are groundwater takes in the catchment .	n/a	n/a	N/A	n/a		1			
Materials	Nil	Nil	n/a	n/a	N/A	n/a		1			
Medicinal	Nil	Nil	n/a	n/a	N/A	n/a		1			
Air	Wetland area	Air purifying function is not known	n/a	n/a	N/A	Local		1			
Climate	Tonnes of Carbon sequestered	The carbon cycling in this wetland is currently being researched by Dave Campbell (Waikato Uni). Generally peat bogs sequestre around 0.5 tonnes of CO_2 per ha per yr although a figure of 4.04t was calculated by Schipper & McLeod 2002. Current carbon rate is $5.55	64.28 - 507.26t	year	$356.75 - $2,815.30	Regional	128.56	2		Sequestration information from DOC website based on research of Waugh (2007). Pprice based on NZU spot price 9/6/2015.	Schipper & McLeod 2002
Hydrological	Flood storage	The hydrology has been significantly altered. Drains flank both sides of the wetland. Provides some water storage which during heavy rainfall will regulate downstream flows and may help to reduce flooding but this is not quantifiable with the current data.	n/a	n/a	N/A	Local	0.00	2		Like other wetlands peat bogs store water and therefore play a role in downstream flow regulation. This is not quantifyable with current information however and would need detailed hydrological information which is likely to be expensive to obtain.	
Waste	Nil	Nil									
Sediment & soils	nil	The wetland that remains is a small remnant of a 7,500 ha peat bog which has provided fertile soils for dairy farming. Peat subsidence rates are approximately 3.7cm/yr in adjacent converted peat and average peat depth is 174cm (Schipper & McLeod 2002)	n/a	n/a	N/A	n/a	n/a	1		No service provided	Schipper & McLeod 2002
Reproduction	Nil	This is an uncommon wetland type which is important habitat for a range of indigenous species including threatened birds and plants.	N/A	Ongoing	N/A	Regional	n/a	3		This indicator has been scored subjectively but could be based on species richness or similar if that data was available.	Subjective
Recreation	Nil	Nil - closed reserve	n/a	n/a	N/A	n/a	n/a	1			
Aesthetic		Nil. Houses nearby may have a view of the wetland but it is unlikely to be a selling point.									
Cognitive information	Number of peer-reviewed scientific studies	Moanatuatua has been intensively studied and is a valuable scientific resource.	1 peer reviewed p	1965-2014			128.6 ha	`		Number of scientific studies does not reflect the significant quantity of grey literature; source: Web of Science	

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status	Overall social/cultural/spiritual value	Overall health value (+/-)			
Moakurarua Stream Wetland	1789330.9	5783024.2	51.71	Wetland	20594.72455	Unknown	Low	-			
		Quantification			Spatial details		Scoring		Comments		Input data
Ecosystem service	Ecosystem Service Indicator	Description	Quantification	Time	$ value	Scale of provision (extent of the impact of provision)	Area (of ecosystem service provision)	Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)	Limitations	Comments	References etc.
Food	Commercial & recreational fisheries	Occasional recreational eel fishing may be done in the stream but this is not a service currently supplied by this wetland.	N/A	N/A	N/A	N/A	N/A	0			Field observations
Biodiversity	Number of Threatened or At Risk species	No Threatened or At Risk species are know to occur at this site and given its highly degraded state it is unlikely that any would.	N/A	N/A	N/A	N/A	N/A	0			Field observations
Water	Water takes	No water is taken from within the wetland but there are a number of groundwater takes in the catchment. The wetland and floodplain do provide water to pasture in the form of groundwater which may be of value to farmers during dry periods.	N/A	N/A	N/A	N/A	N/A	1			
Materials	Nil	No materials are likely to be supplied by this wetland.	N/A	N/A	N/A	N/A	N/A	0			
Medicinal	Nil	No medicinal materials are likely to be supplied by this wetland.	N/A	N/A	N/A	N/A	N/A	0			
Air	Air filtering/oxygen production	Air purifying function is not known	n/a	n/a	N/A	Local		0			
Climate	Carbon sequestration	This wetland is dominated by pasture with some exotic treeland. Carbon sequestration will be occuring but the rates are not known.	N/A	N/A	N/A	Local	51.71	1		Data on sequestration rates for pasture could not be found but these figures may be avaialable. It seems likely that net C sequestration rates would be lower in a pasture-dominated wetland than in an equivalent sized natural wetland.	
Hydrological	Flood water storage	Likely to provide some regulation of flow and storage of flood water however this could not be quantified.	N/A	Ongoing	N/A	Local - Regional	51.71	2	Although the floodplain is intact the lack of wetland vegetation means that flood waters will drain away relatively quickly and therefore the service is reduced by the degraded nature of the wetland.		Field observations
Waste	Nitrate removal	Nitrate is removed by soil microbes particulary in anoxic wetland conditions. Although this wetland has very little natural value it is still ikely to be providing a significant nitrate removal function. This may be somewhat negated by grazing and direct nutrient inputs to the wet soils and parts of the stream.	N/A	Ongoing	N/A	Local	51.71	1		Could be improved with a better understanding of land management.	
Sediment & soils	Removal of sediment from water	This is a riparian wetland which may provide some sediment filtering, particularly from flood water. Some of the inflowing streams are fenced but others are not.	N/A	Ongoing	N/A	Local	51.71	1			Field observations
Reproduction	Nil	Biodiversity in this wetland appears to be very low with very little or no indigenous vegetation cover. It is unlikely to support reproduction of any important species	N/A	N/A	N/A	N/A	N/A	0		Could be improved with further survey.	Field observations
Recreation	Nil	This wetland is privately owned and is unlikely to provide any recreational services. It is primarily an agricultural system with little recreational appeal.	N/A	N/A	N/A	N/A	N/A	0			Field observations
Aesthetic	Nil	A primarily agricultural landscape with very little aesthetic appeal.	N/A	N/A	N/A	N/A	N/A	0			
Cognitive information	Number of peer-reviewed scientific studies	Very little information is available about this wetland and no peer-reviewed studies have been published about it.	0	Since 1965	N/A	N/A	N/A	0			Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status
Kapenga Swamp	1789330.9	5783024.2	166.00	Wetland	1842.8	Eutrophic

		Quantification				Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Duck hunting	The northern part of the wetland is leased by Fish and Game for game bird habitat	28 hunters	per year	N/A	Regional	Approx 25 ha	2			Matthew McDougall, Fish & Game, *pers. comm* 9/6/2015
Biodiversity	Number of threatened species	NZ Dabchick, black shag, Australasian bittern, grey duck, spotless crake, pied stilt, pipit, NI fernbird. The threatened orchid *Spiranthes novae-zelandiae* is also present.	9 species	n/a	N/A	Regional	166.00	3	Some old data used.	More recent information will be available soon. This is a high quality wetland that has had considerable weed control and is in a reasonably natural condition.	Owen 2003. Personal observations
Water	Water Supply	No water is taken from the wetland itself but it stores water which may be used downstream	n/a	n/a	N/A	n/a	n/a	n/a		No direct service provided.	
Materials	Ability to provide flax	Harakakeke (flax, *Phormium tenax*) cover is at least 20% on average.	21.9 ha	ongoing	N/A	Local	166.00	1		Although this ability exists it is unlikely that harakeke is taken from Kapenga in any but the smallest volumes.	Visual observations.
medicinal	Unknown	Although unlikely traditional medicines may be derived from Kapenga	n/a	n/a	N/A	local	0.00	0			
Air	Wetland area	Air purifying function is not known	n/a	n/a	N/A	Local		0			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	498 t C	Annually	N/A	National	166.00	3	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	166 ha	Annually	$138,610.00	National	166.00	3	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood storage	The wetland occupies around 5.9% of the catchment area and provides a certain amount of water storage and flood regulation although this is not readily quantified	n/a	n/a	N/A	Local		1		This would be difficult to quantify without detailed study although it could be quantified using size as a proxy.	
Waste	Nitrate removal	Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service.	151 t nitrate	Annually	Unknown	Local	166.00	3		based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Nil	The wetland will be providing a sediment trapping service, i.e. it will be trapping sediment runoff from surrounding farms and forestry and preventing it travelling downstream. Not quantifiable.	n/a	ongoing	N/A	local	166.00	2		General values for sediment retention may be able to be found.	Subjective.
Reproduction	Nil	Provides habitat for a range of indigenous wetland species. Large intact wetlands such as this are now rare.	Nil	ongoing	N/A	Local	166.00	3		High value wetland	Subjective.
Recreation	Number of duck hunters	Duck hunter utlilise at least part of this site for recreational shooting. Other recreation is probably limited to a few wetland enthusiasts	28 hunters	per year	N/A	Regional	166.00	2	Only really applies to those areas that are hunted.		Matthew McDougall, Fish & Game, *pers. comm* 9/6/2015
Aesthetic	Number of houses with view of wetland	Two or three houses overlook the wetland.	3	ongoing	N/A	Local	166.00	1		Unlikely to be a draw-card for development or an attraction for sightseers	Field observations
Cognitive information	Number of Scientific studies	Studies of the plants and birds have been undertaken by DOC and others but no peer-reviewed papers have been published about Kapenga.	0 Peer-reviewed papers	Since 1965	N/A	N/A					

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status					
Waiotapu Wetland	1894291.407	5749220.692	335.53	Wetland	4126.507175	N/A					

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Nil	No food supply	n/a	n/a	n/a	n/a	n/a	0	n/a	n/a	
Biodiversity	Number of threatened species	The At Risk prostrate kanuka (*Kunzea tenuicaulis*) is the dominant species. Cyclosorus interuptus *and Dicranopteris linearis* (also At Risk) are also present.	2	n/a		Regional	335.53				
Water	Water Supply	No water is taken directly from this wetland but geothermal water is taken from the field at Waiotapu for heating and processing purposes. This is not considered a service provided by the wetland however.	n/a	n/a	n/a	n/a	n/a	n/a			
Materials	Nil	No materials are taken from this site	n/a	n/a	n/a	n/a	n/a	n/a			
medicinal	Unknown	This site does not provide any medical-related products	n/a	n/a	n/a	n/a	n/a	n/a			
Air	Wetland area	Any air purification/oxygen production service from Waiotapu is likely to be out-weighed by emission of CO2, sulphur dioxide and other gasses	n/a	n/a	n/a	n/a	n/a	n/a			http://www.nzgeothermal.org.nz/emissions.html
Climate	Carbon sequestration	This site includes established and regenerating scrub and is likely to be sequestering carbon.	1,005t carbon	per year	$5,577.75	National	335.53	2	A sound figure on carbon sequestration could not be found. Some estimates are up to 9t/ha/yr for kanuka/manuka scrub but others are as low as 3t. The lowest figure was used here.	Better data required here.	http://www.gbict.co.nz/Newsletters/Issue%2018/Sequestration.htm http://maxa.maf.govt.nz/forestry/pfsi/carbon-sequestration-rates.htm
Hydrological	Flood storage	This wetland is unlikely to supply any significant flood storage.	n/a	n/a	n/a	n/a	n/a	1			
Waste	N/a	Much of this site is geothermal wetland which may be helping to filter out toxic chemicals from geothermal fluid and steam.	n/a	n/a	n/a	Local	335.53	1		Very subjective.	
Sediment & soils	Nil	Geothermal sites have unique soils but these only have intrinsic value at this site. The wetland may also filter out a limited amount of sediment from the surrounding forestry land, especially during harvest.	n/a	ongoing	n/a	Local	335.53	1		Very subjective.	
Reproduction	Nil	This is an important geothermal site which supports nationally uncommon vegetation types and At Risk species.	n/a	ongoing	n/a	Regional	335.53	3		Subjective. Could use species richness as a proxy here but would need better data than is currently available.	
Recreation	Number of visitors	Wai-o-Tapu thermal wonderland recieves thousands of visitors each year and the areas of the wetland and geothermal field outside the attraction also receive visitors.	160,000 visitors	Annually	See below	Regional - National	335.53	3			Allison Lawton, Waiotapu GM, *pers. comm.*)
Aesthetic	Number of visitors	Wai-o-Tapu thermal wonderland recieves around 160,000 visitors each year and the areas of the wetland and geothermal field outside the attraction also receive visitors.	160,000 visitors	Annually	$3,944,000	Regional - National	335.53	3	Estimated value	Value based on current admission prices, and an assumed 75% of visitors being adults and 25% being children. Approximate visitor numbers supplied by Waiotapu Thermal Wonderland.	Allison Lawton, Waiotapu GM, *pers. comm.*)
Cognitive information	Number of Scientific studies	Only one peer-reviewed scientific study was found in a search of the Web of Science database but the geothermal features have been well studied and monitored and reported in the grey literature or journals not covered by Web of Science.	1 peer-reviewed study	Since 1965	n/a	National	335.53	1		This does not accurately reflect the level of scientific study undertaken at Waiotapu.	Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status
Waitaramoa Rd	1821495.589	5742585.117	47.45	Wetland	415.438725	Mesotrophic mire

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Food harvested	No food is taken from the wetlands.			N/A					Otorohanga SNA report: Waipapa Ecological Area	
Biodiversity	Number of threatened or at risk species	Provides significant habitat for indigenous species. Part of a highly significant Waipa mires natural area. Threatened or At Risk species include Myriophyllum robustum, Utricularia dichotoma, Prasophyllum hectorii, and North Island Fernbird. Bush falcon & kaka utilise the wider area. Part of the Waipapa Ecological area.	4	N/A	N/A	Regional (habitat for At Risk species)	48 ha +	2			BioWeb Data
Water	Water supply	Limited water filtration. No flow data. No Water takes in nearby area but headwaters of the Waipa River.	No data	N/A	N/A	Local to Regional		2		The amount of water stored could be quantified with further detailed work but this data is not currently available	
Materials	Potential Harakeke supply	Potential supply only - whether harakeke is gathered here is unknown (unlikely). Harakeke cover is approx 10%	4.745	N/A	N/A	local	4.745ha	1			
Medicinal	Nil	Nil			N/A			0			
Air	Air filtering/oxygen production		No data		N/A						
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	142.35 t C	Annually	N/A	National	47.45	1	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	47.45 ha	Annually	$39,620.75	National	47.45	1	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Water storage	Stores water in the headwaters to regulate supply to the Waipa river	No data	N/A	N/A	Local	48 ha +	1	No hard data available	Difficult to assess even if more money for survey was available.	
Waste	Nutrient filtering	Minor filtration of water flowing from surrounding forest land.	No data	N/A	N/A	Local	48 ha +	2	No hard data available		
Sediment & soils	Sediment removal function	Like most wetlands this site is likely to filter out course and some fine sediment	No data	N/A	N/A	Local	48 ha +	2	No hard data available		
Reproduction	Nil	Provides breeding habitat for indigenous biodiversity. Wetland habitat has been severely reduced and mires such as this are very uncommon.	-	N/A	N/A	Local	48 ha +	2	Could we use total species richness for this??		
Recreation	Number of visitors	Trampers, hunters, and campers visit the wider area of which this wetlands is a part	No data	N/A	N/A	Regional	48 ha +	2			
Aesthetic	Number of visitors	Trampers, hunters, and campers visit the wider area of which this wetlands is a part	No data	N/A	N/A	Regional	48 ha +	2			
Cognitive information	Number of scientific studies	Scientific study of these sites appears to be limited to technical reports.	0 peer-reviewed studies	Since 1965	N/A	N/A	48 ha +	0			Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)	Trophic status
Ranginui Rd	1824059.247	5741166.465	17.04	Wetland	198.210671	Mesotrophic mire

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Food harvested	No food is taken from the wetlands.			N/A			0		Otorohanga SNA report: Waipapa Ecological Area	
Biodiversity	Number of threatened or at risk species	Provides significant habitat for indigenous species. Part of a highly significant Waipa mires natural area. Threatened or At Risk species include Myriophyllum robustum, Utricularia dichotoma, Prasophyllum hectorii, and North Island Fernbird. Bush falcon & kaka utilise the wider area. Part of the Waipapa Ecological area.	4	N/A	N/A	Regional (habitat for At Risk species)	17.04	2			BioWeb Data
Water	Water supply	Limited water filtration. No flow data. No Water takes in nearby area but headwaters of the Waipa River.	No data	N/A	N/A	Local to Regional		1		The amount of water stored could be quantified with further detailed work but this data is not currently available	
Materials	Potential Harakeke supply	Potential supply only - whether harakeke is gathered here is unknown (unlikely). Harakeke cover is approx 10%	1.704	N/A	N/A	local	1.704ha	1			
medicinal	Nil	Nil			N/A			0			
Air	Air filtering/oxygen production		No data		N/A						
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	151.12 t C	Annually	N/A	National	17.04	1	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	17.04 ha	Annually	$14,228.40	National	17.04	1	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Water storage	Stores water in the headwaters to regulate supply to the Waipa river	No data	N/A	N/A	Local	17.04	2	No hard data available	Difficult to assess even if more money for survey was available.	
Waste	Nutrient filtering	Minor filtration of water flowing from surrounding forest land.	No data	N/A	N/A	Local	17.04	2	No hard data available		
Sediment & soils	Sediment removal function	Like most wetlands this site is likely to filter out course and some fine sediment	No data	N/A	N/A	Local	17.04	2	No hard data available		
Reproduction	Nil	Provides breeding habitat for indigenous biodiversity. Wetland habitat has been severely reduced and mires such as this are very uncommon.	-	N/A	N/A	Local	17.04	2	Could we use total species richness for this??		
Recreation	Number of visitors	Trampers, hunters, and campers visit the wider area of which this wetlands is a part	No data	N/A	N/A	Regional	17.04	2			
Aesthetic	Number of visitors	Trampers, hunters, and campers visit the wider area of which this wetlands is a part	No data	N/A	N/A	Regional	17.04	2			
Cognitive information	Number of scientific studies	Scientific study of these sites appears to be limited to technical reports.	0 peer-reviewed studies	Since 1965	N/A	N/A	17.04	0			Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)
Forest Rd Wetland	1860121.252	5729429.397	46.35	Wetland	1110.533036

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Nil	This wetland is unlikely to supply any food.	0	n/a	n/a	n/a	n/a	n/a		The adjacent farm land is used as a gamebird hunting lodge and farm-raised pheasants are released on to it. These may utilise wetland habitat for cover from time to time but this service is considered too minor to include.	Wildlands Kinleith Nas data (See South Waikato SNA on server)
Biodiversity	Number of threatened species	Provides significant habitat for indigenous species including Fernbird and *Ranunculus macropus* .	2	ongoing	N/A	local	46.35	2	Based on very limited information which could be improved with basic plant and bird surveys		
Water	Water supply	No water is taken from this wetland although a groundwater bore is present nearby.	N/A	N/A	N/A	N/A	N/A	0			Field observations
Materials	Harakeke cover	Harakeke is present but unlikely to be harvested. This is a potential service only. There is approximately 50% cover of Harakeke.	23.175ha	N/A	?	Local	23.175ha	1		It is npot known whether harakeke is harvested from this site. There is a Marare nearby at Mokai which may require harakeke for weaving from time to time.	Field survey
medicinal	Nil	No medicinal products are likely to be taken from this wetland.	n/a	n/a	n/a	n/a	n/a	n/a			
Air	Air filtering/oxygen production	Air purifying function is not known	n/a	n/a	N/A	Local		0			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	139.05 t C	Annually	N/A	National	46.35	1	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	46.35 ha	Annually	$38,702.25	National	46.35	1	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood storage	The hydrology has been altered by the construction of the road and culvert but this wetland provides valuable headwater storage which during heavy rainfall will regulate downstream flows and may help to reduce flooding. This is not quantifiable with the current data.	No data	N/A		Local	46.35	2			
Waste	Nitrate removal	Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service.	42 t nitrate	Annually	Unknown	Local	46.35	3		based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Nil	The wetland will be providing a sediment trapping service, i.e. it will be trapping sediment runoff from surrounding farms and preventing it travelling downstream. Not quantifiable.	n/a	ongoing		local	46.35	2		General values for sediment retention may be able to be found.	Subjective.
Reproduction	Nil	Provides habitat for a range of indigenous wetland species. Large intact wetlands such as this are now rare.	Nil	ongoing		Local	46.35	3		High value wetland	Subjective.
Recreation	Nil	Unlikely	Nil	n/a		n/a	46.35	0			
Aesthetic	Nil	Two farm houses overlook the wetland but these are unlikely to be here because of the wetland	Nil	n/a	n/a	n/a	n/a	0		Unlikely to be a draw-card for development or an attraction for sightseers	Field observations
Cognitive information	Number of Scientific studies	No published scientific papers have been written about this wetland although it has been surveyed for SNA projects.	0 peer-reviewed papers	n/a	n/a	N/A	N/A	0			Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)
Turangi Swamp	1843992.49	5684642.249	1115.93	Wetland	82226.87798

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Duck hunting	Parts of the wetland may be used for duck hunting but the annual number of hunters is not known.	N/A	Annually	N/A	Local	1115.93 ha	1			
Biodiversity	Number of threatened species	Black Shag , Little Black Shag, Australasian bittern, NZ dabchick, grey duck, banded rail, spotless crake, marsh crake, and North Island fernbird. Plants include *Utricularia australis* and Prasophyllum hectori	11	N/A	N/A	National	1115.93	3	Relatively old data but likely to still be accurate		Cromarty & Scott 1996
Water	Water Supply	No consented water takes from this wetland.	N/A	N/A	N/A	N/A	N/A	0			
Materials	Ability to provide flax	Flax is common in some areas but was not able to be quantified during the site visit.	N/A	Ongoing	N/A	Local	Unknown but significantly less than total wetland area	1		It is highly unlikely that materials in any significant volume are taken frm the wetland.	
Medicinal	Unknown	Unknown but not likely	N/A	N/A	N/A	N/A	N/A	0			
Air	Wetland area	Unknown	N/A	N/A	N/A	N/A	N/A	1			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	3537.5 t C	Annually		National	1115.93	2	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	1115.93	Annually	$931,801.55	National	1115.93	2	Generic figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood storage	Three rivers (Tongariro, Waiotaka, & Waimarino) flow through the wetlands which are likely to provide flood strorage. The hydrology has also been altered by the raising of the Taupo lake level and local drainage but is relatively intact compared to many other sites.	N/A	Ongoing	N/A	Local	1115.93	2		Would require further study to be able to quantify this service.	
Waste	Nitrate removal	Likely to remove a significant quantity of nitrate from groundwater but possibly also lake water. The western part of the wetland recieves disharge of treated wastewater from the Turangi WWTP and provides the final treatment of the effluent.	1018 t nitrate	Annually	Unknown	Local	1115.93	3		based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Removal of sediment from water	This wetland has been formed in part by the natural accretion of land by the sediment-laden Tongariro River. It plays and important role in removing sediment from the waterways in times of flood.	N/A	N/A	N/A	Local	1115.93	3			
Reproduction	Nil	This is a large and diverse wetland which is important habitat for a range of indigenous species including threatened birds, eels, and plants.	N/A	Ongoing	N/A	Regional	1115.93	3		This indicator has been scored subjectively but could be based on species richness or similar if that data was available.	Subjective
Recreation	Visitor facilities	Visitors to the site are generally there for either the fishing in the rivers that run through the wetland or to visit Lake Taupo. The wetland itself is not a destination for recreation	N/A	Ongoing	N/A	Local	1115.93	1		Visitor numbers could be surveyed for this indicator.	Subjective
Aesthetic	Nil	This wetland adds to the general scenic value of the area. State Highway 1 goes through the middle of it and it is highly visible from the road. A number of properties border the wetland and it provides a backdrop to Stump Bay and Motuoapa Bay on Lake Taupo.	N/A	Ongoing	N/A	Local	1115.93	2		Difficult to assess.	Subjective
Cognitive information	Number of Scientific studies	The Web of Science search yielded five scientific studies.	5 published papers	Since 1965	N/A	National	1115.93	2	Based only on published papers and does not include grey literature.		Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Catchment Size (ha) (FENZ)
Lake Rotoaira wetland	1832286.075	5676537.777	553.68	Wetland	4840.67316

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Food	Nil	No food is likely to be taken from this wetland	N/A	N/A	N/A	N/A	N/A	0			
Biodiversity	Number of threatened species	Thismia rodwayi & Urtica linearis recorded from the wetlands or nearby (BioWeb). North Island fernbird are also present and short- and long-tailed bats are present in the wider Rotoaira forest and may utilise the wetlands.	5 species	ongoing	N/A	Regional	553.68	2	Comprehensive biodiversity information is not available		NZFM website, BioWeb
Water	Water Supply	No consented water takes from this wetland.	N/A	N/A	N/A	N/A	N/A	0			
Materials	Ability to provide flax	There is approximately 30% cover of flax in this wetland which could be utilised for fibre but is not known to be at this time.	166 ha flax	ongoing	Unknown	Local	553.68	1		Some flax may be harvested by local marae for use in weaving	Field visit
	Ability to provide manuka honey	The marginal parts of the site are dominated by manuka which amounts to around 15% of overall cover. It is likely that bees utilise this nectar source.	83 ha manuka	Annually	$33,200.00	Local	553.68	2	Based on generic figures	Generic figure of $400/ha for manuka honey production. No information available on how much, if any, manuka is being used for honey production.	http://www.ruralnewsgroup.co.nz/rural-news/rural-management/manuka-option-for-steep-hills?
medicinal	Ability to provide manuka honey	Manuka honey can be used in medical dressings and wound care. This is essentially the same service as manuka honey for food production and cannot be valued twice.	N/A	N/A	N/A	Local	553.68	0			
Air	Wetland area	Unknown	N/A	N/A	N/A	N/A	N/A	1			
Climate	Carbon sequestration	Likely to sequestre carbon dioxide from the atmosphere.	1660 t C	Annually		National	553.68	2	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year	May be able to be improved with local studies. Carbon credit value could be used here but this is not considered a good indicator of the value of carbon sequestration.	Bernal & Mitsch 2012
	Climate regulation	Likely to sequestre carbon dioxide from the atmosphere.	553.68	Annually	$462,322.80	National	553.68	2	Generic per ha figure based on a review by De Groot *et. Al.* 2012 of a number of studies.	Difficult to improve for individual sites but more relevant research may become available in time.	De Groot *et. Al.* 2012
Hydrological	Flood storage	The wetland is likely to provide flood storage and water retention. The hydrology has also been altered by the raising of the Rotoaira lake level for the Tongariro hydro scheme and by the hydro canal which runs through the site. However, it is relatively intact compared to many other sites.	N/A	Ongoing	N/A	Local	553.68	2		Would require further study to be able to quantify this service.	
Waste	Nitrate removal	Likely to remove nitrate from groundwater and possibly also lake water although as neighbouring land has either natural vegetation or pine forest cover this service is not likely to be significant.	505 t nitrate	Annually	Unknown	Local	553.68	3	The generic figure for nitrate removal used here is the potential rather than the actual amount removed because the wetland can't remove nitrogen that is not entering the system.	based on generic nitrate removal figures for constructed wetlands.	Tanner & Sukais 2012
Sediment & soils	Removal of sediment from water	May provide a limited service of sediment removal from adjacent land and lake water	N/A	N/A	N/A	Local	553.68	1			Subjective
Reproduction	Nil	This is a large and diverse wetland which is relatively natural and which is important habitat for a range of indigenous species including threatened birds and plants.	N/A	Ongoing	N/A	Regional	553.68	3		This indicator has been scored subjectively but could be based on species richness or similar if that data was available.	Subjective
Recreation	Visitor facilities	The wetland is unlikely to be used for recreation and there are no visitor facilities	N/A	N/A	N/A	Local	553.68	1		Visitor numbers could be surveyed for this indicator.	Subjective
Aesthetic	Nil	This wetland adds to the general scenic value of the area and is part of a much larger natural area which includes Lake Rotoaira and the adjacent National Park. State Highway 47 goes along the northern edge of the wetland and it is visible from the road in some places.	N/A	Ongoing	N/A	Local	553.68	2		Difficult to assess.	Subjective
Cognitive information	Number of Scientific studies	The Web of Science search yielded no scientific studies.	0	Since 1965	N/A	National	553.68	2	Based only on published papers and does not include grey literature.		Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status
Karapiro	1833502.164	5791911.543	769.6121	Lake	Hydro	50th =	785,389	Unknown

