Lake Waikare and Whangamarino Wetland Catchment Management Plan

State of understanding report

Draft for consultation

March 2017, Updated November 2017

STATE OF UNDERSTANDING REPORT: DRAFT FOR CONSULTATION
Lake Waikare and Whangamarino Wetland Catchment Management Plan

EXECUTIVE SUMMARY

This report describes that an extensive literature review and gap analysis process has been undertaken to date for the Lake Waikare and Whangamarino Wetland Catchment Management Plan (CMP). It should be considered a "draft" and has been developed as a basis for consultation with stakeholders who would like to provide input into this process. Following input from stakeholders, the State of Understanding can be updated and utilised in the capacity of moving forward to the next steps in the CMP development phase.

As part of this technical work, a detailed database has been created which provides a current state of our understanding of approximately 72 research studies, 64 projects and numerous monitoring activities which have been undertaken in the catchment over the last 10 – 15 years. The database has been developed in consultation with some of Waikato Regional Council's collaborative stakeholder partners to the CMP, and with further consultation this database can be extended. It will continue to be used as a valuable resource.

The state of understanding draft report details key issues and gaps which have been identified through the literature. The report clearly highlights that whilst a significant amount of research and on-the-ground projects have occurred to date within the catchment, many of these have tended to focus on the Whangamarino wetland and Lake Waikare, and not within the wider catchment subject to the CMP. In addition, many of the studies and projects have been undertaken by different organisations and in isolation of each other. The result is that some studies overlap each other, and a strategic, prioritised approach to implementation of restoration projects across the catchment has not been implemented.

The report also tables 23 potential studies which could be further prioritised and scoped to fill the identified gaps. One of the key recommendations of this current state of understanding is to consolidate and collate existing information in order to facilitate assessing options and develop a prioritised approach to implementation on an on-going basis. Potential options for management are also tabled for discussion and consultation.

Future work needs to be undertaken in a consolidated, systematic manner by collating existing information in order to facilitate optioneering and develop a prioritised approach to implementation on an on-going basis. This needs to occur in a collaborative manner with all stakeholders contributing resource, expertise and experience into this phase.

TABLE OF CONTENTS

1. INTRODUCTION

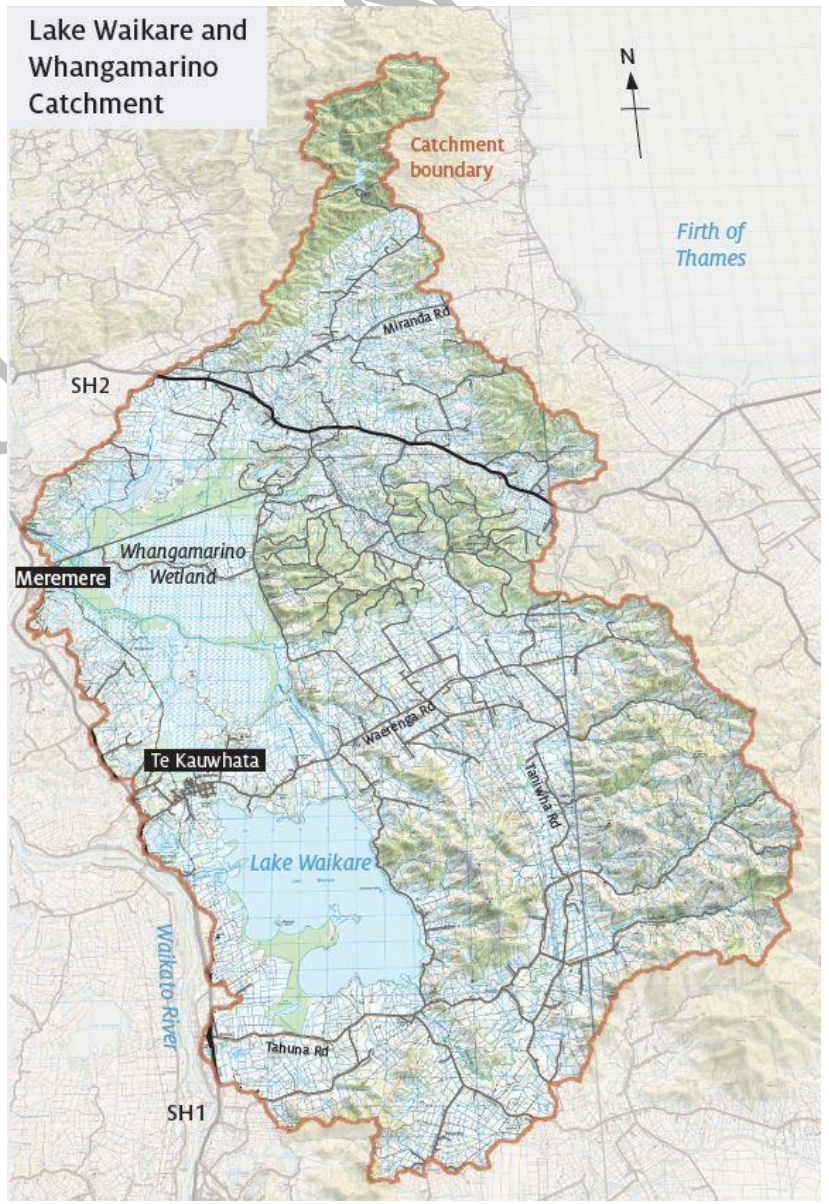
It is widely acknowledged that Lake Waikare, Whangamarino wetland and their catchments have multiple important values and interests to a variety of stakeholders. Often these values are inter-related, and the challenge is to ensure these values and interests are not competing, and instead are brought together to achieve a common vision for the catchments of Lake Waikare and Whangamarino wetland.