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem providing the service)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Electricity produced from water	Provides the header reservoir for the 90MW Karapiro Power station.	334 GWh	Annually	$21,376,000.00	National	769.6121	3			
	Volume of water used for potable or irrigation purposes	Consented potable and irrigation water takes	7555500m3	Annually	$11,333,250.00	Local		3	Based on retail value of water.	Could use more accurate water take data from consents if it is available	
Fisheries	Number of fishers using the lake	Trout fishing. Part of Auckland-Waikato Region which attracts some 3,500 anglers each year.	No data available	-	-	Regional	769.6 ha	2	No data available about number of fishers using karapiro	Would be very didfficult to quantify without the cooperation of Fish and Game and a specific survey	
	Commercial Eel catch	Commercial eel catch is approximately 6,700 kg / year for Karapiro and its catchment.	6,717 kgs	Annually	$49,369.95	Regional	769.6 ha	3			Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
Food	Number of fishers using the lake	Trout, eels	No data available	-	-	Regional	769.6 ha	2	No data available about number of fishers using karapiro	Would be very didfficult to quantify without the cooperation of Fish and Game and a specific survey	
Waterfowl	Number of Hunters	Utilised by duck hunters. Numbers not known	No data available	-	-	Regional	769.6 ha	2	No data available about number of hunters using karapiro	Would be very didfficult to quantify without the cooperation of Fish and Game and a specific survey	
Biodiversity	Number of threatened or at risk species	Provides habitat for dabchick, caspian tern, spotless crake, black shag, little black shag and other wetland and waterfowl. Fish include longfin eel and koura.	6 species	n/a	-	National	769.6 ha	3	Some data is old	The threat status of these spcies is assessed on a national scale so the impact of the service is seen to be national. Surveys of other biodiversity (lake plants, invertebrates etc) could be added and species richness used as an indicator rather than threatened species.	Reeves *et. al.* 2011, Robertson *et. al.* 2012, Goodman *et. al.* 2014.
Nutrient Processing	Water quality	Water quality in the lake is 'satisfactory' (WRC)	Waipa DC data to be added here	-	-	Regional	769.6 ha	2?	Limited water quality data available		
Sediment processing	Quantity of sediment trapped	Approximately 38,000m3 of sediment is trapped by Lake Karapiro annually. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the majority of course sediment (Hicks et.al. 2010).	38,000 m3	p.a.	-	Catchment	769.6 ha	2	Sediment trapping is both a service and a negative impact.		NIWA 2010
Hydrological regulation	Flood storage volume	Provides the header reservoir for the Karapiro power station (96MW) and limited flood flow regulation	7696m³ of water	days	-	Sub-regional	769.6 ha	1	Based on difference between average lake level and max operating level of Karapiro dam (1m).	Not very accurate	Mighty River Power
Climate change mitigation	Carbon sequestered		No data available	-	-	Local	769.6 ha	-		More information on carbon cycling in particular types of lakes will be required.	
Recreation	Recreational use	Important boating lake, trout fishing, duck hunting. Venue for numerous national and international rowing events. At least 8 public boat ramps along with numerous private jettys. Several reserves along the entire length of the lake. The Waikato River Trail starts on Horahora road and follows the lake edge.	-	p.a.	-	National	769.6 ha	3	No hard data available so a general score was given based on the presence of the rowing centre, recreational boating and fishing activity etc	Difficult to quantify without some kind of survey	
Aesthetics	Density of lakeside properties	A desirable location to own property. A number of large houses overlook the lake. Also provides a scenic backdrop to SH1.		n/a		Local	769.6 ha	2	No data available for lake visitors etc		
Cognitive information	Number of Scientific Studies		TBC						TBC - will be based on Web if Science journal search.		
	Interpretation signage	Signage about the lake and hydro schemes are present in several places, including along the Waikato River Trail.	-	n/a	-	local	769.6 ha	2	Difficult to quantify		

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status			
Karapiro	1833502.164	5791911.543	769.6121	Lake	Hydro	50th =	785,389	Unknown			
			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem providing the service)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Electricity produced from water	Provides the header reservoir for the 90MW Karapiro Power station.	334 GWh	Annually	$21,376,000.00	National	769.6121	3			
	Volume of water used for potable or irrigation purposes	Consented potable and irrigation water takes	7555500m3	Annually	$11,333,250.00	Local		3	Based on retail value of water.	Could use more accurate water take data from consents if it is available	
Fisheries	Number of fishers using the lake	Trout fishing. Part of Auckland-Waikato Region which attracts some 3,500 anglers each year.	No data available	-	-	Regional	769.6 ha	2	No data available about number of fishers using karapiro	Would be very didfficult to quantify without the cooperation of Fish and Game and a specific survey	
	Commercial Eel catch	Commercial eel catch is approximately 6,700 kg / year for Karapiro and its catchment.	6,717 kgs	Annually	$49,369.95	Regional	769.6 ha	3			Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
Food	Number of fishers using the lake	Trout, eels	No data available	-	-	Regional	769.6 ha	2	No data available about number of fishers using karapiro	Would be very didfficult to quantify without the cooperation of Fish and Game and a specific survey	
Waterfowl	Number of Hunters	Utilised by duck hunters. Numbers not known	No data available	-	-	Regional	769.6 ha	2	No data available about number of hunters using karapiro	Would be very didfficult to quantify without the cooperation of Fish and Game and a specific survey	
Biodiversity	Number of threatened or at risk species	Provides habitat for dabchick, caspian tern, spotless crake, black shag, little black shag and other wetland and waterfowl. Fish include longfin eel and koura.	6 species	n/a	-	National	769.6 ha	3	Some data is old	The threat status of these spcies is assessed on a national scale so the impact of the service is seen to be national. Surveys of other biodiversity (lake plants, invertebrates etc) could be added and species richness used as an indicator rather than threatened species.	Reeves *et. al.* 2011, Robertson *et. al.* 2012, Goodman *et. al.* 2014.
Nutrient Processing	Water quality	Water quality in the lake is 'satisfactory' (WRC)	Waipa DC data to be added here	-	-	Regional	769.6 ha	2?	Limited water quality data available		
Sediment processing	Quantity of sediment trapped	Approximately 38,000m3 of sediment is trapped by Lake Karapiro annually. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the majority of course sediment (Hicks et.al. 2010).	38,000 m3	p.a.	-	Catchment	769.6 ha	2	Sediment trapping is both a service and a negative impact.		NIWA 2010
Hydrological regulation	Flood storage volume	Provides the header reservoir for the Karapiro power station (96MW) and limited flood flow regulation	7696m³ of water	days	-	Sub-regional	769.6 ha	1	Based on difference between average lake level and max operating level of Karapiro dam (1m).	Not very accurate	Mighty River Power
Climate change mitigation	Carbon sequestered		No data available	-	-	Local	769.6 ha	-		More information on carbon cycling in particular types of lakes will be required.	
Recreation	Recreational use	Important boating lake, trout fishing, duck hunting. Venue for numerous national and international rowing events. At least 8 public boat ramps along with numerous private jettys. Several reserves along the entire length of the lake. The Waikato River Trail starts on Horahora road and follows the lake edge.	-	p.a.	-	National	769.6 ha	3	No hard data available so a general score was given based on the presence of the rowing centre, recreational boating and fishing activity etc	Difficult to quantify without some kind of survey	
Aesthetics	Density of lakeside properties	A desirable location to own property. A number of large houses overlook the lake. Also provides a scenic backdrop to SH1.		n/a		Local	769.6 ha	2	No data available for lake visitors etc		
Cognitive information	Number of Scientific Studies		TBC						TBC - will be based on Web if Science journal search.		
	Interpretation signage	Signage about the lake and hydro schemes are present in several places, including along the Waikato River Trail.	-	n/a	-	local	769.6 ha	2	Difficult to quantify		

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)
Rotoaira	1833846	5675664	1584.50	Lake	Volcanic	12th	14,281	Mesotrophic in 2001 (Dugdale & Wells 2001, cited in Reeves *et. Al.* 2011))	

		Quantification			Spatial details		Scoring	Comments			Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Volume of water used for power generation	Provides the header reservoir for the 240MW Tokaanu Power station. Annual average of 46.77 cumecs.	1.475 km3	Annually	$57,600,000.00	National	1584.50	3	Generic data	The quantity of electricity produced per year was not provided by Genesis because of commercial sensitivity but an average figure of 900GWh was derived from information sourced from Wikipedia. Weekly average wholesale electricity price of 6.4c/kWh was used to calculate the wholesale value of the electricity produced by Tokaanu but this is not necessarily the value of the water supply in Lake Rotoaira as the water is sourced from a number of other locations .	Genesis Energy Unpublished data. https://en.wikipedia.org/wiki/Tongariro_Power_Scheme; http://www.electricityinfo.co.nz/comitFta/price_index.summary
Fisheries	Number of fishers using the lake	Popular trout fishery. A study on the tuna population is underway.	No data	Annually		Local	1584.50	3		Could not obtain fishing permit information.	Genesis Energy 2014: Tongariro power scheme environmental report.
Food	Number of fishers using the lake	Some tuna are harvested by locals.	No data	Annually		Local	1584.50	3			Genesis Energy 2014: Tongariro power scheme environmental report.
Waterfowl	Number of Hunters	It is not known whether hunting is permitted on Lake Rotoaira but waterfowl are abundant and it is likely to be a source of birds for hunting in other areas.	N/A	N/A	N/A	N/A	N/A	0			
Biodiversity	Number of threatened or at risk species	Koaro present in the lake (NZFFD). Bittern, dabchick, fernbird, pied stilt, spotless crake, and marsh crake reported (Reeves *et. Al.* 2011)	7 threatened species	N/A	N/A	Regional	1584.50	3		Other species may also be present.	Reeves et al 2011; NZFFD
Nutrient Processing	Water quality	Lake Rotoaira was mesotrophic in 2001.	N/A							Trophic state is not necessarily a good indicator of nutrient processing other than to say that nutrients are present. More detailed indicators could be used if water quality monitoring data was available.	Dugdale & Wells 2001 cited in Reeves et al 2011
Sediment processing	Quantity of sediment trapped	No data is available for this lake.	N/A	N/A	N/A	N/a	N/A	N/a			
Hydrological regulation	Flood storage volume	Provides the header reservoir for the 240MW Tokaanu Power station and as part of the Tongariro power scheme it provides some flood regulation for the Tongariro catchment. There are regular fluctuations in water level of about 300mm.	4753500m3	N/A	N/A	Local	1584.50	1		The value used here is the lake area multiplied by the 300mm fluctuation. These fluctuation are experienced in the day-to-day operation of the hydro-scheme which is hydrologically complex so this indicator is not very sound.	Genesis Energy 2014
Climate change mitigation	Carbon sequestered	No data available.	No data	N/A	N/A	N/A	N/A	N/a			
Recreation	Recreational use	Trout fishing									
Aesthetics	Nil	Very scenic lake which provides nice views from the main road between Turangi and National Park - lake views with the mountains behind.	N/A	Ongoing	N/A	Local	1584.50	3			Subjective
Cognitive information	Number of Scientific Studies	The historic maori village on the northern shore is signposted	3 published papaers	Since 1965	N/A	National	1584.50	1			Web of Science database

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)
Taupo	1857924.597	5698390.106	61336.00	Lake	Volcanic	1st	343,583	Oligotrophic	+

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision - ha)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Volume of potable water takes	Up to 19,177,830m3 of water can be abstraced for domestic use annually (consented).	19177830	Annually	$13,424,481.00	Local	61336.00	3		Based on consented waer takes. There may be a significant volume of water from non-consented domestic takes.	Consents data. Tongariro-Taupo CMS
Fisheries	Number of fishers using the lake	World-renowned trout fishery. Iwi interest in harvesting smelt for food (Tongariro-Taupo CMS)	41,363 licences sold	Annually	$3,722,670.00	National	61336.00	3		Overall value of the Taupo fishery was assessed as being $29million or the equivalent of 294 FTE jobs.	Taupo Fishery Review 2013
Food	Number of fishers using the lake	As above. There may also be duck hunting on the lake although this is more recreation than food provision.	N/A	N/A	N/A	National	61336.00	3			
Waterfowl	Number of Hunters	Important breeding and feeding habitat for recreational game birds such as mallards, grey teal, and canada goose.	No data	N/A	N/A	Local	61336.00	1			Chromarty & Scott 1996
Biodiversity	Number of threatened or at risk species	Important breeding and feeding habitat for a number of species including New Zealand dabchick, shags, Australasian bittern, grey teal, mallard, paradise shelduck, black swan, spotless crake, red- and black-billed gulls, coot, banded rail and caspian tern (Chromarty & Scott 1996). Also koura, koaro,	12 threatened species	Ongoing	N/A	National	61336.00	3			Chromarty & Scott 1996
Nutrient Processing	Water quality	Lake Taupo is oligotrophic but historical landuse in the catchment and significant lag times for nutrients travelling in ground water means that the trophic status in slikely to degrade over time, despite improved landuse practices. The lake has very long residence times which may improve its ability to process nutrients.	N/A	N/A	N/A	Regional	61336.00	2		Could be improved with input from someone very familiar with the Lake Taupo water quality situation.	
Sediment processing	Quantity of sediment trapped	Taupo recieves a significant quantity of sediment from its catchment and the majority is stored in the lake although some fine suspended sediment is likely to be transported down the Waikato River. The majority of sediment comes from the Tongariro catchment. Hydro dams in several sub-catchments along with landuse practices have altered the sediment regime.	192,000 t	Annually	N/A	Regional	61336.00	3		Could not access the original report.	Hicks et al 2000, cited in BECA 2006.
Hydrological regulation	Hydro storage volume	Provides the header reservoir for the Waikato River which in turn is used to generate electricity, provide potable water, irrigation water etc. Holds 59 cubic km of water. The lake stores 0.8624 km3 of water for hydro purposes and during its highest level in 1956 it held an additional 2,321,800m3 of flood water.	0.8624 km3	ongoing	N/A	Regional	61336.00	3			Paine 2010; McConchie et al 2008
Climate change mitigation	Carbon sequestered	Unknown	N/A	N/A	N/A	N/A	N/A	N/A			
Recreation	Recreational use	Extremely popular tourist and recreation destination. In 2010 total visits to Taupo were forecast to rise to 3.429 million in 2016. Recreational activities directly associated with the lake include boating, trout fishing, multi-sport, cycling, skydiving etc.	See 'Aesthetics'	Annually	N/A	International	61336.00	3		More specific information may be available about the value of recreation to the area but this could not be founf.	
Aesthetics	Visitor Nights	Lake Taupo is the basis of much of the local tourism industry.	3.4 million visitor nights	Annually	$414,000,000	International	61336.00	3		This indicator could be used for either Aesthetics or Recreation as the two are intrinsically linked.	Ministry for Economic Development 2010.
Cognitive information	Number of Scientific Studies	Taupo is extremely well studied and this is reflected in the published literature as well as a significant quantity of grey literature. As well as scientific study the lake provides a range of learning opportunities to the public through signage etc.	239 published papers	Since 1965	N/A	National	61336.00	3	Number of scientific studies does not reflect the significant quantity of grey literature.		Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)		
Whakamaru	1857578.252	5743217.007	538.4206	Lake	Hydro	50th =	586,192	Unknown			

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Volume of potable water takes	Approx. 1,100,000m3 of water is taken from the lake for irrigation purposes.	1,100,000m³	Annually	$154,000.00	Local	538.4206	3	Based on the cost to buy water from irrigation schemes. Actual cost varies considerably.		Reese & Borrie 2014.
	Electricity produced from water	Provides the header reservoir for the 100MW Whakamaru Power station	371 GWh	Annually	$23,744,000.00	National	538.4206	3	No data provided by Might River Power despite requests.	Based on relevant proportion of average output of entire Waikato Hydro Scheme. I.e. Whakamaru is rated at 100MW which is 9.28% of total Waikato capacity which produces an average of 4,000 GWh/yr.	Mighty River Power Website
Fisheries	Number of fishers using the lake	Trout fishing. Part of Auckland-Waikato Region which attracts some 3,500 anglers each year.	N/A	Annually	N/A	Local	538.4206	2		No specific data on fishing in Whakamaru is available.	F&G pers. comm.
	Commercial eel catch	Whakamaru and its catchment support a commercial eel catch of approximately 1,500 kg/year	1,500 kg	Annually	$11,025.00	Regional	538.4206	2	Based on very broad figures and old data	Based on eel fishery value data from NIWA website.	Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
Food	Commercial eel catch	As above.	N/A	N/A	N/A	Regional	538.4206	2			
Waterfowl	Number of Hunters	Probably used by duck hunters but numbers not available. Provides habitat for waterfowl including mallard, shoveler, grey teal, grey duck, swans, and geese.	N/A	Ongoing	N/A	Local	538.4206	2			Field observations
Biodiversity	Number of threatened or at risk species	Indigenous fish include longfin eel, smelt, common bully and koura. Birds include Caspian tern, NZ shoveler, grey teal, black swan, mallard duck, little shag, paradise shelduck and Canada goose.	2	Ongoing	N/A	Local	538.4206	1		Other threatened or at risk species such as spotless crake and NI fernbird may also be present	NZFFD, Field observations
Nutrient Processing	Water quality	Nutrient data available from WRC. Water quality is generally good and on the border of the mesotrophic and eutrophic ranges but important characteristics such as TN are declining.	N/A	Ongoing	N/A	Regional	538.4206	2	Nutrient status is not a very good indicator of nutrient processing as the former does not necessarily affect the latter.		LAWA Website: http://www.lawa.org.nz/explore-data/waikato-region/freshwater/waikato-river/waikato-river-@-whakamaru-tailrace/
Sediment processing	Quantity of sediment trapped	Approximately 35,000m3 of sediment is trapped by Lake Whakamaru annually. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the majority of course sediment (Hicks *e t.al. 2010).*	35,000 m³	Annually	N/A	Regional	538.4206	3		The sediment trapping service provided by the lake may help to remove additional sediment added to the system by landuse practices but it also restricts the flow of riverbed material to the downstream reaches of the Waikato.	Hicks *et. al.* 2010
Hydrological regulation	Hydro storage volume	Provides the header reservoir for the Whakamaru power station and is used to regulate flows to the downstream hydro-dams. The lake can store almost 13 million cubic metres of water between its lowest allowable operating level and its maximum operating level.	12,912,000 m³	N/A	N/A	Local	538.4206	3		This service is intrinsically linked to the provision of water for hydro generation which has been assessed separately.	Mighty River Power Website: http://www.mightyriver.co.nz/Our-Business/generation/Lake-Levels.aspx
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters.	N/A	N/A	N/A	N/A	N/A	-			
Recreation	Recreational use	Utilised for boating and fishing. At least two boat ramps service the lake. There is a Christian camp on the northern shore and public camping areas at two other locations where basic facilities are provided. The Waikato River Trail (walking and biking) runs along the length of the northern shore.	N/A	N/A	N/A	Regional	538.4206	2		The lake has good visitor facilities but it is not known how much it is actually used.	Field observations
Aesthetics	Nil	The lake provides a scenic backdrop to SH30 and the Waikato River Trail. Several houses overlook the lake both in the Whakamaru Village and on rural land.	N/A	Ongoing	N/A	Local	N/A	2		Could be beased on number of properties overlooking the lake or on visitor numbers. Both of these would require additional survey.	Field observations
Cognitive information	Number of Scientific Studies	Five scientific papers were found using Web of Science seraches. There is also some grey literature with information about various aspects of the lake. Some information posted along the Waikato River trail.	5 published papers	Since 1965	N/A	National	538.4206	1			Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)		
Rotopiko (Serpentine)	1803683.668	5797170.805	10.30	Lake	Peat	15th	164	Eutrophic - Supertrophic			

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Consented Water Supplies	No water is taken from these lakes.	N/A	N/A	N/A	N/A	N/A	0			
Fisheries	Commercial or recreational harvest	There is no known fishing activity at Rotopiko although some eels may be caught for recreation or customary purposes	N/A	N/A	N/A	N/A	N/A	1			
Food	Number of fishers using the lake	None known	N/A	N/A	N/A	N/A	N/A	0			
Waterfowl	Number of Hunters	Breeding habitat for ducks and other water fowl. The number of hunters using the lakes is not known but there are a few maimais.	N/A	Annually	N/A	Local	10.30				
Biodiversity	Number of threatened or at risk species	Considered some of the best peat lakes remaining in the region. Support several threatened bird species (bittern, dabchick, caspian tern, crake, and shags) + longfin eel. Has good submerged plant communities. Rotopiko East has a pest-proof fence.	6	N/A	N/A	Regional	10.30	3			Field observations, Reeves *et. al 2011*
Nutrient Processing	Water quality	TLI between 4 and 5.2 for all three lakes (eutrophic - supertrophic). There are plans to install treatment wetlands on inflowing drains.	N/A	N/A	N/A	Local	10.30	2			Dean 2015
Sediment processing	Quantity of sediment trapped	Likely to remove course sediment and some suspended sediment from inflows but the catchment is very small and this is not likely to be a significant service. Sediment traps are likely to be installed in the near future.	N/A	Ongoing	N/A	Local	10.30	1		Could be improved with detailed monitoring or modelling of sediment loads	
Hydrological regulation	Flood storage	Significantly altered hydrology due to drainage and diversion. Nevertheless the lakes provide water storage to regulate flows in heavy rain and a drainage point for surrounding land. The lakes fluctuate by about 0.7m and floods raise the lake by approximately 0.3m from the average level.	30,900m³	N/A	N/A	Local	10.30	2		Based on WRC lake level data for 2009 - 2014	WRC Data
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters.	N/A	N/A	N/A	N/A	N/A	-			
Recreation	Recreational use	Minor. Some walking and possibly hunting. Likely to increase significantly if National Wetland Centre is built	N/A	N/A	N/A	Local	10.30	2		No visitor data could be found.	
Aesthetics		Highly visible from SH3. The National Wetland Centre will capitilise on the scenic value of the lakes when built. Some houses overlook the lakes, with several new lifestyle properties off Jary Road.	N/A	Ongoing	N/A	Local	10.30	2			Field observations
Cognitive information	Number of peer-reviewed scientific studies	Rotopiko has been the subject of a considerable amount of scientific study.	1 peer-reviewed paper	Since 1965	N/A	Regional	10.30	1	The number of peer-reviewed journal articles is not a particularly good indicator for this site as there has been a considerable quantity of scientific study published by councils, doc or in the grey literature.	Based on Web of Science search	Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)
Kaituna	1798314.341	5827468.294	9.65	Lake	Peat	41st =	410	Hypertrophic	

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Consented Water Supplies	No water is taken directly from the lake.	N/A	N/A	N/A	N/A	N/A	0			WRC Consents data
Fisheries	Commercial or recreational harvest	None known.	N/A	N/A	N/A	N/A	N/A	0			
Food	Number of fishers using the lake	None known. Possibly occasional recreational eel fishers.	N/A	N/A	N/A	N/A	N/A	0			
Waterfowl	Number of Hunters	Breeding habitat for ducks and popular hunting site - 7 maimais were observed around the lake.	7 maimais	Ongoing	N/A	Local	9.65	2		Number of hunters not known but probably around 20 per season. Data could be improved by simple survey durin opening weekend of duck season.	Field observations.
Biodiversity	Number of threatened or at risk species	Provides habitat for bittern, dabchick, spotless crake, longfin eel, black mudfish (Reeves *et. Al.* 2011)	5 Species	N/A	N/A	Regional	9.65	2			Reeves et al 2011
Nutrient Processing	Water quality	The lake provides a nutrient processing service through its marginal wetlands and within the water column and bottom sediments. This capacity has been increased recently with the installation of specific nutrient processing wetlands at the lake inflows. The lake itself is at least eutrophic and as it is completely non-vegetated its ability to filter nutrients may be impared.	N/A	Ongoing	N/A	Local	9.65	2		Could be better reported with a better indicator using quantitative methods.	Field observations.
Sediment processing	Quantity of sediment trapped	The lake and its surrounding wetlands undoubtedly provide sediment filtration to the catchment and treatment wetlands installed on the main drains filter both fine and course sediment from the inflowing water.	N/A	Ongoing	N/A	Local	9.65	2		Rebecca Eivers could improve on this considerably.	
Hydrological regulation	Flood storage	Significantly altered hydrology due to drainage and diversion. Nevertheless provides water storage to regulate flows in heavy rain and a drainage point for surrounding land.	No data available	Ongoing	N/A	Local	9.65	2		Could be more accurately assessed with lake level data	
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters.	N/A	N/A	N/A	N/A	N/A	-			
Recreation	Recreational use	There is a walking track around the lake and it is used by duck hunters during the season.	N/A	Ongoing	N/A	Local	9.65	1			Field observations
Aesthetics	Nil	A nice example of a restored wetland and lake but only visible from the road and a few houses nearby.	N/A	Ongoing	N/A	Local	9.65	1			
Cognitive information	Number of peer-reviewed scientific studies	No peer reviewed scientific studies were found but Kaituna has been the site of at least one PHD project as well as a model for lake restoration.	0 peer reviewed papers	Since 1965	N/A	N/A	9.65	0		An indicator that takes grey literature into account would be useful	Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall social/cultural/spiritual value	Overall health value (+/-)	Overall ecological health value (+/-)		
Waahi	1788712.861	5840757.203	460.94	Lake	Riverine	23rd	9,215	Supertrophic					

			Quantification			Spatial details		Scoring	Comments				Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Assumptions**	**Limitations**	**Limitations**	**Comments**	**References etc.**
Water	Consented Water Supplies	No water is taken directly from the lake.	N/A	N/A	N/A	N/A	N/A	0					WRC Consents data
Fisheries	Commercial or recreational harvest	Approximately 4.3 tonnes of eels are fished from the Lake each year. Customary and recreational fishing may also occur.	4.3 t	Annually	$31,605.00	Regional	460.94	3			MPI report catch for Waahi, Whangape and Rotonagaro combined and a simpe proportion was used to estimate catch for Waahi alone. Data is from 2013.	Based on $7.35/kg for eel.	Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
Food	Number of fishers using the lake	As above	N/A	N/A	N/A	N/A	N/A	0					
Waterfowl	Number of Hunters	Hunting is popular in the area and a number of maimais are situated on the lake or on the margins. The popularity of the site may be affected by the poor water quality but there is no data to show this.	N/A	Ongoing	N/A	Local	460.94	2				Number of hunters not known. Data could be improved by simple survey during opening weekend of duck season.	Field observations.
Biodiversity	Number of threatened or at risk species	Longfin eel and black mudfish have been recorded from the lake and its wetlands. Australasian bittern, spotless crake, Caspian tern, black shag, little black shag, pied shag, North Island fernbird, NZ dabchick, and banded dotterel all utilise this habitat.	11 Threatened or At Risk species	Ongoing	N/A	National	460.94	3					Reeves et al 2011, field observations.
Nutrient Processing	Water quality	Lake Waahi is very degraded and is currently supertrophic with a 5-year TLI (2008 - 2012) of 5.8. It is likely to have limited ability to process nutrients.	N/A	Ongoing	N/A	Local	460.94	1				Could be better reported with a better indicator using quantitative methods.	WRC Data. LERNZ website.
Sediment processing	Quantity of sediment trapped	The lake and its surrounding wetlands undoubtedly provide sediment filtration to the catchment. However, because the lake is shallow bottom sediments will be constantly re-suspended with the potential of release into the Waikato River.	N/A	Ongoing	N/A	Local	460.94	1					
Hydrological regulation	Flood storage	Significantly altered hydrology due to drainage and diversion. Nevertheless provides significant water storage to regulate flows in heavy rain and a drainage point for surrounding land. Flood storage is at least 23.8M m3.	23,820,000m^3	Ongoing	N/A	Sub-Regional	460.94	3			Based on simple calculation performed on data in Jones & Hamilton 2014. Actual flood storage is more complex but this is nevertheless a significant ecosystem service of this lake.	Could be more accurately assessed with lake level data	Jones & Hamilton 2014
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters.	N/A	N/A	N/A	N/A	N/A	-					
Recreation	Recreational use	Waahi is used for fishing, hunting and boating although all of these are likely to be affected by poor water quality.	N/A	N/A	N/A	Local	460.94	1			No data available.		
Aesthetics	Nil	The lake is not particularly scenic althoug it is overlooked by several houses.	N/A	Ongoing	N/A	Local	N/A	1				A very minor ecosystem service.	Field observations.
Cognitive information	Number of peer-reviewed scientific studies	A number of peer reviewed scientific papers have been published about Lake Waahi and there is also a considerable grey literature of techincal reports and plans.	13 Peer reviewed papers	Since 1965	N/A	Regional	460.94	3					Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)
Ohinewai	1792301.187	5848064.442	17.07	Lake	Riverine	63rd =	331		+

			Quantification			Spatial details		Scoring		Comments	Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Consented Water Supplies	No water is taken directly from the lake.	N/A	N/A	N/A	N/A	N/A	0			
Fisheries	Commercial or recreational harvest	Commercial eel fishers may utilise Lake Ohinewai but it is unlikely as there is no formal access or any boat ramps.	N/A	N/A	N/A	N/A	N/A	0			
Food	Number of fishers or hunters using the lake	Ohinewai is used for duck hunting but is unlikely to be used for fishing. Hunter numbers are not known.	N/A	Ongoing	N/A	Local	17.07	2		Data could be improved with a survey of lake users.	
Waterfowl	Number of Hunters	A number of maimais are located around the lake edge but hunter numbers are not known. Provides habitat for a number of target species including mallard, swans, and geese.	N/A	Ongoing	N/A	Local	17.07	2			
Biodiversity	Number of threatened or at risk species	A number of bird species utilise Ohinewai, mostly as part of a larger habitt which will include other nearby lakes and wetlands. Species include Caspian tern, black shag, little black shag, and probably Australasian bittern and spotless crake. Fish species include longfin eel. Freshwater mussle are also present.	5 confirmed threatened or at risk species.	Ongoing	N/A	Regional	17.07	2		There are likely to be more threatened or at risk species but survey effort seems to have been relatively low.	Reeves et al 2011
Nutrient Processing	Water quality	Lake Ohinewai was hypertrophic in 2012 with a TLI of 6.3 (WRC shallow lakes indicator data). It provides some nutrient processing for the surrounding catchment and is likely more effective at phosphorus removal than nitrogen.	N/A	Ongoing	N/A	Local	17.07	1			WRC Shallow Lakes Indicator data (website).
Sediment processing	Quantity of sediment trapped	Although there are no dedicated sediment traps the lake margins are well vegetated in planted natives and it is likely that the majority of sediment entering the lake is stored there rather than transported downstream.	N/A	Ongoing	N/A	Local	17.07	2		Could be improved with modelling.	Field observations.
Hydrological regulation	Flood storage	Provides flood storage to the 331 ha catchment. No water level data for the lake is available but it is likely that the water regulation service provided by Ohinewai is significant.	N/A	Ongoing	N/A	Local	17.07	2		Could be improved with modelling. Flood hazard maps may provide useful information.	
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters.	N/A	N/A	N/A	N/A	N/A	-			
Recreation	Recreational use	Lake Ohinewai has no marked public access and hunters during the game bird season are likely to be the only visitors. No visitor assets. A large parcel of adjacent land is recreation reserve but this is leased for grazing and there is no indication that it is public land.	N/A	Ongoing	N/A	Local	17.07	1		There is potential for a significant improvement in this service if a public access was provided along with a basic walkway.	Field observations.
Aesthetics	Nil	Ohinewai is visible from the Ohinewai-Tahuna Road for a short stretch and no houses overlook the lake. Aesthetic value is relatively low.	N/A	Ongoing	N/A	Local	17.07	1			
Cognitive information	Number of peer-reviewed scientific studies	Waikato University have trialled koi carp control methods at Ohinewai including the use of a one-way fish barrier at the outlet, electro-fishing, pod traps, and fyke nets (Dean-Spiers et al 2014). However, no peer-reviewed papers were found.	0 peer-reviewed papers	Since 1965	N/A	N/A	N/A	0			Dean-Spiers et al 2014

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha) (FENZ)	Trophic status	Overall ecological health value (+/-)		
Puketi	1748582.891	5872811.466	5.90	Lake	Dune	N/A	78	Mesotrophic - Eutrophic	+		

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Consented Water Supplies	No water is taken directly from this lake. It has until recently been unfenced and provided water for stock.	N/A	N/A	N/A	N/A	N/A	0			Jackson Efford (WRC) pers.comm.
Fisheries	Commercial or recreational harvest	Unknown but commercial harvest from this lake is unlikely. Fish have not been surveyed since 1980 and at that time only shortfin eel, raibow trout, rudd, and bullies were present (NZFFD). Occasional recreational fishing for eels may occur.	N/A	N/A	N/A	Local	5.90	1		No public access to this lake so fishing would only be allowed with landowner permission.	
Food	Number of fishers or hunters using the lake	Duck hunter use the lake and recreational fishers may use it but these activities are more recreational than for food. This is considered a minor service.	N/A	N/A	N/A	Local	5.90	1			
Waterfowl	Number of Hunters	Recreational duck hunter use the lake. Approximately 7 maimais are present. The lake proviceds habitat for common waterfowl including mallard ducks, black swans and Canada geese.	N/A	N/A	N/A	Local	5.90	2			Jackson Efford (WRC) pers.comm.
Biodiversity	Number of threatened or at risk species	No nationally Threatened or At Risk plant species have been recorded but several species which considered threatened or rare in the Auckland region (Stanley *et.al.* 2005) occur here on Auckland's southern boundary. These include *Cyperus ustulatus, Isolepis distigmatosa, Lachnagrostis filiformis, Sparganium subglobosum, Galium trilobum, Gratiola sexdendata, Myriophyllum votschii and Ranunculus macropus* . Threatened bird species include NZ dabchick, Australasian bittern, and North Island fernbird. The lake retains its submerged flora and although this is dominated by the exotic *Egeria densa* a number of indigenous species are also present (Burton *et. al.* 2014).	11 species	Ongoing	N/A	Regional	5.90	3	Some of these species are only rare in the adjacent Auckland Region.		Jackson Efford (WRC) pers.comm.
Nutrient Processing	Water quality	The lake recieves overland flow and ground water from a small catchment dominated by pasture. The lake and its marginal wetlands are likely to be effective at removing the majority of excess nutrients from inflowing water and recent riparian fencing and planting will aid this process. The lake was eutrophic in 2011 (Dean-Spiers *et. al.* 2014)	N/A	Ongoing	N/A	Local	5.90	2	No recent water quality data.		Dean-Spiers et. al. 2014
Sediment processing	Quantity of sediment trapped	No information is available about sediment processing at this lake but it is likely that only very small quantities of suspended sediment enter the lake and the majority would settle.	N/A	Ongoing	N/A	Local	5.90	2			
Hydrological regulation	Flood storage	No water level data is available but this is a very small catchment with sandy soil and no permanent streams so it is unlikely that the lake plays a significant role in hydrological regulation.	N/A	Ongoing	N/A	Local	5.90	1			
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters. The status of this lake is not known.	N/A	N/A	N/A	N/A	N/A	-			
Recreation	Recreational use	Puketi supports recreational hunters but is unlikely to provide any other significant recreational activities	N/A	Ongoing	N/A	Local	5.90	1			
Aesthetics	Nil	While the lake is picturesque it is not visible from any public viewing point or road and only one house has a view of the lake.	N/A	Ongoing	N/A	Local	N/A	1			
Cognitive information	Number of peer-reviewed scientific studies	Very little formal survey or scientific study has been done at Puketi. NIWA included the lake in regional surveys of submerged macrophytes and some fish survey was done in the early 1980s. No peer-reviewed papers have been written about the lake however.	0 peer-reviewed papers	Since 1965	N/A	N/A	N/A	0			Web of Science

Site Name	Easting	Northing	Area (ha)	Type	Lake Type	Regional Ranking (Reeves *et. Al.* 2011)	Catchment Size (ha)	Trophic status	Overall ecological health value (+/-)
Otamatearoa	1749521.91	5871077.261	4.87	Lake	Dune	16th =	68		

			Quantification			Spatial details		Scoring	Comments		Input data
Ecosystem service	**Ecosystem Service Indicator**	**Description**	**Quantification**	**Time**	**$ value**	**Scale of provision (extent of the impact of provision)**	**Area (of ecosystem service provision)**	**Provision ranking (0-3 or 0%, <30%, 30-70%, >70%)**	**Limitations**	**Comments**	**References etc.**
Water	Consented Water Supplies	There are no consented water takes from the lake but photographs show a pump shed on the lake edge so water may be taken for domestic or farm use.	No data available.	Ongoing	N/A	Local	4.87	1		Based only on photographs.	
Fisheries	Commercial or recreational harvest	Unknown but commercial harvest from this lake is unlikely. Fish species present include shortfin eel, common bully, catfish, rainbow trout and goldfish (Dean-Spiers *et. al.* 2014). The lake has previously been stocked with trout by Fish & Game but no longer is. Occasional recreational fishing for eels and trout may occur.	N/A	Ongoing	N/A	Local	4.87	1			Dean-Spiers *et. al.* 2014; http://www.nzfishing.com/FishingWaters/AucklandWaikato/AWFishingWaters/AWOtamatearoa.htm
Food	Number of fishers or hunters using the lake	This lake is unlikely to provide a food resource. Hunters and fishers using the lake are more likely to be doing so for recreation.	N/A	Ongoing	N/A	Local	4.87	1			
Waterfowl	Number of Hunters	It is not known whether hunting occurs around the lake but no maimais are present. The lake is likely to support common waterfowl such as mallards, swans, and Canada geese.	N/A	Ongoing	N/A	Local	4.87	1			
Biodiversity	Number of threatened or at risk species	Threatened or At Risk plants include *Ranunculus macropus, Utricularia australis,* and *Myriophyllum robustum* (Dean-Spiers *et. al.* 2014). No information on birds is available but it is likely that NI fernbird, Australasian bittern, and NZ dabchick which are present at Puketi also utilise this lake at least periodically.	3 threatened species.	Ongoing	N/A	Local	4.87	2			Dean-Spiers et. al. 2014
Nutrient Processing	Water quality	Water quality in the lake is reasonably good with a TLI of between 3 and 4 (i.e.mesotrophic). The lake retains submerged plants (Burton *et. al.* 2014) which may improve nutrient processing ability. However, the lake is not fenced and stock have access to the water so more nutrients are likely to be entering the lake than is necessary.	N/A	Ongoing	N/A	Local	4.87	1		The score for this service is low because the scale of provision is so low. There is no outlet to the lake so the water is only used *in situ* .	Burton *et. Al.* 2014;
Sediment processing	Quantity of sediment trapped	The lake does not have any outlet so all sediment entering the lake is stored there. Sediment will only enter via overland flow or lake shore erosion however. This is a very minor service for this lake.	N/A	Ongoing	N/A	Local	4.87	1			
Hydrological regulation	Flood storage	Lake Otamatearoa has potential to store a significant volume of water because it is situated in a wide basin but with no permanent inflow it will only receive rain water and overland flow and is therefore unlikely to flood very often. The lake does store water which may be beneficial to surrounding pasture during dry periods.	N/A	Ongoing	N/A	Local	4.87	1			
Climate change mitigation	Carbon sequestered	Some lakes sequester carbon while others are emitters. The status of this lake is not known.	N/A	N/A	N/A	N/A	N/A	-			
Recreation	Recreational use	Otamatea may support limited recreational hunting but is unlikely to provide any other significant recreational activities	N/A	Ongoing	N/A	Local	4.87	1			
Aesthetics	Nil	The lake is visible from Whiriwhiri Road and one house has been built to overlook it.	N/A	Ongoing	N/A	Local	N/A	1			
Cognitive information	Number of peer-reviewed scientific studies	Very little formal survey or scientific study has been done at Otamatearoa. NIWA included the lake in regional surveys of submerged macrophytes and some fish survey was done by the University of Waikato in 2009 . No peer-reviewed papers have been written about the lake however.	0 peer-reviewed papers	Since 1965	N/A	N/A	N/A	0			Web of Science

Appendix E: Database

Attachment E1: Summary of Biophysical and Ecological Conditions of Sampled Ecosystems

ES_SITE_NUMBER		SITE_NAME	ECO_CONDITION_INDICATOR	ECOLOGICAL_CONDITION	DATA_SOURCE and COMMENT
1	Lake	TAUPO CONTROL GATES	Mean/median flows (m3/s)	175	DIA (2013). The flow rate ranges from 50 to 300 m3/s. The average, 175m3/s is reported
2	Lake	TAUPO CONTROL GATES	E. coli microbial contamination (median Number/100ml)	2	LAWA Website (www.lawa.org.nz). E. coli microbial contamination as a surrogate for sediment mainly using the data on the Land, Air, Water Aotearoa (LAWA) website (PCE 2012)
3	Lake	TAUPO CONTROL GATES	TN contamination (median g/m3)	0.0775	LAWA Website (www.lawa.org.nz). Total Nitrogen (TN) contamination as a surrogate for sediment mainly using the data on the Land, Air, Water Aotearoa (LAWA) website (PCE 2012)
4	Lake	TAUPO CONTROL GATES	TP contamination (median g/m3)	0.004	LAWA Website (www.lawa.org.nz). Total Phosphorous (TP) contamination as a surrogate for sediment mainly using the data on the Land, Air, Water Aotearoa (LAWA) website (PCE 2012)
5	Lake	TAUPO CONTROL GATES	turbidity (median NTU)	0.5	LAWA Website (www.lawa.org.nz). Turbidity as a surrogate for sediment mainly using the data on the Land, Air, Water Aotearoa (LAWA) website (PCE 2012)
6	Lake	TAUPO CONTROL GATES	Median E.coli (n/100ml)	2	LAWA Website (www.lawa.org.nz). E.coli (n/100ml) as reported in the Land, Air Water Aotearoa (LAWA) website has been used as an indicator of Human Health regulation. Median value: E.coli 2/100ml. Potential Human Health ranking = Excellent (see comments). Median value: E.coli 2/100ml. Potential Human Health ranking = Excellent (see comments).
7	Lake	TAUPO CONTROL GATES	E.coli concentration (n/100ml) to assess swimming suitability.	2	LAWA Website (www.lawa.org.nz). The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/
8	River	OHAAKI BR	Water flow rate (mean or median flows m3/sec)	166.5	Tulagi (2014) Flow 172-263m3/sec. The average is reported here.
9	River	OHAAKI BR	Volume of waste water discharge (m3/day)	800	http://giswrcmaps.waikatoregion.govt.nz/wrcmaps/?variant=Resource-Consents. The maximum discharge (i.e. m3/day) and rate of discharge (m3/sec) of treated water. Discharge consent: overflow of geothermal water up to 800 tonnes per day to land and/or the Waikato River.
10	River	OHAAKI BR	Median level of E coli (n/100ml)	13	There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website.
11	River	OHAAKI BR	Amount of TN (g/m3)	0.12	LAWA Website. There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website.
12	River	OHAAKI BR	Amount of TP (g/m3)	0.01	LAWA Website
13	River	OHAAKI BR	Median value of turbidity (NTU)	0.71	LAWA Website
14	River	OHAAKI BR	Median level of E.coli (n/100ml)	13	LAWA Website. Median value: E.coli 13/100ml. Potential Human Health ranking = Excellent (see comments).

15	River	OHAAKI BR	Level of water clearity in median level of E coli (n/ml)	13	LAWA Website. Median water clarity 3.8 m (LAWA) Median value: E.coli 13/100ml (LAWA). The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/
16	River	OHAAKI BR	Median water clearity (m)	3.8	LAWA Website. Possible indicators: Identified as a natural outstanding/iconic or similar landscape feature; water clarity (m); price differential for property values ($). Median water clarity 3.8 m (LAWA) - in the best 25% of like sites
17	River	OHAKURI TAILRACE BR	Median level of E coli as a surrogate for sediment (n/100ml)	3	There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website.
18	River	OHAKURI TAILRACE BR	Median level of TN as a surrogate for sediment (g/m3)	0.225	http://www.lawa.org.nz/explore-data/waikato-region/freshwater/waikato-river/waikato-river-@-ohakuri-tailrace-br/. There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website. Median values TN = 0.225 g/m3
19	River	OHAKURI TAILRACE BR	Median level of TP as a surrogate for sediment (g/m3)	0.019	There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website.
20	River	OHAKURI TAILRACE BR	Median level of turbidity as a surrogate for sediment NTU)	1.03	http://www.lawa.org.nz/explore-data/waikato-region/freshwater/waikato-river/waikato-river-@-ohakuri-tailrace-br/. There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website.Median value turbidity 1.03 NTU
21	River	OHAKURI TAILRACE BR	Median level of E.coli (n/100ml)	3	http://www.lawa.org.nz/explore-data/waikato-region/freshwater/waikato-river/waikato-river-@-ohakuri-tailrace-br/. Median value: E.coli 3/100ml. Potential Human Health ranking = Excellent (see comments). Median value: E.coli 3/100ml. Potential Human Health ranking = Excellent (see comments).
22	River	OHAKURI TAILRACE BR	Number of scientific publications (Numbe)	4	A search on Google Scholar showed < 5 references for this site.. Number of scientific peer - reviewed publications Does not include technical report or 'grey' literature. Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract.
23	River	OHAKURI TAILRACE BR	Number of angling/fishing visits (Number)	2,150	Unwin (2009). 2150 ± 740
24	River	OHAKURI TAILRACE BR	Median water clearity as a measure of swimming suitability. (m)	2.2	LAWA website (http://www.lawa.org.nz/). The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median water clarity 2.2 m Median value: E.coli 3/100ml. Median water clarity 2.2 m Median value: E.coli 3/100ml
25	River	OHAKURI TAILRACE BR	Median water clearity as a measure of swimming suitability. (n/100ml)	3	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median water clarity 2.2 m Median value: E.coli 3/100ml.
26	River	OHAKURI TAILRACE BR	Median water clearity (m)	2.2	LAWA website (http://www.lawa.org.nz/)
27	River	WAIPAPA TAILRACE	Average rate of water flow as indicator of water supply for fire rescue (m3/s)	267	Tulagi (2014). Flow 172 - 362 m3/sec

28	River	WAIPAPA TAILRACE	Average water flow as a potential source of waste disposal (m3/s)	267	Tulagi (2014). Flow 172 - 362 m3/sec
29	River	WAIPAPA TAILRACE	Median level of E coli as a surrogate for sediment (n/100ml)	8	Tulagi (2014). Flow 172 - 362 m3/sec
30	River	WAIPAPA TAILRACE	Median level of TN as a surrogate for sediment (g/m3)	0.0331	Tulagi (2014). Flow 172 - 362 m3/sec
31	River	WAIPAPA TAILRACE	Median level of TP as a surrogate for sediment (g/m3)	0.026	Tulagi (2014). Flow 172 - 362 m3/sec
32	River	WAIPAPA TAILRACE	Median level of turbidity as a surrogate for sediment NTU)	1.3	Tulagi (2014). Flow 172 - 362 m3/sec
33	River	WAIPAPA TAILRACE	Median level of E coli as a surrogate for sediment (n/100ml)	8	Median value: E.coli 8/100ml. Potential Human Health ranking = Excellent (see comments).
34	River	WAIPAPA TAILRACE	Median water clearity as a measure of swimming suitability. (n/100ml)	8	LAWA website (http://www.lawa.org.nz/). The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median water clarity 1.8 m Median value: E.coli 8/100ml
35	River	WAIPAPA TAILRACE	Median water clearity as a measure of swimming suitability. (m)	1.8	LAWA website (http://www.lawa.org.nz/)
36		HAMILTON TRAFFIC BR	Average rate of water flow as indicator of water supply for fire rescue (m3/s)	287	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
37		HAMILTON TRAFFIC BR	Average water flow as a potential source of waste disposal (m3/s)	287	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
38		HAMILTON TRAFFIC BR	Median level of E coli as a surrogate for sediment (n/100ml)	74	LAWA website (http://www.lawa.org.nz/)
39		HAMILTON TRAFFIC BR	Median level of TN as a surrogate for sediment (g/m3)	0.44	LAWA website (http://www.lawa.org.nz/)
40		HAMILTON TRAFFIC BR	Median level of TP as a surrogate for sediment (g/m3)	0.035	LAWA website (http://www.lawa.org.nz/)
41		HAMILTON TRAFFIC BR	Median level of turbidity as a surrogate for sediment NTU)	2.17	LAWA website (http://www.lawa.org.nz/)
42		HAMILTON TRAFFIC BR	Median level of E coli as a surrogate for sediment (n/100ml)	74	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 74/100ml. Potential Human Health ranking = Satisfactory (see comments).
43		HAMILTON TRAFFIC BR	Lenght of walkway and cycle way running along the banks of the Waikato River in Hamilton city (km).	10	See comments.
44		HAMILTON TRAFFIC BR	Median level of E coli as a surrogate for sediment (n/100ml)	74	LAWA website (http://www.lawa.org.nz/)
45	River	RANGIRIRI BR	Rate of water flow as potential indicator of water supply in case of fire accident (m3/s).	0.45	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
46	River	RANGIRIRI BR	Rate of water flow as indicator of potential waste discharge (m3/s)	0.45	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
47	River	RANGIRIRI BR	Median level of E coli as a surrogate for sediment (n/100ml)	130	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 130/100ml. Potential Human Health ranking = Satisfactory (see comments). Median value: E.coli 130/100ml. Potential Human Health ranking = Satisfactory (see comments).
48	River	RANGIRIRI BR	Number of scientific peer-reviewed publications (Number)	20	Google Scholar. Number of scientific peer-reviewed publications Does not include technical report or 'grey' literature. Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract. 20 peer reviewed and unpublished studies found in Google scholar as of 14 September 2015