This high level of interest has meant that the catchment has been the focus of a significant number of studies, as well as restoration projects and ongoing state of the environment monitoring. In addition, the future management and enhancement of Lake Waikare and Whangamarino wetland is a key focus for many key stakeholders, including iwi and local landowners, and the wider community. There is a general desire to have a co-ordinated approach with managing the catchments of Lake Waikare and Whangamarino wetland, therefore, the development of a collaborative catchment management plan (CMP) was initiated.

As part of the CMP process the project team undertook an extensive literature review and gap analysis in order to develop a "state of understanding" about the catchment. The purpose of this report is to summarise the "state of understanding" process and provide recommendations as to the types of projects which would be needed to fill key gaps in our knowledge about the catchment.

This report should be considered "draft" and has been developed as a basis for consultation with stakeholders who would like to provide input into this process. As a result of this input the State of Understanding can be updated and utilised in the capacity of moving forward to the next steps in the CMP development phase.

The report first describes the methodology used during the literature review and gap analysis; it then summarises identified issues and gaps, and documents recommended studies to fill the identified gaps; and finally it tabulates potential options for management which have been highlighted for further investigation through the literature.



2. METHODOLOGY

The first task related to developing the current state of understanding for the Lake Waikare and Whangamarino wetland catchment was to update the literature review which was undertaken by Latitude Planning Services (June 2015), entitled *Literature/ Projects Review 2015*, on behalf of Waikato Regional Council. Additional literature searches were undertaken, and some stakeholders provided input into the gap analysis database through a series of workshops, meetings and/ or phone conversations. The CMP project team also had an opportunity to provide input via the fortnightly team meetings. Department of Conservation, Fish and Game, Waikato-Tainui, Waahi Whaanui Trust and Ngaa Muka Development Trust, and Waikato Regional Council staff provided input into the state of understanding.

In addition to the studies and projects identified there is also a significant knowledge of the catchment from a flood control perspective. The Lower Waikato-Waipa Flood Control Scheme operates within the catchment and provides for flood protection on a large scale. This scheme has been operating since 1965 and as a result many catchment studies and surveys have occurred and informed the ongoing flood control scheme operation. These aspects have also been considered within this review.

Literature, evidence and work undertaken through the Section 128 consent review process (from all parties involved); the Waikato Regional prioritisation project; the *Waikato and Waipā River Restoration Strategy*; and *Healthy Rivers/Wai Ora Proposed Waikato Regional Plan Change 1*; have also been a source of information for the database.

Landowners are identified as a key stakeholder group and their input (especially relating to their 'on-the-ground' experience in the catchment), which still needs to be incorporated, is a critical component of the state of understanding process. An open day was held at the Te Kauwhata Golf Club on 13 November 2017. Many landowners showed an interest in the process and their stories about the catchment should be captured as part of the CMP process.

The parameters of the state of understanding were set by summarising a set of potential CMP scope objectives (attachment A). These objectives were developed from the consultation workshops held between Waikato Regional Council and key stakeholders in March – May of 2015, as well as key strategic planning documents such as the "The Vision and Strategy for the Waikato River". It is noted that these objectives were used purely to guide and inform the extent of the gap analysis and state of understanding. It is not intended that they be used as outcome objectives for the CMP document itself as these will be specifically and collaboratively developed over the CMP development process.

An excel database was developed to record research, projects and monitoring work that was identified as being undertaken in the catchment. Where possible, the database (attachment B) captures and summarises the following information.

- Study / project title / monitoring parameter.
- Source / reference of the document.
- Work stream area which the study / project / monitoring covers, namely:
    - soil and land

    - biodiversity
    - water quality
    - water management
    - values.
- Sub-catchment area to which the study relates.
- Organisation which undertook the research/ project/ monitoring.
- A summary of the report/ works.
- Identified gaps / options / recommendations.
- General comments.

In addition, funding and implementation – while not a specific work stream in itself – was considered as a component of the review assessment.

The spreadsheet was developed in such a way that gaps could be identified based on a range of parameters, including issue, geographical area, work stream area or organisation. In addition, those documents which could be sourced electronically have been saved onto the project shared "ftp" drive.

It should be noted that the gap analysis and database is currently at a "draft" development stage, and will be continually updated throughout the life of the CMP development process as further information is sourced and developed.