49	River	RANGIRIRI BR	Number of angler days (Number)	4,950	Unwin (2009). Estimated annual angler days for the Waikato River below Karapiro ± 1 SE 4950 ± 980 (Unwin 2009) [4950 visits]. Close to home, ease of access, area of fishable water are key attributes attracting fishermen and women to this section of the river. Mean enjoyment score 1.77 (range 1.24-4.08) (Unwin 2013).
50	River	RANGIRIRI BR	Median level of E coli (n/100ml) as indicator of swimability	130	LAWA website (http://www.lawa.org.nz/). The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. No water clarity data for this site. Median value: E.coli 130/100ml. This is above the suitable concentration for swimming.
51	River	TUAKAU BR	Median level of E coli as a surrogate for sediment (n/100ml)	100	LAWA Website (www.lawa.org.nz) E. coli (n/100ml) as reported in the Land, Air Water Aoteroa (LAWA) website has been used as an indicator of Human Health Regulation. Median value is 2/100ml. Potential Human Health ranking is excellent.
52	River	TUAKAU BR	Median level of TN as a surrogate for sediment (g/m3)	0.635	LAWA Website (www.lawa.org.nz) E. coli (n/100ml) as reported in the Land, Air Water Aoteroa (LAWA) website has been used as an indicator of Human Health Regulation. Median value is 2/100ml. Potential Human Health ranking is excellent.
53	River	TUAKAU BR	Median level of TP as a surrogate for sediment (g/m3)	0.057	LAWA Website (www.lawa.org.nz) E. coli (n/100ml) as reported in the Land, Air Water Aoteroa (LAWA) website has been used as an indicator of Human Health Regulation. Median value is 2/100ml. Potential Human Health ranking is excellent.
54	River	TUAKAU BR	Median level of turbidity as a surrogate for sediment NTU)	8.9	LAWA Website (www.lawa.org.nz) E. coli (n/100ml) as reported in the Land, Air Water Aoteroa (LAWA) website has been used as an indicator of Human Health Regulation. Median value is 2/100ml. Potential Human Health ranking is excellent.
55	River	TUAKAU BR	Median level of E coli as a surrogate for sediment (n/100ml)	100	LAWA Website (www.lawa.org.nz) E. coli (n/100ml) as reported in the Land, Air Water Aoteroa (LAWA) website has been used as an indicator of Human Health Regulation. Median value is 2/100ml. Potential Human Health ranking is excellent.
56	River	TUAKAU BR	Median level of E coli (n/100ml) as indicator of swimability	100	LAWA Website (www.lawa.org.nz) E. coli (n/100ml) as reported in the Land, Air Water Aoteroa (LAWA) website has been used as an indicator of Human Health Regulation. Median value is 2/100ml. Potential Human Health ranking is excellent.
57	River	TUAKAU BR	Level of water clarity as indicator of swimability (m)	0.6	Possible indicators: Identified as a natural outstanding/iconic or similar landscape feature; water clarity (m); price differential for property values ($).
58	Stream	PIRONGIA-NGUTUNUI RD BR	Median level of E coli as a surrogate for sediment (n/100ml)	330	Median value: E.coli 330/100ml. Potential Human Health ranking is satisfactory . Source for N-yield: Alexander et al (2002). Prince of N is about $400/kg/ha if above the cap and trade limit (Duhon et al 2009)
59	Stream	PIRONGIA-NGUTUNUI RD BR	Median level of TN as a surrogate for sediment (g/m3)	0.295	Median value: E.coli 330/100ml. Potential Human Health ranking is satisfactory . Source for N-yield: Alexander et al (2002). Prince of N is about $400/kg/ha if above the cap and trade limit (Duhon et al 2009)
60	Stream	PIRONGIA-NGUTUNUI RD BR	Median level of TP as a surrogate for sediment (g/m3)	0.052	Median value: E.coli 330/100ml. Potential Human Health ranking is satisfactory . Source for N-yield: Alexander et al (2002). Prince of N is about $400/kg/ha if above the cap and trade limit (Duhon et al 2009)
61	Stream	PIRONGIA-NGUTUNUI RD BR	Median level of turbidity as a surrogate for sediment NTU)	11.5	Median value: E.coli 330/100ml. Potential Human Health ranking is satisfactory . Source for N-yield: Alexander et al (2002). Prince of N is about $400/kg/ha if above the cap and trade limit (Duhon et al 2009)
62	Stream	PIRONGIA-NGUTUNUI RD BR	Median level of E.coli (n/100ml) as an indicator of Human Health regulation (n/100ml).	330	Median value: E.coli 330/100ml. Potential Human Health ranking is satisfactory . Source for N-yield: Alexander et al (2002). Prince of N is about $400/kg/ha if above the cap and trade limit (Duhon et al 2009)
63	Stream	PIRONGIA-NGUTUNUI RD BR	Level of water visibility as a measure of clarity for swiming (m)	0.6	Median value: E.coli 330/100ml. Potential Human Health ranking is satisfactory . Source for N-yield: Alexander et al (2002). Prince of N is about $400/kg/ha if above the cap and trade limit (Duhon et al 2009)

64	River	WAITAHANUI RIVER	Water flow rate as indicator of water availability for fire control (m3/s)	4.7	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
65	River	WAITAHANUI RIVER	Median water flow rate as indicator of waster discharge service (m3/s)	4.725	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
66	River	WAITAHANUI RIVER	Sediment export from the catchment (ton/ha)	0.79	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
67	River	WAITAHANUI RIVER	Median level of E coli (microbial contamination) (n/100ml)	16	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
68	River	WAITAHANUI RIVER	Median level of TN contamination (g/m3)	0.5	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
69	River	WAITAHANUI RIVER	Median level of TP contamination (g/m3)	0.045	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
70	River	WAITAHANUI RIVER	Median level of NTU contamination (NTU)	0.8	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
71	River	WAITAHANUI RIVER	E.coli contermination as an indicator of Human Health regulation. (n/100ml)	16.0	Median value: E.coli 16/100ml. Potential Human Health ranking = Excellent (see comments).
72	River	WAITAHANUI RIVER	Length of walking/tramping track (km)	5	Approximately 5 km of walking track based on an NZ Topo map of the site. Tracks are mainly for fishing access.

73	River	WAITAHANUI RIVER	Median level of E coli concentration (n/100ml)	16	The Waikato Regional Council use clarity (m) (at least 1.6 m visibility for swimming) and E.coli (n/100ml) to assess swimming suitability. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/. Median value: E.coli 16/100ml. This is above the suitable concentration for swimming. The clarity of 0.6m is below the WRC standard for good visibility for swimming. However, WRC rate this site as unsatisfactory for swimming.
74	Stream	KAWAUNUI STM	Average aquatic biota numbers/density/taxa richness/indices i.e. Macroinvertebrate community index (MCI)	110	Aquatic biota numbers/density/taxa richness/indices i.e. Macroinvertebrate community index (MCI), Quantitative MCI (QMCI). The Macroinvertebrate Community Index (MCI) has been used as a biological indicator of WQ: >120 clean water, 100-199 doubtful quality or possible mild pollution, 80-99 probable moderate pollution, <80 probable severe pollution (Boothroyd & Stark 2000). MCI estimated 80-140 from graph; probable moderate pollution to clean water
75	Stream	KAWAUNUI STM	Mean water flow rate as indicator of waste discharge service (m3/s)	0.112	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
76	Stream	KAWAUNUI STM	N export from the catchment (ton/ha)	0.0064	Estimated watershed yield Upper Waikato 6.4 kg N ha-1 yr-1;
77	Stream	KAWAUNUI STM	P export from the catchment (ton/ha)	0.0007	0.7 kg P ha-1 yr-1
78	Stream	KAWAUNUI STM	Median value of E. coli contamination (n/100ml)	250	LAWA website (www.lawa.org.nz)
79	Stream	KAWAUNUI STM	Median value of TN contamination (g/m3)	2.98	LAWA website (www.lawa.org.nz)
80	Stream	KAWAUNUI STM	Median value of TP contermination (g/m3)	0.0875	Median value TP = 0.0875 g/m3
81	Stream	KAWAUNUI STM	Median value of turbidity (NTU)	3.55	LAWA website (www.lawa.org.nz)
82	Stream	KAWAUNUI STM	Median value of E. coli contamination (n/100ml)	250	LAWA website (www.lawa.org.nz). Median value: E.coli 250 n/100ml. Potential Human Health ranking = Satisfactory (see comments). Median value: E.coli 250 n/100ml. Potential Human Health ranking = Satisfactory (see comments).
83	Stream	KAWAUNUI STM	Habitat Score (HS)	151	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat. Habitat Score (HS) as an indicator of habitat provision in selected freshwater sites in the region. The HS is based on substrate and organic material, maximum score 180
84	Stream	KAWAUNUI STM	Median water clarity as indicator of swimming suitability (m)	1.2	LAWA website (www.lawa.org.nz)
85	Stream	KAWAUNUI STM	Median water clearity (m)	1.2	LAWA website (www.lawa.org.nz)
86	Stream	KAWAUNUI STM	Mean acquatic invertebrate species richness (Number)	18	Possible indicators: indigenous biodiversity i.e. species/taxa richness (number); threatened or at risk species (number); iconic landscape. Insufficient data to fully assess this ES for fish. Mean aquatic invertebrate species richness = 18
87	Stream	WHIRINAKI STM	Volume (m3/year) of drinking water taken from the site	5475	MCI estimated 80-125 from graph; probable moderate pollution to clean water. increasing trend indicative of improving WQ
88	Stream	WHIRINAKI STM	Mean volume of water flow for fire control (m3/s)	0.111	MCI estimated 80-125 from graph; probable moderate pollution to clean water. increasing trend indicative of improving WQ
89	Stream	WHIRINAKI STM	Average macroinvertebrate community index of Aquatic biota numbers/density/taxa richness/indices (MCI)	102.5	MCI estimated 80-125 from graph; probable moderate pollution to clean water. increasing trend indicative of improving WQ
90	Stream	WHIRINAKI STM	Mean water flow for waster discharge (m3/s)	0.1113	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
91	Stream	WHIRINAKI STM	N export from the catchment (ton/ha)	0.0064	Alexander et al. (2002)
92	Stream	WHIRINAKI STM	P export from the catchment (ton/ha)	0.0007	Alexander et al. (2002)

93	Stream	WHIRINAKI STM	Mean value of E. coli microbial contamination (n/100ml)	11	LAWA website (www.lawa.org.nz)
94	Stream	WHIRINAKI STM	Median value of TN as indicator of water quality (g/m3)	0.805	There are many indicators for WQ. We have used 4 key indicators (PCE 2012); E. coli (microbial contamination), TN (total nitrogen), TP (total phosphorus) and turbidity (as a surrogate for sediment) mainly using the data on the Land, Air, Water Aotearoa (LAWA) website. WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
95	Stream	WHIRINAKI STM	Median value of TP as indicatorsfor water quality (g/m3)	0.063	LAWA website (www.lawa.org.nz)
96	Stream	WHIRINAKI STM	Median value of NTU as indicator of water quality, turbidity (NTU)	0.49	LAWA website (www.lawa.org.nz)
97	Stream	WHIRINAKI STM	Median level of E.coli (n/100ml)	11	LAWA website (www.lawa.org.nz). Median value: E.coli 11n/100ml. Potential Human Health ranking = excellent (see comments). Median value: E.coli 11n/100ml. Potential Human Health ranking = excellent (see comments).
98	Stream	WHIRINAKI STM	Mean Habitat Score (HS) as an indicator of habitat provision (score)	120	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
99	Stream	WHIRINAKI STM	Median water suitability for swiming (clarity in distance m)	2.7	Median water clarity 2.7 m Median value: E.coli 11/100ml
100	Stream	WHIRINAKI STM	Median water suitability for sweeming (E coli concentration in g/100ml)	11	Median water clarity 2.7 m Median value: E.coli 11/100ml
101	Stream	WHIRINAKI STM	Differential property value (median water clearity, m)	2.7	LAWA website (www.lawa.org.nz)
102	Stream	WHIRINAKI STM	Mean of invert taxa richness (Number).	22	EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat. No fish data on NIWA FBIS. Mean Invert taxa richness: 22 (WRC spreadsheet
103	Stream	POKAIWHENUA STM	Mean water flow rate for fire control (m3/s)	0.111	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
104	Stream	POKAIWHENUA STM	Macroinvertebrate community index (MCI)	97.5	MCI estimated 75-120 from graph; probable severe pollution to doubtful quality or possible mild pollution - stable trend
105	Stream	POKAIWHENUA STM	Mean water flow rate as indicator of waste discharge (m3/s)	2.926	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
106	Stream	POKAIWHENUA STM	Median concentration of E. coli (n/100ml)	150	PCE (2012); LAWA website (www.lawa.org.nz)
107	Stream	POKAIWHENUA STM	Median value of TN (g/m3)	2.03	LAWA website (www.lawa.org.nz)
108	Stream	POKAIWHENUA STM	Median value of TP (g/m3)	0.106	LAWA website (www.lawa.org.nz)
109	Stream	POKAIWHENUA STM	Median value of Turbidity (NTU)	2.7	LAWA website (www.lawa.org.nz)
110	Stream	POKAIWHENUA STM	Median value of E.coli concentration (n/100ml)	150	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 150n/100ml. Potential Human Health ranking = Satisfactory (see comments).
111	Stream	POKAIWHENUA STM	Mean annual water flowrate (m3/s)	0.0029	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 150n/100ml. Potential Human Health ranking = Satisfactory (see comments).
112	Stream	POKAIWHENUA STM	Mean river chanel width (m)	16.3	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 150n/100ml. Potential Human Health ranking = Satisfactory (see comments).
113	Stream	POKAIWHENUA STM	Mean river depth (m)	0.5	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 150n/100ml. Potential Human Health ranking = Satisfactory (see comments).
114	Stream	POKAIWHENUA STM	Mean river wetted width (m)	15.4	LAWA website (http://www.lawa.org.nz/). Median value: E.coli 150n/100ml. Potential Human Health ranking = Satisfactory (see comments).

115	Stream	POKAIWHENUA STM	Habitat Score (HS) as an indicator of habitat provision	119	The HS is based on substrate and organic material, maximum score 180. WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
116	Stream	POKAIWHENUA STM	Median water clarity (m)	3.3	LAWA website (www.lawa.org.nz)
117	Stream	POKAIWHENUA STM	Median level of E coli conc (n/100ml)	150	LAWA website (www.lawa.org.nz)
118	Stream	POKAIWHENUA STM	Median water clarity (m)	1.19	Median water clarity 1.19 m. Sections of the Pokaiwhenua Stream are recognised as Significant Natural Areas under the 2015 South Waikato District Council District Plan. The streams scenic values include geological features, falls, cascades, and pools
119	Stream	POKAIWHENUA STM	Mean Invert taxa richness (Number)	22	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
120	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean annual water flow rate (m3/s)	0.0002	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
121	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Average macroinvertebrate community index (index)	80	Boothroyd & Stark (2000)
122	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean average annual water flow rate for waste discharge (m3/s)	0.0002	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
123	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Median value of E. coli microbial contamination (n/100ml)	475	PCE (2012); LAWA website (www.lawa.org.nz)
124	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Median value TN (g/m3)	1.8750	LAWA website (www.lawa.org.nz)
125	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Median value TP (g/m3)	0.4150	LAWA website (www.lawa.org.nz)
126	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Meadian value turbidity (NTU)	22	LAWA website (www.lawa.org.nz)
127	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Median value E.coli concentration (n/100ml)	475	LAWA website (www.lawa.org.nz). Median value: E.coli 150n/100ml. Potential Human Health ranking = Satisfactory (see comments).
128	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean annual water flowrate (m3/s)	0.0002	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
129	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean river chanel width (m)	5.8	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
130	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean river depth (m)	0.53	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
131	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean river wetted width (m)	4.5	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
132	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Mean Habitat Score (Score)	93	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
133	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Median water clarify for swiming (m)	0.41	http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/
134	Stream	MANGAKOTUKUTUKU STM (RUKUHIA)	Median concentration of E. coli (n/100ml)	475	http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Rivers/healthyrivers/Water-quality-glossary/
135	Stream	MANGAUIKA STM	Mean value of anual water flow for fire control (m3/s)	5.091	James & Dewson (2008).
136	Stream	MANGAUIKA STM	Aquatic biota numbers/density/taxa richness/indices measured in (MCI)	147.5	MCI 147-148 (indicative of clean water). http://www.ew.govt.nz/Environment/Natural-resources/Water/Rivers/Our-other-rivers/River-biology-monitoring-map1/.

137	Stream	MANGAUIKA STM	Mean water flow rate (m3/s)	5.0910	James & Dewson (2008)
138	Stream	MANGAUIKA STM	Maximum rate of consented waste water discharge (m3/s)	0.0087	James & Dewson (2008)
139	Stream	MANGAUIKA STM	Watershed N yield (ton/ha/yr)	0.0147	James & Dewson (2008)
140	Stream	MANGAUIKA STM	Watershed P yield (ton/ha/yr)	0.0011	James & Dewson (2008)
141	Stream	MANGAUIKA STM	Median value of E. coli microbial contamination (n/100ml)	71	PCE (2012); LAWA Website
142	Stream	MANGAUIKA STM	Median value TN (g/m3)	0.2770	PCE (2012); LAWA Website
143	Stream	MANGAUIKA STM	Median value TP (g/m3)	0.008	PCE (2012); LAWA Website
144	Stream	MANGAUIKA STM	Meadian value turbidity (NTU)	1.76	PCE (2012); LAWA Website
145	Stream	MANGAUIKA STM	Median value of E.coli (n/100ml) as an indicator of Human Health regulation.	41	LAWA Website (http://www.lawa.org.nz/). Median value: E.coli 71n/100ml. Human Health ranking = Satisfactory (see comments).
146	Stream	MANGAUIKA STM	Mean water flow (m3/s)	5.091	James & Dewson (2008)
147	Stream	MANGAUIKA STM	Mean Habitat Score (Score)	161	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat. Mean HS 161. Riffles mean % 100
148	Stream	MANGAUIKA STM	Median water clarity (m)	3.3	LAWA Website (http://www.lawa.org.nz/). Median water clarity 3.3m Median value: E.coli 71/100ml
149	Stream	MANGAUIKA STM	Median E coli concentration (n/100ml)	71	LAWA Website (http://www.lawa.org.nz/). Median water clarity 3.3m Median value: E.coli 71/100ml
150	Stream	MANGAUIKA STM	Median water clarity (m)	3.3	Median water clarity 3.3 m.
151	Stream	OTAUTORA STM	Aquatic biota numbers/density/taxa richness/indices i.e. Macroinvertebrate community index (MCI)	140	Littler et al. (2011). MCI 136-145 (indicative of clean water)
152	Stream	OTAUTORA STM	Mean river depth (m)	0.2	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
153	Stream	OTAUTORA STM	Mean river chanel width (m)	3.6	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
154	Stream	OTAUTORA STM	Mean river wetted width (m)	2.5	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
155	Stream	OTAUTORA STM	Estimated main stream channel (m)	4,600.0	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
156	Stream	OTAUTORA STM	Mean Habitat Score (Score)	160.0	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
157	Stream	MANGATAWAI STM	Mean river width (m)	10.0	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
158	Stream	MANGATAWAI STM	mean wetterd width (m)	7.5	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat

159	Stream	MANGATAWAI STM	mean depth (m)	0.4	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
160	Stream	MANGATAWAI STM	Habitat score (score)	155	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
161	Stream	MANGATAWAI STM	Mean intertebrate taxa richness (index)	29	Henderson and Ward (2006); WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat)
162	Stream	WAIKATO RIVER TRIB	Mean river depth (m)	0.11	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
163	Stream	WAIKATO RIVER TRIB	Mean river chanel width (m)	3.7	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
164	Stream	WAIKATO RIVER TRIB	Mean river wetted width (m)	1.5	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
165	Stream	WAIKATO RIVER TRIB	Average Habitat score (score)	140	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
166	Stream	WHAKAKAI STREAM	Instantaneous waste discharge (m3/s)	64	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
167	Stream	WHAKAKAI STREAM	Median value of TN (g/m3)	0.19	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
168	Stream	WHAKAKAI STREAM	Median value of TP (g/m3)	0.05	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
169	Stream	WHAKAKAI STREAM	Median turbidity (NTU)	6.2	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
170	Stream	WHAKAKAI STREAM	Median river depth (m)	0.22	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
171	Stream	WHAKAKAI STREAM	Median river channel width (m)	4.1	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
172	Stream	WHAKAKAI STREAM	Median wetted widith (m)	2.4	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
173	Stream	WHAKAKAI STREAM	Average Habitat score (score)	149	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat
173	Stream	KAWAUNUI STM	Mean flows (m3/s)	0.112	WRC spreadsheet 30495_Land_Cover_by_Freshwater_Monitoring_Point_Catchments
173	Stream	KAWAUNUI STM	Average Habitat score (score)	151	WRC spreadsheet EWDOCS_n3272017_v1_Information_Request_of_REMS_data_for_Femi_Olubode_January_2015-inverts & habitat

Report for the Waikato Regional Council

Pilot study on the freshwater ecosystem services provided by wadeable and non-wadeable streams in the Waikato River catchment

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REPORT INFORMATION SHEET

REPORT TITLE	PILOT STUDY ON THE FRESHWATER ECOSYSTEM SERVICES PROVIDED BY WADEABLE AND NON-WADEABLE STREAMS IN THE WAIKATO RIVER CATCHMENT
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Pilot study on the freshwater ecosystem services provided by wadeable and non-wadeable streams in the Waikato River catchment.

Background, Scope and Limitations

The Waikato Regional Council (WRC) currently maintains a database of scientific data on water quality and other ecological characteristics of selected sites along the different waterways in the region. Water quality information (such as *Escherichia coli* content, water clarity and nutrients levels) are collected periodically, and this information is available to the public online through the WRC and Land and Water Aotearoa (LAWA) websites. This information is very comprehensive but is not presented in a format that can be easily understood by lay people. However, it could be communicated in such a way that would allow the general public to have a better understanding of the ecosystem services provided by the Waikato River catchment, including the effects of water quality and ecological characteristics on well-being (e.g. recreational opportunities), prosperity (e.g. economic opportunities) and the environment (ecological conservation).

Objective 3.7 of the proposed Waikato Regional Policy Statement (RPS) relates to ecosystem services (ES), which are the benefits people obtain from nature. Under this objective, the region seeks to 'recognise and maintain or enhance ecosystem services' to enable their ongoing contribution to regional wellbeing (Waikato Regional Council, 2012). Currently there is no database of these ecosystems with their associated services and values, and this information is needed to monitor the effectiveness of the relevant regional policies.

The WRC has contracted Scion to undertake a small pilot study to assess the freshwater ecosystem services provided by a selection of 9 wadeable and 9 non-wadeable rivers/streams in the Waikato River catchment (Table 1; Appendix 1). This study is part of a larger pilot study aimed at assessing the ES provided by freshwater resources in the Waikato River catchment. These sites were selected to cover the geographical range (Appendix 1) and land-use range (Table 1) within the Waikato River catchment. The pilot study was based on a desktop exercise in which readily available data sources were used in the freshwater ecosystem services assessment. Field visits to some of the sites complemented the desktop exercise.

The entire upstream catchment was considered in the ecosystem services assessment for the wadeable stream sites. Including the entire upstream catchment for the non-wadeable sites was outside the scope of this study as it would have encompassed the entire Waikato River catchment. Instead, the assessment focused on freshwater ecosystem services within the immediate vicinity of each water quality (WQ) monitoring site, although the wider catchment was included for some ecosystem services. Māori cultural values were also outside the scope of this pilot study and may be assessed separately in the future. The desktop assessment provided an initial indication of the freshwater ecosystem services at each of these sites. The extent of the desktop exercise was governed by the time availability in the project and is a pre-cursor to potentially more comprehensive freshwater ecosystem service assessments (see Recommendations). We acknowledge that the indicators identified in this desktop exercise are not a comprehensive list and there may be additional indicators that would be appropriate to include e.g. sequestration services for sediment and nutrients.

Table 1: Wadeable and non-wadeable sites assessed for ecosystem services in the pilot study

Site Number.	Site Name	Easting	Northing	Predominant land-use
Wadeable stream sites				
A1	Kawaunui Stream	2802100	6308100	High-producing grassland
A2	Whirinaki Stream	2795702	6317097	High-producing grassland
A3	Pokaiwhenua Stream	2749051	6345843	High-producing grassland & planted forest
A4	Mangakotukutuku Stream	2712745	6374200	High-producing grassland & urban
A5	Mangauika Stream	2697800	6350300	Indigenous forest
A6	Otautora Stream	2736681	6346017	Indigenous forest
A7	Mangatawai Stream	2748969	6223909	Indigenous forest, shrubland, alpine & sub-alpine vegetation
A8	Waikato River tributary	2665837	6423399	Indigenous forest & shrubland
A9	Whakakai Stream	2692600	6378500	Indigenous forest
Non-wadeable stream sites				
B1	Taupo control gates	2777133	6275733	Urban & high-producing grassland
B2	Ohaaki Bridge	2798071	6291450	High-producing grassland, planted & indigenous forest
B3	Ohakuri tailrace	2779596	6306083	High-producing grassland, planted & indigenous forest, & lake
B5	Waipapa tailrace	2745012	6320697	High-producing grassland, planted & indigenous forest, & lake
B7	Hamilton traffic Bridge	2711800	6376400	High-producing grassland, planted & indigenous forest, & lake
B9	Rangiriri Bridge	2698700	6416700	High-producing grassland, planted & indigenous forest
B11	Tuakau Bridge	2691787	6433612	High-producing grassland, planted & indigenous forest
B12	Waipa at Pirongia	2682750	6432184	High-producing grassland, planted & indigenous forest
B13	Waitahanui River	2703700	6352900	Planted & indigenous forest

Project Implementation

The project was implemented in four stages (Figure 1). The first stage involved scoping the pilot freshwater ecosystem services project and determining the number and location of the sites to be included. The second stage focused on the development of a spreadsheet for the pilot desktop assessment. This spreadsheet was based on the blueprint provided by the WRC[1], which contained a comprehensive list of potential freshwater ecosystem services and indicators. The WRC blueprint, along with other key references (i.e. MEA 2005, TEEB 2010, UKNEA 2011, Grizzetti et al. 2015), was used to develop a set of ecosystem services considered most relevant to the assessment of the selected wadeable and non-wadeable stream sites. Key economic, environmental and social indicators were identified and developed for each of these ecosystem services (Microsoft Excel files 'Pilot Freshwater ES study Waikato non-wadeable streams' and

[1] This blueprint was adapted from the design suggested by Crossman et al. (2013), which aims to consistently quantify and map ES in national accounts.

'Pilot Freshwater ES study Waikato wadeable streams'). When developing the list of indicators, it was important to recognise that the most important freshwater ecosystem services were not necessarily the ones that were the easiest to assess or where the data was readily available. In addition, any freshwater ecosystem services indicators selected need to be pertinent and applicable to the New Zealand situation. Eleven provisioning ecosystem services, 15 regulating ecosystem services and 11 cultural ecosystem services were identified for this desktop exercise .(Microsoft Excel files 'Pilot Freshwater ES study Waikato non-wadeable streams' and 'Pilot Freshwater ES study Waikato wadeable streams').

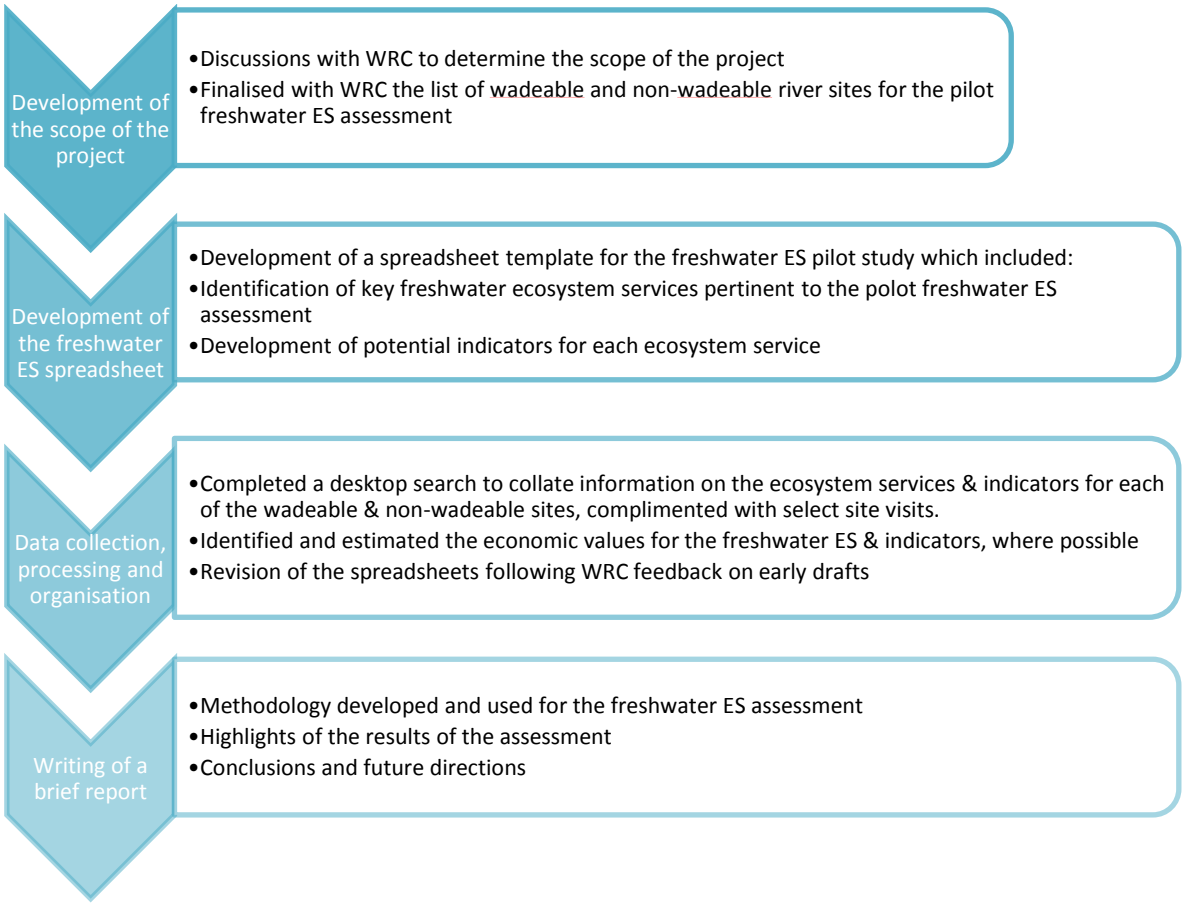

Figure 1: Flow diagram showing the four stages of the project

In the third stage of the project, a desktop search was undertaken to populate the spreadsheets with information on each of the 11 provisioning ecosystem services, 15 regulating ecosystem services and 11 cultural ecosystem services for the 9 wadeable and 9 non-wadeable stream sites. Key sources of data included a generic Google search, Google scholar, the WRC website databases, specific data provided by the WRC, the LAWA website and NIWA databases. This desktop exercise was complemented with field visits to a selection of the sites. Online search tools (e.g. Google, Google Scholar) were used to identify relevant literature that contain economic values for the identified freshwater indicators. Key economic values found are summarised in the spreadsheet "Summary of ES econ values" in the two Microsoft Excel files. The fourth stage involved the production of this report.

Results of the pilot assessment of freshwater ecosystem services provided by wadeable and non-wadeable sites.

The key ecosystem services identified in the pilot freshwater ecosystem services assessment are outlined in Figure 2 and are represented in no particular order. The major provisioning services identified in the selected river and stream sites were: commercial production of long- and short-finned eels (food); water supply for households and farms (water); and generation of electricity (power). These all contribute to New Zealand's gross domestic product (GDP) so they are easily represented in policy discussions.

The major regulating services identified were: provision of habitats to native species; hydrological regulation; sediment and nutrient regulation and export; carbon sequestration; and water quality. These services are extremely important to environmental conservation but they do not have market values, which make them less visible in policy discussions. However, changes in the provision of these services can be monetised using non-market valuation techniques (e.g. a production function approach). The monetisation of regulating services can help express the value of natural capital and demonstrate its limits. As Barbier (2014) pointed out, "Economic indicators that omit the depletion and degradation of natural resources and ecosystems are misleading".

The major cultural services identified by selected waterways in the region were: recreation (e.g. walking, fishing and swimming); scientific studies; aesthetics; historic values and tourism. These services represent the social benefits provided by the freshwater study sites.

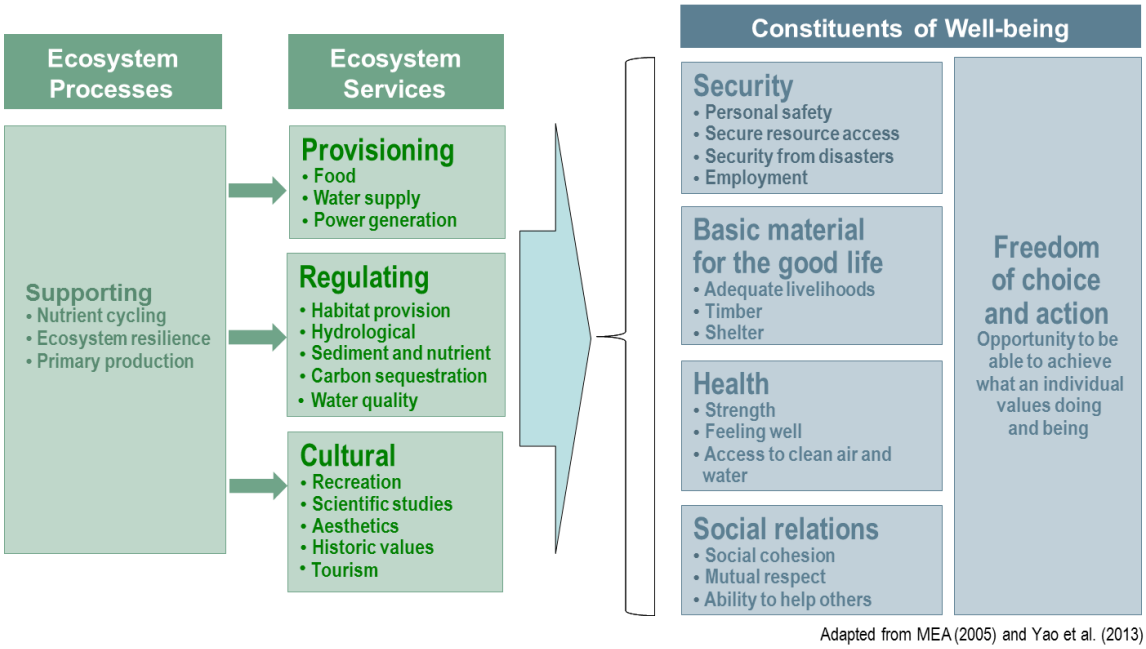

Figure 2: Diagram showing the major freshwater ecosystem services identified in selected rivers and streams in the Waikato region.

The three ecosystem services groups (provisioning, regulating and cultural) outlined above and in Figure 2 contribute to economic prosperity and improvement of the quality of life of people (collectively called as "constituents of well-being") by providing employment, raw materials and improving human health. This exercise did not identify indicators for supporting services as these underpin the provision of the other three ecosystem services groups discussed above. Including supporting services in the analysis may lead to double counting (Fu et al. 2011).

This study enabled indicative economic values to be provided for: water supply; hydro-power generation; food sources provided by fish; recreational fishing; and tourism. Data on the market value of irrigation water, hydro-power generation and commercially sold fish were found. The non-market value of a recreational visit in the region had been estimated previously by McBeth (1997) and Matthews (2009). Some ecosystem services were described qualitatively or through some form of ranking rather than quantitatively. For instance, information about the Otautora stream was found online at the Geocaching website but data on the number of visits to the stream was not available. Water quality was ranked as excellent, satisfactory and unsatisfactory based on the level of *E. coli* at the site.

Only a few of the ecosystem services identified at the desktop level of assessment could be clearly categorised as applicable/non-applicable at a particular site e.g. whether a hydro-power station was present or not. Therefore, many of the ecosystem services were rated as 'unknown'. This does not necessarily mean that there are no data or information available to assess this ecosystem services; instead it indicated that information was not readily available at the pilot desktop level. The potential next step is to undertake a more comprehensive assessment of the Waikato River catchment that would enable more extensive qualitative and quantitative valuation of the freshwater ecosystem services to be undertaken (see Recommendations). Conducting this step would provide more robust information when communicating the benefits of the ecosystem services provided by the Waikato River to the well-being of the region.

Recommendations

This initial desktop ecosystem services assessment exercise provided the opportunity to identify potential considerations for a more comprehensive assessment of the freshwater ecosystem services to be provided by the Waikato River catchment in the future. These recommendations are listed below:

Undertake a comprehensive economic, environmental, cultural and social assessment of the freshwater ecosystem services at the sub-catchment level, as the next step in assessing and valuing the ecosystem services provided by the Waikato River. The pilot study has provided a useful starting point for this process. A comprehensive ecosystem service assessment across the entire catchment is likely to be cost prohibitive but starting at a sub-catchment level would be a more feasible undertaking. Methodologies could then be applied across the wider catchment. Key considerations are:

- A team approach should be used by incorporating multi-disciplinary skills such as: freshwater modelling (i.e. biophysical, hydrological and economic models); use of geographic information services (GIS); ecosystem services assessment and economics; and social expertise.

- A possible approach would be to investigate the suitability of using one of the freshwater management units (FMUs) that Regional Councils are establishing under the National Policy Statement for Freshwater as a trial site. These FMUs, along with their collaborative stakeholder groups, could provide a suitable framework to advance the assessment of freshwater ecosystem services in the Waikato River catchment.

- Some services, particularly regulating services (i.e. flow, sediment and nutrient regulation) could potentially be quantified and valued by undertaking further modelling work (i.e. Guo et al. 2000, Vigerstol and Aukema 2011). This would

provide an opportunity to capture these ecosystem services more comprehensively than was possible in the desktop exercise.

- Many of the provisioning and cultural ecosystem services that could not be readily identified through a desktop exercise (i.e. local food sources, recreational activities, and cultural values) could be assessed and valued by other means such as interviews and surveys of key stakeholder groups and communities residing within or regularly visiting the catchment (Alyward et al. 2010; Phillips 2014; Matthews 2009; Yao and Kaval 2010; Yao et al. 2014).This approach would allow an objective estimation and representation of these important ecosystem services values in investment and policy decision making (MEA 2005; TEEB 2010; UKNEA 2011).

- Key markets for the ecosystem services should be identified as part of the study. Potential mechanisms to achieve this include tax credits and payments from downstream or neighbouring beneficiaries (to compensate for the cost incurred by suppliers who can efficiently and effectively sustain ecosystem services provision). Studies on assessing ecosystem services values and evaluation of incentive instruments are an essential component in the development of new markets for ecosystem services (Gómez-Baggethun et al. 2010; Barry et al. 2014; Méral 2015).

- The WRC will need to determine the scale of the next sub-catchment ecosystem service assessment, depending on financial resources and this will also determine the most appropriate approach taken. There are several ways of undertaking such an assessment, from rapid through comprehensive and long-term (Peh et al. 2013, Yao and Velarde 2014, Sharp et al. 2015).

Future Directions

This project served as a very useful scoping exercise that provided insights on developing a conceptual framework for a comprehensive assessment of freshwater ecosystem services in a particular catchment. There is the potential to publish a peer-reviewed paper from this project (subject to funding availability). Such a paper would incorporate a literature review, the conceptual framework and the results of this pilot study on assessing freshwater ecosystem services provided by the Waikato River catchment.

Scion would be interested in meeting with WRC to discuss the outcomes of this project and to explore potential opportunities to develop the next phase of the project.

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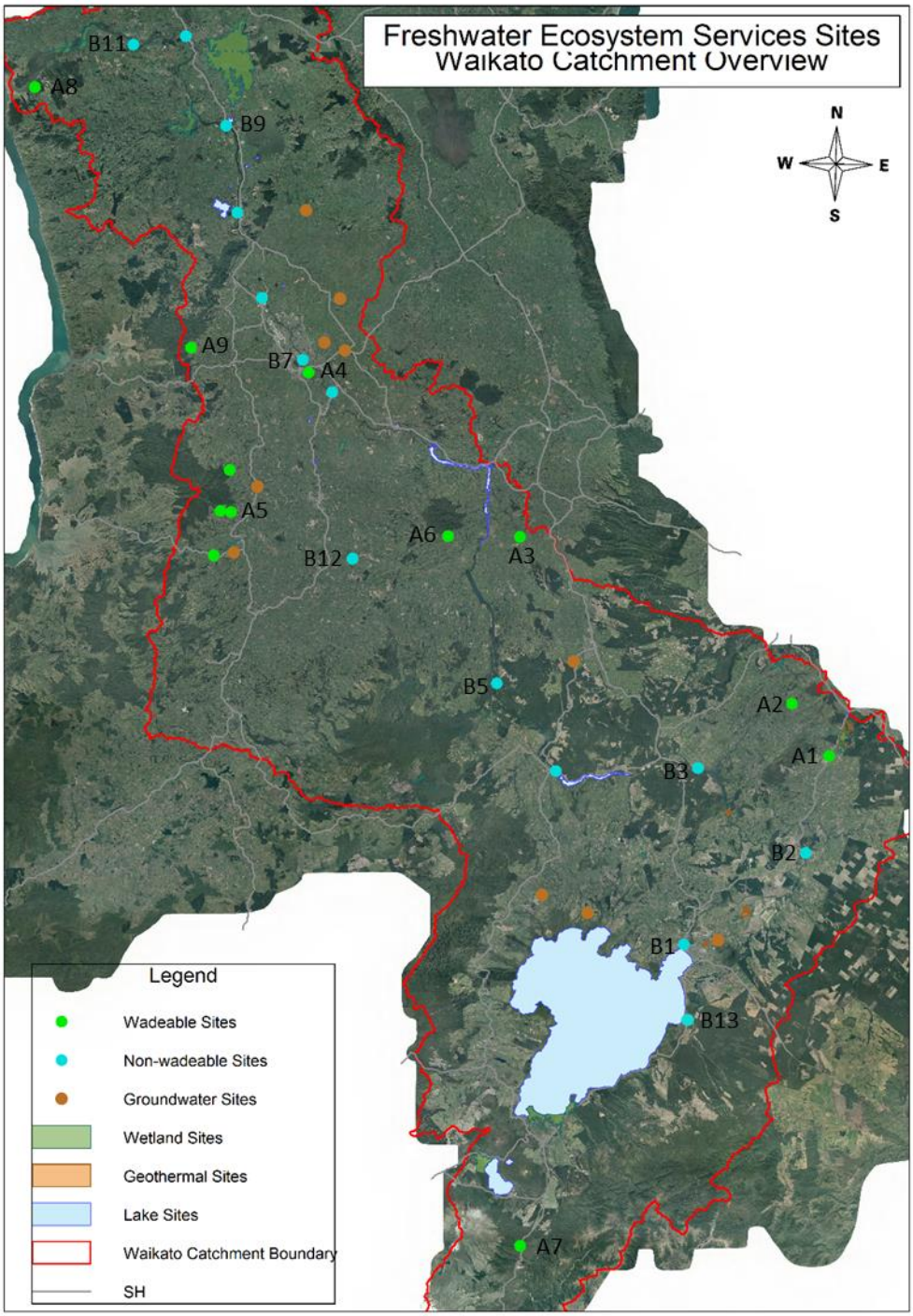
Appendix 1: Wadeable and non-wadeable sites assessed in the Waikato River catchment freshwater ecosystem services pilot study



Attachment E2: Summary of Sampled Ecosystem Services

ES_ID	ES_SITE_NUMBER	LONGITUTDE_DD	LATITUDE_DD	SITE_NAME	SITE_TYPE	SITE_SUBTYPE	DESCRIPTION	CATCHMENT_AREA_HA	ECO_SERVICE_CATEGORY	ECO_SERVICE_DIVISION	ECO_SERVICE_GROUP	ECO_SERVICE_CLASS	ECO_SERVICE_INDICATOR	SERVICE_QUANTITY	SERVICE_QUANTITY_AREA_HA	SERVICE_QUANTITY_TIME	INPUT_DATA_SOURCE	QUANTIFICATION_METHOD	DATA_DATE	WELLBEING_ECONOMIC	COMMENT_OR_INFO_SOURCE
12	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Provisioning	Nutrition	Biomass	Wild animals and their outputs	number of angling/fishing days/visits (Number)	4950	831798	annual	literature search	proxy based on literature	2013	341550	Estimated annual angler days for the Waikato River below Karapiro ± 1 SE 4950 ± 980 (Unwin 2009) [4950 visits]. Close to home, ease of access, area of fishable water are key attributes attracting fishermen and women to this section of the river. Mean enjoyment score 1.77 (range 1.24-4.08) (Unwin 2013).
13	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	0.226534773	831798	annual	literature search	proxy based on literature	2014	432534.96	This is equivalent to 0.08ton. If sediment export rates can be modelled for this site, $6.50/tonne of sediment per year based on Barry et al. (2014) can be used to estimate the cost of sedimentation per year. The natural sediment regulation ES (Hicks et al. 2004, Hicks & Hill 2010, Ritchie, 2012) will be compromised by the influence of the control gates on the flow and flood regime of the Waikato River.
14	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156	831798	annual	literature search	proxy based on literature	2009	Non Applicable	Alexander et al. 2002. Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009)
15	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014	831798	annual	literature search	proxy based on literature	2002	Non Applicable	Alexander et al. 2002
16	6	175.25	(37.68)	Kaituna	Lake	Peat Lake			Provisioning	Nutrition	Biomass	Wild animals and their outputs	number of hunters (maimais/Number)	7	9.65	annual	Aggregated statistics	proxy based on literature	2013	Non Applicable	The ecosystem is a breeding habitat for ducks and popular hunting site. 7 maimais were observed around the lake during observation (April 2015)
17	6	175.25	(37.68)	Kaituna	Lake	Peat Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	5	9.65	annual	Aggregated statistics	proxy based on literature	2011	Non Applicable	Provides habitat for bittern, dabchick, spotless crake, longfin eel, black mudfish. Field observations, Reeves P, Garrick A, Dean-Speirs, T 2011. Significant Natural Areas of the Waikato Region – Lake Ecosystems. Appendices. Wildland Consultants Ltd Contract Report No. 2109b.
18	14	176.23	(38.24)	Kapenga Swamp	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings)	Intellectual and representative interactions	Aesthetic	number of houses with view of wetland (Number)	3	166	NA	Aggregated statistics	empirical	2015	Non Applicable	Two or three houses overlook the wetland. Unlikely to be a draw-card for development or an attraction for sightseers. Field observations
19	14	176.23	(38.24)	Kapenga Swamp	Wetland	Wetland			Provisioning	Materials	Biomass	Fibres and other materials from plant, algae and animals for direct us or processing	area of Flax (harakeke, phormium tenax) plant (ha)	21.9	21.9	annual	Aggregated statistics	empirical	2015	No Data	Visual observations. Harakakeke (flax, Phormium tenax) cover is at least 20% on average. Although this ability exists it is unlikely that harakeke is taken from Kapenga in any but the smallest volumes.
20	14	176.23	(38.24)	Kapenga Swamp	Wetland	Wetland			Provisioning	Nutrition	Biomass	Wild animals and their outputs	number of duck hunter (Number)	28	166	annual	Aggregated statistics	empirical	2015	No Data	The northern part of the wetland is leased by Fish and Game for game bird habitat. Duck hunting was reported on approximately 25ha, Matthew McDougall, Fish & Game, pers. comm 9/6/2015. Duck hunter utlilise at least part of this site for recreational shooting. Other recreation is probably limited to a few wetland enthusiasts. Only really applies to those areas that are hunted. Matthew McDougall, Fish & Game, pers. comm 9/6/2015
21	14	176.23	(38.24)	Kapenga Swamp	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	498	166	annual	Aggregated statistics	literature	2012	138610	1827.7 t CO_2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
22	14	176.23	(38.24)	Kapenga Swamp	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	9	166	annual	Aggregated statistics	proxy based on literature	2002	Non Applicable	NZ Dabchick, black shag, Australasian bittern, grey duck, spotless crake, pied stilt, pipit, NI fernbird. The threatened orchid Spiranthes novae-zelandiae is also present. Personal observations. More recent information will be available soon. This is a high quality wetland that has had considerable weed control and is in a reasonably natural condition. Owen K 2002. Survey of the Birds of the Kapenga Wildlife Management Reserve, Rotorua District. Department of Conservation, Rotorua. 32 pp.
23	14	176.23	(38.24)	Kapenga Swamp	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO_3) removal (ton)	151	166	annual	Aggregated statistics	literature	2012	Non Applicable	Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd.

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24	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4	769.61	annual	Aggregated statistics	proxy based on literature	2014	Non Applicable	Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
25	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Hydrological regulation	Mediation of flows	Liquid flow	Flood protection	volume of flood storage (m^3)	7696	769.61	Daily	Aggregated statistics	Empirical	ND	Non Applicable	Provides the header reservoir for the Karapiro power station (96MW) and limited flood flow regulation. This data is based on the difference between average lake level and maximum operating level of Karapiro dam (1m). Not very accurate Mighty River Power
26	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for hydro power generation (m^3)	547388888.9	769.61	annual	Aggregated statistics	literature	2014	21895555.55	The assumed volume of water was estimated based on 334GWh of electricity compared to other hydro power generation ecosystem where volume of water was found. The value is based on current electricity price NZX Electricity Price Index (2016) rolling-average regional electricity price. Accessed online at http://www.electricityinfo.co.nz/comitFta/price_index.summary
27	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Provisioning	Nutrition	Biomass	Wild animals and their outputs	amount of commercial eel catch (ton)	6.717	769.61	annual	Aggregated statistics	empirical	2013	49369.95	Based on eel fishery value of $7.35/kg (industry value) Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
28	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Provisioning	Nutrition	Water	Surface water	volume of water take for domestic use/drinking (m^3)	7555500	769.61	annual	Aggregated statistics	empirical	2014	11333250	$ calculated based on NZ$1.5/$m^3$ current water price for regional/metropolitan areas (2015). Consented potable and irrigation water takes. Data would be more accurate using actual consent data. There may be a significant volume of water from non-consented domestic takes.
29	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	6	769.61	annual	Aggregated statistics	proxy based on literature	2011	Non Applicable	The species include dabchick, caspian tern, spotless crake, black shag, little black shag and other wetland and waterfowl, longfin eel and koura.Reeves P, Garrick A, Dean-Speirs, T 2011. Significant Natural Areas of the Waikato Region – Lake Ecosystems. Appendices. Wildland Consultants Ltd Contract Report No. 2109b. Robertson HA, Dowding JE, Elliot GP, Hitchmough RA, Miskelly CM, O'Donnell CFJ, Powlesland RG, Sagar PM, Scofield RP, Taylor GA 2013. Conservation status of New Zealand birds, 2012. New Zealand Threat Classification Series 4. Department of Conservation, Wellington.
30	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Regulation and Maintenance	Mediation of flows	Mass flows	Buffering and attenuation of mass flows	amount of sediment trapped as waste treatment (m^3)	13419.57335	769.61	annual	Aggregated statistics	proxy based on literature	2010	Non Applicable	Approximately 38,000m^3 of sediment is trapped by Lake Karapiro annually. Note: Sediment trapping is both a service and a negative impact. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the majority of coursesediment (Hicks et. al. 2010)
31	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	1		NA	literature search	proxy based on literature	2013	Non Applicable	Doole, G. J. (2013). Evaluation of policies for water quality improvement in the Upper Waikato catchment. University of Waikato Report, Hamiltonp (Unpublished). Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
32	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	1		NA	Aggregated statistics	proxy based on literature	2013	Non Applicable	Doole, G. J. (2013). Evaluation of policies for water quality improvement in the Upper Waikato catchment. University of Waikato Report, Hamiltonp (Unpublished).
33	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Provisioning	Nutrition	Water	Surface water	volume of water take for domestic use/drinking (m^3)	5475	1513	annual	WRC Data	literature/resource consent	2015	Non Applicable	The volume of water taken from the stream was source from WRC data (permitted water use of 15m^3/day per property). The volume of drinking water supplied per year can be multiplied by the price per m^3 of $1.70 (WDCIC 2015) to arrive at the value of water supplied for each property. http://www.waikatoregion.govt.nz/PageFiles/1247/3892_Guide%20to%20permitted%20Activites%20Booklet_2014-WEB.pdfhttp://www.waikatoregion.govt.nz/PageFiles/1247/3892_Guide%20to%20permitted%20Activites%20Booklet_2014-WEB.pdf
34	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064	1513	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009). Estimated watershed yield Upper Waikato 6.4 kg N ha-1 yr-1;