3. STATE OF UNDERSTANDING

The gap analysis process identified that 75 research studies and approximately 70 projects have been undertaken (or are currently underway) in the Lake Waikare and Whangamarino catchment. The list of literature and projects is not exhaustive, but it is believed that the main studies relating to the catchment have been included in the database (attachment B). Monitoring is currently undertaken in the catchment by both Waikato Regional Council and DOC (attachment B). A significant amount of research and on-the-ground projects have occurred to date within the catchment, however, many of these have tended to focus on the Whangamarino wetland and Lake Waikare and not within the wider catchment subject to the CMP. In addition, many of the studies and projects have been undertaken by different organisations and in isolation of each other. The result is that some studies overlap each other, and a strategic, prioritised approach to implementation of restoration projects across the catchment has not been implemented. One of the key recommendations of this current state of understanding is to consolidate and collate existing information in order to facilitate assessing options and develop a prioritised approach to implementation on an on-going basis.

3.1 Issues

Key issues confirmed and identified through the state of understanding include:

- Aquatic and terrestrial weed species (such as alligator weed and yellow flag iris)
- Aquatic pests (such as koi carp and catfish)
- Unfenced areas along the streams, wetland and lakes are leading to damage of sensitive riparian, wetland and lake areas by stock grazing
- Unstable and erosion-prone land in the upper catchments
- Accelerated stream channel erosion from increased stormwater peak flow rates
- Sediment deposition in the lower catchment areas of Lake Waikare and Whangamarino wetland
- Resuspension of sediment in Lake Waikare
- Discharge of nutrients and other contaminants such as E.coli into Lake Waikare and Whangamarino wetland
- High algal levels in Lake Waikare
- The bathymetry and size of Lake Waikare as an obstacle to restoration
- The lack of macrophyte growth in Lake Waikare
- Uncertainty regarding the interaction of the Whangamarino weir and the northern outlet control gate (Lake Waikare) in terms of operating water levels: how the two gates function and how the change in water level in Lake Waikare is affecting the wetland is still debated
- Existing threats to the mauri of water, cultural values and how future options could impact on wāhi tapu
- Existing threats to social and recreational values in the catchment (such as duck hunting, kayaking, etc)
- Threats to the economic viability of farming land from existing and future flooding, as well as stream erosion and land instability
- Threats to Lake Waikare and Whangamarino Wetland from the urban development of Te Kauwhata (stormwater and wastewater discharges)

3.2 Gaps

Key gaps identified are shown in the table on the next page.

Identified gaps / issues	Potential study(s) to fill gap
Significant studies on vegetation mapping, weed species, floral and faunal values and aquatic pests. But studies often done in isolation of each other. Clear gap is a consolidation / write-up of existing knowledge and state of the environment.	Vegetation mapping, values, weed and pest strategy. Collate SOE work relating to the lake and wetland. Vegetation mapping has been completed as part of the Waikato District SNA project, but could be integrated into the weed and faunal pest strategy.
Potential farming effects on wetland where farms abut wetland and feeder streams – nutrients as well as invasion of weeds. Strategy for management.	Erosion and weed mapping for the catchment - could be part of a Watercourse Management Framework for the headwater streams which links to setting out a plan for ongoing restoration (planting and fencing), weed management and erosion control.
Active management of weeds but only certain ones in certain areas - need to collate with study below and create a weed management plan for the catchment.	
Significant studies on alligator weed and yellow flag iris - no updates provided on status of other weed species.	
Concern around aquatic pests, specifically koi carp and cat fish.	
Ongoing restoration work needed.	
Rehabilitation of unstable, erosion prone land - mapping of this land (from aerial photography) to inform future works?	
Lack of data and information regarding key issues affecting headwater streams and the upper sub-catchments within the Lake Waikare and Whangamarino catchment area.	Streamwalks (targeted).
More work incorporating measurement of sediment accumulation rates in sediment cores at different locations within the wetland could be used to better understand how the Pungarehu Canal operation, and the weir on the outlet of the Whangamarino River, affects sediment deposition in the wetland.	Sediment budget for the catchment - coring work and sources of sediments needs further investigation. A catchment-wide understanding of sediment hydrodynamics is needed (predictive contaminant model). A whole of catchment approach is needed which also takes account of lake water levels and flooding and accommodates the necessary statutory requirements from within associated consents.