ES_ID	ES_SITE_NUMBER	LONGITUTDE_DD	LATITUDE_DD	SITE_NAME	SITE_TYPE	SITE_SUBTYPE	DESCRIPTION	CATCHMENT_AREA_HA	ECO_SERVICE_CATEGORY	ECO_SERVICE_DIVISION	ECO_SERVICE_GROUP	ECO_SERVICE_CLASS	ECO_SERVICE_INDICATOR	SERVICE_QUANTITY	SERVICE_QUANTITY_AREA_HA	SERVICE_QUANTITY_TIME	INPUT_DATA_SOURCE	QUANTIFICATION_METHOD	DATA_DATE	WELLBEING_ECONOMIC	COMMENT_OR_INFO_SOURCE
35	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064		annual	literature search	proxy based on literature	2015	No Data	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
36	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007	1513	annual	literature search	proxy based on literature	2002	Non Applicable	0.7 kg P ha-1 yr-1. Source for P-yield Alexander et al. (2002)
37	34	176.34	(38.38)	KAWAUNUI STM	River or stream	wadable		1513	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007		annual	literature search	proxy based on literature	2002	No Data	Source for P-yield Alexander et al. (2002)
38	20	175.69	(39.03)	Lake Rotoaira wetland	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings)	Intellectual and representative interactions	Scientific	number of monitoring sites by scientists (Number)	1		NA	empirical	proxy based on literature	2014	Non Applicable	This is one of the state of the environment Monitoring sites for Waikato Regional Council
39	20	175.69	(39.03)	Lake Rotoaira wetland	Wetland	Wetland			Provisioning	Materials	Biomass	Fibres and other materials from plant, algae and animals for direct us or processing	area of Flax (harakeke, phormium tenax) plant (ha)	166	166	annual	Aggregated statistics	empirical	2015	No Data	Field visit. Some flax may be harvested by local marae for use in weaving. There is approximately 30% cover of flax in this wetland which could be utilised for fibre but is not known to be at this time. Field observation.
40	20	175.69	(39.03)	Lake Rotoaira wetland	Wetland	Wetland			Provisioning	Materials	Biomass	Wild animals and their outputs	amount of manuka honey provision (ha)	83	83	annual	Aggregated statistics	empirical	2015	33200	Generic figure of $400/ha for manuka honey production. http://www.ruralnewsgroup.co.nz/rural-news/rural-management/manuka-option-for-steep-hills?
41	20	175.69	(39.03)	Lake Rotoaira wetland	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	1660	553.68	annual	Aggregated statistics	proxy based on literature	2012	462322.8	6092.2 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
42	20	175.69	(39.03)	Lake Rotoaira wetland	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	5	553.68	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	NZFM website, BioWeb. Comprehensive biodiversity information is not available. Thismia rodwayi & Urtica linearis recorded from the wetlands or nearby (BioWeb). North Island fernbird are also present and short- and long-tailed bats are present in the wider Rotoaira forest and may utilise the wetlands.
43	20	175.69	(39.03)	Lake Rotoaira wetland	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO_3) removal (ton)	505	553.68	annual	Aggregated statistics	proxy based on literature	2012	Non Applicable	Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd.
44	37	175.30	(37.81)	MANGAKOTUKUTUKU STM (RUKUHIA)	River or stream	wadable		2660	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	30		NA	literature search	proxy based on literature	2009	Non Applicable	Example of a study found include Collier et al. (2009). NIWA has been reported to conduct a habitat enhancement study - http://www.streamcare.org.nz/Restoration.htm. A list of publications on the stream may be accessed at http://www.streamcare.org.nz/links.html. A brief description of an MS thesis in the stream may be accessed at http://www.streamcare.org.nz/new.htm; Neal Utting has PPT show on YouTube about gully restoration https://www.youtube.com/watch?v=rKSxfHVnNjM.
45	37	175.30	(37.81)	MANGAKOTUKUTUKU STM (RUKUHIA)	River or stream	wadable		2660	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Heritage, cultural	number of freshwater springs (puna) being used in Maori cenemonies (Number)	1	2260	annual	literature search	proxy based on literature	2015	Non Applicable	There are 3 pa sites in the Peacocks area alone and other pa sites in other parts of the stream. There are also freshwater springs (puna) used in Maori ceremonies. http://www.streamcare.org.nz/catchment.htm

ES_ID	ES_SITE_NUMBER	LONGITUTDE_DD	LATITUDE_DD	SITE_NAME	SITE_TYPE	SITE_SUBTYPE	DESCRIPTION	CATCHMENT_AREA_HA	ECO_SERVICE_CATEGORY	ECO_SERVICE_DIVISION	ECO_SERVICE_GROUP	ECO_SERVICE_CLASS	ECO_SERVICE_INDICATOR	SERVICE_QUANTITY	SERVICE_QUANTITY_AREA_HA	SERVICE_QUANTITY_TIME	INPUT_DATA_SOURCE	QUANTIFICATION_METHOD	DATA_DATE	WELLBEING_ECONOMIC	COMMENT_OR_INFO_SOURCE
46	37	175.30	(37.81)	MANGAKOTUKUTUKU STM (RUKUHIA)	River or stream	wadable		2660	Cultural services	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Other cultural outputs	Existence	number of pa site in the Peacocks area (Number)	3	2260	annual	literature search	proxy based on literature	2015	Non Applicable	There are 3 pa sites in the Peacocks area alone and other pa sites in other parts of the stream. There are also freshwater springs (puna) used in Maori ceremonies. http://www.streamcare.org.nz/catchment.htm
47	37	175.30	(37.81)	MANGAKOTUKUTUKU STM (RUKUHIA)	River or stream	wadable		2660	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	10	2260	annual	literature search	proxy based on literature	2015	Non Applicable	10 native fish, 10-11 types of invertebrate, 2 native stream plants. ES is based on the assumption that people will value their natural heritage, including the rarer species. For the pilot study, mainly based on fish and aquatic invertebrates. http://www.streamcare.org.nz/catchment.htm
48	37	175.30	(37.81)	MANGAKOTUKUTUKU STM (RUKUHIA)	River or stream	wadable		2660	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156		annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
49	37	175.30	(37.81)	MANGAKOTUKUTUKU STM (RUKUHIA)	River or stream	wadable		2660	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014		annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
50	40	175.76	(39.16)	MANGATAWAI STM	River or stream	wadable		831	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	Google Scholar	proxy based on literature	2006	Non Applicable	A search on Google Scholar found <5 references for this stream. Example: Henderson, I. M., & Ward, J. B. (2006). Four new species of the caddis genus Philorheithrus (Trichoptera: Philorheithridae) from New Zealand. Records of the Canterbury Museum, 20, 21-33.
51	40	175.76	(39.16)	MANGATAWAI STM	River or stream	wadable		831	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064		annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
52	40	175.76	(39.16)	MANGATAWAI STM	River or stream	wadable		831	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007		annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
53	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	9		NA	Google Scholar	proxy based on literature	2015	Non Applicable	Less than 10 references found. Example: Swales, S., & West, D. W. (1991). Distribution, abundance and conservation status of native fish in some Waikato streams in the North Island of New Zealand. Journal of the Royal Society of New Zealand, 21(4), 281-296.
54	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	300	978	annual	literature search	proxy based on literature	2009	6900	Anglers days Dec-Jan 2007-08, 10 ± 10 (SE). Visitors per year Class 3: 100-499. Based on Unwin (2009) and low flows, we have assumed an average annual visit of 100. We multiply this by $69 based on Macbeth (1997). The number of visits should be updated with a more accurate estimate in the future. A pleasant water to fish, but is subject to low flows due to Waipa District Council's supply requirements. http://www.hac.org.nz/fishing-info.html Unwin (2009); Duncan and Wilkins (2006)
55	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for public supply (m^3)	6935000	978	annual	literature search	proxy based on literature	2015	11789500	Awamutu, Pirongia and Fonterra Dairy Factory and Waipa District Council take drinking water supply of 6,935,000 m^3/year from the upper intake area of the stream. This volume of water is multiplied by the price per m^3 of $1.70 (WDC 2015) to arrive at the total economic value. The total estimated value is an initial approximation and does not account for factors such as wastage, evaporation, etc.
56	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for public supply (m^3)	1350500	978	annual	literature search	proxy based on literature	2015	2295850	Waipa District Council take drinking water supply of 1,350,500 m^3/year from the lower intake area of the stream. This volume of water is multiplied by the price per m^3 of $1.70 (WDC 2015) to arrive at the total economic value. The total estimated value is an initial approximation and does not account for factors such as wastage, evaporation, etc.
57	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	22	978	annual	literature search	proxy based on literature	2015	Non Applicable	Fish species richness: native - 6; salmonids - 3. Native fish rarity (threatened or at risk): 2 (longfin eel & torrent fish) Invert taxa richness: 15-18
58	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0147	978	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).

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59	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0011	978	annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
60	38	175.14	(38.03)	MANGAUIKA STM	River or stream	wadable		978	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by ecosystem	Filtration/sequestration/storage/accumulation by ecosystems	amount of consented waste water discharge (m^3/s)	0.0087	978	annual	literature search	proxy based on literature	2015	Non Applicable	Mangauika Stream is providing a specific dilution service for the water treatment plant. The Waipa District Council has a consent to discharge treated backwash water to the Mangauika Stream. Source: http://giswrcmaps.waikatoregion.govt.nz/wrcmaps/?variant=Resource-Consents. The maximum discharge of treated water to the Mangauika Stream shall not exceed 750 cubic metres in any 24 hour period. The maximum rate of discharge shall not exceed 8.7 litres per second.
1	18	175.98	(38.55)	Forest Rd	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings)	Intellectual and representative interactions	Scientific	number of monitoring sites by scientists (Number)	1	46	annual	empirical	proxy based on literature	2014	Non Applicable	This is one of the state of the environment Monitoring sites for Waikato Regional Council
2	18	175.98	(38.55)	Forest Rd	Wetland	Wetland			Provisioning	Materials	Biomass	Fibres and other materials from plant, algae and animals for direct us or processing	area of Flax (harakeke, phormium tenax) plant (ha)	23.175	23.18	annual	Aggregated statistics	empirical	2015	No Data	Harakeke is present but unlikely to be harvested. This is a potential service only. There is approximately 50% cover of Harakeke. Field survey. It is npot known whether harakeke is harvested from this site. There is a Marare nearby at Mokai which may require harakeke for weaving from time to time.
3	18	175.98	(38.55)	Forest Rd	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	139.05	46.35	annual	Aggregated statistics	literature	2012	38702.25	510.3 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
4	18	175.98	(38.55)	Forest Rd	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	2	46.35	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Based on very limited information which could be improved with basic plant and bird surveys. Provides significant habitat for indigenous species including Fernbird and Ranunculus macropus. Based on very limited information which could be improved with basic plant and bird surveys
5	18	175.98	(38.55)	Forest Rd	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO3) removal (ton)	42	46.35	annual	Aggregated statistics	literature	2012	Non Applicable	Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd.
6	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	19		NA	literature search	proxy based on literature	2011	Non Applicable	Hill (2011); McConchie et al. (2005). Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract. < 20 references. Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
7	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of scenic boat passengers per year (Number)	10270	831798	annual	Aggregated statistics	proxy based on literature	2015	364585	About 10,270 scenic cruises per year. 70% adults ($40/person) and 30% ($25/person) children based on a telephone conversaton with Darren Mills of Waikato Explorer on 14 September 2015. Source: Personal communication with Darren Mills on 14 September 2015. http://www.waikatoexplorer.co.nz/. Although people may be visiting this site for other tourism purposes, no quantitative data was found in the desktop exercise.

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8	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of water related sport organisation (Number) Waikato rowing club house on site http://www.wrc.net.nz/learn-to-row/	1	831798	annual	literature search	proxy based on literature	2015	Non Applicable	Site of the NZ University rowing champioships. Waikato rowing club house on site http://www.wrc.net.nz/learn-to-row/
9	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water extracted for irrigation (m^3)	245720	831798	annual	Aggregated statistics	proxy based on literature	2011	29486.4	Irrigation value added of $0.12 per m^3 derived from Denne et al. (2011). Hamilton City Council takes surface water from the Waikato River for the Hamilton Gardens operations (0.045 m^3/sec, 1850 m^3/day, 245720 m^3/year). http://waterallocation.waikatoregion.govt.nz/
10	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Provisioning	Materials	Water	Surface water	volume of water take for domestic use/drinking (m^3)	116000	831798	Daily	Aggregated statistics	proxy based on literature	2015	7114800	The Waikato River provides Hamilton city with its water supply. Hamilton City Council Water Treatment Station Water Take Consent Application until 30 December 2020: max. daily take 116,000 m^3, max rate 2.28 m^3/sec. 116,000 m^3 maximum daily take
11	27	175.29	(37.79)	HAMILTON TRAFFIC BR	River or stream	non wadable	Hamilton Traffic Bridge, Bridge St, Hamilton (WARIMP) Hamilton city	831798	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for waste water treatment plant (m^3)	4000	831798	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	The maximum discharge (i.e. m^3/day) and rate of discharge (m^3/sec) of treated water. A resource consent is held to take up to 4,000 cubic metres per day of water from Waikato River for sewage plant operation purposes at Pukete Rd, Hamilton.
72	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	4	392328	annual	literature search	proxy based on literature	2014	Non Applicable	Sources: http://ei.niwa.co.nz/search/fbis; Goodman et al 2014.. Possible indicators: indigenous biodiversity i.e. species/taxa richness (number); threatened or at risk species (number); iconic landscape. Indigenous fish species richness - 3; Indigenous fish rarity (threatened or at risk) - 1 (longfin eel). http://ei.niwa.co.nz/search/fbis; Goodman et al 2014
73	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064	392328	Annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
74	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007	392328	Annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
75	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by ecosystem	Filtration/sequestration/storage/accumulation by ecosystems	volume of waste water discharge (m^3/day)	800	392328	Daily	literature search	proxy based on literature	2015	Non Applicable	Source: http://giswrcmaps.waikatoregion.govt.nz/wrcmaps/?variant=Resource-Consents. The maximum discharge (i.e. m^3/day) and rate of discharge (m^3/sec) of treated water. Discharge consent: overflow of geothermal water up to 800 tonnes per day to land and/or the Waikato River. Discharge consent: overflow of geothermal water up to 800 tonnes per day to land and/or the Waikato River. http://giswrcmaps.waikatoregion.govt.nz/wrcmaps/?variant=Resource-Consents
76	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	literature search	proxy based on literature	1965-2014	Non Applicable	Example: Coulter, G. W., Davies, J., & Pickmere, S. (1983). Seasonal limnological change and phytoplankton production in Ohakuri, a hydro-electric lake on the Waikato river. New Zealand journal of marine and freshwater research, 17(2), 169-183. Number of scientific peer - reviewed publications Does not include technical report or 'grey' literature. Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract.
77	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	2150		9 months	literature search	proxy based on literature	2007/2008	148350	2150 ± 740. The $69 per fishing visit was derived from McBeth (1997) multiplied by 2,150 visit in 2007/2008 from Unwin (2009). Trout is the most popular Hicks et al. 2013. Fishing activity in the Waikato and Waipa rivers. ERI report number 7. University of Waikato, Hamilton. There is excellent fishing for rainbow & brown trout below the Ohakuri Dam http://www.nzfishing.com/fishingwaters/aucklandwaikato/awfishingwaters/erohakuri.htm.
78	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take by the WQ site, Pengxin New Zealand Farm Group Limited (m^3)	705000	503767	annual	literature search	proxy based on literature	2015	84600	Irrigation value added of $0.12 per m^3 derived from Denne et al. 2011. Gap Analysis of Freshwater Economic Valuation Information. Report prepared for MfE. Source: Bear, S. 2008.

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79	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for hydro power generation (m^3)	655555555.6	503767	annual	literature search	proxy based on literature	2015	26222222.22	Water from the Waikato River is diverted to a hydrolectric dam. The economic value of water dammed was used. This compares well with using price of KWh of electricity of $0.0613 based on Electricity Info (2015) and was multiplied by its capacity of 400 million KWh per year which gives $24,520,000. (https://en.wikipedia.org/wiki/Ohaaki_Power_Station). A future study can estimate the cost of water taken from and returned to the river. Assumption: We assumed that all power generated was consumed.
80	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Provisioning	Nutrition	Biomass	Wild animals and their outputs	average annual catch of long-finned and short-finned eels (ton)	16.3	503767	annual	literature search	proxy based on literature	2015	342300	Sources of data: Ngati Porou (2015) and Hicks et al (2013). For this section of the river: Average annual commercial catch of long-fin eel 2.1 tonnes, short-fin eel 14.2 tonnes (Hicks et al. 2013).
81	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064	503767	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
82	23	176.09	(38.41)	OHAKURI TAILRACE BR	River or stream	non wadable	Ohakuri Tailrace Bridge (WARIMP routine)	503767	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007	503767	annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
83	12	175.06	(37.42)	Opuatai stream	Wetland	Wetland			Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of surface water take for agricultural, irrigation and industrial use (m^3)	26400	660.95	Daily	Aggregated statistics	proxy based on literature	2014	3696	WRC resource consent. Water take from Opuatia stream within the wetland, as well as from groundwater from wetland. $ calculated based on NZ$0.14/$m^3$ water price for irrigation water (2014). Consented potable and irrigation water takes. Data would be more accurate using actual consent data. There may be a significant volume of water from non-consented domestic takes. Reese P, Borrie N 2014. Cost of Irrigation Scheme Water Supply in New Zealand. 2014 Update. Irrigation New Zealand. 11pp.
84	12	175.06	(37.42)	Opuatai stream	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	1983	660.95	annual	Aggregated statistics	proxy based on literature	2012	551893.25	7277.6 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
85	12	175.06	(37.42)	Opuatai stream	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	18	660.95	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Australasian bittern, NI fernbird, black mudfish and giant kokopu have been recorded from Opuatia. Threatened plants include Ophioglossum petiolatum, Lycopodiella serpentina, Juncus holoschoenus, Myriophyllum robustum, Pterostylis paludosa, Pterostylis micromega, Utricularia australis, Utricularia delicatula, Prasophyllum hectorii, Amphibromus fluitans, Pterostylis foliata, Sporodanthus ferrugineus, Pomaderris pylicifolia and Ranunculus macropus. DOC Bioweb, NZFFD There appears to be very little data on the birds of Opuatia. Moynihan 1986; NZFFD
86	12	175.06	(37.42)	Opuatai stream	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO3) removal (ton)	603	660.95	annual	Aggregated statistics	proxy based on literature	2012	Non Applicable	Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd.
87	9	174.69	(37.29)	Otamatearoa	Lake	Dune Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	3	4.87	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Threatened or At Risk plants include Ranunculus macropus, Utricularia australis, and Myriophyllum robustum (Dean-Spiers et. al. 2014). No information on birds is available but it is likely that NI fernbird, Australasian bittern, and NZ dabchick which are present at Puketi also utilise this lake at least periodically. Dean-Spiers T, Neilson K, Reeves P, Kelly J 2014. Shallow lakes management plan: Volume 2. Shallow lakes resource statement: Current status & future management recommendations. Waikato Regional Council Technical Report 2014/59. Waikato Regional Council, Hamilton.
88	39	175.58	(38.06)	OTAUTORA STM	River or stream	wadable		345	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156		annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).

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89	39	175.58	(38.06)	OTAUTORA STM	River or stream	wadable		345	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014		annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
90	32	175.20	(38.01)	PIRONGIA-NGUTUNUI RD BR	River or stream	non wadable	Pirongia Cableway Pirongia-Ngutunui Rd (RERIMP Waipa River) Waipa River site	215190	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	3	215190	annual	literature search	proxy based on literature	ND	Non Applicable	Example: Stenger, R., Woodward, S., Shokri, A., & Hill, R. N and P concentration-discharge relationships across a range of Waikato catchments. Report.
91	32	175.20	(38.01)	PIRONGIA-NGUTUNUI RD BR	River or stream	non wadable	Pirongia Cableway Pirongia-Ngutunui Rd (RERIMP Waipa River) Waipa River site	215190	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	880	215190	10 months	literature search	proxy based on literature	2007/2008	60720	Estimated annual angler days for the Waipa River ± 1 SE 880 ± 250 for 10 months of the year (Unwin 2009). Ease of access, scenic beauty, area of fishable water & angling challenge are key attributes attracting fishermen and women to this section of the river. Mean enjoyment score 2.27 (range 1.24-4.08) (Unwin 2013).
92	32	175.20	(38.01)	PIRONGIA-NGUTUNUI RD BR	River or stream	non wadable	Pirongia Cableway Pirongia-Ngutunui Rd (RERIMP Waipa River) Waipa River site	215190	Provisioning	Nutrition	Biomass	Wild animals and their outputs	average annual catch of long-finned and short-finned eels (ton)	10600	215190	annual	literature search	proxy based on literature	2015	222600	Sources of data: Ngati Porou (2015) and Hicks et al (2013). For this section of the Waipa River: Average annual catch of long-fin eel 4.8 tonnes, short-fin eel 5.8 tonnes (Hicks et al. 2013).
93	32	175.20	(38.01)	PIRONGIA-NGUTUNUI RD BR	River or stream	non wadable	Pirongia Cableway Pirongia-Ngutunui Rd (RERIMP Waipa River) Waipa River site	215190	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	3.129011548	215190	annual	literature search	proxy based on literature	2014	8092.16	This is equivalent to 1.105ton. Cost of sediments calculated using $6.50 ($5.50 filter a m^3 of sediment from the waikato river and $0.90 per m^3 flood damge) based on Barry et al. (2014). The estimated specific sediment yields for the Waipa above (Otewa) & below (Whatawhata) this site at Pirongia are 156 & 65 t/km2/yr respectively (Hicks et al. 2011).
94	32	175.20	(38.01)	PIRONGIA-NGUTUNUI RD BR	River or stream	non wadable	Pirongia Cableway Pirongia-Ngutunui Rd (RERIMP Waipa River) Waipa River site	215190	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156	215190	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
115	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014	1235738	annual	literature search	proxy based on literature	2002	Non Applicable	Alexander et al. 2002
116	2	175.71	(39.06)	Rotoaira	Lake	Volcanic Lake			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	3	14281	annual	Aggregated statistics	proxy based on literature	2014	Non Applicable	Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
117	2	175.71	(39.06)	Rotoaira	Lake	Volcanic Lake			Hydrological regulation	Mediation of flows	Liquid flow	Flood protection	volume of flood storage (m^3)	4753500	1584.5	annual	Aggregated statistics	proxy based on literature	2014	Non Applicable	The ecosystem provides the header reservoir for the 240MW Tokaanu Power Station and as part of the Tongariro power scheme it provides some flood regulation for the Tongariro catchment. There are regular fluctuations in water level of about 300mm. The value used here is the lake area multiplied by the 300mm fluctuation. these fluctuation are experienced in the day-to-day operation of the hydro-scheme which is hydrologically complex so this indicator is not very reliable Genesis Energy (2014)
118	2	175.71	(39.06)	Rotoaira	Lake	Volcanic Lake			Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for hydro power generation (m^3)	1475000000	1584.5	annual	Aggregated statistics	proxy based on literature	2014	57600000	The quantity of electricity produced per year was not provided by Genesis because of commercial sensitivity but an average figure of 900GWh was derived from information sourced from Wikipedia. Weekly average wholesale electricity price of 6.4c/kWh was used to calculate the wholesale value of the electricity produced by Tokaanu but this is not necessarily the value of the water supply in Lake Rotoaira as the water is sourced from a number of other locations. Genesis unpublished data. Genesis Energy Unpublished data; Genesis Energy 2014: Tongariro power scheme environmental report. https://en.wikipedia.org/wiki/Tongariro_Power_Scheme; http://www.electricityinfo.co.nz/comitFta/price_index.summary
119	2	175.71	(39.06)	Rotoaira	Lake	Volcanic Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	7	14281	annual	Aggregated statistics	proxy based on literature	2011	Non Applicable	Koaro present in the lake (NZFFD). Bittern, dabchick, fernbird, pied stilt, spotless crake, and marsh crake reported; Cromarty P, Scott DA (eds) 1996. A Directory of Wetlands in New Zealand. Department of Conservation, Wellington.Reeves P, Garrick A, Dean-Speirs, T 2011. Significant Natural Areas of the Waikato Region – Lake Ecosystems. Appendices. Wildland Consultants Ltd Contract Report No. 2109b.

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120	5	175.32	(37.95)	Rotopiko (Serpentine)	Lake	Peat Lake			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	1	10.3	annual	Aggregated statistics	proxy based on literature	2011	Non Applicable	Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
121	5	175.32	(37.95)	Rotopiko (Serpentine)	Lake	Peat Lake			Hydrological regulation	Mediation of flows	Liquid flow	Flood protection	volume of flood storage (m^3)	30900	10.3	annual	Aggregated statistics	Primary	2009-2014	Non Applicable	Based on WRC lake level data fro 2009-2014. Significantly altered hydrology due to drainage and diversion. Neverthless the lakes provide water storage to regulate flows in heavey rain and a drainage point for surrounding land. The lakes fluctuate by about 0.7m and floods raise the lake by approximately 0.3m from teh average level
122	5	175.32	(37.95)	Rotopiko (Serpentine)	Lake	Peat Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	6	10.3	annual	Aggregated statistics	proxy based on literature	2011	Non Applicable	bittern, dabchick, caspian tern, crake, and shags, longfin eel. Field observations. Reeves P, Garrick A, Dean-Speirs, T 2011. Significant Natural Areas of the Waikato Region – Lake Ecosystems. Appendices. Wildland Consultants Ltd Contract Report No. 2109b.
123	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	EntertainmentAestethic/Heritage	number of night/tourist visits for boating, trout fishing, multi-sport, cycling, skydiving etc(Number)	3400000	343583.08	annual	Aggregated statistics	literature	2006, 2010	414000000	Ministry for Economic Development 2010. New Zealand Regional Tourism Forecasts 2010-2016. Lake Taupo RTO. Tourism Strategy Group, Ministry for Economic Development, Wellington.
124	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	249	343583.08	annual	Aggregated statistics	proxy based on literature	2014	Non Applicable	Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
125	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for hydro power generation (m^3)	862400000	61336	annual	Aggregated statistics	Primary	2014	34496000	Paine S 2010. Lake Generation Potential History. Prepared for the Electricity Commission. Opus International Consultants. 60pp. McConchie J, Freestone H, Knight J, Morrow F 2008. Taupo District Flood Hazard Study Stage 1 – Lake Taupo Foreshore. Prepared for Environment Waikato and Taupo District Council. Opus International Consultants. 85pp.
126	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Provisioning	Nutrition	Biomass	Wild animals and their outputs	number of commercial/recreational fish/duck hunting activities (Number)	41363	61336	annual	Aggregated statistics	licence register	2013	3722670	Overall value of the Taupo fishery was assessed as being $29 million or the equivalent of 294 FTE jobs. Taupo Fishery Review 2013. Exploring Future Opportunities for the Taupō Fishery. A Review of the Taupō Fishery. 20 May 2013.
127	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Provisioning	Nutrition	Water	Surface water	volume of water take for domestic use/drinking (m^3)	19177830	61336	annual	consent register	Primary	2014	13424481	Consented water takes based on resource consent by Waikato Regional Council surface water allocation. There may be a significant volume of water from non-consented domestic takes. Estimated $ value calculated based on NZ$0.7/$m^3$ current water price (Tongariro-Taupo Catchment Management Strategy Plan, 2015).
128	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	12	343583.08	annual	Aggregated statistics	proxy based on literature	1996	Non Applicable	The species include dabchick, shags, Australasian bittern, grey teal, mallard, paradise shelduck, black swan, spotless crake, red- and black-billed gulls, coot, banded rail and caspian tern, koura, koaro. Cromarty P, Scott DA (eds) 1996. A Directory of Wetlands in New Zealand. Department of Conservation, Wellington.
129	1	175.97	(38.83)	Taupo	Lake	Volcanic Lake			Regulation and Maintenance	Mediation of flows	Mass flows	Buffering and attenuation of mass flows	amount of sediment trapped as waste treatment (m^3)	67804.16011	343583.08	annual	Aggregated statistics	proxy based on literature	2006	No Data	This volume is equivalent to 192,000ton of sediment. Taupo receives a significant quantity of sediment from its catchment and the majority is stored in the lake although some fine suspended sediment is likely to be transported dowin the Waikato River. The majority of sediment comes from the Tongariro catchment. Hydro dams in several sub-catchments along with landuse practices have altered the sediment regime. BECA 2006. Lake Taupo Shoreline Erosion Study. Report prepared for Lake Taupo Risk Management Strategy. December 2006. Hicks DM, Gomez B, Trustrum NA 2000. Erosion thresholds and suspended sediment yields, Waipaoa River Basin, New Zealand. Water Resources Research 36 (4): 1129-1142.
130	21	176.07	(38.68)	TAUPO CONTROL GATES	River or stream	Non wadable	Taupo Gates (WARIMP routine) Outlet Lake Taupo	65	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	2		NA	Google Scholar	proxy based on literature	2015	Non Applicable	Number of scientific peer-reviewed publications Does not include technical report or 'grey' literature. Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract. Two peer reveiewed studies found: (1) Shanmuganathan et al. 2006; and (2) Shanmuganathan et al. 2003.