Identified gaps / issues	Potential study(s) to fill gap
There is a lack of knowledge as to how present nutrient and sediment levels, wave climate and fish influence can be mitigated so that macrophytes can be established in Lake Waikare.	Desk-top international literature search on rehabilitation of large lakes with wind-wave fetch, hyper-eutrophic problems, including potential options to reduce these effects (such as the use of artificial plants, buoys or ropes to dampen wave action).
Lack of data and knowledge as to the treatment performance of wetlands for fine sediments, along with the possibility of flocculating to increase sediment deposition. The viability of "in-line" sacrificial wetlands also needs to be understood.	Investigation into the role of wetlands for treating fine sediments, flocculation testing and understanding of long term performance of flocculation and effects on biota.
The following critical gaps in knowledge were identified as needing to be addressed to improve evaluation of mitigation options. • Better quantification of sediment and nutrient inputs and outputs. In particular, more data is needed on concentrations of suspended sediment in the Northern Outlet Canal to more accurately determine the volume of sediment being discharged to different regions of the Whangamarino wetland. • The quantification of the extent of surface flooding within the Whangamarino wetland at different water levels, and how these are influenced by the operation of the Lake Waikare control gate. • The contribution that introduced fish make to suspended sediment levels within Lake Waikare and the Whangamarino wetland.	Need to understand nutrient inputs and contribution from the wastewater system (not just farm runoff). Links to the above comment around a whole of catchment modelling approach and water levels/ flooding. Information presented at s.128 hearing focusses on 'ad hoc' nature of studies to date.
Lake Waikare and Whangamarino weir / northern outlet control gate operating levels: there is a need to understand how the two gates function and how the change in water level in Lake Waikare is affecting the wetland. Studies done previously have been in isolation of the rest of the catchment. A systems approach to integrating this with hydrological changes from the rest of the catchment is needed.	As above – a systems approach to understanding water management issues is needed. A hydrological model for entire catchment could be developed and linked to a contaminant model. Need to be able to model different lake

Identified gaps / issues	Potential study(s) to fill gap
	level scenarios as well as sediment and nutrient source scenarios.
No studies undertaken to date around long-term funding and implementation.	Need to investigate alternative sources of funding. Structure to support on-going implementation in a strategic, planned manner.
Economic value and ecosystem services - very few studies undertaken (only 1 relating to economic value of the wetland and this was done in 2007).	Could do a more in-depth investigation of the available ecosystem services and see if there are means to provide ongoing funding through these services.
No information exists on the costs of potential options.	Cost benefit analysis of options needs to be considered.
Monitoring - potential overlap of monitoring parameters by DOC and Waikato Regional Council. Also need to ascertain if any key monitoring parameters are missing.	Collaborative monitoring plan (water quality, quantity, weed removal).
Need to understand what measurable water quality targets could be implemented for the catchment and what level of contaminant removal would be required to meet these targets. Relates mainly to sediments and nutrients.	Links to catchment-wide contaminant and hydrodynamic modelling and understanding of sources of contaminants.
Whilst some information does exist, a better and well documented understanding of the cultural values of the catchment is needed. This information needs to be able to build an understanding of the effect of different options on cultural values.	Collate existing studies and undertake a full assessment of cultural values, sites of importance, etc. A mauri model for the catchment could be developed to assist with optioneering.
Lack of understanding of the potential effects of wastewater and stormwater discharges on Lake Waikare and the Whangamarino Wetland from the urban expansion of Te Kauwhata, and options to manage those effects.	Updated Te Kauwhata CMP to include latest growth projections and wastewater as well as stormwater issues.

3.3 Potential investigations

Following an analysis of the key information gaps (Section 3.2 above), a process was undertaken to identify potential projects which could be further scoped to fill these gaps. This information is tabulated below and is provided for discussion purposes and consultation. Key aspects of all future studies are that they should:

- take a whole-of-catchment approach,
- support future optioneering, and
- if applicable, consider implementation issues such as cost, ongoing maintenance, capacity and governance mechanisms.

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
1	Vegetation mapping undertaken in 2011 of Whangamarino and Surrounds.			Y			Need to focus new work on upper catchment areas	Consolidate Wildlands (2011) mapping work to identify any major changes since 2011 and further map (desktop analysis) the remainder of the catchment.	Now completed as part of the Waikato District SNA project.
2	Summary of floral and faunal values in the catchment.			Y			Significant work already provided as part of the s.128 process for the Whangamarino wetland area. Need to focus new work on upper catchment areas	Consolidate s.128 work relating to floral and faunal values. Investigate biodiversity values in upper catchment areas and Lake Waikare. Other sources of information not investigated to date include SOE monitoring information consent applications and farm plans in upper catchment areas.	A desk-top study - would require a relevant expert to collate this information into a very short report, with key output being maps of biodiversity values. Would require funding.
3	GIS mapping and database of planting and other "on-the-ground" projects	Y	Y	Y			Catchment-wide	GIS mapping of past and current planting initiatives and other on-the-ground projects in the catchment. The map would be supported by a database of projects which contains more detail about each. It could also include a "user" page which	GIS department at Waikato Regional Council. Gap Analysis database could be used to inform the map and then

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
								allows stakeholder to input new projects which they would be working on.	stakeholders can ground-truth it. "Ripple Effect" website could be used as an example for the user inputs.
4	Pest management strategy – alligator weed, yellow flag iris, willow, koi carp, cat fish		Y	Y		Y	Catchment-wide	A pest management strategy should be developed which focusses on key pests identified here. Literature contains significant work on issues relating to koi and weeds - the strategy would need to review this work and set out a process for long-term weed and faunal-pest management. The strategy should also investigate whether or not there are any other key pests which could pose a risk to the catchment in the future.	Literature review as well as options for management - would require a relevant expert to collate the information and recommend management options (in consultation with stakeholders).
5	Stream management – the stocktake of existing literature has highlighted that one of the key sources of sediment is from stream erosion in the upper catchment areas.	Y	Y	Y		Y	Upper catchments	A stream management plan needs to be developed which focusses on understanding the locations of unstable, erosion prone land in the catchment. Options for reducing upper catchment stream erosion and sedimentation should be investigated and a series of options for ongoing management identified. Ground-truthing of the erosion prone land identified in the prioritisation strategy maps should be undertaken and a series of management maps developed. Work undertaken as part of the pest management strategy, GIS projects mapping and values mapping work would help to inform this strategy. In addition to	Using the priorisiation maps, streams requiring further investigation should be identified. Streams walks to be done along key streams. Riparian expert likely needed to complete this work and correlate it with any existing SOE monitoring on streams. Work can be done concurrently with mapping and values projects above, but would need to be updated/

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
								other options, fencing and planting sites could be identified in a prioritised ad strategic manner (rather than ad hoc).	finalised following completion of those projects.
6	Long term watercourse management framework	Y	Y	Y		Y	Catchment-wide	The purpose of this Framework is to integrate the vegetation mapping, pest management and stream management items identified above, along with Waikato Regional Council's prioritisation Strategy maps, to outline, schedule and map a prioritised approach to on-going riparian management (planting, restoration, fencing, pest and erosion control initiatives) over the next 50 years in the catchment.	Internal project team
7	Ecosystem services	Y	Y	Y	Y	Y	Catchment-wide	In 2007 DOC investigated the economic value of the Whangamarino wetland. The report showed the high level of value of the wetland both to the community as well as for conservation purposes. Further investigations are required to determine the potential of the catchment to provide ecosystem services supporting the generation of revenue. This revenue could become a funding source for the on-going management of the greater catchment. An example of such a "service" could be the koi carp fish trap project currently undertaken by council's Science and Strategy team. There may also be traditional activities that could be undertaken by local marae.	Boutique project which may require very specialised skills - an economist and ecologist, along with a cultural specialist. Would need to be carefully scoped but could be a key project for identifying potential future funding opportunities resulting from either pests or values within the catchment itself (self-perpetuating funding).

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
8	Cultural values Assessment					Y	Catchment-wide	A number of existing studies have been identified which reference historical sites and accounts within the catchment area. It is recommended that a full cultural assessment of values be undertaken, key cultural concerns and issues identified, and cultural sites of significance be mapped as part of the CMP process. As part of this a mauri model could be developed assess effects of management options on cultural values.	Cultural specialist/ consultant to undertake this work
9	State of the environment - the lakes	Y	Y	Y	Y	Y	Lakes Waikare, Ohinewai, Kopuera, Rotokawau and Penewaka Lagoon	Using existing literature, summarise the current state and value of the four lakes within the catchment area. The Shallow Lakes Management Plan (2014) provides documents current knowledge about the lakes. This is due to be updated in early 2018.	Internal project team – to be undertaken as part of the 2018 update to the Shallow Lakes Management Plan.
10	State of the environment - Whangamarino wetland	Y	Y	Y	Y	Y	Whangamarino Wetland	Using existing literature, summarise the current state and value of the Whangamarino wetland.	Internal project team
11	WWW catchment hydrological model				Y		Catchment-wide	Key gaps identified include quantification of the extent of surface flooding within the Whangamarino wetland at different water levels, and how these are influenced by the operation of the Lake Waikare control gate. Better understanding of how the two flood gates function integrated with the hydrological changes from the greater catchment. A hydrological model is needed to model flows and water levels on a catchment-wide basis. The *Modelling Inventory*	Specialist consultant/ modeler to be hired to develop a model for the catchment. Important to see if existing models can be integrated in order to reduce model set-up costs.

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
								Report by Streamlined Environmental provides a good indication of the types of available models and what has been done. Model needs to be able to integrate with the contaminant load modelling discussed in item 12 below. Model also needs to be able to support optioneering.	
12	Whangamarino wetland catchment contaminant study		Y				Catchment-wide	The Whangamarino wetland is the final receiving environment within this catchment. The Wetland receives sediment, nutrients and E.coli from four sub-catchments, including Lake Waikare. Whilst there have been numerous studies relating to sources of sediments in the catchment, no work has been undertaken to integrate and understand the existing and long term accumulation of sediment and other contaminants in the wetland. The scope of the study could entail: • field investigations (and use of existing monitoring/ coring material) • the development of a suite of computer models for rural sediment, chemical contaminant and nutrient loads • wetland hydrodynamics (linked to the hydrology model above) and wetland sediment and contaminant dispersion and accumulation • application of these models to project the likely fate of sediment, chemicals and nutrients over the long term, along with an ability to	Specialist consultant/ modeler to be hired to develop a predictive model for the catchment. Important to see if existing models can be integrated in order to reduce model set-up costs.