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131	21	176.07	(38.68)	TAUPO CONTROL GATES	River or stream	Non wadable	Taupo Gates (WARIMP routine) Outlet Lake Taupo	65	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	2150		9 months	literature search	proxy based on literature	2007/2008	148350	Waikato River (Huka Falls to L Ohakuri). The quantity is 2150 ± 740. The $69 per fishing visit (in 2015 NZ$) was derived from McBeth (1997) and was multiplied by 2,150 visits in 2007/2008 from Unwin (2009) to arrive at $148,350 per year.
132	21	176.07	(38.68)	TAUPO CONTROL GATES	River or stream	Non wadable	Taupo Gates (WARIMP routine) Outlet Lake Taupo	65	Provisioning	Nutrition	Water	Surface water	volume of water take for domestic use/drinking (m^3)	89580	65	annual	WRC Data	literature/resource consent	2015	152286	Taupo Nui-a-tia College and Lake Taupo Hospice Development Trust Inc take drinking water supply of 65,700 m^3/year and 23,880 m^3/year, respectively. The total of which is multiplied by the price per m^3 of $1.70 (WDC 2015) to arrive at the total economic value. The total estimated value is an initial approximation and does account for factors suh as wastage, evaporation, etc.
133	21	176.07	(38.68)	TAUPO CONTROL GATES	River or stream	Non wadable	Taupo Gates (WARIMP routine) Outlet Lake Taupo	65	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	4	65	annual	literature search	proxy based on literature	2014	Non Applicable	Indigenous fish species richness - 3; Indigenous fish rarity (threatened or at risk) - 1 (koaro). Possible indicators: indigenous biodiversity i.e. species/taxa richness (number); threatened or at risk species (number); iconic landscape. http://ei.niwa.co.nz/search/fbis; Goodman et al 2014.
134	21	176.07	(38.68)	TAUPO CONTROL GATES	River or stream	Non wadable	Taupo Gates (WARIMP routine) Outlet Lake Taupo	65	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064	65	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
135	21	176.07	(38.68)	TAUPO CONTROL GATES	River or stream	Non wadable	Taupo Gates (WARIMP routine) Outlet Lake Taupo	65	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007	65	annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
136	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Heritage, cultural	number of historic/heritage site (Number)	1	1410363	annual	literature search	proxy based on literature	2015	Non Applicable	Tūākau was originally a trading centre for passing waka, but after war broke out in 1863 it was occupied by British troops. They built the Alexandra Redoubt, which still stands, on a tall bluff above the river. http://www.nzhistory.net.nz/keyword/tuakau. Historically, the Waikato River provided a critical communications and transport link for the Māori & European communities along the river and Hamilton became a busy centre of economic activity. The river was of military importance in the land wars between New Zealand and rebel Māori Kingitanga forces during 1863–64, New Zealand developed its first "navy", the Waikato Flotilla. https://en.wikipedia.org/wiki/Waikato_River. http://cambridgemuseum.org.nz/HeritageWalks/hwriver.htm. Inland, rivers were the easiest transport routes. The Waikato River was navigable from Port Waikato to Cambridge and the Waipā to Alexandra (now Pirongia). Paddle steamers and barges plied both rivers, carrying freight, passengers, livestock and mail. The Waikato River system was used for freight until after the Second World War. However, shifting sandbars at Port Waikato, willow infestation and sediment build-up began to impede navigation. Port Waikato closed in 1955, heralding the end of most river transport. http://www.teara.govt.nz/en/waikato-region/page-7.
137	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	amount of fish harvest for whitebait (ton)	3	1410363	annual	literature search	proxy based on literature	2015	180000	Prices vary between $50 and $70 per kg reported at https://en.wikipedia.org/wiki/Whitebait (Average price used = $60/kg). (3,000 kg of whitebait in the year 2000) - as reported by Spiers (2001)
138	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for sand extraction (m^3/year)	219000	1410363	annual	literature search	proxy based on literature	2011	26280	Water supply - for sand extraction (by Winstone aggregates). Irrigation value added of $0.12 per m^3 derived from Denne et al. (2011).
139	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for construction and dust supression (m^3)	91250	1410363	annual	literature search	proxy based on literature	2015	10950	Value of water supply assumed to be the same as irrigation value added of $0.12 per m^3 derived from Denne et al. (2011). Taken from the site. http://waterallocation.waikatoregion.govt.nz
140	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Materials	Water	Surface water	volume of water take for domestic use/drinking (m^3)	13505000	1410363	annual	literature search	proxy based on literature	2015	22958500	drinking water to Auckland (by Watercare). Sources: (1) Watercare. Undated., (2) WDCIC (2015) of drinking water extracted by Watercare for Auckland distribution (average of 37,000 m^3 per day). https://www.watercare.co.nz/about-watercare/our-services/waikato-river-water/Pages/default.aspx.

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141	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for dust supression, fire fighting and compost row(m^3)	177600	1410363	annual	literature search	proxy based on literature	2015	21312	Water supply - dust suppresion, fire fighting, compost row (by EnviroFert Limited). Value of water supply assumed to be the same as irrigation value added of $0.12 per m^3 derived from Denne et al. (2011). Taken from the site. http://waterallocation.waikatoregion.govt.nz/
142	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for growing vegetables (m^3)	187480	1410363	annual	literature search	proxy based on literature	2015	22497.6	Water supply - for growing vegetables (by Wai Shing Limited). Irrigation value added of $0.12 per m^3 derived from Denne et al. (2011). Taken from the site. http://waterallocation.waikatoregion.govt.nz/
143	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for growing vegetables (m^3)	145000	1410363	annual	literature search	proxy based on literature	2015	17400	Water supply - for growing vegetables (by Hira Bhana & Co Limited) Irrigation value added of $0.12 per m^3 derived from Denne et al. (2011). Taken from the site. http://waterallocation.waikatoregion.govt.nz/
144	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Nutrition	Biomass	Wild animals and their outputs	amount of fish (grey mullet) catch (ton)	150	1410363	annual	literature search	proxy based on literature	2013	463500	volume of grey mullet harvested multiplied by $2.41/kg (2004 NZ$) converted to 2015 NZ$ = $3.09/kg (Source: http://www.option4.co.nz/Fisheries_Mgmt/documents/GreyMullet.pdf). (150,000 kg of grey mullet per year) - as reported by Hicks (2013)
145	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Provisioning	Nutrition	Biomass	Wild animals and their outputs	average annual catch of long-finned and short-finned eels (ton)	58.6	1410363	annual	literature search	proxy based on literature	2015	1230600	Price of eel at $21 per kg based on the Ngati Porou (2015) Ngati Porou Eel model. Other data source: Hicks et al. (2013). Catch of longfin eel - 2.1 tonnes, shortfin eel 14.2 tonnes (Hicks 2013)
146	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	9	1115.93	annual	literature search	proxy based on literature	2015	Non Applicable	There were no records on the NIWA fbis database at this site, but a record further downstream was used as an indicator of the indigenous fish biodiversity at this site. The presence of exotic pest fish species in this section of the Waikato River compromises the intrinsic ES of this site. Cost of pest fish removal a potential negative ES indicator for this site. Sources: http://ei.niwa.co.nz/search/fbis; Goodman et al 2014. Fish species richness: native - 4; exotic pest fish - 2 (potential negative ES indicator). Native fish rarity (threatened or at risk): 3
147	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	1.047723324	1410363	annual	literature search	proxy based on literature	2014	3391923.02	This is equivalent to 0.37ton. Cost of sediments calculated using $6.50 ($5.50 filter a m^3 of sediment from the waikato river and $0.90 avoided flood damge) based on Barry et al. (2014). Estimated natural sediment yield of the Waikato River at the coast, downstream from this site is 0.53 t/ha/yr; yield with hydro-dams 0.37 t/ha/yr Hicks et al. 2011.
95	32	175.20	(38.01)	PIRONGIA-NGUTUNUI RD BR	River or stream	non wadable	Pirongia Cableway Pirongia-Ngutunui Rd (RERIMP Waipa River) Waipa River site	215190	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014	215190	annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
96	36	175.72	(38.06)	POKAIWHENUA STM	River or stream	wadable		43178	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	Google Scholar	proxy based on literature	1998	Non Applicable	Example: Davies-Colley, R. J., & Quinn, J. M. (1998). Stream lighting in five regions of North Island, New Zealand: control by channel size and riparian vegetation. New Zealand Journal of Marine and Freshwater Research, 32(4), 591-605.
97	36	175.72	(38.06)	POKAIWHENUA STM	River or stream	wadable		43178	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Heritage, cultural	number of visitors to site (Number)	300	43178	annual	literature search	proxy based on literature	2009	8625	Anglers days Dec-March 2007-08, 50-70 ± 40 (SE) (Unwin 2009). Visitors per year Class 3: 100-499 (Duncan & Wilkins 2006)
98	36	175.72	(38.06)	POKAIWHENUA STM	River or stream	wadable		43178	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	60	43178	ND	literature search	proxy based on literature	2009	8625	Based on Unwin (2009), we have assumed an average annual visit of 125. We multiply this by $69 based on Macbeth (1997). Anglers days Dec-March 2007-08, 50-70 ± 40 (SE) (Unwin 2009). Visitors per year Class 3: 100-499 (Duncan & Wilkins 2006)
99	36	175.72	(38.06)	POKAIWHENUA STM	River or stream	wadable		43178	Provisioning	Materials	Water	Surface water	volume of water take for domestic use/drinking (m^3)	21900000	43178	annual	WRC Data	proxy based on literature	2012	2628000	The volume of water taken from the stream was source from WRC data (permitted water use of 15m^3/day x 365 days. http://www.waikatoregion.govt.nz/PageFiles/1247/3892_Guide%20to%20permitted%20Activites%20Booklet_2014-WEB.pdf The volume of water supplied per year is multiplied by the price per m^3 of $0.12 (Denne et al. 2012) to arrive at the total economic value.
100	36	175.72	(38.06)	POKAIWHENUA STM	River or stream	wadable		43178	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	0.481386392	43178	annual	literature search	proxy based on literature	2014	47711.69	This is equivalent to 0.17ton. The estimated specific sediment yields for the Pokaiwhenua is 17 t/km2/yr or 0.17 tonnes/ha/yr (Hicks et al. 2011). The volume of sediment yield for this site was multiplied by $6.50/tonne based on Barry et al. (2014) to provide an estimate of the cost of sediment export per year.

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101	36	175.72	(38.06)	POKAIWHENUASTM	River or stream	wadable		43178	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156		annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
102	36	175.72	(38.06)	POKAIWHENUASTM	River or stream	wadable		43178	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014		annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
103	8	174.68	(37.28)	Puketi	Lake	Dune Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	11	5.9	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	No nationally Threatened or At Risk plant species have been recorded but several species which considered threatened or rare in the Auckland region (Stanley et.al. 2005) occur here on Auckland's southern boundary. These include Cyperus ustulatus, Isolepis distigmatosa, Lachnagrostis filiformis, Sparganium subglobosum, Galium trilobum, Gratiola sexdendata, Myriophyllum votschii and Ranunculus macropus. Threatened bird species include NZ dabchick, Australasian bittern, and North Island fernbird. The lake retains its submerged flora and although this is dominated by the exotic Egeria densa a number of indigenous species are also present (Burton et. al. 2014; Jackson Efford (WRC) pers.comm.). Longfin eel and black mudfish have been recorded from the lake and its wetlands. Australian bittern, spotless crake, caspian tern, black shag, little black shag, peid shag, North Island fernbird, NZ dabchick, and banded dotterel all utilise this habitat. The species are Cyperus ustulatus, Isolepis distigmatosa, Lachnagrostis filiformis, Sparganium subglobosum, Galium trilobum, Gratiola sexdendata, Myriophyllum votschii and Ranunculus macropus. Threatened bird species include NZ dabchick, Australasian bittern, and North Island fernbird. Jackson Efford (WRC) pers.comm.
104	17	175.57	(38.45)	Ranginui Rd	Wetland	Wetland			Provisioning	Materials	Biomass	Fibres and other materials from plant, algae and animals for direct us or processing	area of Flax (harakeke, phormium tenax) plant (ha)	1.704	1.7	annual	Aggregated statistics	proxy based on literature	2015	No Data	Potential supply only - whether harakeke is gathered here is unknown (unlikely). Harakeke cover is approx 10%
105	17	175.57	(38.45)	Ranginui Rd	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	151.12	17.04	annual	Aggregated statistics	proxy based on literature	2012	42061.23	Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be able to be improved with local studies. Bernal & Mitsch 2012. 554.6 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
106	17	175.57	(38.45)	Ranginui Rd	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	4	17.04	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Provides significant habitat for indigenous species. Part of a highly significant Waipa mires natural area. Threatened or At Risk species include Myriophyllum robustum, Utricularia dichotoma, Prasophyllum hectorii, and North Island Fernbird. Bush falcon & kaka utilise the wider area. Part of the Waipapa Ecological area. DOC Bioweb
107	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	20		NA	Google Scholar	proxy based on literature	1989	Non Applicable	Example of a study: Campbell S. Nelson , Thomas G. Northcote & Chris H. Hendy (1989). Potential use of oxygen and carbon isotopic composition of otoliths to identify migratory and non-migratory stocks of the New Zealand common smelt: A pilot study, New Zealand Journal of Marine and Freshwater Research, 23:3, 337-344. Number of scientific peer-reviewed publications Does not include technical report or 'grey' literature. Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract. 20 peer reviewed and unpublished studies found in Google scholar as of 14 September 2015

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108	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Heritage, cultural	number of cultural/historical sites (Number)	1		ND	literature search	proxy based on literature	2015	Non Applicable	The Battle of Rangiriri was a major engagement in the invasion of Waikato, which took place on 20–21 November 1863 during the New Zealand land wars. The battle cost both sides more than any other engagement of the land wars. In 1995 the Crown apologised for its actions. https://en.wikipedia.org/wiki/Battle_of_Rangiriri. Historically, the Waikato River provided a critical communications and transport link for the Māori & European communities along the river and Hamilton became a busy centre of economic activity. The river was of military importance in the land wars between New Zealand and rebel Māori Kingitanga forces during 1863–64, New Zealand developed its first "navy", the Waikato Flotilla. https://en.wikipedia.org/wiki/Waikato_River. http://cambridgemuseum.org.nz/HeritageWalks/hwriver.htm. Inland, rivers were the easiest transport routes. The Waikato River was navigable from Port Waikato to Cambridge and the Waipā to Alexandra (now Pirongia). Paddle steamers and barges plied both rivers, carrying freight, passengers, livestock and mail. The Waikato River system was used for freight until after the Second World War. However, shifting sandbars at Port Waikato, willow infestation and sediment build-up began to impede navigation. Port Waikato closed in 1955, heralding the end of most river transport. http://www.teara.govt.nz/en/waikato-region/page-7
109	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	4950	1235738	annual	literature search	proxy based on literature	2007/2008	341550	The Rangiriri site is a recreational fishing location for eel, coarse fish (koi carp, goldfish, perch, tench, rudd) and trout (Hicks et al. 2013). The $69 per fishing visit (in 2015 NZ$) was derived from McBeth (1997) and was multiplied by 4,950 visits in 2007/2008 from Unwin (2009). Estimated annual angler days for the Waikato River below Karapiro ± 1 SE 4950 ± 980 (Unwin 2009) [4950 visits]. Close to home, ease of access, area of fishable water are key attributes attracting fishermen and women to this section of the river. Mean enjoyment score 1.77 (range 1.24-4.08) (Unwin 2013).
110	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for construction and dust supression (m^3)	600	1235738	Annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	A resource consent (reference: AUTH121253.01.03) is held to temporarily take up to 600 cubic metres of water per day from the Waikato River for construction activities and dust suppression purposes at Glen Murray Road, Rangiriri.
111	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Provisioning	Nutrition	Biomass	Wild animals and their outputs	average annual catch of long-finned and short-finned eels (ton)	58.6	1235738	annual	literature search	proxy based on literature	2009	1230600	The $69 per fishing visit was derived from McBeth (1997) multiplied by 4,950 visits in 2007/2008 from Unwin (2009) to arrive at approximately $341,550 per year.
112	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	21		ND	literature search	proxy based on literature	2015	Non Applicable	Fish species richness: native - 10; exotic pest fish - 6 (potential negative ES indicator). Native fish rarity (threatened or at risk): 5. There were no records on the NIWA fbis database at this site, but a record further downstream was used as an indicator of the indigenous fish biodiversity at this site. The presence of exotic pest fish species in this section of the Waikato River compromises the intrinsic ES of this site. Cost of pest fish removal a potential negative ES indicator for this site. Sources: http://ei.niwa.co.nz/search/fbis; Goodman et al 2014.
113	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	0.594653778	1235738	annual	literature search	proxy based on literature	2014	1686782.37	This is equivalent to 0.21ton. If sediment export rates can be modelled for this site, $6.50/tonne of sediment per year based on Barry et al. (2014) can be used to estimate the cost of sedimentation per year. The natural sediment regulation ES (Hicks et al. 2004, Hicks & Hill 2010, Ritchie, 2012) will be compromised by the influence of the control gates on the flow and flood regime of the Waikato River.
114	29	175.13	(37.43)	RANGIRIRI BR	River or stream	non wadable	Rangiriri Bridge (WARIMP routine)	1235738	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156	1235738	annual	literature search	proxy based on literature	2009	Non Applicable	Alexander et al. 2002. Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009)
61	13	175.37	(37.92)	Moanatuatua	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	1		NA	Aggregated statistics	proxy based on literature	1965-2014	Non Applicable	Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false WRC database: http://waterallocation.waikatoregion.govt.nz/.

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62	13	175.37	(37.92)	Moanatuatua	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	235.9	128.6	annual	Aggregated statistics	proxy based on literature	2007	65653.33	The report indicates a range, 235.9 - 1861.6 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Sequestration information from DOC website based on research of Waugh (2007). Price based on NZU spot price 9/6/2015. The carbon cycling in this wetland is currently being researched by Dave Campbell (Waikato Uni). Generally peat bogs sequestre around 0.5 tonnes of CO2 per ha per yr although a figure of 4.04t was calculated by Schipper & McLeod 2002. Current carbon rate is $5.55. Sequestration information from DOC website based on research of Waugh (2007). Pprice based on NZU spot price 9/6/2015. Schipper & McLeod 2002
63	13	175.37	(37.92)	Moanatuatua	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	4	128.6	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Threatened Lycopodiella serpentina and At risk Sporodanthus ferrugineaus, Utricularia delicatula and North island Fernbird. Clarkson, B. R., Ausseil, A. G. E., & Gerbeaux, P. (2013). Wetland Ecosystem Services. Ecosystem services in New Zealand: conditions and trends, 192-202; Bioweb. A valuable remnant of a highly under-represented raised peat bog ecosystem which include the Threatened Lycopodiella serpentina and At risk Sporodanthus ferrugineaus, Utricularia delicatula and North island Fernbird. The site also has one of the last natural populations of Sporodanthus ferrugineus and is the only significant example of a peat bog in the Hamilton basin. Clarkson 1997. Bioweb
64	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	literature search	proxy based on literature	1965-2014	Non Applicable	A search on Google Scholar showed < 5 references for this site. Example: Webster-Brown, J. G., & Lane, V. (2005). The environmental fate of geothermal arsenic in a major river system, New Zealand. In Proc. World Geothermal Congress.
65	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	2150	392328	9 months	Aggregated statistics	proxy based on literature	2007/2008	148350	Waikato River (Huka Falls to L Ohakuri). The $69 per fishing visit was derived from McBeth (1997) multiplied by 2,150 visit in 2007/2008 from Unwin (2009). The value is 2150 ± 740 (Unwin 2009)
66	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for cooling tower filling, drilling, steamfield activities in the Ohaaki Geothermal Power Station (m^3/day)	30000	392328	Daily	WRC Data	proxy based on literature	2015	Non Applicable	Source: http://waterallocation.waikatoregion.govt.nz/. The cooling service provided by 30,000 m^3 of water to the power plant may be valued in a future exercise. Water volume in m^3/day. Ohaaki Geothermal Power Station: To take and use up to 30,000m^3 per day of water from the Waikato River for cooling tower filling, cooling purposes, drilling, steamfield activities. http://waterallocation.waikatoregion.govt.nz/.
67	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for geothermal power activities - cooling tower, filling, cooling purposes, drilling, steamfield activities (30,000m^3/day).	300000	392328	Daily	Aggregated statistics	proxy based on literature	2015	12000	The value of annual output of the geothermal power, 400 GWh is $24520000. The station takes and use up to 30,000m^3 per day of water from the Waikato River for cooling tower filling, cooling purposes, drilling, steamfield activities).
68	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for pasture irrigation purposes (m^3/year)	526680	392328	Daily	WRC Data	proxy based on literature	2011	63201.6	Source: http://waterallocation.waikatoregion.govt.nz/ Irrigation value added of $0.12 per m^3 derived from Denne et al. (2011).. Water volume in m^3/day. Take water from the Waikato River for pasture irrigation purposes: 0.087 m^3/sec, 4389 m^3/day, 526680 (m^3/year) http://waterallocation.waikatoregion.govt.nz/.
69	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for pasture irrigation purposes (m^3/year)	518400	392328	Daily	WRC Data	proxy based on literature	2011	62208	Water volume in m^3/day. Take water from the Waikato River for pasture irrigation purposes: 0.072 m^3/sec, 4320 m^3/day, 518400 m^3/year. http://waterallocation.waikatoregion.govt.nz/.
70	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for pasture irrigation purposes (m^3/year)	483600	392328	Daily	WRC Data	proxy based on literature	2011	58032	Source: http://waterallocation.waikatoregion.govt.nz/ Irrigation value added of $0.12 per m^3 derived from Denne et al. (2011). Water volume in m^3/day. Take water from the Waikato River for pasture irrigation: 0.093 m^3/sec, 4030 m^3/day, 483600 m^3/year. http://waterallocation.waikatoregion.govt.nz/.