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
								use the models to assess a range of mitigation options. Modeling can also be used to assess and understand the implications of the Healthy Rivers Wai Ora proposed plan change for this catchment.	
13	Collaborative monitoring plan	Y	Y	Y	Y	Y	Catchment-wide	Monitoring within the catchment is being undertaken primarily by DOC and Waikato Regional Council. Each organisation monitors a number of different parameters, some of which are potentially duplicated. Creating the Collaborative Monitoring Strategy is a two-step process. Firstly, a map of all monitoring undertaken within the catchment needs to be developed, underpinned by a database which describes details of each monitoring location. Using this map as a base, monitoring in the catchment can be strategically reviewed and a strategy developed.	Internal project team (working with key liaison from council's Science and Strategy team and DOC)
14	Alternative and on-going funding sources	Y	Y	Y	Y	Y	Catchment-wide	A study needs to be undertaken to investigate potential sources of funding (targeted rates, pollution tax, funding bodies, etc.) for long-term implementation of the CMP.	Internal project team
15	Investigation into the institutional framework needed to support long-term governance and implementation of works	Y	Y	Y	Y	Y	Catchment-wide	An institutional capacity and implementation framework needs to be developed to support ongoing implementation of CMP recommendations in the long term. This study would need to include an understanding of land ownership, private	Internal project team

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
								and public integration, governance issues and responsibilities for implementation.	
16	Investigation into nutrient and E.coli sources in the catchment and links to algal growth		Y				Catchment-wide	Need to understand the nutrient and E.coli inputs and contribution from the wastewater system and investigate potential other sources such as animal waste, bird droppings, etc. Need to better understand and quantify the issue relating to algal growth and blooms in Lake Waikare.	Specialist input needed
17	Effect of exotic fish on sediment sources		Y				Lake Waikare, Whangamarino wetland	Need to understand what effect exotic fish have on the lacustrine and wetland systems in terms of sediment generation and resuspension. Partly covered by the Lehman, et al. 2017 report (contribution of Koi Carp on suspended sediment levels in Lake Waikare (as well as their effect on nutrient excreted) and Ohinewai.	Specialist input needed – could form an update to Lehman, et al., 2017 and include other exotic fish species.
18	Historic profile and analysis of Whangamarino wetland and Lake Waikare	Y	Y	Y	Y		Lake Waikare, Whangamarino wetland	By information from pollen and diatoms in the sediment cores (extracted for the contaminant modelling study), a historic profile of the lake and wetland could be developed. This would assist with setting long term restoration targets and goals for the catchment. Could be correlated with the existing MSc/ DPhil studies which have looked at this in the Whangamarino Wetland (Fry, 1976; Swamp and Shearer (1997).	Potentially an MSc or PhD project
19	Historic narrative of the catchment					Y	Catchment-wide	A narrative could be written about the recent history of the catchment as told by landowners and iwi. This narrative could help with understanding social and cultural values in the catchment, as well	Potential MA/ MPhil project (series of landowner interviews written as a narrative)

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
								as with setting long term social and cultural goals for the catchment.	
20	Desktop international literature review of the rehabilitation of large shallow lakes		Y			Y	Lake Waikare	Depends on outcomes of the contaminant modelling and sources work. Identified as a potential gap and future option through previous literature, so could be further investigated as a separate initiative. Wind-fetch, hyper-eutrophic lakes, exotic fish and wave action are key issues which would need to be addressed through the literature review.	Specialist input needed
21	Investigation into the costs of options	Y	Y	Y	Y	Y	Catchment-wide	As part of optioneering, implementation and long term costs of options need to be investigated.	Internal Waikato Regional Council project
22	Investigation into the treatment performance of sacrificial wetlands (in-line and off-line), and flocculated wetlands		Y				Lake Waikare/ Whangamarino wetland	Depends on outcomes of the contaminant modeling and sources work. Identified as a potential gap and future option through previous literature and s.128 process, so could be further investigated as a separate initiative. Separate flocc trials could also be included, but effects of long term flocc usage on the wetland also need to be considered. Cultural impacts of in-line wetlands need to be investigated.	Specialist input needed

	Study/ investigation Identified to fill gaps	Funding and implementation					Catchment area - focus	Recommendation (work type/ study/ monitoring)	Potential resourcing
		Land & Soil	Water Quality	Bio-diversity	Water manage-ment	Values (social & cultural)			
23	Investigation into the feasibility of setting contaminant management targets for the catchment		Y				Catchment wide, with focus on Whangamarino wetland	Closely linked to the outcomes of the contaminant modelling and sources work. It is needed in order to be able to set long term measurable objectives for the catchment.	Specialist input needed
24	Update to the Te Kauwhata Catchment Management Plan	Y	Y		Y	Y	Areas which drain the existing and future growth areas of Te Kauwhata	Updated Te Kauwhata CMP to include latest growth projections and wastewater as well as stormwater issues.	Joint WDC and WRC study.

3.4 Options identified for further investigation

In addition to identifying key gaps within the literature, 34 options for further investigation were also identified and are tabulated below. These options provide a valuable starting point in terms of understanding what could be done to address the key issues identified in section 3.1. They would need to be reviewed and updated following the results of investigations identified in section 3.3 above.

Option identified for further investigation	Source	Optioneering project-linkage
Increase water inflows from Te Onetea Stream	DOC report	Systems approach to hydrological modelling – project 11: whole-of-catchment hydrological model
Manage the western bays of Lake Waikare (use as a trial area for structures to reduce sediment re-suspension) – option of sacrificial wetlands	DOC report	Systems approach to contaminant management – project 12: WW catchment contaminant study
Flush the lake by raising and lowering of lake water levels on a regular basis.	DOC report/ Waikato Regional Council report	Systems approach to hydrological modelling – project 11: whole-of-catchment hydrological model
Stop the discharge of treated sewage from Te Kauwhata sewage treatment plant into Lake Waikare	DOC report	Project 15 investigates key sources of nutrients and E.coli and would need to investigate the impact on nutrient loads if sewage discharges into the lake were to cease
Investigate the cost-benefit of a number of potential lake levels	DOC report	Needs to be done once options for management have been narrowed down through the systems-based contaminant and hydrological modelling work. Project 21
Options for long term weed management (including willow)	DOC reports (done primarily by NIWA)	To be incorporated into the consolidated report on weed management and into the pest management strategy (project 4)
Fence Lake margins/create more wetland habitat	DOC report	Projects 11 and 12 – also projects around values and rehabilitation strategies
Establish aquatic vegetation/ macrophytes in Lake Waikare as an option to stabilize sediments and take up nutrients.	Waikato Regional Council report	Project 20 – rehabilitation of large shallow lacustrine systems
Options to implement vegetative soil conservation measures to protect against streambank erosion or deposition, tunneling (soil piping), gullies, landslides and slumps.	Waikato Regional Council report	Project 5 – stream management strategy

Evaluation of restoration options for Lake Waikare include: • external nutrient load reduction (for example silt traps, riparian planting, constructed wetlands) • internal nutrient load reduction and dredging • bio manipulation (for example removal of coarse fish, use of enclosure cages).	Waikato Regional Council report	Combination of options recommended to be investigated through the contaminant management study (project 12), pest management strategy (project 4) and stream management strategy (project 5)
Weir in lake with sediment deposition basin in Lake Waikare upstream of northern outlet control gate, including flocculating the sediment basin	s.128 sediment options report	Will require understanding of total suspended solids (TSS) concentrations under a range of lake conditions and understanding of flow over the weir under a range of environmental conditions (wind, wave, lake level, gate opening) – Projects 11, 12 and 20. Need for flocculation testing.
Provide a partial permeable rock bund as a wave and density current barrier with downstream settlement pond and flocculation, for enhanced sedimentation, upstream of northern outlet control gate.	s.128 sediment options report	Will require understanding of TSS concentrations under a range of lake conditions and understanding of flow over the weir under a range of environmental conditions (wind, wave, lake level, gate opening) – Projects 11, 12 and 20. Need for flocculation testing.
Parallel wetland on land adjacent to the Pungarehu Canal including flocculation of wetland.	s.128 sediment options report	Information on treatment performance of wetlands with a large aspect ratio is required, including verification of design. Need for flocculation testing to understand performance. Project 22
Wetland adjacent to the lower Pungarehu Canal on adjacent farm land, conventionally shaped wetland (additional option could be to flocculate the wetland).	s.128 sediment options report	Information and verification of treatment performance of wetland with fine TSS fraction. Need for flocculation testing to understand performance. Project 22
Sediment bypass pond (floc treated) parallel to canal to allow sedimentation before discharging back into canal downstream.	s.128 sediment options report	Information and verification of treatment performance. Understanding of hydraulics of off-line parallel system. Project 22