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71	22	176.30	(38.53)	OHAAKI BR	River or stream	non wadable	Ohaaki Bridge (WARIMP routine)	392328	Provisioning	Nutrition	Biomass	Wild animals and their outputs	average annual catch of long-finned and short-finned eels (ton)	16300	392328	annual	Aggregated statistics	proxy based on literature	2015	342300	Price of eel at $21 per kg based on the Ngati Porou (2015) Ngati Porou Eel model. Other data source: Hicks et al. (2013). Catch of longfin eel - 2.1 tonnes, shortfin eel 14.2 tonnes (Hicks 2013)
176	25	175.69	(38.29)	WAIPAPA TAILRACE	River or stream	non wadable	Outlet Waipapa Lakes (WARIMP routine)	676291	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007	676291	annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
177	33	176.10	(38.83)	WAITAHANUI RIVER	River or stream	non wadable	Waitahanui River near Blake Rd. Planted forest site	19640	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	literature search	proxy based on literature	2015	Non Applicable	Example: Dedual, M. (2002). Lipid content in rainbow trout (Oncorhynchus mykiss) fry and parr reared in spawning tributaries of Lake Taupo, New Zealand.
178	33	176.10	(38.83)	WAITAHANUI RIVER	River or stream	non wadable	Waitahanui River near Blake Rd. Planted forest site	19640	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Heritage, cultural	number of visitors to site (Number)	13500	19640	annual	literature search	proxy based on literature	2013	931500	Visitors per year Class 1: > 1000 (Duncan & Wilkins 2006). Estimated visitor numbers 13,500 (Angus & Associates Ltd. 2013)
179	33	176.10	(38.83)	WAITAHANUI RIVER	River or stream	non wadable	Waitahanui River near Blake Rd. Planted forest site	19640	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	5	19640	annual	literature search	proxy based on literature	2015	Non Applicable	Fish species richness: native - 4. Native fish rarity (threatened or at risk): 1 http://ei.niwa.co.nz/search/fbis
180	33	176.10	(38.83)	WAITAHANUI RIVER	River or stream	non wadable	Waitahanui River near Blake Rd. Planted forest site	19640	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	2.831684659	19640	annual	literature search	proxy based on literature	2014	52801.78	This is equivalent to 8.01ton. Cost of sediments calculated using $6.50 ($5.50 filter a m^3 of sediment from the waikato river and $0.90 avoided flood damge) based on Barry et al. (2014). The specific mean annual sediment yields in the Tauranga-Taupo (a nearby catchment similar to the Waitahanui) at Te Kono Slackline is estimated to be 79 t/km2/y (37.9 yrs flow data). This is at the low end of the range for NZ rivers (Hicks et al. 2004).
181	16	175.54	(38.44)	Waitaramoa Rd	Wetland	Wetland			Provisioning	Materials	Biomass	Fibres and other materials from plant, algae and animals for direct us or processing	area of Flax (harakeke, phormium tenax) plant (ha)	4.745	4.75	annual	Aggregated statistics	empirical	2015	No Data	Potential supply only - whether harakeke is gathered here is unknown (unlikely). Harakeke cover is approx 10%.
182	16	175.54	(38.44)	Waitaramoa Rd	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	142.35	4.75	annual	Aggregated statistics	proxy based on literature	2012	39620.75	Generic figure based on a review by De Groot et. Al.2012 of a number of studies. Difficult to improve for individual sites but more relevant research may become available in time. De Groot et. Al. 2012. 522.4 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
183	16	175.54	(38.44)	Waitaramoa Rd	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	4	4.75	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Myriophyllum robustum, Utricularia dichotoma, Prasophyllum hectorii, and North Island Fernbird. DOC Bioweb. Provides significant habitat for indigenous species. Part of a highly significant Waipa mires natural area. Threatened or At Risk species include Myriophyllum robustum, Utricularia dichotoma, Prasophyllum hectorii, and North Island Fernbird. Bush falcon & kaka utilise the wider area. Part of the Waipapa Ecological area. BioWeb Data
184	42	175.07	(37.78)	WHAKAKAI STREAM	River or stream	wadable		309	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	15	309	annual	Google Scholar	proxy based on literature	2015	Non Applicable	More than 15 references found in Google scholar. The Whakakai Stream is part of the Whatawhata research area and is used in research as a benchmark or reference site to compare with other land uses i.e. Hicks 2003; Quinn & Stroud 2002, Dodd et al. 2008.
185	42	175.07	(37.78)	WHAKAKAI STREAM	River or stream	wadable		309	Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	32		annual	literature search	proxy based on literature	2015	Non Applicable	Sources: Hicks 2003, Goodman et al. 2014. No information found in the FBIS database. Fish species based on Hicks 2003: crans bully, banded kokopu, giant kokopu, longfin & shortfin eel. Other - crayfish. Fish species richness: native - 5 Native fish rarity (threatened or at risk): 2 (longfin eel & giant kokopu) Mean Invert taxa richness: 25
186	42	175.07	(37.78)	WHAKAKAI STREAM	River or stream	wadable		309	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Buffering and attenuation of mass flows	storage/trapping of sediments	amount of sediment export from the catchment (m^3/ha)	1.699010796	309	annual	literature search	proxy based on literature	2015	1205.1	This is equivalent to 0.6ton. Potential water supply for fire if there is one in the vicinity of the stream. However, it is unknown whether water from this stream is used in fire control. Instantaneous discharge 26-102 l/sec (Hicks 2003).

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187	42	175.07	(37.78)	WHAKAKAI STREAM	River or stream	wadable		309	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of disolved organic carbon export (ton/ha)	0.0202	309	annual	literature search	proxy based on literature	2014	Non Applicable	Average dissolved organic carbon export 20.2 kg/ha/yr (Quinn & Stroud 2002). Rivers and streams can export carbon from the system in the form of dissolved and particulate organic carbon (Carey et al. 2005; Galy et al. 2014).
188	42	175.07	(37.78)	WHAKAKAI STREAM	River or stream	wadable		309	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.002	309	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-export is Quinn & Stroud (2002): Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009). However, as there amount of expert is very low compared to the allowable N leaching in a nutrient trading scheme, we did not put a price on the N export.
189	42	175.07	(37.78)	WHAKAKAI STREAM	River or stream	wadable		309	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.00058	309	annual	literature search	proxy based on literature	2002	Non Applicable	0.58 kg/ha/yr. Source for P-export is Quinn & Stroud (2002). As P is not yet traded in the market, we did not assign a price for P export.
190	4	175.95	(38.42)	Whakamaru	Lake	Hydro Lake			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	5		NA	Aggregated statistics	proxy based on literature	2014	Non Applicable	Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
191	4	175.95	(38.42)	Whakamaru	Lake	Hydro Lake			Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for hydro power generation (m^3)	608027777.8	538.42	annual	Aggregated statistics	proxy based on literature	2014	24321111.11	No data provided by Mighty River Power despite request. The volume of water is assumed used to generate 371GWh of electricity based other similar water take for electricity generation in other ecosystems. This is based on relevant proportion of average output of entire Waikato Hydro Scheme. I.e. Whakamaru is rated at 100MW which is 9.28% of total Waikato capacity which produces an average of 4,000 GWh/yr. $ values based on current electricity price (http://www.electricityinfo.co.nz/comitFta/price_index.summary)
192	4	175.95	(38.42)	Whakamaru	Lake	Hydro Lake			Provisioning	Nutrition	Biomass	Wild animals and their outputs	amount of commercial eel catch (ton)	1.5	538.42	annual	Aggregated statistics	empirical	2013	11025	Based on eel fishery value of $7.35/kg (industry value) Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
193	4	175.95	(38.42)	Whakamaru	Lake	Hydro Lake			Provisioning	Nutrition	Water	Surface water	volume of water take for domestic use/drinking (m^3)	1100000	538.42	annual	Aggregated statistics	proxy based on literature	2014	154000	This is based on the cost to buy water from irrigation scheme which varies considerably. $ calculated based on NZ$0.14/$m^3$ water price for irrigation water (2014). Consented potable and irrigation water takes. Data would be more accurate using actual consent data. There may be a significant volume of water from non-consented domestic takes. Reese P, Borrie N (2014) Cost of Irrigation Scheme Water Supply in New Zealand. 2014 Update. Irrigation New Zealand. 11pp.
194	4	175.95	(38.42)	Whakamaru	Lake	Hydro Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	2	538.42	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	Indigenous fish include longfin eel, smelt, common bully and koura. Birds include Caspian tern, NZ shoveler, grey teal, black swan, mallard duck, little shag, paradise shelduck and Canada goose. NZFFD, Field observations. Other threatened or at risk species such as spotless crake and NI fernbird may also be present.
195	3	175.66	(37.99)	Karapiro	Lake	Hydro Lake			Regulation and Maintenance	Mediation of flows	Mass flows	Buffering and attenuation of mass flows	amount of sediment trapped as waste treatment (m^3)	12360.13335	538.42	annual	Aggregated statistics	proxy based on literature	ND	Non Applicable	Approximately 35,000m^3 of sediment is trapped by Lake Whakamaru annually. This is equivalent to 12,360ton. Note: Sediment trapping is both a service and a negative impact. This has a negative aspect as there is a riverbed material deficit in the lower Waikato as a result of the hydro lakes trapping the najority of course sediment (Hicks et al. 2010). The sediment trapping service provided byt eh lake may help to remove additional sediment added to the systm by landuse practices by it also restricts the flow of reiverbed matieral to the downstream reaches of the Waikato. Hicks et al. 2010
196	10	175.13	(37.33)	Whangamarino wetland	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	Aggregated statistics	proxy based on literature	1965-2014	Non Applicable	Whangamarino has been extensively studied both in the peer-reviewed literature and in technical reports and grey literature. Source: Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false

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197	10	175.13	(37.33)	Whangamarino wetland	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	18413	6137.67	annual	Aggregated statistics	proxy based on literature	2012	5124954.45	May be able to be improved with local studies. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. 67575.7 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61. Bernal & Mitsch 2012
198	10	175.13	(37.33)	Whangamarino wetland	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	19	6137.67	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	DOC Bioweb, NZFFD. Threatened fauna includes the Australasian bittern ,black mudfish, inanga, torrentfish, longfin eel, spotless crake, and North Island fernbird. Threatened plant species include swamp helmet orchid, Utricularia delicatula, U. australis, Myriophyllum robustum, Cyclosorus interruptus, Pterostylis micromega, Pterostylis paludosa, Juncus holoschoenus, Prasophyllum hectorii, Gratiola concinna, Lycopodium serpentinum and Spiranthes novae-zelandiae.Whangamarino has a very high biodiversity value and provides habitat for a range of threatened species and ecosystems. It includes a range of wetland types from mineralised swamp to domed peat bog. Threatened fauna includes the Australasian bittern ,black mudfish, inanga, torrentfish, longfin eel, spotless crake, and North Island fernbird. Threatened plant species include swamp helmet orchid, Utricularia delicatula, U. australis, Myriophyllum robustum, Cyclosorus interruptus, Pterostylis micromega, Pterostylis paludosa, Juncus holoschoenus, Prasophyllum hectorii, Gratiola concinna, Lycopodium serpentinum and Spiranthes novae-zelandiae.Many of the species present are uner threat within the wetland by pests, weed invasion, and eutrophication. DOC spends considerable amounts of money managing these threats. DOC Bioweb, NZFFD
199	10	175.13	(37.33)	Whangamarino wetland	Wetland	Wetland			Regulation and Maintenance	Mediation of flows	Liquid flow	Flood protection	volume of flood storage (m^3)	94800000	6137.67	annual	Aggregated statistics	Empirical	2007	6100000	Whangamarino plays an important role in flood regulation in the lower Waikato. It recieves water from Lake Waikare via canal and flood waters from the Waikato River are preented from entering the wetland by flood gates. The Whangamarino-Waikare system provides 94.8 million m^3 of flood storage. Based on flood storage for the Waikare-Whangamarino system rather than just the wetland. Data is now relatively old. Based on a study by DOC on the economic value of Whangamarino with values converted to 2015 dollars. $ values based on a study by DOC on the economic value of Whangamarino with values converted to 2015 dollars. Department of Conservation 2007. The economic values of Whangamarino Wetland. DOCDM-141075. Department of Conservation, Hamilton. 8 pp.
200	10	175.13	(37.33)	Whangamarino wetland	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO3) removal (ton)	5601	6137.67	annual	Aggregated statistics	proxy based on literature	2012	Non Applicable	Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service. Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd. based on generic nitrate removal figures for constructed wetlands. Tanner & Sukais 2012
201	35	176.27	(38.30)	WHIRINAKI STM	River or stream	wadable		1080	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	Google Scholar	proxy based on literature	ND	Non Applicable	Example: Irwin, J., & Heath, R. A. (1972). Winter temperature structure in lakes atiamuri and ohakuri, New Zealand. New Zealand journal of marine and freshwater research, 6(4), 492-496.
202	35	176.27	(38.30)	WHIRINAKI STM	River or stream	wadable		1080	Provisioning	Nutrition	Water	Surface water	volume of water take for domestic use/drinking (m^3)	5475		annual	literature search	proxy based on literature	2015	657	The volume of water taken from the stream was assumed to be the same as Kawaunui stream (i.e. permitted water use of 15m^3/day x 365 days) because the mean flow is very similar between the two streams (0.111 m^3/sec for Whirinaki and 0.112 m^3/sec for Kawaunui). The volume of water supplied per year is multiplied by the price per m^3 of $0.12 (Denne et al. 2012) to arrive at the total economic value.
203	35	176.27	(38.30)	WHIRINAKI STM	River or stream	wadable		1080	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064		annual	literature search	proxy based on literature	2015	No Data	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).

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204	35	176.27	(38.30)	WHIRINAKI STM	River or stream	wadable		1080	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0007		annual	literature search	proxy based on literature	2002	No Data	Source for P-yield Alexander et al. (2002)
148	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156	1410363	annual	literature search	proxy based on literature	2009	11282.9	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
149	31	174.95	(37.30)	TUAKAU BR	River or stream	non wadable	Tuakau Bridge (WARIMP routine)	1410363	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014	1410363	annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
150	19	175.83	(38.96)	Turangi swamp	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	5		NA	Aggregated statistics	proxy based on literature	1965-2014	Non Applicable	The Web of Science search yielded five scientific studies. Based only on published papers and does not include grey literature. Web of Science database. Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
151	19	175.83	(38.96)	Turangi swamp	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings)	Intellectual and representative interactions	Scientific	number of monitoring sites by scientists (Number)	1	1115.93	annual	empirical	proxy based on literature	2014	Non Applicable	This is one of the state of the environment Monitoring sites for Waikato Regional Council
152	19	175.83	(38.96)	Turangi swamp	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	3537.5	1115.93	annual	Aggregated statistics	proxy based on literature	2012	931801.55	12982.6 CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
153	19	175.83	(38.96)	Turangi swamp	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	11	1115.93	annual	Aggregated statistics	proxy based on literature	1996	Non Applicable	Black Shag , Little Black Shag, Australasian bittern, NZ dabchick, grey duck, banded rail, spotless crake, marsh crake, and North Island fernbird. Plants include Utricularia australis and Prasophyllum hectori. Old data but likely to be still accurate. Cromarty P, Scott DA (eds) 1996. A Directory of Wetlands in New Zealand. Department of Conservation, Wellington.
154	19	175.83	(38.96)	Turangi swamp	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO_3) removal (ton)	1018	1115.93	annual	Aggregated statistics	proxy based on literature	2012	Non Applicable	Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd.
155	7	175.14	(37.56)	Waahi	Lake	Riverine Lake			Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	13	460.94	annual	Aggregated statistics	proxy based on literature	2014	Non Applicable	A number of peer reviewed scientific papers have been published about Lake Waahi and there is also a considerable grey literature of technical report and plans. Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
156	7	175.14	(37.56)	Waahi	Lake	Riverine Lake			Hydrological regulation	Mediation of flows	Liquid flow	Flood protection	volume of flood storage (m^3)	23820000	460.94	annual	Aggregated statistics	Empirical	2007	Non Applicable	Based on simple calculation preformed on data in Jones and Hamilton 2014. Actual flood storage is more complex but this is nevertheless a significant ecosystem service of this lake. The data could be more accurately assessed with lake level data. Significantly altered hydrology due to drainable and diversion. Nevertheless provides significant water storage to regulate flows in heavy rain and a drainage point for surranding land. Flood storage is at least 23.8M m^3

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157	7	175.14	(37.56)	Waahi	Lake	Riverine Lake			Provisioning	Nutrition	Biomass	Wild animals and their outputs	amount of commercial eel catch (ton)	4.3	460.94	annual	Aggregated statistics	empirical	2013	31605	Approximately 4.3tons of eels are fished from the Lake each year. Customary and recreational fishing may also occur. MPI report catch for Waahi, Whangape and Rotonagaro combined and a simple proportion was used to estimate catch for Waahi alone. Data is from 2013. The economic value is based on eel fishery value of $7.35/kg (industry value) Beentjes 2013; https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/pressures-on-new-zealand-populations/commercial-tuna-fisheries
158	7	175.14	(37.56)	Waahi	Lake	Riverine Lake			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	11	460.94	annual	Aggregated statistics	proxy based on literature	2011	Non Applicable	Longfin eel and black mudfish have been recorded from the lake and its wetlands. Australasian bittern, spotless crake, Caspian tern, black shag, little black shag, pied shag, North Island fernbird, NZ dabchick, and banded dotterel all utilise this habitat. Field observations. Reeves P, Garrick A, Dean-Speirs, T 2011. Significant Natural Areas of the Waikato Region – Lake Ecosystems. Appendices. Wildland Consultants Ltd Contract Report No. 2109b.
159	41	174.76	(37.38)	WAIKATO RIVER TRIB	River or stream	wadable		55.5	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0156		annual	literature search	proxy based on literature	2015	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).
160	41	174.76	(37.38)	WAIKATO RIVER TRIB	River or stream	wadable		55.5	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Phosphorous (P) export (P yield) from the catchment (ton/ha/year)	0.0014		annual	literature search	proxy based on literature	2002	Non Applicable	Source for P-yield Alexander et al. (2002)
161	11	174.85	(37.28)	Waikato river wetland	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	11	837.02	NA	Aggregated statistics	proxy based on literature	1965-2014	Non Applicable	The Waikato River wetlands have been the subject of anumber of scientific studies but particularly of technical reports produced by Regional Council and other government agencies. Number of scientific studies does not reflect the significant quantity of grey literature; source: Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
162	11	174.85	(37.28)	Waikato river wetland	Wetland	Wetland			Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of surface water take for agricultural, irrigation and industrial use (m^3)	47000	837.02	Daily	Aggregated statistics	proxy based on literature	2014	6580	Consents are in place to take at least 47,000m^3 water per day from the Waikato River where it passes through the wetlands. Consents are for irrigation, agricultural and industrial use including 40,000 m^3 per day for Glenbrook Steel Mill. Water is supplied by the river rather than the wetland. Reese P, Borrie N 2014. Cost of Irrigation Scheme Water Supply in New Zealand. 2014 Update. Irrigation New Zealand. 11pp.
163	11	174.85	(37.28)	Waikato river wetland	Wetland	Wetland			Provisioning	Nutrition	Biomass	Wild animals and their outputs	number of white bait stands consented (Number)	542	837.02	annual	Aggregated statistics	proxy based on literature	ND	No Data	At least 542 consented whitebait stands are situated along the margins of this wetland. Technically whitebait are fished from the Waikato River but the wetlands play an important role In supporting the fishery. WRC consents data
164	11	174.85	(37.28)	Waikato river wetland	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	2511	837.02	annual	Aggregated statistics	proxy based on literature	2012	698911.7	9215.4 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. Based on a figure from a USA study but other studies gave similar figures around 3t carbon/ha/year. May be improved with local values. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies.Bernal B, Mitsch WJ 2012. Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology 18: 1636 - 1647. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
165	11	174.85	(37.28)	Waikato river wetland	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	15	837.02	annual	Aggregated statistics	proxy based on literature	2010	Non Applicable	The lower Waikato River and its wetlands are important breeding grounds for inanga and other diadromous fish as well as many birds. Threatened or At Risk fish species include inanga, longfin eel and black mudfish. Birds include banded rail, NZ dabchick, NI fernbird, Australasian bittern, grey duck, spotless crake, pied stilt, white-fronted tern, Caspian tern, black shag, little black shag and pied shag. Cromarty & Scott 1996; NIWA 2010. Threatened or At Risk fish species include inanga, longfin eel and black mudfish. Birds include banded rail, NZ dabchick, NI fernbird, Australasian bittern, grey duck, spotless crake, pied stilt, white-fronted tern, Caspian tern, black shag, little black shag and pied shag. Cromarty P, Scott DA (eds) 1996. A Directory of Wetlands in New Zealand. Department of Conservation, Wellington. NIWA 2010. Waikato River independent scoping study. NIWA Client Report HAM2010-032. NIWA, Hamilton.

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166	11	174.85	(37.28)	Waikato river wetland	Wetland	Wetland			Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	amount of nitrate (NO3) removal (ton)	764	837.02	annual	Aggregated statistics	proxy based on literature	2012	Non Applicable	Based on generic nitrate removal figures for constructed wetlands. Tanner CC, Sukias JPS, Yates CR 2010. New Zealand guidelines: Constructed Wetland Treatment of Tile Drainage. NIWA Information Series No. 75. National Institute of Water & Atmospheric Research Ltd. Likely to remove a significant quantity of nitrate from groundwater and some from surface water. Also provides a significant phosphorus removal service. based on generic nitrate removal figures for constructed wetlands.Tanner & Sukais 2012
167	15	176.37	(38.35)	Waiotapu	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Intellectual and representative interactions	Scientific and educational	number of scientific projects, articles, studies (number)	1	355.53	NA	Aggregated statistics	proxy based on literature	1965-2014	Non Applicable	Only one peer-reviewed scientific study was found in a search of the Web of Science database but the geothermal features have been well studied and monitored and reported in the grey literature or journals not covered by Thomson Reuters (2015) Web of Science is a single research engire for exploring citation universe across subjects and around the world. The engine claims to be the world's largest citation index with most reliable and integrated source of multidisciplinary research database. http://ipscience.thomsonreuters.com/product/web-of-science/?utm_source=false&utm_medium=false&utm_campaign=false
168	15	176.37	(38.35)	Waiotapu	Wetland	Wetland			Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings)	Entertainment/ Symbolic	Aesthetic	number of visitors to site (Number)	160000	355.53	annual	Aggregated statistics	empirical	2014	3944000	Estimated value. Value based on current admission prices, and an assumed 75% of visitors being adults and 25% being children. Approximate visitor numbers supplied by Waiotapu Thermal Wonderland. Allison Lawton, Waiotapu GM, pers. comm.) Wai-o-Tapu thermal wonderland recieves around 160,000 visitors each year and the areas of the wetland and geothermal field outside the attraction also receive visitors. Value based on current admission prices, and an assumed 75% of visitors being adults and 25% being children. Approximate visitor numbers supplied by Waiotapu Thermal Wonderland.
169	15	176.37	(38.35)	Waiotapu	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation and reduction of greenhouse gas concentrations	amount of carbon (C) sequestrated from atmosphere (ton)	1005	355.53	annual	Aggregated statistics	proxy based on literature	2015	279721.65	3688.3 t CO2 equivalents. Equivalents calculated based on atomic weight of carbon and oxygen, with one ton of carbon equivalent to 6.67 tons of carbon dioxide. A sound figure on carbon sequestration could not be found. Some estimates are up to 9t/ha/yr for kanuka/manuka scrub but others are as low as 3t. The lowest figure was used here. $ value is a generic figure based on a review by De Groot et al. 2012 of a number of studies. http://www.gbict.co.nz/Newsletters/Issue%2018/Sequestration.htm http://maxa.maf.govt.nz/forestry/pfsi/carbon-sequestration-rates.htm. De Groot, Rudolf, et al. "Global estimates of the value of ecosystems and their services in monetary units." Ecosystem services 1.1 (2012): 50-61.
170	15	176.37	(38.35)	Waiotapu	Wetland	Wetland			Regulation and Maintenance	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	number of threatened or at risk species (Number)	2	355.53	annual	Aggregated statistics	proxy based on literature	2015	Non Applicable	The At Risk prostrate kanuka (Kunzea tenuicaulis) is the dominant species. Cyclosorus interuptus and Dicranopteris linearis (also At Risk) are also present. Field observation.
171	25	175.69	(38.29)	WAIPAPA TAILRACE	River or stream	non wadable	Outlet Waipapa Lakes (WARIMP routine)	676291	Cultural services	Intellectual and Experiential	Information and Knowledge	Scientific and educational	number of scientific projects, articles, studies (number)	4		NA	Google Scholar	proxy based on literature	1965-2014	Non Applicable	Example: Spencer, M. J., & Ramsay, A. J. (1978). Bacterial populations, heterotrophic potentials, and water quality in three New Zealand rivers. New Zealand journal of marine and freshwater research, 12(4), 415-427. Number of scientific peer-reviewed publications Does not include technical report or 'grey' literature. Only counted publications where the research was on the river site. Used Google Scholar as other search engines mainly covered Title, Keywords and Abstract. < 5 references
172	25	175.69	(38.29)	WAIPAPA TAILRACE	River or stream	non wadable	Outlet Waipapa Lakes (WARIMP routine)	676291	Cultural services	Physical and intellectual interactions, with biota, ecosystems, and landscape/seascapes (environmental settings	Physical and experimental interactions	Physical use of land-/seascapes in different environmental settings	number of angling/fishing days/visits (Number)	2150	676291	annual	literature search	proxy based on literature	2007/2008	148350	No information found about the number of fishing visits. However, we have assumed that the stream gets 2,150 fishing visits a year. The $69 per fishing visit was derived from McBeth (1997) multiplied by 2,150 visit in 2007/2008 from Unwin (2009). Trout is the most popular Hicks et al. 2013. Fishing activity in the Waikato and Waipa rivers. ERI report number 7. University of Waikato, Hamilton. Noted for good fishing although below the Waipapa Dam fishing quality varies depending on turbine activity. There is a boat ramp at this site. http://www.nzfishing.com/FishingWaters/AucklandWaikato/AWFishingWaters/AWArapuni.htm.LAWA identifies this site as suitable for fishing. http://www.lawa.org.nz/explore-data/waikato-region/freshwater/waikato-river/waikato-river-@-waipapa-tailrace/

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173	25	175.69	(38.29)	WAIPAPA TAILRACE	River or stream	non wadable	Outlet Waipapa Lakes (WARIMP routine)	676291	Provisioning	Materials	Water	Surface water for non-drinking purposes	volume of water take for hydro power generation (m^3)	83583.33	676291	annual	Aggregated statistics	proxy based on literature	2015	3343.33	The 51MW capacity was estimated to volume of water use based on other water take for electricity generation. This site is just downstream from the Waipapa power station which holds a generic resource consent for hydropower: (reference: AUTH105227.01.03) to dam the Waikato River and divert and take water (including any energy or material included therein,) for water level control, generation of hydro-electricity, and operation of the Waikato hydro system, commencing on 12/04/2006 expiring on 12/04/2041. Price of KWh of electricity of $0.30 was based on http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=10780269 and was multiplied by 331 million KWh. Source of 51 MW capacity from https://en.wikipedia.org/wiki/List_of_power_stations_in_New_Zealand
174	25	175.69	(38.29)	WAIPAPA TAILRACE	River or stream	non wadable	Outlet Waipapa Lakes (WARIMP routine)	676291	Provisioning	Nutrition	Biomass	Wild animals and their outputs	average annual catch of long-finned and short-finned eels (ton)	16.3	676291	annual	literature search	proxy based on literature	2015	342300	Sources of data: Ngati Porou (2015) and Hicks et al (2013). For this section of the river: Average annual commercial catch of long-fin eel 2.1 tonnes, short-fin eel 14.2 tonnes (Hicks et al. 2013).
175	25	175.69	(38.29)	WAIPAPA TAILRACE	River or stream	non wadable	Outlet Waipapa Lakes (WARIMP routine)	676291	Regulation and Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by ecosystems	amount of Nitrogen export (N yield) from the catchment (ton/ha/year)	0.0064	676291	annual	literature search	proxy based on literature	2009	Non Applicable	Source for N-yield: Alexander et al. (2002). Price of N is about $400/kg/ha if above the cap and trade limit (Duhon et al. 2009).