Reduced inflow from the Waikato River via Te Onetea gate.	s.128 sediment options report	Significant hydrology, hydraulic and engineering design information required. Project 11.
Discharging water from Lake Waikare to the Waikato River rather than to the Whangamarino wetland - existing Te Onetea as outlet.	s.128 sediment options report	Significant hydrology, hydraulic and engineering design information required. Project 11.
Change Te Onetea gate structure and stream to increase discharge capacity from lake into Waikato River.	s.128 sediment options report	Significant hydrology, hydraulic and engineering design information required. Project 11.
Catchment management erosion control in Lake Waikare catchment - riparian fencing and planting, retirement of land in erosion prone areas.	s.128 sediment options report	Water erosion prediction project (WEPP) or similar catchment models. Information is available on catchment management, which may require verification or validation to local conditions. Project 5.
Above option plus modifications to rural drainage system (detention bunds, wetlands) to capture sediment.	s.128 sediment options report	WEPP or similar catchment models. Information is available on catchment management, which may require verification or validation to local conditions. Project 5.
Catchment management erosion control in catchments of the Whangamarino wetland (other than Lake Waikare) including riparian fencing and planting, retirement of land in erosion prone areas.	s.128 sediment options report	WEPP or similar catchment models. Information is available on catchment management, which may require verification or validation to local conditions. Project 5.
Above option plus modifications to rural drainage system (detention bunds, wetlands) to capture sediment.	s.128 sediment options report	WEPP or similar catchment models. Information is available on catchment management, which may require verification or validation to local conditions. Project 5.
Alter wave climate in Lake Waikare	s.128 sediment options report	Wind and wave climate and effect of this on bed sediment re-suspension. Project 20.
Pump water from Lake Waikare into the Rangiriri Stream to reduce or eliminate discharge through the northern outlet control gate.	s.128 sediment options report	Hydrology, hydraulic and engineering design information required to support design. Project 11

4. MAPPING

A number of maps have been currently being developed to facilitate stakeholder engagement on the catchment management plan (CMP) and to provide key information within the CMP document itself. These include:

- General catchment map with sub-catchments shown and labelled
- Topographical background
- Series of maps showing
    - Landownership parcels including sites of significance
    - Properties showing land use types (dairying, beef and lamb, cropping, vegetable, horticulture, etc.)
    - Cultural sites, marae, hapū boundaries
    - Flood protection scheme assets
    - Monitoring stations and parameters monitored
    - Existing restoration or other projects underway in the catchment
    - Topographical features
    - Aerial photographs
    - Waikato lite prioritisation maps
    - Roading lifeline infrastructure
    - Vegetation mapping (when available)
    - Weed and pest mapping (when available)
    - Erosion prone areas (may be included in prioritization maps)
    - Stream walk maps (when available)

Weed and pest maps, as well as stream walk maps should also be produced.

The maps which have been produced to date should also be considered as drafts for consultation. Whilst they are based on information which is currently available to Council, they may contain some errors and feedback has been requested from stakeholders in order to improve their accuracy.

5. SUMMARY AND NEXT STEPS

This report describes that an extensive literature review and gap analysis process has been undertaken to date. In addition, a detailed database created which provides a current state of our understanding of research, projects and monitoring activities which have been undertaken in the catchment over the last 10 – 15 years. The database has been developed in consultation with some of Waikato Regional Council's collaborative stakeholder partners to the CMP, and with further consultation this database can be extended. It will continue to be used as a valuable resource throughout.

Future work needs to be undertaken in a consolidated, systematic manner by collating existing information in order to facilitate optioneering and develop a prioritised approach to implementation on an on-going basis. This needs to occur in a collaborative manner with all stakeholders contributing resource, expertise and experience into this phase.

The next steps which are needed to complete the current state of understanding with respect to the technical science aspects of the CMP are as follows:

- distribution of this document for consultation
- a workshop with key stakeholders to work through the gap analysis and obtain feedback on the current state of understanding
- prioritization and further scoping of agreed investigations, including associated resourcing and timing
- continued development of agreed LWWW-CMP maps
- further scoping of potential options for management, for inclusion in the optioneering process
- writing of investigation work briefs/ funding applications to support such investigation programmes
- agreement on the investigations that will occur in the short term to inform the CMP development and those that can be incorporated as recommendations within the CMP itself.

ATTACHMENT A – POTENTIAL OBJECTIVES USED TO SET THE PARAMETERS OF THE STATE OF UNDERSTANDING

	SoU/CMP Scope Objectives (collated from reviewed documents and March - May 2015 stakeholder workshops)
1	To give effect to the Vision and Strategy
2	To maintain Lake Waikare and the Whangamarino Wetland as a wildlife refuge (waterfowl numbers are declining since the macrophyte collapes)
3	To reduce yellow flag iris and alligator weed
4	To enhance biodiviersity where practicable
5	To ensure the obligations for RAMSAR wetlands are met for the Whangamarino Wetland
6	To, within the first xx months/ years of implementation, set measurable targets for:
	- water quality improvement (sediment and nutrients)
	- reducing yellow flag iris and alligator weed
	- reducing faunal pests (koi)
	- fencing of riparian land (xxm of fencing per year)
	- macrophyte restoration in Lake Waikare and Whangamarino Wetland
7	To, within the first xx months/ years of implementation, set timeframes around the achievement of the measurable targets.
8	To recognise and enhance cultural values
9	To maintain and enhance the recreational potential of the Lake and Wetland
10	To increase social and environmental connectedness (green corridors) between the Lake and Wetland
11	To maintain existing flood levels
12	To secure adequate resources for enabling the objectives of the CMP to be met
13	To ensure a co-ordinated approach to implementation of CMP works/ recommendations
14	to maintain and improve the sports fish and game resource

ATTACHMENT B – STATE OF UNDERSTANDING DATABASE

[attached electronically as an excel file]